13th INTERNATIONAL SYMPOSIUM ON FUELS AND LUBRICANTS

MARCH 17-19, 2023

Theme: Fuels & Lubricants as Enablers for Net-Zero Goal

Organized by

IndianOil R&D The Power of Possibilities

Under the aegis of

Indian Society on Fuels and Lubricants

Abstract Book (e-Poster Sessions)

ISFL 2023: Program at a Glance

March 17, 2023 (Friday)	March 18, 2023 (Saturday)	March 19, 2023 (Sunday)
Registration (0800 hrs onwards) Tea (0800-0915 hrs)	**Plenary Session - II** (0900-1030 hrs)	**Technical Session – V** (0900-1015 hrs)
Opening Remarks by Chairman, NSC, ISFL 2023 **Plenary Session - I** (0915-1100 hrs)		TS V A: EV fluids TS V B: H2 as Future Fuel TS V C: Greases
Inauguration Symposium, Exhibition & Posters (1115-1245 hrs)	**Tea**	**Tea**
	Panel Discussion- II (1045-1215 hrs)	**Plenary Session – IV** (1030-1200 hrs)
Lunch	**Plenary Session - III** (1215-1345 hrs)	**Valedictory Session** (1215-1315 hrs)
Panel Discussion-I (1345-1515 hrs)		
Tea	**Lunch**	**Lunch**
Technical session – I (1545-1715 hrs)	**Technical Session – III** (1430-1600 hrs)	
TS I A: AO-I TS I B: Oxygenated Fuels TS I C: Industrial Lubricants	TS III A: NGEOs & Fluids TS III B: Bio-Technology TS III C: Metal Working Oils	
Tea	**Tea**	
Technical Session – II (1730-1900 hrs)	**Technical Session – IV** (1615-1745 hrs)	
TS II A: AO-II TS II B: Fuel Testing & Additives TS II C: Circular Economy	TS IV A: Base Oil & Additives TS IV B: Alternative Fuels TS IV C: Refining Technology	
e-Poster Session – I (1230 – 1600 hrs)	**e-Poster Session – III** (1230 – 1600 hrs)	
e-Poster Session – II (1600 – 1900 hrs)	**e-Poster Session – IV** (1600 – 1900 hrs)	
Networking Dinner (1900 – 2100 hrs)	**Cultural Program & Conference Dinner** (1930 – 2200 hrs)	

25 Years of Energising Fuels & Lubricants Industry

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E-Poster Session-1 on Lubricant Technology

Paper ID 211: Effect of fuel-efficient engine oil on the durability of heavy-duty diesel engines

Anand Prakash Gupta, Amitava Pal, Tarunendr Singh, Mohammad Sohail Akhtar, Debashis Ganguli

BPCL R&D Centre, Bharat Petroleum Corp. Ltd., Mumbai, India

Research has shown that low viscosity engine oil could help to save fuel, reduce environment pollution &carbon footprint, simply by switching from high viscosity engine oil to low viscosity engine oil. In India, many truckers, fleet owners are skeptical of lower viscosity engine oils, believing they won't offer enough protection. Hence, study was carried out to evaluate the effect of low viscosity (SAE 10W-30) heavy duty diesel engine oil on wear characteristics, deposit formation tendency and durability of the engine parts by dismantling the engine completely before and after the field evaluation with respect to the reference engine oil (SAE 15W-40). The best way to establish the durability of an engine is to dismantle the engine before and after field evaluation and measure the wear of various engine parts such as piston rings, bearings, liner etc, and deposit formation on various locations of all the pistons and inlet & exhaust valves. In this study, four heavy-duty diesel vehicles of similar age were taken and divided in two categories i.e. trial vehicles (SAE 10W-30) and reference vehicles (SAE 15W-40). Out of the above mentioned two categories, one vehicle from each category was dismantled completely before and after trial completions After dismantling, photographs of engine parts were also taken before and after trial for visual inspections along with physical measurement of various engine parts. Physiochemical analysis of engine oils was done to predict the durability of other trial and reference vehicles, for which engine was not dismantled. During the field evaluation, in-service engine oil samples were taken from the all the four vehicles under study at regular intervals (20000 km) and analyzed them for various performance parameters. This helped in understanding the effect of low viscosity engine oil on the wear pattern of various engine parts such as piston rings, bearings, liner etc and, the oil’s performance parameters such as soot loading capacity, wear mechanisms of rubbing surfaces in an engine.

Paper ID 213: 1,1,3,3-Tetramethylguanidine based dicarboxylate ionic liquids as efficient additives for lubricants

Praveen K. Khatria, Gananath D. Thakreb, Suman L. Jaina

Chemical and Material Sciences Division, CSIR-Indian Institute of Petroleum, Dehradun, India

Owing to the inherent properties like low vapor pressure, non-flammability, high thermal and chemical stability, high ionic conductivity and strong polarity, ionic liquids (ILs) have been extensively used in scientific and industrial applications.1-3 Due to the stringent environmental regulations, the development of metal, phosphorus, and halogen-free additives specifically ionic liquids (ILs) have gained a significant interest as an alternative of most widely employed zinc dialkyldithiophosphate (ZDDP). The immense potential of ILs as lubricant or lubricant additives is directly related to their dipolar character and capability of tribo-film creation by healthy interaction with the tribo-surfaces to reduce wear and friction. More particularly, dicationic ionic liquids have gained significant interest and well acknowledged as superior candidates over the traditional monocationic analogous for lubrication applications. However, the research on dianionic ILs is still at the infancy stage and needs to be explored further. As per the existing prior art, dicarboxylated ILs have shown efficient reduction in tribo characteristics such as wear and friction than monocarboxylic acids.4-5 During the present study, we have synthesized a series of dicarboxylic acids (dodecanoic acid, sebacic acid, suberic acid and adipic acid) based dianionic ILs by using 1, 1, 3, 3-tetramethylguanidine (TMG) as a cationic counterpart. Tribo performance of the synthesized ILs was evaluated over a four-ball tribo test machine as per ASTM D4172B standard test method. The effect of alkyl chain length was also investigated and among the different acids, sebacic acid and dodecanoic acid remained most effective. Blends of the ILs were prepared using polyol ester as a base fluid at very low concentrations of 0.025, 0.05 and 0.1 wt% at different loads of 20 and 40kg. Tribotest results revealed that ILs having long alkyl chain displayed improved wear resistance and friction modifier properties in contrast to ionic liquids with shorter alkyl chains. A maximum reduction of 58% at 0.025wt% dose was observed in wear scar diameter (WSD) for dodecanoic acid derived IL having the highest number of methylene units while 55% reduction in coefficient of friction (COF) for sebacic acid derived IL.

Paper ID 214: Mitigation study of foaming in high TBN marine oils - Role of defoamants in individual as well as in combined forms in controlling foaming tendency of highly polar marine lubricants

Ramanathan R, Kannan S,Venkatesan S

Lube (QC), LBP Chennai, Indian Oil Corp. Ltd., India

Commercial production of high TBN marine oils usually encounter with the issue of exorbitant forming tendency which causes delay in finalizing and releasing of commercial batches in blending plants. Defoamants optimized at micro scale need not to reproduce their performance for commercial batches. A detailed study on the effectiveness of defoamants to mitigate the foaming issue in blending plants has been conducted. As an extension, the role of oil polarity and effectiveness of base oil and their substitutes in marine oil formulations has also been studied.

Different commercially available defoamants were evaluated individually as well as in combined forms to study their effectiveness in reducing the foaming tendency of a 70 BN marine oil. Both Silicon and non- Silicon based defaomants were selected for the study. It has been observed that silicon based defoamant was effective in controlling the foaming when used individually and also at lower treat rate as compared to non-silicon candidates. Non-Silicon defoamants were observed to be effective at higher dosage as compared to silicon based defoamant when used individually. Upon combination, silicon based defoamant is observed to be playing an antagonistic effect with non-silicon defoamants and combination of non silicon defoamants yielded excellent results. Non silicon defoamant combo at a treat rate of 0.10 wt % was observed to be the most effective combo in reducing the foam to ‘Nil’. Effect of oil base number (TBN) towards contributing foaming has also been evaluated by studying a range of marine oils with varying TBN (10 to 70) and correlation has been established between oil polarity and foaming tendency.

Different types of thickeners were also evaluated by replacing the base oil as an alternate approach to study the role of thickener to control foam. Replacing the base oil with thickeners has no effect in reducing the foaming tendency.

Paper ID 219: Circular economy & ESG in used lubricants & sectors

Bhavti Patadia

Minimac Systems Pvt Ltd, Khed Taluka, Maharashtra, India

Oil flushing is the most inevitable step for commissioning any plant or even equipment. Without its proper execution, the equipment should not be allowed to take into function. Today, oil flushing is not confined to pre-commissioning but also in practice at the time of planned turndowns, oil replacement, annual shutdown and breakdown outages, etc. With the latest developments in predictive maintenance culture focusing on Lubrication Technologies for Rotary and Hydraulic Equipment, flushing has now become a mandatory activity for improving the efficiency & reliability of an asset. The flushing procedure involves heated fluid passage through the pipelines with high velocity & turbulence, which dislodge the contaminants & forces them out of the system. It is done on critical equipment or pipelines to avoid contaminants, scaling, sludge, etc., which support production or maintenance goals, saving costly unscheduled downtime and generation losses. An asset's life cycle depends not only on preventive or predictive maintenance implementation but also on forecasting potential challenges, failures, and breakdowns. With this technical white paper, we attempted to offer a solution with decades of practical research, case studies, purely result-oriented execution, and continuously improved methodology. We strive to create awareness about the importance of oil flushing for a plant.

Paper ID 269: Next-gen mobile gas engine oil for Indian heavy duty CNG fleet applications

Bijan Roy, Shiv Kumar Vabbina, Yogesh Kumar Sharma, Sarita Seth, Pankaj Bhatnagar, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Natural gas vehicles have been penetrating Indian market steadily in recent years. Rapid buildup of gas infrastructure, efforts to curb pollution, sky-rocketing prices of liquid fuels and lower total cost of ownership are major drivers behind the sales growth of gas-fuelled vehicles in both passenger car and commercial vehicle segments. Natural gas engines possess unique lubrication demands. High combustion temperature and gaseous nature of fuel cause severe threat to oil's stability; in particular oil oxidation and nitration are major challenges, often generating corrosive by-products. Gas Engine oils also have to possess robust wear protection to engine hardware. In

absence of standard specification for GEOs, OEM-approval through field-trial is essential, especially for commercial fleet application.

At present, gas engine oils for CNG heavy duty applications are suitable for 10-20k kms operation. IndianOil also has introduced GEOs with 20k kms ODI capability, are approved by the major OEMs. Targeting to maximize savings and to minimize downtime, IndianOil R&D has developed a new GEO aiming 40k kms of operational life, potentially helpful to reduce carbon footprint. The present paper discusses comparative laboratory studies of candidate oil and field trial evaluation. Oils for longer operational life has to be robust against thermal degradation, alongside must possess superior cleanliness and wear protection. The candidate oil was evaluated via oxidation test-PDSC, Detergency tests-KHT and TEOST, corrosion tests- ISOT and HTCBT, and Nitration bench test. The field trial was carried out for 50k kms in 6 BS VI CNG buses. In-service oil samples were collected from each bus at regular intervals and were analysed for various parameters against acceptable limits. All used oil parameters were found to be within the rejection criteria which indicated less wear in engine cylinder, head and excellent performance for the cylinder and crank shaft wear protection. In addition, the vehicles performed trouble free and no oil related issues appeared during the entire field trial. Developed candidate oil has fully demonstrated its long drain capability through the lab and field studies conducted under this research work.

Paper ID 228: Establishing shear stability index as per thickening efficiency model for olefin copolymers

K. Naresh Kumar, Anil Bhardwaj,Pankaj Bhatnagar and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Lubricant as per requirement contains various performance additives along with polymer-based viscosity index improver (VII). These VI Improvers are special types with strict structural requirement whose functionality is derived from their shear stability Index and thickening efficiency for viscosity-temperature relationship. There are different additive chemistries and architectures available, all of which have advantages as well as disadvantages and affect solution viscosity through different mechanisms. Olefin Copolymers (OCP) of the type ethylene/propylene copolymers are a class of VI improvers extensively used in Lube formulations. Performance of these OCP is a function of their composition, co-monomer sequence distribution and molecular weight/ molecular weight distribution. Even small differences in structural composition of these

olefin copolymers with strict structural requirement accounts for substantial changes in viscosity parameters (Viscosity @ 40°C and 100°C, Viscosity index, SSI and thickening efficiency) of OCP blended base oils. Intrinsic viscosity (η) of a polymeric solution is an important "dilute solution viscosity" parameter, which is easily measurable using Ubbelohde viscometer and can provide information about the molar mass of a polymer using the Mark-Hawkins relationship. In the proposed work, intrinsic viscosity of candidate lab synthesized Olefin copolymers in cyclohexane as a solvent at 30°C were correlated with Weight average molecular weight (Mw) as well as with the kinematic viscosity (@ 40°C and 100°C and thickening efficiency (viscosity lift) as measured for blended base oils using these copolymers, in three different base oils. Excellent correlations between intrinsic viscosity of a copolymer with all the above said parameters have been obtained. These correlation studies enable prediction of performance of an olefin copolymer in blended base oil based on an easily and quickly measurable intrinsic viscosity parameter, leading to faster screening of large number of olefin copolymers for their utility as VII in lubricants, in a short span of time without many resources. Based on the lab evaluation adopted with variation in the concentration of OCP along with base oil even prediction of different SSI can be achieved.

Paper ID 234: Study of effect of additives on hydrolytic stability of rapeseed oil and trimethylolpropane trioleate

Shruthi K. S., Shobhashankar Kumhar, Naresh Kumar K, Nagesh N Samant, Anil Bhardwaj, Pankaj Bhatnagar and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Esters have been largely used in lubricants, esters shows good lubricity, improve the solubility of additives, have an affinity for metal surface, and improve cleanliness and sludge control etc., and now there is growing interest for using them for development of environmentally acceptable and biodegradable lubricants. Unfortunately, natural and synthetic esters are vulnerable to either acid or base catalyzed hydrolysis. Improving the hydrolytic stability of esters can provide the possibility of creating longer life environmentally acceptable and bio degradable lubricants. In this paper author has studied the effect of acid catcher additives, triblock polyalkylene glycols (PAGs) and oil soluble polyalkylene glycols (PAGs) on hydrolytic stability of rapeseed oil and Trimethylolpropane Trioleate. Hydrolytic stability was measured using ASTM D2619 test method in which additives were examined at various concentrations

Paper ID 239: Effect of amine phosphates on the oxidation stability characteristics in synthetic compressor oil

Umashankar Male, Shobhashankar Kumhar, Anil Bhardwaj, Pankaj Bhatnagar, and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

The interactions of different additives in lubricating oils can create synergistic or antagonistic effects. This paper studies the effect of incorporating amine phosphate based multi-functional additive on the performance of phenolic anti-oxidant in synthetic compressor oil. Amine phosphates are known to provide rust-inhibition, anti-wear and anti-scuffing properties to lubricating oils. The effect of amine phosphate on oxidation stability of synthetic hydrocarbon based compressor oils was studied by preparing a series of trial blends by varying the amount of amine phosphate, while keeping the other additives in constant amount. In a typical trial formulation, polyalphaolefin was used as base oil, and other general performance additives such as phenolic anti-oxidant, amine phosphate, and anti-corrosive additives are used. The trial blends were tested for oxidation stability, rust inhibition, and anti-wear properties. Oxidation stability of the oil was studied by following the ASTM D 2272 test method, rust inhibition characteristics was evaluated w.r.t ASTM D 665 B test method for 24 h, and anti-wear properties by ASTM D 4172 B test method. A total of six amine phosphates were tested, and the results show that the addition of amine phosphate should be controlled to obtain optimum performance in both rust inhibition, and oxidation stability, either increase or decrease of amine phosphate will cause negative effect on oxidation stability or rust inhibition properties, respectively. The optimized dosages for all six types of amine phosphates have shown similar anti-wear properties.

Paper ID 240: Study on oxidation stability of lubricant base stocks by rotary bomb oxidation test and pressurised differential scanning calorimetry

Kashinath Sutar, Khalid Z. Mohammed, Sohail Akhtar, Debashis Ganguli

BPCL R&D Centre, Bharat Petroleum Corp. Ltd., Sewree, Mumbai, India

Oxidation is the prime cause of lubricant degradation and reduction in effective service life of lubricants. It is the prime reason for numerous lubricant problems such as viscosity increase, sludge and sediment formations, varnish deposit, filter plugging, loss in foam control, rust formation and corrosion, etc. As lubricants are either pure base oils (straight oils) or the combination of base oil (major) and performance additives (minor), oxidation stability of base oils

is one of the most important parameters for selection of base oil for formulation of lubricants in demanding application. In current study, oxidation stability of two mineral base oils, representing API Group-I (BO-I) and Group-II (BO-II), are studied by rotary bomb oxidation test (RBOT) and pressurised differential scanning calorimetry (PDSC). The relative oxidation stability of two base oils observed in RBOT and PDSC was compared with the composition of base oil to interpret the effect of composition on overall stability of the base oils. RBOT test utilizes oxygen-pressured vessel to evaluate the oxidation stability of oils. The test oil, water, and copper catalyst coil, contained in a covered glass container were placed in a vessel equipped with a pressure gage. The vessel was charged with 99.5% pure oxygen to a gauge pressure of 620 kPa (90 psi,6.2 bar), placed in a constant temperature dry bath taken at 150°C, and rotated axially at 100 rpm at an angle of 30° from the horizontal. The number of minutes required to reach a specific drop in gage pressure 175 kPa (25.4 psi, 1.75 bar) is the oxidation stability of the test sample. PDSC oxidation stability test was conducted with Tzero PDSC cell. Aluminium and copper sample pans were used in current study. Study shows that, optimum concentration of sulphur in the form of heterocyclic compounds and hydrocarbon composition (paraffins, naphthenes and aromatics) is essential for the oxidation stability of the base oil for use without inhibition. The sulphur containing materials acts by peroxide decomposing mechanism which prevents hydroperoxide decomposition into free radicals. Aliphatic hydrocarbons are more oxidative stable than aromatics, however moderate concentration of aromatics helps to trap the radicals or oxidation products derived from aromatic compounds are responsible for inhibition. Study also indicates the catalytic effect of copper (transition metal) on the oxidation reaction in comparison with aluminium as pan material in PDSC.

Paper ID 252: Development of indigenous pour point depressants (PPDs) additive to formulate both automotive and industrial lubricants

Santosh K. Sahoo, Gurmeet Singh, Ravindra Singh, Ravindra Kumar, Sandeep Kumar, Sarita Seth, Anju Chopra

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

IOCL is on the forefront for serving engine oils and various lubricants to the nation. Engine oil, or engine lubricant is used for the lubrication of internal combustion engines and consist of chemical additives and other components which are added to impart various properties to these lubricants. For improving and maintaining the required viscosity of oils, preventing any kind of wax crystals formation and maintain cold flow properties, Pour Point Depressants (PPDs) are used. Poly-methacrylate (PMA) based additives are high performance additives acting used as PPD for

lubricating oils and have been found to impart Viscosity Index Improvement to the base oils. They are applied to enable the lubricants to remain flowable at low temperatures by restricting the wax formation growth. At IOCL-R&D, substantial research and development activities are being undertaken for the development of PMA based PPDs. Variety of alkyl acrylates and methacrylates based polymers and co-polymers were synthesized by varying different parameters such as initiators, polymerization temperature range (60-100°C), reaction time (3 to 8 hrs), comonomer composition, chain length and solvents. Further, the polymethacrylates bearing a wide range of molecular weights varying from 15,000 to 60,000 dalton also have been synthesized in the laboratory. Various physiochemical properties of the polymers and pour point depression in various oils were measured. After optimizing the synthetic process and scrutinizing many synthetic and structural parameters, suitable indigenous PPDs have been developed which provide high pour point depression efficacy, amongst improvement in other parameters of the formulations as well.

Paper ID 253: Development of cost-effective heavy duty diesel engine crank-case lubricants through in-house developed soot dispersancy engine test method

Bhuvenesh Tyagi, Ashish Kachhawa, A. S. Ramadhas, M. Sithananthan, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

The need for evaluating the dispersancy characteristics of diesel engine oil for varying levels of soot forms the basis of the present study. Soot particles are formed in diesel engines due to incomplete combustion of fuel. These particles eventually go into the crank-case via blow-by gases and mix with the engine oil. When soot particles in engine oil come in contact with each other, they have a tendency to agglomerate and hence the particle size increases. This soot accumulation in lubricating oil results in lubricant's viscosity increase affecting its pumping ability and degrades the performance of the lubricant. Critical engine components then may be starved of lubricating oil resulting in engine wear. With the increasing presence of new engine technologies there is demand for developing high performance level of lubricants particularly with respect to their soot handling ability. This paper describes an experimental approach to develop a cost effective indigenous test method to evaluate high performance diesel engine oils for soot mediated oil thickening.

Various engine hardware parameters affecting the soot formation were optimized to make the engine ready to deliver about 6% soot content in oil at the end of 250 hrs test. The tests were conducted on a BS II commercial, four cylinder, 4-stroke, water cooled, direct injection turbocharged diesel engine. The test severity was generated in order to match real time environment by incorporating various engine hardware modifications like inlet air restriction, retarded injection timing, increased fuel delivery, auxiliary oil sump unit, and reduction in injector pressures. The soot levels generated were correlated to the FSN (Filter smoke number) values. Oil samples were drawn at the end of every 25 hrs and the soot percentage in oil was determined through TGA analysis. The wear metal analysis of used oil was carried out using ICAP spectrometer. After establishing the test procedure, three engine oils were evaluated at fix soot level of 6% in oil at the end of test. The oils are SAE-40, API CF-4, SAE-40, API CI-4 and SAE 10W-40, API CK-4. The test method successfully differentiated the performance of all three different candidate oils with respect to soot induced wear of engine components as well as the viscosity changes due to soot loading. The test procedure was found to be cost effective when compared to standard engine test procedures.

Paper ID 262: Fuel and engine oil auxiliaries: Functionally modified polyisobutylenes as ash-less dispersants

Tota Rajsekhar, Gurmeet Singh, Sujit Mondal, Anju Chopra, Ajay Arora

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Fuel and oil additive industry typically use PIB based ash-less dispersants, due to their unique properties of cleaner burning, low toxicity, good thickening properties, high shear stability, water and oxidation resistance, tackiness, and cohesive strength. Furthermore, PIB based dispersants possess various other value-added advantage including less char formation at high temperature performance conditions and ability to improve final lubricant and fuel performance.1 Basically the precursors of PIB based dispersants consist of olefinic group/ double bond. Based on the double bond position, the PIB precursors are broadly classified in to two categories: (i) conventional PIB consists of internal double bonds, and (ii) HR PIB consists of external double bond.2,3 Among these two, HR PIB is functionally modified towards the preparation of motor oils and fuel auxiliaries. Moreover, HR PIB having Mn (number average molecular weight) in the range of 500-5000 Dalton with at least 70 mole % reactive vinylidene at the terminus are of high commercial value. In order to synthesize polyisobutylene succinic anhydride (PIBSA) and then to polyisobutylene succinic imide (PIBSI); HR-PIB is generally being used as precursor. The PIB

based dispersants, PIBSIs, are prepared in two steps. In the first step, PIB chain terminated with succinic anhydride (PIBSA) is generated mostly via Alder-ene reaction. In comparison to internal olefin ends containing PIBs (conventional PIBs), PIB with external/ terminal vinylidene functionality is highly reactive toward maleic anhydride to give PIBSA. Then, PIBSA is reacted with polyamines to produce PIBSI dispersant, which has numerous applications in fuel and lubricant additive industry. The scientific motivation behind these materials development, applications and results along with characterization of PIBSA and PIBSI, synthesized from HR PIB, will be highlighted.

Paper ID 265: Studies on lead and copper corrosiveness of heavy duty diesel engine oils

Rajesh Nimmakuri, Sandeep Kumar, Snigdhamayee Praharaj, Sarita Seth, Pankaj Bhatnagar, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

To meet the modern-day stringent emissions legislations, high power outputs, reliable and cost-effective engines, diesel engines experience harsh conditions to deliver the optimum performance. With increase in load, operating temperatures, extended oil drain intervals and exhaust gas recirculation (EGR) - diesel engines oils are more susceptible for oxidation and enhanced sludge build up, piston deposits, wear and fatigue. Increased oil deterioration can lead to corrosive attack of key engine parts, such as soft-metal-containing bearings (tri-metallic & di-metallic), bushing and follower bronze pins, which are already under a huge mechanical stress. Hence, corrosive wear is one of the important causes for bearings failure due to removal of bearings overlay as a function of engine lubricants. In general, lead surface is predominately attacked by acidic species present in lubricating oil, whereas decomposition products of sulfur-containing additives i.e. active sulfur species corrode the copper surfaces. Hence, the additive chemistry plays a prominent role in modern day engine oils that can neutralize the acidic species effectively to reduce lead corrosion and optimal balance of sulfur-containing additives to reduce the copper corrosion. In order to evaluate the anti-corrosive ability of diesel engine oils, API & ACEA specifications includes lead/copper corrosion bench test as one of the necessary performance parameters. Currently, Mack T-9, Mack T-10 and Mack T-12 engine tests and High Temperature Corrosion Bench Test (HTCBT) are used to evaluate the lead and copper corrosion in engine bearings.

In this work, the corrosiveness of heavy-duty diesel engine oils meeting CK-4/CI-4 plus specifications was evaluated using High Temperature Corrosion Bench Test (HTCBT). Extensive studies were done using API CK-4/CI-4 plus diesel engine oils (SAE 10W30 & 15W40 grades) as

the baseline formulations. The effect of molybdenum-based friction modifiers in formulated diesel engine oils on lead & copper corrosion was studied by a high temperature corrosion bench test (ASTM D 6594). It was observed that, at higher FM concentrations copper surfaces corrode aggressively, whereas lead corrosion was minimal. Further, a correlation was established between the concentration of molybdenum-based friction modifiers and metal deactivators on lead/copper corrosion. For this purpose, triadiazole and benzotriazole based copper passivators were screened and benzotriazole based additives found to be superior in corrosion inhibition. An optimal combination of benzotriazole based copper passivators and a molybdenum-based friction modifier for effective corrosion inhibition was established for various API CK-4/CI-4 plus engine oils.

Paper ID 270: Study on ashless & zinc based bearing oils for no twist rod mills (NTM)

M N K Prasad Bolisetty, Chanakya Tripathi, Kavita Rai, Ajay K Harinarain, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Efficient lubrication of steel plant equipment is a major challenge due to operating conditions like extreme heavy loads, very high speed, variation in temperature, dusty polluted environment and water ingress. For the lubrication of roll neck bearings and gear boxes of No Twist Wire Rod Mill of steel plants, bearing oil meeting the Morgoil Advanced Lubricant specification is required. As water is used as the coolant in many operations of steel mills, its ingress into machines and mixing up with the bearing oils is unavoidable. Hence, the bearing oil should have outstanding water separation characteristics, good resistance to oxidative degradation, excellent rust & corrosion protection.

In order to compare the performance of ashless & various zinc based bearing oils detailed lab study was undertaken. In this paper authors have compiled the lab evaluation of water separating characteristics at normal & low temperature as per the requirements of Morgoil specification. Effect of the composition of the zinc based bearing oils was also evaluated and compared with ashless bearings oil by means of filterability, rust, corrosion, oxidative and thermal stability.

Paper ID 272: Study on antioxidant and antiwear interaction in industrial oils

Sumit Bhaskaran, K. N. Yadav, Rameshwar Chaudhary, L. M. Pandey, Kavita Rai, Ajay Kumar Harinarain, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Lubricant additives are chemical moieties which when added together to a lubricant may react to produce beneficial (synergistic) or detrimental (antagonistic) effects to affect the physiochemical/ performance characteristic of the end product. Therefore, it is necessary to assess these interactions to ensure that these additives are able to meet their end purpose in the lubricant. This paper discusses the interactions between various antioxidants (aminic, phenolic, hindered phenol) and different antiwear additives (Zn based & ashless chemistries) to study the effect on their performance in Industrial lubricant with respect to changes in oxidation as well as the anti-wear characteristics. The lubricant oxidative stability and anti-wear properties are characterized using various techniques to simulate various conditions prevailing in the end applications.

Paper ID 248: Reduced tendency to form sludge in oil: An effect of alkylation on phenyl and diphenyl amines antioxidants

Debashis Ganguli, Sarvesh Singh Tomar, Ashish Kumar Mishra

BPCL R&D Centre, Bharat Petroleum Corp. Ltd., Sewree, Mumbai, India

Phenyl and diphenyl amine derivatives have been known to function as antioxidant for engine oil, transmission fluids and industrial lubricants. This study focuses on the branched alkyl-substituted phenyl and diphenylamine in a lubricant composition to provide a reduced tendency to form sludge in a mineral oil having a low aromatic content containing no aromatic ring in its structural unit. Mineral oils such as Group II, Group II+, Group III and Group III+ having a low aromatic content and synthetic oils, such as poly-alpha-olefin (PAO) oils, which do not contain any aromatic rings in the structural units thereof, are themselves poor in oxidation stability. The mineral oils or synthetic oils have a good response to antioxidants and the resulting lubricating oil compositions exhibit high oil stability. The problem involved in these compositions is that the solubility of antioxidants in the oils is low. Antioxidants invariably undergo a change in quality in them when their function is exhausted during their use, presenting a problem if substances formed by their oxidation are left as sludge. Certain phenyl and diphenyl amine derivatives are useful as additives for lubricants, and that such amines exhibit oxidation-inhibiting effects. However, such amines suffer from the disadvantage that the conversion products thereof are poor in oil solubility and thus form sludges.

We have made studies in relation to the high oxidation-inhibiting performance of such amines in an attempt to overcome their disadvantage of forming sludge and have found that when amines having a specific structure is added to oil, it exhibits excellent oxidation-inhibiting performance with reduced sludge formation.

Paper ID 293: Hot rolling oil for stainless steel

Vilas Ramtenki, N.Sivasurian, Simmi Datta, Subinoy Paul, Pankaj Bhatnagar and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Nowadays suitable “Lubrication System” and “Hot Rolling Oil” are being used by modern steel plants. IOC has developed and successfully commercialized various grades of Servosteerol H series of hot rolling oils for different applications such as flat, structural & edger rolling in reputed steel plants. This paper covers development and commercialization of a tailor made hot rolling oil for stainless steel. The composition of this hot rolling oil is a synergistic combination of vegetable ester, mineral oil and performance additives. This Hot rolling oil is applied on roll surface in the form of fine dispersion. It reduces coefficient of friction at the interface of “Work Roll” and “Hot Stainless Steel Sheet” and thus providing higher reduction in steel thickness at similar roll specific force. The innovative combination of performance additives provides wear protection for enhancing the life of work roll.

Paper ID 304: Evaluation of long drain capability of diesel engine oils by laboratory and in-house engine testing studies

Sathyam Reddy Yasa, Snigdha Praharaj, Sanjeev Singh, Bhuvnesh Tyagi, Sarita Seth, Pankaj Bhatnagar, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Lubricating oils play an important role in enhancing life of vehicle engines by providing superior cleanliness, less wear & tear and better engine efficiency. There is continuous focus on reduced total cost of operation (TCO) of vehicular fleets and hence operating cost is becoming increasingly important to large fleet operators that use heavy-duty diesel engines. One way to reduce operating cost is to increase oil service intervals by using superior quality of oil with extended oil drain interval (ODI) performance. ODI enhancement is achieved by inhibition of degradation of engine

oil and by maintaining the engine oil performance as long as possible. It is important to mention that ODI can be established by conducting vehicle field trials which are time consuming and expensive procedures. There is a need to have shorter evaluation and screening test procedures to assess the oil degradation behavior in lab scale which can throw some insight to oil's capability and recommendations can be made based on lab studies.

The present study describes the assessment of long drain capability of diesel engine oils by laboratory performance and in-house engine tests for three grades of engine oils viz., two mono-grade oils API CF4 and API CI4 of SAE 40 grade and one multi-grade oil API CK4 SAE 10W-40 candidate oils formulated with different additives and base oils. The comparative performance data on the candidates under study has been generated by Thermo-oxidation engine oil simulation test (TEOST), Komatsu Hot Tube test (KHT), Pressure differential scanning calorimetry (PDSC) and Glass tube oxidation tests (modified IP 48 and TOST) to differentiate the laboratory performance of engine oils under study. The tribological characteristics were also evaluated to assess anti-wear and anti-friction properties on four-ball tribo tester and on SRV test machine. Finally, in-House Engine Tests (Oil Thickening Engine Test and Piston Deposit Test) for high-temperature performance like oil thickening control, sludge handling, oil consumption and engine wear protection were done on selected candidates. Based on laboratory performance and in-house engine test studies, it is concluded that API-CK4 SAE 10W-40 engine oil has excellent performance in terms deposit control and oxidation inhibition w.r.t API-CI4 SAE 40 and API-CF4 SAE 40 which demonstrates potential long drain capability of diesel engine oil meeting API CK4 credentials in SAE10W-40 chosen for the study.

Paper ID 306: Studies on oxidation & deposit forming properties of API CI4 plus diesel engine oil with addition of biodiesel

Sandeep Kumar, Rajesh Nimmakuri, Snigdhamayee Praharaj, Sarita Seth, Pankaj Bhatnagar, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Biodiesel is considered as an alternative renewable source of automotive petroleum fuel and its usage is encouraged in automobile sector to reduce dependency on fossil fuels. Global biodiesel consumption trend is growing as it is an environmentally friendly fuel and its combustion properties are similar to conventional diesel fuel. The goal of National Policy on Biofuels 2018 is to facilitate the availability of biofuels and increase its percentage in conventional fuels to reduce the import

dependency of crude oil in India Indian Government has approved 5% blending of biodiesel in conventional diesel as an indicative target proposed by 2030 which includes harnessing of biodiesel to meet the energy security of India However, erudition of biodiesel dilution effect on diesel engine oil lubricant is not large enough to understand the lube oil properties degradation mechanism. Though Bharat Stage VI emission norms had been introduced during April 2020, still large population of BSIV vehicles is running on the Indian roads. As API CI4 plus category diesel engine oils are primarily used in BSIV commercial vehicles in Indian market, Authors have studied the effect of biodiesel fuel mixed in diesel engine oil meeting API CI 4 Plus to mitigate the air pollution from BSIV vehicles. Candidate oils meeting SAE 10W-30 viscosity grade and API CI4 Plus were chosen to study the impact of Biodiesel fuel on engine lubricant's performance. Oil oxidation tests such as Pressure Differential Scanning Calorimetry (PDSC), Thin Film Oxygen Uptake Test (TFOUT), Bulk Oxidation Test (IP 48), Thermo Engine Oil Oxidation Simulation Test (TEOST-MHT) and Komatsu Hot Tube (KHT) tests were used to investigate the effect of biodiesel on engine oil properties at varying doses. Effect of antioxidant and detergent were also assessed in lab studies. This study concluded that oxidation stability of API CI4 Plus diesel engine oil doped with biodiesel can be improved by aminic antioxidant and it results in lesser deposit formation and enhanced oxidation stability.

Paper ID 349: Lifecycle enhancement of turbine oils

Arjun G Singh Tuteja, Peeyush Dubey, S Venkatesan

Indian Oil Corp. Ltd., Head Office, Mumbai, India

In Thermal power generation, fossil fuels such as oil, liquid natural gas (LNG), coal, and other substances are burnt to generate steam to run generators for electricity. Considering the extreme conditions prevalent, the lubricating oil and the associated systems must be designed, operated and maintained for extreme reliability to prevent any shutdown.

The moving parts of the Steam, gas and hydro turbines especially the support bearings are lubricated by R&O (Rust and Oxidation inhibited) type turbine oils. Turbine oils must have excellent thermal and oxidation resistance at bearing oil temperatures that may approach 100oC in typical steam turbine or industrial heavy-duty gas turbine. Turbine lubricants must not cause any rust and corrosion detrimental to the precision surfaces. These are also required to resist foaming due to air entrainment, which could severely impair lubrication. The oil should a very high viscosity

index to allow operation over a wide range of operating temperatures. These oils should not experience any key additive depletion during filtration.

Turbine oils are expected to provide long trouble-free operation with their outstanding thermal and oxidation stability. Turbine oil could be expected to run for over 15 years, sometimes never even getting changed with only oil topping up over the entire life of the equipment. Steam turbines tend to experience varnish formation on turbine bearings. With increasing turbine capacity and decreasing sump sizes, this phenomenon has become more common now-a-days. This is primarily because of heavy thermal stress on the oil.

This paper elaborates on the leading industry specifications applicable for these high-performance turbine oils. It also delves into the importance of monitoring the key properties of turbine oils and. It also elucidates on condition monitoring techniques used to monitor the critical parameters of the turbine oils. During offline condition monitoring, a sampling frequency of six months is generally followed, however it has been noticed that oil degradation leading to failure has happened within this six-month period. So to ensure trouble free turbine operation, remote online condition monitoring tools are being increasingly adopted to monitor these key parameters on a real time basis.

This paper talks about a steam turbine case study wherein a customer observed frequent filter choking issues. The oil had experienced a sudden drop in oxidative life value from the laboratory RPVOT studies carried out. The detailed investigation led to the identification of the reasons for drop in RPVOT value and resultant frequent filter choking. The various actions taken to restore the RPVOT values are also discussed. These steps also led to a decrease in frequent filter choking and in restoration of the normal operation of the turbine.

E-Poster Session-2 on Fuels & Additives

Paper ID 226: Optimization of industrial alkaline electrolyser plant using a simulation-based approach

Rahul Garg, K.A. Subramanian, Renny Andrew

Corporate R&D Centre, Bharat Petroleum Corp. Ltd., Greater Noida, India

To achieve the Net Zero targets, Green H2 would be playing a major role in the overall energy ecosystem globally. In the overall system, apart from the alkaline electrolyzer stack for pure Hydrogen & oxygen gas generation, the Balance of the plant (BoP) is also a major component due to the requirement of Electrolyte management, and hydrogen & oxygen gas purity enrichment. The BoP majorly consists of electrolyte flow pumps, gas equalizing tanks, bubble coalescers, gas separators, and gas scrubbers. It has been reported that a substantial amount of energy (AC power) & CAPEX is attributed towards the electrolyzer BoP with greater impact on alkaline electrolyzer as compared to PEM. Hence, the BoP optimization can result in saving space, weight & auxiliary power consumption and ultimately enhancing the efficiency of H2 generation. This paper includes an overview of Alkaline bipolar electrolysis overview with a major emphasis on a detailed study of BoP design, operation, control logic & safety interlock arrangements. The study follows the approach of preparing the baseline simulation model in Aspen Plus & MATLAB Simulink, its validation through experimentation of analogous plant data & identifying the possible areas of optimizing the subsystems of Balance of Plant (BoP). In this study, a mass & energy balance simulation model is developed for an Alkaline electrolyzer for enabling cost & energy consumption optimization through various system controls & operating parameters. Since, the balance of the plant consists of various components such as Gas separators, Heat exchangers, Gas coolers, and Deoxidizer, hence energy and mass balance of each unit are modeled & solved in MATLAB connected through a SIMULINK environment. Every unit including the stack was having various input parameters that were varied through sensitivity analysis to obtain the unit performance trend. This model can further be fine-tuned based on data obtained from various alkaline electrolyzer installations. Such kind of research study of optimization & value engineering will result in substantial electrical & financial savings for Higher capacity BoP installations (MW scale H2 generation systems). This study can also be extended to the PEM electrolyzers with few modifications.

Paper ID 229: Performance evaluation of high octane fuels on BS-VI motorcycle

Mrinmoy Kalita, Shyamsher Saroj, Pradeep Patanwal , Prashant Kumar, Maya Chakradhar, Ajay Kumar Arora, M Sithananthan and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

The Indian automotive industry has the potential to emerge as one of the largest in the world. India ranks number two globally in the two-wheeler segment next only to China. It ranks 11th in car production and 13th in commercial vehicle production globally. India is the largest market leader in the world for two wheeler segment. The two and three wheelers population in the country is around 22 crore and is growing with a rate of 8-10% per annum. India's net import of petroleum was 212 Mt in 2021-22. The two wheelers account for 74% and consume 2/3rd of the gasoline by volume. There is an increasing demand for automotive vehicle of better fuel economy and lower exhaust emission through various routes including the development of energy efficient engine lubricants and high performance fuels. In this background, a study was taken up to investigate the impact of fuels with different octane numbers. Gasoline with RON 91 was used as reference fuel. Experiment was done to compare the performance of Gasoline with RON 97 and RON 100 with respect to RON 91.

Experiments were conducted on a Bharat-Stage-VI compliant Bajaj Dominar 400 motorcycle (373 cc) using chassis dynamometer. Indian driving cycle (IDC) was performed in BS VI motorcycle. Fuel consumption was measured by mass flow meter based on Coriolis Principle. The test results indicate an increase of 0.9% and 2.18% in fuel economy for Gasoline with RON 97 and RON 100 respectively compared to Gasoline with RON 91. Similarly Wide Open Throttle (WOT) Power at different constant speed increased in the range 0.11 to 0.58 and 0.9 to 1.35 for Gasoline with RON 97 and RON 100 respectively compared to Gasoline with RON 91.

Paper ID 243: Synthesis of high energy-density polycyclic hydrocarbon fuel on mesoporous supported nanocatalyst

Nizamuddin Khan, Harish Kumar, Jyoti Srivastava

Defence Materials and Stores R&D Establishment (DMSRDE-DRDO), Kanpur, India

High energy-density (HED) hydrocarbon fuel compounds have always been required for strategic purposes due to high volumetric heat of combustion which help to increase the range of missiles/Aircraft. Two hydrocarbon moieties, Dicyclopentadiene (DCPD) and Bicycloheptadiene or Norbornadiene (NBD) are generally used due its compactness and additional cyclic appendages. This study focused on the synthesis of HED fuel compound that can be obtained through cyclodimerization of bicycloheptadiene (BCH) over siliceous mesoporous supported Cobalt-Nickel nanocatalyst. The catalytic material synthesized via wetness impregnation method, parameters concerning the reactivity of the catalyst optimized that shows to have well-ordered mesoporous structure and large pore size. Cyclodimerization of BCH conducted in a batch reactor in order to optimize the reaction parameters, temperature, and pressure with synthesized catalysts. Physicochemical properties of HED fuel, such as density (1.05 g/ml), heat of combustion (10550 cal./g), viscosity and Flashpoint are evaluated which can be applicable for missile system. In house synthesized catalyst could be easily recovered through filtration and recycled up to four times with more than 60% yield.

Paper ID 263: Material compatibility studies with high octane fuels (XP100 and XP95)

Fariha Saleem, K. Lopinti, M. Chakradhar, A. K. Arora, A. K. Harinarain and M. Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Worldwide implementation of stringent emission regulations for achieving net zero targets of individual nations has curtain raised the development of transportation fuels with superior quality. Advanced engine technology along with superior quality fuels helps in reduction of harmful emissions. Advanced or high performing engines require high quality gasoline with high octane number/octane rating for better output. Octane rating or octane number is one of the critical properties of gasoline fuel which is ability to resist "knocking" or "pinging" during combustion, caused by the air/ fuel mixture detonating prematurely in the engine. High octane gasoline is able

improve compression & reduce the knocking which results in fuel economy, reduction in harmful emissions and improves the overall engine performance.

IOCL has been producing and supplying high octane gasoline in the brand names of XP100 and XP95 with octane number of 100 and 95 respectively. These high octane gasoline fuels were developed from regular gasoline blended with optimized dosages of octane booster and high performing multifunctional additive in line with BSVI gasoline standards IS: 2796-2017 specs. Most prominently two major categories of octane boosters are available based on their chemistry namely oxygen-based (ether and alcohol) and nitrogen-based (aniline derivatives). Hence, compatibility of materials used in automobiles with high octane gasoline fuels having octane boosters and multifunctional additive is to be studied.

The study involves compatibility of high octane gasoline having octane boosters and multifunctional additives with polymeric materials used in automobile fuel system such as elestomers and plastics. The selected elastomers such as Epichlohydrin (ECO), Fluroelastomer (FKM) and Nitrile Butadiene Polyvinyl Chloride (NBR-PVC) of automobile fuel system were used and tests were conducted as per SAE J1748 test standards. The impact of high octane fuels on critical properties of elastomers such as weight change, volume change, tensile strength, hardness and elongation were evaluated as per SAE J1748 test methods. The details of study will be presented in the full paper.

Paper ID 271: Combustion behaviour of octane boosters in gasoline streams on a fuel injection based single cylinder engine

Navarun Saikia, A S Ramadhas, Maya Chakradhar, Lokesh Kumar, M Sithananthan, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Gasoline is a mixture of refinery streams of carbon number ranging from C4 to C12. The blending streams have significant influence on the fuel properties of final product. The key fuel properties of gasoline include density, volatility and octane number etc. that affect the engine combustion and performance. Higher octane number fuel can help in increasing the performance of the high compression ratio engines. Additives are added to improve gasoline characteristics especially its octane number. Earlier TEL is used as octane booster and it is banned worldwide due to environmental health effect. The commonly used additives are alcohols and amines. As on date

most of the vehicles on-road designed to run on neat gasoline with RON 91. During the mileage accumulation the compression ratio of the engine will increase and demands high octane gasoline to meet its demand.

In study, normal gasoline RON 91 is used as base gasoline and its octane number was enhanced to RON 95 and RON 100 by optimizing the additive dosages. Engine tests are conducted to assess the combustion and performance of the high octane gasoline on a BS IV fuel injector based motor cycle engine under controlled test cell environment. Full throttle performance tests conducted over the speed range 1500 rpm to 8000 rpm. The combustion parameters such as peak pressure, heat release rate, burn duration etc., and engine performance & emission parameters are analysed and discussed in detail in the paper.

Paper ID 273: Value addition of LVFO as green fuel LSHS (premium)

Manisha Saraswat, Srimanta Guin, Vipin K.Bansal, Tanmay Mandal, Ajay K.Arora, Ajay K.Harinarain and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Fuel oil is a dark and viscous residual fuel oil which is obtained by blending residual products with suitable diluent usually middle distillates. The fuel oil grades are being marketed under different specifications depending upon the viscosity range of the fuel oil. One of the categories of fuel oil is the low viscosity fuel oil (LVFO). As per directive from NGT usages of fuel oil is being banned in many states in India In present scenario, there was a requirement to convert LVFO to value added product through an appropriate blending with suitable streams. IOC is presently marketing LSHS (low sulphur heavy stock- (premium) as low polluting product. A good market share of LSHS (premium) has been established as of now. Further, in view of increasing demand of LSHS in post NGT scenario, a feasibility study has been conducted to convert LVFO to LSHS (Premium).

LSHS (Premium) is superior quality and environmentally friendly residual fuel due to its low sulphur content, high gross calorific value, low KV and low pour point as compare to FO. It is generally used in lieu of fuel oil in the same applications where the fuel oil is suitable such as for firing boilers, furnaces etc. As per the specification of LSHS (Premium), the pour point requirement for summer is +210C while that for winter is +60C. Since LVFO is produced from crude oil of high wax content, the challenging aspect was to achieve the winter pour point of LSHS (P) which is +60C as per the specifications. So to achieve the required pour point, two approaches were adopted: (a) additization and (b) use of cutter stocks. Extensive lab blending and evaluation

studies have been carried out to develop LSHS (Premium) and new formulations have been optimized meeting the LSHS (Premium) specification. Further the optimized product meets the criteria of winter pour point and advantageous with respect to calorific value, KV and sulfur content. Details of the study about the development of LSHS (Premium) formulations and the results will be discussed in the technical paper.

Paper ID 274: Study on potential FSII for application in high flash ATF Fuel (JP-5)

Kiran K.Chakrahari, Tanmay Mandal, Manisha Saraswat, Ajay K.Arora, Ajay K.Harinarain, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Fuel System Icing Inhibitor (FSII) is a chemical compound used for application in aviation fuels for preventing formation of ice crystals in fuel filters, fuel lines and other fuel system related components by lowering the freezing point of water entrapped in fuel. Presently, ethylene glycol monomethyl ether (EGME) and diethylene glycol monomethyl ether (DiEGME) have been used as prominent fuel system icing inhibitor additives in both military and commercial aircrafts. As per the literature reports both of these de-icing compounds are toxic at the concentrations that are doping for effective deicing of water entrapped in fuel. Further, high vapor pressure of ethylene glycol monomethyl ether compounds also causes the peeling of fuel tank topcoat material which leads to increase in maintenance costs and decreases aircraft mission capabilities. Therefore, more efficient and environmentally non-toxic fuel system anti-icing additive suitable for aviation fuels especially JP-5 fuel application is essentially required. Hence, present work is focused on exploring potential, nontoxic, FSII compounds for deicing of water entrapped in ATF fuels.

Present work reveals presence of long chain alkyl ethers as potential FSII. Dosage of new FSII compounds in ATF fuel was optimized for better performance of anti-icing at various low temperatures. Proposed FSII were also evaluated for no-harm test in ATF fuel as per IS 1571 specification at recommended dosage and found meeting the specification. These new FSII compounds have lower vapor pressures compared to commercial additives and are less toxic, fuel stable and show similar icing inhibitor characteristics. A detailed study will be presented in the full paper.

Paper ID 282: Study of real driving emission of ethanol blended gasoline fuel with portable emission measurement equipment on RDE compliant route

Chander Kant, Prashant Kumar, Maya Chakradhar, M Sithananthan, Ajay K Arora, A K Harinarain, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

India has leapfrogged BS-IV emission norms to BS-VI 1.0 in April, 2020 and now ready for the implementation of stringent BS-VI 2.0 (RDE) with measurement of on-road real driving emissions (RDE). The discrepancies between emission values measured in the laboratory (under controlled ambient conditions) and actual emission values on the road (under real driving conditions) will be reduced with the implementation of BS-VI 2.0 A study was conducted on BS-VI vehicle on RDE compliant route (Faridabad specific) for the evaluation of different set of test fuels as per IRDE BS6 2.0 (Indian Real Drive Emissions) norms. Advanced fuel formulations like ethanol blended fuels and differentiated diesel fuels will also play significant role in achieving the real driving emissions. The data was generated with AVL make RDE PEMS equipment (Portable Emission Measurement System) as per RDE test procedure. The test vehicle was driven on-road as per RDE compliant route, boundary conditions and conformity factors were calculated in each case for CO & NOx pollutants. Reference CO_2 values were measured on standard regulatory test cycle (Modified Indian Driving Cycle) on chassis dynamometer. The RDE test was passes with all of the fuel formulations and significant reduction was observed in CO emissions. The RDE test was conducted as per BS6 IRDE (Indian Real Drive Emissions) test procedure. The study suggests that novel fuel formulation can support the OEM's in meeting the upcoming stricter emission regulation in terms achieving the better conformity factors.

Paper ID 283: Effect of iso-propanol as a co solvent on phase stability and volatility behavior of ethanol blended motor gasoline

Nihar Dash & Dhanapal Tamilvendan

Indian Oil Corp. Ltd., (MD) Una Terminal, Pekhubela, Una, India

Motor gasoline is hydrophobic in nature whereas ethanol is hydrophilic; the mixture of hydrophobic and hydrophilic liquids get contact with water the phase separation is happened. Anhydrous ethanol is an oxygenated compound for blending in motor gasoline as it can positively influence the physico-chemical characteristics of gasoline rather than other oxygenated compounds. When ethanol is mixed with gasoline, phase stability issues arise, which result in phase separation in the

fuel handling system. The drop-in atmospheric temperature also causes phase separation in ethanol blended motor gasoline. The water solubility and phase stability of the ethanol gasoline blend are the main topics of experimental analysis. This research looked at how co-solvents affected the phase stability, vapour pressure, and distillation properties of ethanol-gasoline. According to the results, adding iso propanol to ethanol-gasoline has various benefits, including improving the fuel blends' stability at low temperatures and lowering vapour pressure. When utilized as a co-solvent in gasoline with ethanol blend, isopropanol demonstrated greater resistance to phase separation. Additionally, it was revealed that isopropanol has no detrimental effects on the fuel blends' volatility qualities. The influence of several co-solvents on the phase stability and distillation properties of ethanol-gasoline is described in the current work. Initially, we have established the method for estimation of water- ethanol ratio in separated aqueous layer of ethanol blended motor gasoline by measuring its density. To regenerate the separated aqueous layer, the present study exhibited that the higher water retention can be achieved by addition of IPA as a co-solvent. Additionally, it was established that adding IPA reduced volatility throughout the middle of the distillation curve, preventing the problem of vapour lock formation. An azeotrope is produced when ethanol and gasoline are combined, increasing the vapour pressure of the resulting combination. With IPA addition, such a situation does not take place. In contrast to ethanol, the phase stability of IPA in gasoline fuel mixtures in contact with water or ambient moisture is improved at low temperatures. Water crystals are not present in the fuel mixture at low temperatures. Unlike ethanol, IPA does not transition to the aqueous phase. At the low blending percentages now being used for ethanol, the low-molecular-weight alcohols (ethanol, methanol) can significantly boost RVP (e.g., E10). The IPA's lower RVP impact at low gasoline blending ratios may also make them more appealing than ethanol. VLI decreases when IPA is added to hydrous ethanol-gasoline mixes. These benefits support the use of iso propanol as a potential extender or stabilizer for ethanol-gasoline blends.

Paper ID 285: Performance and emission characteristics of GEM fuel in a constant speed SI engine

M.K. Shukla, Peeyush Gairola, Wittison Kamei, Sunil Pathak M.K.Shukla, AFLAD

CSIR-Indian Institute of Petroleum, Dehradun, India

The development of industry, transportation, agriculture, and power production all rely heavily on fuels based on petroleum. Active research has been carried out recently on alternate fuel sources due to increased environmental regulation and deep concerns about the availability of petroleum

resources. The combustion gases released from ICEs (internal combustion engines), which negatively impact nature and human health, are another vital concern. Nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and particulate pollutants are the leading harmful exhaust gases released from ICEs. Due to its contribution to global warming, CO2 emissions are considered pollutants. India has adopted a minimum of 5% and a maximum of 20% ethanol blending in petrol to increase the use of renewable fuels. Also, in India, there is an interest in methanol-blended gasoline (M15). If M 15 is adopted, there might be a case of mixing of blended petrol-methanol fuel and petrol-ethanol fuel. Hence there is a need to understand the effect of gasoline-ethanol-methanol mixture fuels (GEM) fuel on engine performance and emissions. In current work, two fuel blends: GE5M10 (Gasoline 85%, Ethanol 5%, and Methanol 10%) and GE10M5 (Gasoline 85%, Ethanol 10%, and Methanol 5%), are used for studying the engine combustion, performance, and emission characteristics. Comparative evaluation of performance and emission characteristics for both the fuel blends was carried out on a constant-speed carbureted SI engine. Physico-chemical properties also have been evaluated before the testing in the engine. Performance and emission for both fuels were found to be comparable with those of gasoline at all engine loads.

Paper ID 289: Green hydrogen as enabler to achieve the net zero goal

Mukul Gupta, Praseed Sahu

GAIL Pata Petrochemical Complex, Auraiya, Uttar Pradesh, India

Hydrogen is light, storable, energy-dense, and produces no direct emissions of pollutants or greenhouse gases. Supplying hydrogen to industrial users is now a major business around the world. Demand for hydrogen, which has grown more than threefold since 1975, continues to rise. Hydrogen can be extracted from fossil fuels and biomass, from water, or from a mix of both. Natural gas is currently the primary source of hydrogen production, accounting for around three-quarters of the annual global dedicated hydrogen production. The production cost of hydrogen from natural gas is influenced by a range of technical and economic factors, with gas prices and capital expenditures being the two most important. While less than 0.1% of global dedicated hydrogen production today comes from water electrolysis, with declining costs for renewable electricity, there is growing interest in electrolytic hydrogen. Dedicated electricity generation from renewables or nuclear power offers an alternative to the use of grid electricity for hydrogen production. With declining costs for renewable electricity, in particular from solar PV and wind, interest is growing in electrolytic hydrogen. Building electrolysers at locations with excellent

renewable resource conditions could become a low-cost supply option for hydrogen, even after considering the transmission and distribution costs of transporting hydrogen from (often remote) renewable locations to the end users. Hydrogen can help tackle various critical energy challenges. It offers ways to decarbonize a range of sectors – including Oil & Gas. It can also help improve air quality and strengthen energy security. It can be transported as a gas by pipelines or in liquid form by ships, much like liquefied natural gas (LNG). Hydrogen is one of the leading options for storing energy from renewables and looks promising to be the lowest-cost option for storing electricity.

The Honourable PM first announced a “National Hydrogen Mission” on 15th August 2021. The aim of the mission is to help the country achieve its target of producing 5 million tonnes of “green hydrogen” by 2030 and the related development of renewable energy capacity. In line with the National Aspirations, GAIL (India) Ltd. has taken a pioneering step and is setting up a 4.3 TPD Green hydrogen plant in its Vijaipur complex in Madhya Pradesh. GAIL can use its existing gas pipeline infrastructure for blending green hydrogen into its city gas distribution system. GAIL is also building a 10 MW solar park in its Vijaipur Gas Complex which can cater to a part of the renewable energy required for the generation of green hydrogen. In order to popularize the idea of green hydrogen, GAIL has been doing numerous public outreach programs to make people aware of the benefits of green hydrogen.

Hydrogen is already widely used in some industries, but it has not yet realized its potential to support clean energy transitions. Ambitious, targeted, and near-term action is needed to further overcome barriers and reduce costs. The time is right to tap into hydrogen’s potential to play a key role in a clean, secure, and affordable energy future.

Paper ID 298: A novel cost effective multi-functional corrosion inhibitor for LPG pipelines

Kottari Naresh, KR Krishna

HPCL Green R&D Centre, Bengaluru, India

Pipeline transportation is a cost effective and safe mode for long distance transportation of petroleum products. Corrosion is one of the major problems in pipeline transportation due to the presence of carbon dioxide (CO_2), hydrogen sulphide (H_2S) and free water. To mitigate the problem, the corrosion inhibitors (CI) are injected into pipelines at very low dosage level (ppm). The corrosion inhibitor forms a protective film on the metal surfaces and thereby inhibits corrosion

caused by acidic moieties petroleum products in the pipeline. At present very few commercials additives available for LPG pipelines. We have developed novel cost effective corrosion inhibition formulations consists of multifunctional film forming-biocide for LPG pipelines. A novel accelerated corrosion evaluation method is developed based on rotating cage experiment compliance to ASTM G-209 and validated by standard commercial CI sample. During the accelerated corrosion evaluation test with in-house developed formulations, the corrosion rates for different MOCs, such as, Carbon steel, SS316 was found to be <1mpy. The best formulations from lab trials were synthesized in tonnage scale and been used in MHB LPG pipelines since September 2017. The cost of the in-house developed CI formulations approximately 50% of imported product price.

Paper ID 301: Performance evaluation of 5kW hydrogen fuel cell for heavy duty mobility

Tarun Jindal, Kapil Sonkar, Sachin Chugh, Rajesh M. Badhe,
Umish Srivastva, SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Transforming the transportation sector to put it on a Net Zero pathway will require technological innovation by switching to electrical power generators i.e. either battery or fuel cells. Hydrogen and fuel cell based solutions is an excellent pathway to curb GHGs emissions. Heavy-duty vehicles is a potential market for hydrogen fuel cells, due to high payload and long range requirements of this e-category, making the higher gravimetric energy density of hydrogen a critical factor. IndianOil R&D has embarked a research cum demonstration program of operating 15 fuel cell buses. The stack technology to be used in the buses needs comprehensive development and optimization as per the Indian driving operating and conditions. This would introduce hydrogen as a new dimension for emerging e-mobility paradigm.

This work aims towards benchmarking a miniaturized version of the fuel cell stack to be used in the buses. A 5kW commercial fuel cell stack consisting of 20 cells with cell active area of 240 cm^2 is evaluated to understand the real-time behavior of the hybrid power source with transitional drive cycle. The stack was integrated with multiple fittings and connections to connect it with the Fuel Cell Test Station and positioned in horizontal position taking due care that the inlet ports are always at same/higher elevation than the outlet ports for the reactant and oxidant streams. The flow rates of these gases are controlled through the pneumatic mass flow controllers in dry or humidified conditions, as per the testing requirements. The reactant streams are humidified using

two gurgle humidifier tanks filled with de-ionized water at the preset temperature, as required to maintain a defined degree of humidification of the inlet gas streams. To this purpose, a low speed Delhi bus driving cycle (DBDC) is being considered for simulating the dynamic duty cycle for city heavy duty buses. Apart from this analysis, the steady state performance of the stack to derive the polarization characteristics at variable temperature, humidity, pressure and stoichiometric conditions shall be undertaken. The outcome of the durability testing of the stack with hydrogen fuel will also be deliberated in this study.

Paper ID 303: Single step electrochemical production of green hydrogen blended compressed biogas

Chinmay Chaudhari, K Mohanraju, Kapil Sonkar, Sachin Chugh, Rajesh Badhe, Umish Srivastava, SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Hydrogen blending in existing natural gas distribution for various applications like transportation, domestic cooking and power generation is being examined as an interim way of decarbonising the energy sector. The hydrogen enriched mixture has certain advantages like reduced GHG emissions, improved combustion characteristics, reduced knocking/detonation tendency in IC engines and better fuel economy etc.

Many methods have been proposed for producing hydrogen enriched natural gas (NG) or bio-gas mixture or mixture of hydrogen with other gases which include partial reforming of methane/ NG, high temperature co electrolysis of CO_2 and steam to form methane, water electrolysis and high pressure mixing arrangement for hydrogen and methane. However all of these processes are either cost/energy intensive, need additional infrastructure, utilities and result in significant energy loss, thereby making the blending process very complex.

The current study describes the method to overcome the demerits associated with the above techniques, by presenting a single step process for hydrogen production and its mixing with bio-gas or any other gas. The process offers the advantages of quick start up and shut down time, low temperature operation (40-70°C) and zero CO_2 footprint. The solution can also be deployed for centralized and decentralized production of hydrogen spiked compressed biogas for city gas distribution and automotive applications. This work also presents an ingenious solution to elude catalyst poisoning especially due to CO present in the feed gas though material

modification/engineering interventions enabling the single step operation. With energy efficiency of 60-65%, the process also presents flexibility in handling wider turn down ratios, type of feed gas with additional advantage of generation of pure oxygen which can be utilized for relevant applications. The work showed promising reproducibility with desired hydrogen enrichment levels (10-90% by volume) achieved through this electrochemical process on a short stack.

Paper ID 307: Investigation of combustion catalyst efficacy for heavy fuels

Raktim Maji, Nikhil Kumar, M Rajendran, Debashis Ganguli

BPCL R&D Centre, Bharat Petroleum Corp. Ltd., Sewree, Mumbai, India

Industries in developing countries use heavy fuel oil to operate boilers and furnaces. However, the combustion efficiency of heavy fuel oils has always been a challenge. Moreover, environmental impact, demands immediate steps to curb the use of heavy fuels in the industry. With this concern, researchers worldwide are working extensively on improving combustion efficiency to directly reduce heavy fuel oil consumption.

Various fuel-borne catalyst technology has been introduced over the period having different working mechanisms to improve fuel combustion efficiency. Such catalysts have transition metals viz. Mn, Fe, Cu, Ba, Ce, and Pt to improve the combustion processes. One such metal-based catalyst uses the combination of iron and magnesium to provide synergistic behavior to improve the combustion efficiency of fuels.

To investigate the efficacy of the catalyst technology, the burning efficiency of the fuel-borne catalyst was measured in furnace oil using various thermal analysis techniques viz. thermogravimetric analysis and differential scanning calorimetry. When dozed with the catalyst, the enthalpy of combustion of the furnace oil increased by 18%. The effectiveness of the additive technology was further investigated during a field trial conducted at a US-based pharmaceutical manufacturing company. The field trial was conducted on the smoke tube boilers, which used furnace oil as fuel. The amount of steam produced per unit of fuel consumption was monitored to measure the effectiveness of the additized furnace oil. The fuel economy of furnace oil improved by around 7 % and the stack temperature of the boilers was reduced by up to 29 ˚C while using the additized furnace oil. Also, the considerable de-carbonization of the boilers resulted in reduced operation and maintenance costs.

Paper ID 310: Experimental investigation on performance of BS VI complaint EFI motorbike with oxygenated fuel blends (E0, E10, E20 & M15)

Yaman Sahu, P Sakthivel, M Sithananthan, Justin Paul Raj J, Maya Chakradhar, Ajay Kumar Arora, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Net-zero emission ambitions coupled with availability of oxygenated fuels like ethanol encouraged the Government towards commercial implementation of fuels like E20. In this background, a study was taken up to assess the impact of alcohol blended fuels on performance and emission characteristics of a BS-VI complaint motorbike. A single cylinder, 113-cc spark ignition, ECU based electronic fuel injection motorbike was used for conducting tests. Pure gasoline (E0), 10% ethanol-gasoline (E10), 20% ethanol-gasoline (E20) and 15% methanol-gasoline (M15) blends meeting respective IS standards were used as test fuels. The oxygen content of E10, E20 and M15 fuels were 3.7%, 7.4% and 8.35% by weight respectively. Experiments were conducted following worldwide motorcycle test cycle (WMTC) as per AIS 137 standard and also wide-open-throttle (WOT) test cycle, using chassis dynamometer.

The experimental results on WMTC tests indicated that the fuel consumption of the vehicle increased with increase in oxygen content of the test fuels. The maximum increase in fuel consumption was 6.40% with M15 fuel as compared to E0 fuel. CO_2 emission decreased moderately with the use of oxygenated fuels due to lower carbon content. CO and THC emissions decreased with oxygenated fuels and E20 fuel resulted in lowest level compared to all other test fuels. NOx emission increased linearly with increase in oxygen content of the test fuels and M15 recorded the highest. Under WOT conditions, the carbon emissions (CO, THC) decreased significantly with oxygenated fuels, with increase in NOx emission due to better combustion. However, CO2 emission was higher for oxygenated fuels due to high fuel consumption to achieve desired power output under full load operation. Overall, the alcohol blends help to decrease the CO and THC emissions with slight penalty on fuel economy. Fine-tuning of ECU parameters specific to fuel, has potential to improve fuel economy while reducing emissions.

Paper ID 312: Performance of a diesel engine using biodiesel

Senthil kumar G, Narayana Reddy J, Somasekar D, Ashok Raaj K, Sathyanandan M, and Krishnan Sadagopan

Ashok Leyland Technical Center, Vellivoyal Chavadi, Chennai, India

Diesel engines are an internal combustion engine with high thermal efficiency, which also uses biodiesel fuel, environmentally friendly, non-toxic, and low sulfur content. Biodiesel has been around for a long time due to its similar characteristics to diesel fuels which has limited availability. However, several disadvantages are associated with biodiesel, such as poor volatility and high viscosity, which reduces engine performance. Therefore, this study was carried out to assess the impact of Two different grades of Biodiesel namely B20, B30 by using them as test fuel on a 6 cylinder CRS –BSVI Emission Norm engine, In this exercise the back to back performance assessment conducted using both Diesel and Bio diesel on a 6 cylinder BSVI Emission Norm engine. The B20 and B30 Grades of Biodiesel were used for the testing on the engine. It was observed that, there is reduction in power and torque 0.5% and 1.2% with B20 and B30 respectively compared to diesel. 2. However, the variation of power and torque is well within allowable limit of +/-2%. SFC is deteriorated by ~1% and ~1.5% with B20 and B30 respectively compared to diesel. 2. Drop is SFC is due to lower calorific value of biodiesel (~2%-3% for B20 and B30). Boost pressure was found to be comparable. There was a reduction of TC Inlet and outlet temperatures observed basically due to drop in turbine inlet and pressure values. There is 7kg/hr increase in the air mass flow with B30. Fuel flow is ~0.5% higher with B20/B30 compared to diesel. This is due to higher density of biodiesel. There is drop in TC outlet temperature 2% and 4% with B20and B30 respectively compared to diesel. ~20°C reduced with biodiesel.

PFP is reduced by 3bar with B20 compared to diesel. Part throttle SFC deteriorated approximately from 2.5% to 5% for both B20 and B30 when compared to Diesel. NOx emission values were found to be comparable. In terms of emission comparison for both Engine Out and System out all emission parameters found to be within acceptable limits in both WHTC and WHSC cycles.

Paper ID 316: COx free hydrogen production through multi-walled carbon nanotubes (MWCNT) process

Bhanumurthy Samala, Dr Narayanam Seshubabu, P Mohana Sundaram, Dr I Devotta and Dr Umish Srivastva

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Hydrogen is of great interest throughout the world because of its cleanest and sustainable nature. Hydrogen as a fuel has no impact on the environment and has a potential to replace the fossil fuels in the near future to a greater extent. However, the major hurdle for this gas is its high production cost, storage at high pressure & transportation. Further, the conventional production process invariably associated with Cox & NOx, as a result the produced gas need to be rigorously purified to achieve >99% purity, that is suitable to use Fuel Cell grade applications. In this regard, production of hydrogen without Cox & NOx at low temperature is in great demand.

In this paper, COx & NOx free hydrogen production process is disclosed by an alternating route. The process produces MWCNT is as a main product and Hydrogen as a by-product. The product ratio of MWCNT & Hydrogen is fine-tuned with tailoring of the catalyst composition and process conditions. The major advantage of process is the reduction in production cost of hydrogen and it doesn't contain any Cox, NOx hence Hydrogen purification process is much easier. In this process, a hydrocarbon feed is cracked over a heterogeneous catalyst to guide the carbon deposition into Muti-Walled Carbon Nanotubes (CNT) and remaining is gaseous mixture is sent for hydrogen purification. Hydrogen production through this process is more economical compared to any other process as the feed is a low value feed stock which is available in the refinery and CNT has more commercial value compared to any carbon powder. The product gas mixture has mostly hydrogen (60 to 80 vol%) and remaining is unconverted hydrocarbons. The hydrogen is further purified to ~99.99 vol% purity through a pressure swing adsorption (PSA). As this purified hydrogen doesn't contain any Cox & NOx it has the potential to use as fuel for fuel cell application.

Paper ID 320: Post-flame oxidation of unburned hydrocarbon: A review on timeline of formation of soot particle into different engine deposits

Yogesh Jagannath Patil, Vipin Dhyani, S. Ravi Teja, Shekhar Kansara, M. Muralidharan

HPCL Green R&D Centre, Bengaluru, India

The automobile industry has created many solutions to address the current difficulties of maximising energy efficiency with minimal negative environmental effects. However, most of these methods have wider implications for the tribological performance of the engines resulting in soot build up. Soot formation briefly includes formation of molecular precursors of soot, nucleation or inception of particles from heavy PAH molecules, mass growth of particles by addition of gas phase molecules, coagulation via reactive particle–particle collisions, carbonization of particulate material and oxidation.

In the current paper, the phenomenology, kinetics, and mechanism of soot formation in hydrocarbon combustion are reviewed. From an ecological standpoint, the effects of various factors on the formation of polycyclic aromatic hydrocarbons, fullerenes, and soot, low-temperature soot formation in cool flames, combustion in an electric field, and the Para magnetism of soot particles are considered. With a focus on post-flame oxidation of unburned hydrocarbons, as a differences in the oxidative kinetics of flame-induced and fuel-derived soot are observed due to mass of burned gas entrained into an unburned gas parcel. In particular, flame soot has significantly higher activation energy for oxidation due to the presence of metals, possibly coming from lubricating oils. So the process by which condensed-phase carbonaceous nanoparticles, i.e., incipient soot, are formed in hydrocarbon flames using gas-phase molecules is also highlighted. Significant improvements in experimental methods have made it possible to directly monitor the precursors in the gas phase and the transition from molecules to nanoparticles. Thus, it is possible to understand the timeline of formation and correlation between these soot particles and different engine deposits. These engine deposits, like intake valve deposits, combustion chamber deposits, injector coking, sticky piston rings etc., in return cause power loss, slow acceleration, poor driveability, poor cold starts, and increased emissions which is highly undesirable.

Paper ID 322: A novel approach towards hydrogen generation by aqueous reforming of methanol over hydrotalcite catalysts

Meeta Sharma, G. Siva Rama Krishna, Rajesh M Badhe, Umish Srivastva

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Hydrogen (H2) is a promising energy carrier for use in fuel cells to generate clean electricity for stationary and mobile applications. Hydrogen can be produced from different sources such as fossil fuels (natural gas reforming, coal gasification), renewable and nuclear energy, biomass processes, photo-electrolysis, biological production, high-temperature water splitting, and electricity (water electrolysis). However, current methods for hydrogen production require immense energy requirement, high temperature and pressure. Therefore, nowadays, the aqueous-phase reforming (APR) of methanol has attracted much interest in the generation of safe and convenient means of hydrogen (H2) production. Moreover, it offers a simpler and higher energy-efficient pathway towards superior-quality H2 (with less CO) generation. In the present work, Ni-based hydrotalcite catalyst (Ni-CuAl HTlc) was synthesized by the Co-precipitation method and its physical properties were characterized by Brunauer–Emmet–Teller method (BET), X-ray diffraction (XRD) and scanning electron microscopy (SEM). The catalytic activity of the catalyst for methanol APR was investigated in a fixed bed tubular reactor at 190-2300C temperature and 22.4 to 28 bar pressure using aqueous methanol solutions. The results showed that Ni-CuAl HTlc catalyst exhibits good catalytic performance with H2 selectivity of 80-85%. In addition, the effect of various operating parameters such as the presence of catalyst, temperature and pressure on the H2 yield was also studied. Furthermore, the present study revealed that the developed catalyst is found to be efficient towards methanol conversion into hydrogen by APR as an active, selective and stable catalyst under variable APR conditions.

E-Poster Session-3 on Alternative Fuels & e-mobility

Paper ID 334: Effect of absorbing low sulphur aviation fuel as interface plug on quality of ethanol blended gasoline

Manoj Kumar Shuklaa, Nihar Dashb, Mamta Kumaric

Indian Oil Corp. Ltd., Panipat, Haryana, India

One of the major tasks in petroleum supply chain was to maintain the quality of finished oil products during the transportation in multi-product pipeline from the producer to the final delivery points to consumers. Ethanol blended motor gasoline is the most commonly used transportation fuel. Currently EBMS is being transferred through multiproduct pipeline along with other petroleum products. During this pipeline transfers, low sulphur kerosene/low sulphur aviation /low sulphur other fuels are being used as a separation plug between ethanol blended gasoline, which are being pushed back-to-back through the pipeline as per current industrial practice. During this process certain percentage of interface will get mix with ethanol blended gasoline which may degrade the quality of gasoline. The addition of LSATF to ethanol blended gasoline slightly reduced the RVP in a way that is directly proportional to the LSATF content, but the addition of ethanol increased the RVP of the blend only up to 35% v/v. Thus, the addition of LSATF helps to slightly compensate for the RVP increase produced by the ethanol. Regarding the distillation curves, the parameters most affected by the addition of oxygenates were those characterizing the light (E70) and medium (E100) fractions. The addition of LSATF increases the distillation temperature. However, the final boiling and recover at 70,100 and 150°C point of the fuel blends never exceeds the final boiling point of the pure gasoline. The octane number of mixtures is mainly influenced by the octane numbers of the individual components. LSATF reduces the octane number and total sulphur content in ethanol blended gasoline, but the decrease is not so significant. Thus the use of LSATF as compatible and suitable interface plugs in MPPL. It also solves the problem of down grading the ethanol blended gasoline in to transmix product.

Paper ID 335: Physicochemical studies on aviation turbine fuel & biodiesel blends

Ravi Gajera, MSPD Raj, Mehul Bhatt & Gobind Singh

Central Lab, Indian Oil Corp. Ltd., Sewree, Mumbai, India

The last century saw a preponderance in the consumption of crude oil derivatives and the development of technologies at a very fast pace. Consequently, all machines including aircraft today are heavily dependent on crude oil products. Crude oil is a diminishing resource. As the

consumption of oil escalates, its polluting emissions too will rise along with its price. As a result, a time will come when the supply and demand ratio is going to make petroleum products prohibitively expensive, thus, forcing us to find and adopt alternative, sustainable fuels which have lower emissions, are cheaper and biodegradable; but are especially synthesized for aircraft as per aviation norms of density, freezing points, specific impulse and their ability to be used in the existing fleet of aircraft. The Dehradun-based Indian Institute of Petroleum has successfully finished a pilot test to convert used cooking oil into bio-aviation turbine fuel (Bio-ATF), which can be blended with conventional ATF and used as aircraft fuel. Bio-fuels have now become a global necessity due to the international commitment to reduce Green House Gases (GHGs) and emissions in consonance with the Kyoto Protocol.

Central Lab, Sewree have been carried out studies of different blends of Aviation turbine fuel with bio diesel (B-100). The present study reflect the properties of BIO ATF as per the standard IS specification 1571 & 17081

Paper ID 336: Catalytic conversion of bio-oil for the production of green transportation fuel

Sandeep K Saxena

CSIR-Indian Institute of Petroleum, Dehradun, India

Fuel production from biomass is continuously gaining importance and zeolite-catalyzed processes are emerging as practical solutions for the effective conversion of such feedstock through the production of hydrocarbons belong to a wide range of fuels and chemicals. The oil extracted from a non-edible source such as Jatropha oil is one of the primary feed sources for the economical way of production of fuels. Bio-diesel production is widely studied by adopting trans-esterification reactions among the various fuel types. However, the process requires long reaction times and consumes a high quantity of methanol. The bio-diesel obtained by this method alone cannot meet the practical applications of the fuel and requires fossil fuel as a blending stock to make it suitable for use in the diesel engine. The huge amount of glycerol (about 10%) obtained as an unavoidable by-product during bio-diesel production also affects product yields and process economics. The second pyrolysis method needs high energy consumption to facilitate high temperatures reactions and produces mostly gaseous products and straight-chain hydrocarbons. While much is reported for producing middle distillate range hydrocarbons, attempts are scarce for producing gasoline from the Jatropha oil.

Paper ID 338: Fuel storage issues in ethanol blended fuels (EBMS): A case study

Rajiv Srivastava, Manoj Kumar Sinha, Akash Kumar Saarsar,
Arvind Prakash Verma

Indian Oil Corp. Ltd.

Ministry of Petroleum and Natural Gas (MOPNG) is promoting the usage of Ethanol Blended Petrol (EBMS) in the Indian market. The target is to blend 20% Ethanol by 2025. Currently Motor Spirit (MS) is blended with 10% Ethanol and supplied through IOCL retail outlets across India A problem occurred with one of the IOCL customers. When customer started dispensing IOCL supplied EBMS fuel to their vehicles, the engines could not fire and their filter got choked. This issue was reported to IOCL and when fuel in the Underground Storage Tank was tested for moisture contamination using conventional Dipstick method, it was untraceable. The matter was investigated and resolved with the finding that fuel had got contaminated with water in the underground storage tank leading to phase separation.

The case study of this incident and its findings will be useful in relooking at the current SOPs to handle EBMS and prompts us to revise the same.

Paper ID 208: SAF - Viable production process for SBCs in Indian perspective

Manish Malhan

Quality Control, Indian Oil Corp. Ltd., Head Office, Mumbai, India

With ever increasing focus on climate change, world must do more to tackle carbon emissions. In October 2021, the global air transport industry committed to achieving net-zero emissions by 2050. To meet this emissions reduction goal therefore, the aviation industry must abate a cumulative total of 21.2 gigatons of carbon between now and 2050. In the wake of a global mandate for emission reductions adopted by the ICAO applicable to Indian airline operators from 2026, it is critical for the Indian aviation industry to prepare itself for the emerging challenge. An alternative to the current use of fossil fuels by the aviation sector is to use sustainable aviation fuel (SAF), which is going to be the most important building block in the airline industry's commitment to reduce its CO2 emissions. One of the ways SAF can be produced is by using bio-based resources. This could be a major solution to decarbonization of the aviation industry in the near

future. SAF benefits from high greenhouse gas (GHG) savings potential, is based on widely available feedstock, and uses rapidly maturing technologies to process this feedstock into sustainable fuel. The technology landscape for production of SAF is changing and many new technologies and pathways are rapidly becoming commercialized.

The BIS has defined national specifications for SAF (IS17081) and has already approved several technology pathways, including hydro-processed esters & fatty acids (HEFA), which uses waste lipids such as cooking oil as feedstock, alcohol-to-jet (ATJ), which utilizes agricultural residues and carbohydrate-based feedstock, and Fischer Tropsch Hydro-processed Synthesized Paraffinic Kerosene (FT-SPK) which utilizes municipal solid waste, and wood and energy crops, as well as coal. This paper is an attempt to review and identify the suitable route for production of SBCs with long term perspective in Indian parlance.

Paper ID 233: Bio-based surfactant from alternative fuels: Production and optimization using response surface methodology

Neha Rawat, Aman Kumar Bhonsle, Jayati Trivedi and Neeraj Atray

CSIR-Indian Institute of Petroleum, Dehradun, India

Surfactants are amphiphilic compound that act as wetting agents to lower the surface tension of liquids or the interfacial tension of two-phase systems due to adsorption at the surface or interface respectively. Surfactants have been used in every industrial area ranging from household detergents to drilling muds and food items to pharmaceuticals. Therefore, production, optimizations, and utilizations of the surfactants for various applications have been the research interest among researchers. However, due to increasing environmental concerns, the hazardous nature of surfactants posed due to their non-degradable properties is of great concern. For combating such problems, bio-based surfactants could serve as a potential alternative. In the present study, biosurfactant was produced in two step process and the reaction was optimized using response surface methodology. A Box-Behnken Design (BBD) was used to study the effect of different parameters viz. mole ratio, temperature and time on the yield of the reaction. In first step cooking oil was converted into biodiesel using CSIR-IIP Room Temperature Biodiesel process. In the second step, this UCO biodiesel was used to synthesize methyl ester sulphonate (MES) by incorporating a sulphonate group. The synthesized MES was characterized using Fourier Transform Infrared (FTIR) and Nuclear Magnetic Resonance (Proton NMR) Spectroscopy techniques and all the peaks are in agreement with the literature values. The surface tension properties were measured to calculate the CMC values of the developed surfactant. Utilization of

bio-based surfactants will be the next step towards cost-effective thus creating sustainable economics and promoting sustainable development goals.

Paper ID 287: Vertigo testing model for ensuring working at height to prevent fall from height of persons due to acrophobia

Ananta Bhende

Gujarat Refinery, Indian Oil Corp. Ltd., India

Falls are among the most common causes of serious work related injuries and deaths. The safety guideline aims to ensure Safety while working at height (more than 1.8 meter height) and protection from fall. The development of a national occupational health Scheme that will allow the construction industry to both monitor the occupational health status of its workforce and also make a step-Change in the health improvement of its two million plus workers is a challenging, yet achievable objective. There is a definite commitment to the 'idea' of a national scheme but progressive steps toward its implementation need to be taken carefully to ensure that all of the Stakeholders' needs are considered. The main issues to be addressed are securing the support of the quality providers within the Occupational health community to inevitably change some of their working practices and systems; ensuring that any scheme caters for all Sizes of construction company and not just those with the financial resource to deliver on IT based solutions; and ensuring that the data Held is both managed in accordance with legal requirements and is subject to appropriate quality assurance. Looking to seriousness and Criticality of working at height job in OIL REFINERY like various critical jobs like we deals in day in and out like stacks painting of more than 100m, scaffolding erection, flare line replacement, FCCU stack monitoring or any type of critical erection activities etc. These all are very critical activities we perform as and when required and during plant shutdown. Working at Height job is one of the critical activities and not everybody is fit or competent for working at Height job. Some may have acrophobia or height phobia, contract worker engaged in WAH job are deployed after medical fitness certificate from competent authority i. e. Doctor. Depend upon health and Competency of workers are given training and then tested on Vertigo model which is in-house design and developed by us to overcome this critical job related issue.

Paper ID 323: Biohydrogen ($BioH_2$) production from biomass

Sandipam Srikanth, Manoj Kumar, RP Gupta,
Debasis Bhattacharyya, SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Hydrogen (H_2) is considered as one of the most promising, sustainable, renewable and green alternative fuel in the realm of fossil fuel depletion and environmental pollution. High calorific value of H_2 (122 kJ/g) which is 2.75 folds greater than that of hydrocarbon fuels with zero carbon emission makes it an ideal, clean and carbon neutral energy carrier. In current scenario, H_2 production is majorly from fossil sources or water electrolysis or through biomass pyrolysis/gasification. All these options are highly energy intensive, cost inclusive and further, they leave hazardous/noxious waste which needs again treatment to reach the net zero goals. In this context, H_2 production from biomass/organic waste through microbe-assisted route is being considered as futuristic option to meet the escalating energy demand as well as to meet the sustainable net zero goals of energy industry. Significant efforts have been put to develop technology to use organic waste/wastewater as feedstock for H_2 production through biological route but minimal efforts made to use biomass as feedstock due to its complexity and also requirement of additional pretreatment steps. Considering its high energy content, abundant availability and advantage of environmental benign nature, H2 production from biomass is a potential option for future. H_2 can be produced from biomass through different microbe-assisted routes, viz., dark fermentation (BioH_2) and microbial electrolysis cell (MEC).

Dark fermentation facilitates the conversion of biomass into H_2 at mild operational conditions in the presence of specific biocatalyst. H_2 production through dark fermentation also generate volatile organic acids as intermediates which are energy rich precursors for different energy applications like biogas, drop-in fuels, medium chain fatty acids, etc. Hence, integration of this process with additional energy generation systems will open new avenues in the energy sector. MEC is a hybrid process of using biocatalyst in an electrode-assisted system to increase the efficiency of biocatalyst to many folds under small external energy input. Energy required is lesser than electrochemical system and efficiency is higher than biological system in MEC due to the enhanced metabolic activities of microbes. The breakdown of biomass by enhanced bacterial metabolism releases the desired electrons and protons on one electrode, while they combine at the other electrode under mild applied potential, releasing H_2. MEC has tremendous potential application but efficient and scalable designs are required for its successful implication. Miniscule work has been carried out in the direction of improving the technology and up scaling the same. Extensive work has been carried out by IOC R&D with a focus of developing optimized process in

both dark fermentation and MEC. This paper presents complete outlook on microbe assisted H2 production along with the experimental outcome obtained at IOC R&D.

Paper ID 324: Evaluation of piston deposits, fuel economy, oil consumption and wear characteristics for developing eco-friendly new generation engine oil for light duty vehicles

Sanjeev Kr. Singh, Tomendra Kumar, Neeraj Kumar, A. S. Ramadhas, M. Sithanathan, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Latest generation commercial vehicles have common rail direct injection engines and running under very severe operating conditions. These vehicles require better engine piston cleanliness and corrosion resistance on engine components whereas the customers demand better performance engine oils at lower cost. Currently, SAE 10W-40 meeting API CK-4 specification is widely used in the Commercial vehicles segment. Development of low-cost environmentally friendly engine oil is required to be developed to meet the customer demands and for better lubricant performance. This paper describes an experimental approach to develop an indigenous engine test method to evaluate high performance diesel engine oils for detergency characteristics and utilized in the evaluation of new engine oil development programmes. An in-house test method is developed equivalent to the CEC Test method- CEC L-12-A-76 on Mahindra Jeeto Test Bench for assessing the detergency Characteristics. The engine test bench is based on a BS IV naturally aspirated, Single-cylinder, 625 cc, engine of ~ 11.8 kW. This test method has been developed under severe operating test conditions that are maintained throughout 100 hrs test in order to increase test severity. These conditions include increased higher coolant and oil temperatures, positive crank case ventilation and reduced sump size resulting into lesser initial oil charge. After establishing the test procedure, three engine oils Viz. SAE-40 API CF-4, SAE-40 API CI-4 and SAE 10W-40, API CK-4 were evaluated. There is no topping-up of lubricating oil during the test. The used oil analysis was carried at the end of test, the engine is dismantled for visual inspection, post test wear measurement and deposit rating of engine components. The test method successfully differentiated the performance of all three different candidate oils with respect to deposits of engine components, Fuel economy, Oil consumption and wear. The results indicate that API CK-4, 10W-40 engine oil performs much better in terms of piston deposits, fuel economy, engine wear and oil consumption as compared to other two engine oils.

Paper ID 325: Synthesis of copper nanofluids for heat transfer applications

Om Parkash, Pankaj kasliwal, J. Christopher, C. Kannan & SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Heat transfer is one of the most important challenges faced by various industries. Nanofluids are a new class of advanced heat-transfer fluids engineered by dispersing nanoparticles smaller than 100 nm in diameter in conventional heat transfer fluids. The high surface area of nanoparticles, compared to those of conventional particles has potential to improve heat transfer capabilities of the fluids. These nanofluids exhibit better thermal properties than conventional heat transfer fluids. In the present paper, Copper nanofluids are synthesized in ethylene glycol medium by using a chemical process, wherein Copper salt is reduced by a reducing agent and stabilized in-situ by Polyvinylpyrrolidone (PVP). The synthesized stable Copper Nanofluids are characterized for size by using Dynamic light scattering (DLS) & Transmission electron microscopy (TEM). The average particle size of the synthesized Copper nanoparticles is ~ 10 nm. Concentration of Copper in Copper nanofluids is measured using ICP (Inductively Coupled Plasma) Spectroscopy. Further, thermal conductivity of the synthesized Copper nanofluids are measured using Thermal conductivity measurement instrument. Thermal conductivity of the copper nanofluids (Copper concentration of 100 ppm) is observed ~15 % more as compared to reference fluids in temperature range 30 to 100 degree centigrade. Hence, based on the above analysis, it is concluded that Copper nanofluids can be employed in heat transfer applications of various industries including automotive.

Paper ID 291: EV fluids - An exciting opportunity for development of novel testing units and standard protocols

Krishnaswamy N. Ponnai, Greg Miiller

Labcon Scientific Instruments, Mumbai, India

With the rapid increase in EV mobility of all types (like EV, BEV and variants of these), the need for EV fluids with special performance specifications and characteristics is exploding. Already several EV designers and manufacturers are finding the conventional lubes are inadequate and can be dangerous in some situations also to be used in EV's.

Apart from the standard tribological properties of lubes and greases (needed for conventional IC engines and variants), the EV fluids will need

- Resistance to copper wire/windings and coupon corrosion in vapor and liquid phase immersion at higher temperature for extended periods of time using non-ohmic heating voltages
- Ability to function at more severely constrained tribological and heat transfer situations coupled with electrical stability and high electrical resistivity.
- Reducing the possibility of dendritic growth and bridging in circuit boards which come in direct contact with lubes and greases and mitigation of the same.

It is obvious that conventional test methods for tribological and thermo-oxidative degradation will not suffice. In the last few years, the lube oil Industry is engaged in developing and standardizing innovative testing methods for addressing these emerging opportunities for developing EV FLUIDS.

In this presentation we propose to describe two such test methods under development. The two test methods for EV fluids are the Wire resistance test method WCT in vapor phase and liquid phase immersion (with co-testing of coupons for surface changes) and the Conductive Deposit Circuit Board Test (CDCBT) or CDT in short.
The details of the two test units, the methods development and some preliminary results will be shared in this seminar. The need for comprehensive evaluation of EV fluids using both the methods apart from standard lube testing methods is brought out.

This presentation hopefully gives examples of the excitements over EV fluid special properties development in next generation lubes and greases, especially the novel emerging designs of test units and test protocols.

We will also discuss briefly how these test methods, protocols and cooperative and consultative efforts to bring about scientific and technical consensus are built into a final acceptable and workable specification to all stake holders and common public.

Paper ID 333: Lignin depolymerization to produce high value chemicals

Prakram Singh Chauhan, Alok Satlewal, ,Ravindra Singh, A. S. Mathur,
Ravi P. Gupta, SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

"Lignin is one of the major components of plant cell wall besides cellulose and hemicellulose, accounting for 10–40 wt% (w/w) of plant cell wall on weight basis. It is an aromatic abundant renewable source that is rich in guaiacyl (G) and syringyl (S) units, whether in the woody or herbaceous plants. It is an amorphous, random branched heteropolymer comprising of phenylpropanoid units. It is intrinsically structurally heterogeneous and low reactive, because of inert C–O and C–C linkages (accounting for approximately 70% and 30%, respectively). Therefore lignin is currently under-utilized and routinely combusted to generate process heat in the paper and pulp industry because of lack of effective routes for lignin valorization. However, recent economic studies have suggested that the effective lignin valorization would yield at least 10 times more value as compared to burning it for energy production.

As future biorefineries will generate substantial amounts of lignin, the effective valorization of lignin into value-added low molecular weight chemicals, such as guaiacol, catechol, muconic acid, pyrogallol, gallic acid, vanillin etc., is essential for its economic viability and sustainability. Based on a global market survey, the demand for high-value chemicals such as guaiacol, pyrogallol and other aromatics are increasing year by year. Typically, annual demand for guaifenesin, vanillin, and eugenol is 37 000, 16 000, and 7300 t per year, respectively, all of which may be synthesized from guaiacol.

Guaiacol is a naturally-occurring organic compound with the formula $C_6H_4(OH)(OCH_3)$. Although it is biosynthesized by a variety of organisms, this aromatic is usually derived from guaiacum or wood creosote. It is also found in essential oils from celery seeds, tobacco leaves, orange leaves, and lemon peels. The compound contributes to the flavor of many substances and used in cosmetics, food, flavor, beverages and agriculture industry in huge amount (market demand US$310 million annually). Pyrogallol is an another organic compound with the formula $C_6H_3(OH)_3$. It is a white, water-soluble solid although samples are typically brownish because of its sensitivity toward oxygen.

Using lignin as a cheap and renewable feedstock to selectively produce above aromatics has great potential, but it is a challenge because of its heterogeneity and inert reactivity. Here we optimized the catalytic depolymerization of lignin using cost effective synergistic catalyst which led to the production of high value aromatics. Analytical techniques such as FTIR, GC-MS have been conducted for identification and characterization of lignin derived monomers. GC-MS result showed that identified aromatics have promising applications in diverse sector. XPS showed that lignin depolymerization was achieved by breaking high energy bonds and oxidation. This study

provides techno-economically feasible route for the production of lignin derived platform chemical moieties.

Paper ID 340: Eco sustainable synthetic ester oil formulations for micro electro mechanical systems: Tribological investigations

Ponnekanti Nagendramma, Anjan Ray, Ankit Pandey and Atul Pratap Singh

CSIR-Indian Institute of Petroleum, Dehradun, India

Micro electro-mechanical systems (MEMS) offer an exciting future for the engineering sector. Though biodegradable lubricants have been extensively explored in industrial and automotive applications, they have yet to see extensive adoption in MEMS applications. The development of such lubricants enables a strategic foothold in sectors such as aircraft and their components, with increasing demands for sustainability in the global aviation sector.

We have developed a novel catalyst and method for producing new-generation lubricant formulations from indigenous raw materials for aircraft precision instruments and other components such as delicate bearings, gauges, chronometers, and clocks. The resulting biodegradable mineral oil-free lubricant formulations have excellent biodegradability, high viscosity index, low pour point, high flash point, excellent lubricity, good oxidative stability, excellent wear protection, corrosion inhibiting characteristics, and suitability for use with commercial additives. The developed bio-lubricant formulations are a superior alternative to known commercial products like conventional mineral oils, fluoro ethers, and PFPE, based lubricants having issues of toxicity, non-biodegradability, and durability.

This paper will describe the synthesis, physicochemical characterization, and performance evaluations of biodegradable ester oils for precision instruments in the aerospace and defense sectors.

Paper ID 311: Effect of MWCNT in lithium-ion battery electrochemical activity

Senthilkumar Krishnan, Veena Yadav, Irudayaraj Devotta, Umish Srivastva

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Lithium-ion batteries (LiB) have played an important role in the develop of electric vehicles (EV) and plug-in hybrid EV (PHEV) in the near future, which require high energy density and high-power density, corresponding to the long range and fast charge demand, respectively. Substantial research efforts on novel anode materials have brought them ever close to real-life application1. There is an urgent need to develop matchable cathode counterpart to realize the long-awaited high-energy batteries. LiFePO4 shows promise as a cathode material for EVs owing to its high specific capacity (170 mAhg-1)2 and excellent structural stability. Good environmental compatibility and the high abundance of iron are also in favour of the wide application of LiFePO4 cathodes. However, its poor electronic conductivity (10-9Scm-1) and low lithium diffusion rate due to its olivine crystal structure significantly limit its performance at elevated charge and discharge rates3. Therefore, in this paper main studies on LiFePO4 have been focused on improving its rate capability. Coatings of conductive materials, embedment of conductive network, and doping of some special cations have been reported to improve the electronic conductivity4. Miniaturizing LiFePO4 into nano sizes can significantly help to reduce the diffusion length of Li-ions, and shorten the electron-conducting channels during lithiation and de-lithiation process. Recent efforts have been made to improve rate performance of the LiFePO4 by embedding LiFePO4 into conductive network. Graphene, CNT, and other graphitic or amorphous carbon have been combined with LiFePO4 5–7. The thickness of cathode electrode in LiB, for instance LiFePO4 is >100 µm and it requires long range conductivity. Therefore, high aspect ratio MWCNT is an attractive inevitable conductive carbon material for LiB. Herein, we report a comparative electrochemical evaluation of commercial MWCNT and Conductive carbon black. The discrete lower outer diameter MWCNT (<8 nm) with less than three layers significantly reduces overpotential and increases LiFePO4 electrochemical activity.

Paper ID 275: New generation antifreeze coolant for electric vehicles

Naresh Gutta, Neelam Agarwal, Simmi Datta, Subinoy Paul, Pankaj Bhatnagar and Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

"Electric vehicles (EV) are gaining importance due to zero emission, solving energy shortage and environmental problems. Performance and longevity of the battery are the two key aspects for the sustainable future of the e-mobility, which mainly, rely on the battery thermal management system (BTMS). In EVs, liquid cooling plays a critical role in efficient heat dissipation and maintaining the optimal operational temperature. Although, conventional coolants address the typical properties

such as anti-freezing, heat reduction, corrosion protection towards various metallurgies, they are not designed to take care of low conductivity requirement, which is a critical parameter for EV application. A specially designed coolant having low electrical conductivity minimises the current leakages/electrical shocks while direct contact with the battery.

Currently, conventional coolant chemistries mainly consist of DM water, glycol and organic/inorganic additives, to meet the various physico-chemical properties and corrosion protection requirements as per ASTM or OEM specifications. However, these coolants have high electrical conductivity, which is not suitable for EV coolant systems. Hence, a coolant for EV's should meet the preliminary requirements of anti-freezing, heat reduction properties besides having low electrical conductivity and corrosion protection as per OEM specifications. In this paper, authors have developed a series of EV coolants meeting various low electrical conductivity requirements and discussed the test results of developed EV coolants vis-à-vis conventional coolants.

Paper ID 314: Battery technologies for E-Mobility

Veena Yadav, Palvannan Mohana Sundaram, Irudayaraj Devotta, Umish Srivastava

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Development of rechargeable batteries for energy storage and electric mobility is a huge drive all over the world. Interest on producing Electric vehicles (Evs) by the government and public in the industrialized countries is because of air pollution and global warming mainly due to enhance in green house gases emissions from transportation.

Electric vehicles could play a significant role in combating carbon dioxide emissions. Replacing conventional vehicles with EVs can help to improve roadside air quality and reduce greenhouse gas emissions.

Paper ID 337: Performance aspects of 2,5- Dimethylfuran blends stratified charge Gasoline Direct Injection (GDI) engine on lean limit operation

P. Rajkumar

Department of Mechanical Engineering, Annamali Universiy, Annamalai Nagar, Chidambaram, TN, India

The transport sector occupies the second position in terms of total energy consumption in a country. The traditional sources of energy are exporting and destroying the planet, leaving many carbon footprints in their wakes... Phase-I saline waste bottles made of low density polyethylene (LDPE) degraded under the low temperature in active catalyst Neyveli lignite fly ash to produce hydrocarbons such as ethylene, acetylene, ethane, etc. when cat/pol ratio was 02% degradation was observed with 75% of distilled plastic pyrolysis oil formation. Phase-II Biomass seems to have the potential to become a significant energy source for future automobile fuels. Liquid 2,5-dimethylfuran yields have increased due to recent biological and chemical advancement in the conversion of carbohydrates obtained from biomass (DMF). Due to its superior physicochemical qualities over ethanol, this finding has made DMF a potential for gasoline derived from petroleum. In this investigation, a single cylinder gasoline direct –injection (GDI) research engine was used to study the feasibility of 2,5-dimethylfuran (DMF) as a bio fuel 5% (v/v) blending with gasoline 95%. The task required a modified engine and fuel injection module. Varied spark timing from 14° to 2°bTDC.air-fuel ratio beyond stoichiometric, and variable injection timing from 60° to 140° bTDC at compression stroke were tested. Direct injection at 1500r\min and a set fuel low heating value can stabilize combustion, accelerate beginning flame propagation speed, decrease combustion duration, and widen the upper limit of excess air coefficient in lean burn situation. Specific fuel consumption can be reduced by 11.1%compared to stoichiometric. Changing the spark timing and 2,5-dimethylfuran (DMF) 5%(v/v) blend with gasoline 95% can achieve optimum combustion phase under varied. While increasing advances the optimum heat release centre. Experiment demonstrated that maximum breaking torque timing. Air fuel ratio and injection timing effect lean limit operation, fuel efficiency, and exhaust emission reduction. The engine reached lean limit at air fuel ratio 16.7 without speed fluctuation. For stratified charge gasoline direct injection, it was discovered that the optimal module had on air –to- fuel ratio of 16.7, an SOI of 1000 degree, and an MBT of 18 degree before top dead centre. Fuel consumption, HC, CO and NOx were reduced 15.62, 83.33, 14.28 and 30.08 percent at SOI 100 degree bTDC At AFR 16.7 with baseline PFI engine operating at AFR 14.7.

Paper ID 224: Organosilicon-based polyisobutylene succinimide/esters as multifunctional lubricant additives

S. Raizada, S. Kaur, G. S Kapur, R. Shankar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Lubricant oil additives play a pivotal role in overall lubricant performance, thus are incorporated in the engine oils to enhance overall engine oil performance 1. Polyisobutylene succinic anhydride (PIBSA) is a popular dispersant, and is widely used as an intermediate for synthesis of various lubricant additives (LA). Their scaffold comprises of a polar head and polyisobutylene-stabilizing tail. The polar head adsorbs onto the carbon deposit precursors and the non-polar tail prevents the aggregation of the carbon precursors. An important factor governing the extent of adsorption is the polarity of the polar head group.

In the present work we have synthesized polyisobutylene succinic anhydride by polyisobutylene(PIB) and maleic anhydride (MA)(Scheme 1) and further modified the polyisobutylene succinic anhydride (PIBSA) by using various alkoxysilanes/siloxanes which forms the polar head part (R group) (Scheme 2) and imparts enhanced polarity to synthesized additives2. The performance of synthesized additives (LA#1-4) was evaluated relatively with the model polyisobutylenesuccinimide (PIBSI) in terms of various tribological attributes such as anti-wear(AW), friction reduction and physical parameters such as viscosity index, dispersion etc. The synthesis of the derivatives was confirmed by different spectroscopic techniques such as Infrared and NMR spectroscopy. The worn surface analysis of the anti-wear(AW) metallic four balls was also performed for SEM, EDAX and XPS which corroborates the findings attained from the tribological studies indicating efficient adsorption of the synthesized additives(LA#1-4) on the metal interface. The synthesized lubricant additives (LA#1-4) showed encouraging results for the tested tribological and other evaluated physical parameters.

E-Poster Session-4 on Refining Technology & Analytical Techniques

Paper ID 209: State-of-the-art methodology for determination total aromatics in VGO samples By FTIR

Dr Mamta Kumari, Dr Y S Jhala, Dr Ashok Kumar, Dr Rajiv Gandhi, M Elamaran, Utpal Deka, Hitesh Shah

Indian Oil Corp. Ltd., Panipat Refinery, Haryana, India

Aromatics are key components for processing of VGO in secondary processing units. To know the better product the identification of Aromatics are very essential. Based on this aromatics we can run plant with process parameters to get optimize output. Due to the complex composition of VGO, characterization by the individual molecular types is not possible, and elemental analysis is unattractive because it gives only limited information about the constitution of petroleum due to the constancy of elemental composition. Therefore, hydrocarbon group type analysis is commonly employed. Major groups of compounds present in petroleum are saturated hydrocarbons (straight chained, branched and cyclic hydrocarbons), aromatic hydrocarbons, sulphur bearing compounds, resins and very large aromatic asphaltene compounds.

A large number of analytical techniques including high performance liquid chromatography (HPLC), nuclear magnetic resonance (NMR), mass spectrometry (MS), fluorescence spectroscopy, Raman and infrared spectroscopy have been widely applied in the analysis of hydrocarbons and their derivatives. These techniques have produced good results but some of them are expensive and usually not available in the laboratories. Present work determines the viability of the use of Fourier Transform Infrared (FTIR) spectroscopy as a substitute to traditional SARA anlyser and NMR techniques for quantification of total aromatic in Vaccum Gas Oil Sample. In this work VGO sample used for the prediction of aromatics of different VGO samples using Fourier transform infrared coupled to attenuated total reflectance (ATR–FTIR) spectrophotometer. The samples were correlated by SARA Analyzer results with their ATR–FTIR analysis. The validation showed satisfactory results for the prediction of the Aromatics in Vacuum Gas oil Samples. The IR spectroscopy coupled with the ATR cell techniques provides an alternative way for the quantitative prediction of the wt% aromatic content with minimal handling of the samples in a short period of time. The IR spectroscopy coupled with the ATR cell techniques provide an alternative way for the quantitative pre- diction of the wt% total aromatic content in VGO sample with good repeatability, minimal handling of the samples in a short period of time, which makes it a fast, economic and non-contaminant solution.

Paper ID 227: Detection of adulteration in biodiesel and its blends with virgin vegetable or used cooking oil from FTIR spectral analysis

Pankaj Kumar Mondal and Suresh Kumar

Eastern Regional Lab, Indian Oil Corp. Ltd. (Mkt. Div), Mumbai, India

Guidelines for a just transition towards environmentally sustainable economies and societies is not sufficient, in today's scenario existing work force re-skilling and skills transferability is leader's big challenges in the era of net zero for business existence and energy transition phase. Need developing such a system which will be rely on close collaboration of sector skills groups and other partners to assess the existent training provision, as well as gaps in provision, so that a proactive skills pipeline that matches the emerging commercial opportunities from energy industry. Detection of adulteration in biodiesel and its blends with used / virgin vegetable cooking oil in the field test at terminal depots or retail outlet is today's busyness challenge in renewable energy sector. It may be possible to detect adulteration in renewable bio-fuel from Near-IR/FTIR spectral data, the present study attempt to explore the simplest methods for detection of adulteration in biodiesel and its blends in field level by using FTIR spectral technique and data library.

Paper ID 249: Unified Laboratory Intelligence System (ULIS): A sustainable approach for fuels and lubricants analysis with case studies

Ravindra Kumar, Sujit Mondal, J. Christopher, G.S. Kapur

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

Products and formulations are commercially produced by many companies to achieve desired effects for enhancing performance and meeting safety requirements. Companies who develop new products are under increasing pressure due to rising commodity costs, retailer price, and increase in competition, as well as tighter regulations for product approval. These and other pressures require the need for more creative approaches to find better, faster, safer, and easier ways to understand products & formulations that lead to market-leading products. One key area of R&D spending for companies who developing specialized products and formulations are on capital equipment to generate various forms of analytical data for understanding ingredient or component mixtures. The full investment increases when the cost and time to run and maintain highly specialized equipment, including standards and supplies, are factored into account. Many organizations either employ or contract out to Analytical Service or Problem-Solving groups who assist formulation scientists or chemists, plant engineers, or customer services in a variety of tasks

which may include investigation of product failure, competitive bench-marking, legal inquiries pertaining to patent infringement, counterfeiting, or new R&D product.

Unified Laboratory Intelligence (ULI) is a scientific approach to R&D informatics that collects and unifies chemical, structural, and interpreted analytical data. This approach provides better opportunities to re-use analytical data and knowledge focused on laboratory productivity improvements. In this paper we introduce how the fundamentals of a Unified Laboratory Intelligence technology approach can be applied to enhance and accelerate the characterization of ingredients at Indian Oil R&D centre for fuel and lubricants and also discussed two case studies in detail each one from fuel and lubricants area. ULIS has been used for identification of adulteration in diesel and studied marine lubricants chemistry and derived the structure of detergents present in marine lubricant. In first case study diesel adulteration problem was referred to R&D by Marketing Division and the samples were handed over to Analytical department to identify & quantify the adulterated compounds present in HSD. No analytical techniques were able to identify the structure of compounds. Preliminary investigation by WDXRF indicated presence of significant amount of Chlorine in the HSD indicating presence of some chlorinated compounds in HSD. HSD and various chlorinated compounds used in various industries were analyzed by NMR spectroscopy. The structure of chlorinated paraffins derived by simulation and ULIS software and confirmed by NMR spectroscopy. The adulterated components were then identified as chlorinated paraffins by NMR and their structure was derived.

In second study identified detergents present in marine lubricants and derived the structure of detergents. Simulated NMR spectra of different type salicylates by ULIS and derived the structure of Calcium salicylates present in sample. First time estimated average alkyl chain length of salicylate and other detergents.

Paper ID 264: Identification and quantification of recalcitrant molecules in industrial wastewater using GC-MS technique

Dheer Singh, Sravan Bompelli, Manoj Kumar, J. Christopher, SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

The biological section of Effluent Treatment Plant (ETP) plays a pivotal role in meeting the effluents discharge limits. In the wastewater from refinery, petrochemical, and rubber processing, there are several compounds which are recalcitrant for biological removal. The characterization and identification of these compounds may help in selecting and enriching suitable microbes. In

view of this, the present study is aimed to develop suitable analytical method/protocol to identify such molecules in inlet (untreated) and outlet (treated) wastewater of refinery, petrochemical, and rubber processing unit using GC-MS technique.

A GC-MS method using selected ion monitoring mode (SIM) mode was developed for the separation & Identification of recalcitrant molecules in the control and treated industrial wastewater samples (DCM & toluene extract). . Column selection and oven programming was done for proper separation of the molecules. Identification of the components was done using NIST library and quantification of the components was done using the reference standards. The results showed that along with higher paraffin, three types of aromatic compounds were present in the control sample, viz; styrene, cyclic and long chain aromatic hydrocarbons (1.0ppm to 0.2wt%). In the treated samples, the concentration of contaminants was reduced by about 95%. Thus, the developed protocol by GC-MS is able to separate and identify the toxic compounds at trace level, which will be useful for categorizing microbes based on their ability to degrade such compounds.

Paper ID 294: automated determination of relative density of Methanol/ Water Mixtures (MWM) used in aviation industry

T Subramanyam , Snehasish Jana, CLN Reddy, Sreekumar N V

Indian Oil Corp. Ltd., Bengaluru, India

The world aviation industry basically uses two types of fuel with distinct characteristics, known as aviation gasoline (AVGAS) and aviation kerosene or jet fuel. The power output of an engine is directly related to the mass or weight of the airflow passing through the engine, and thus, when operating under high temperature and/or high altitude conditions where air density is low, power is reduced. The power augmentation is achieved in such cases by a jet of water or methanol/water mixture into the engine. Modern gas turbine engines do not require the use of either water or water/methanol mixture. However, for certain designs of engine such as for Rolls-Royce Dart turboprop engine, water alone or methanol/water mixture is the most significant power augmentation fluid. These fluids have a high latent heat of vaporisation and act by cooling the airflow to raise its density and thereby increase the weight of the airflow through the engine. The methanol water mixture (Type-1) shall meet Rolls-Royce Material Specification MSRR 9359 having a relative density 0.9408 to 0.9441 g/m3 at 15°C. After blending methanol having specification complying to BS-506 and Water meeting MSRR 9435 to prepare desired MWM mixture, conventionally specific gravity determined at test temperature using hydrometer and relative density at 15°C is deduced from a graph provided in MSRR 9359. This is cumbersome

and often susceptible for personnel error. This paper discuss a new alternative method for the determination of relative density of methanol water mixture using auto density meter based on oscillating U-tube. For this study series of blends of methanol and water prepared and analyzed and the results found in good agreement. Additionally this technique can also be used to monitor the percentage of methanol in the MWM. Thus by using the highly sensitive table top auto density meter, relative density of methanol water mixtures a can be determined accurately.

Paper ID 300: Multi-dimensional chromatographic analysis for molecular level characterization of bio-oil.

Kottari Naresh, Ch Sivakesava raju

HPCL Green R&D Centre, Bengaluru, India

Ligno-cellulosic biomass materials are emerging as renewable alternate feedstock for transportation fuels. The key process steps involved in the conversion of biomass to fuels are (i) Pyrolysis of biomass to form bio oil and (ii) Hydro-deoxygenation of bio oil to obtain the hydrocarbons fuels. The elucidation of chemical structure of bio-oil is critical for subsequent catalyst development for hydrodeoxygenation and final blending with fossil based fuels. The detailed composition of bio-oils in terms of chemical identification and quantification remains a challenging task for analytical chemists. The compounds in the bio-oil range cover the broad range of hydrocarbons to oxygenates (phenols, ethers, acids etc). The bio oil compounds present a complex mixture of volatile hydrocarbons, oxygenates and non-volatile polymeric sugar oligosaccharide derivatives. In this regard, the combination of analytical techniques, such as multidimensional gas (GCXGC) and liquid chromatography (LCXLC) has been used for the molecular level characterization of bio oil. The comprehensive GCXGC technique has been used to identify the different types of hydrocarbons and oxygenates in volatile bio-oil fraction. Different sources of biomass were subjected to pyrolysis in pyrolyzer coupled with GCXGC-TOF MS to determine the chemical composition from each biomass. The non-volatile oxygenates and sugar oligosaccharides has been analyzed by using LCXLC-QTOF technique. The combination of multidimensional GC and LC tools have facilitated the elucidation of the structure of the bio-oil obtained from pyrolysis of biomass and provided insight into subsequent up gradation process.

Paper ID 202: HP-Bottoms cracking additive for FCCU

Narasimharao Kanna, Srinivas Rao G, K Naga Raja, G. Valavarasu

HPCL Green R&D Centre, Bengaluru, India

Heavy fuel oil in bottoms have both normal paraffins (C14-C34) having a molecular size in the range of 12 to 20 Å and heavy aromatic molecules (C14-C60)having a molecular size in the range of 12 to 25Å,however the zeolite present in the FCC additives has a pore size below 7.5 Å. Therefore, the hydrocarbons present in the heavy fuel oil are too large to fit into the zeolite pores for cracking. Due to which, the large hydrocarbon molecules are first cracked on surface of FCC catalyst matrix to produce smaller hydrocarbons, that in turn cracked inside zeolite pores. The overall process leads to the over-cracking of the hydrocarbons, resulting in the formation of coke and dry gases. There is, therefore, felt a need for the development of an FCC additive composition that mitigates the drawbacks mentioned here in above. HP-BCA is designed for maximizing bottoms conversion in FCC unit. These in-house additives were shortlisted based on physico-chemico characterization and testing. New synthesis protocols were developed in order to enhance acidity and product selectivity. No raw materials were imported for the additive synthesis. In-house methods were developed for testing and validation of physical parameters like attrition and density. The developed synthesis methodology can be applied to various acidity driven catalytic cracking reactions. HPCL is currently importing bottom cracking additive (BCA) for refineries in VR and MR. Performance of these in-house additive were superior when compared to the benchmark additives. The in-house designed additive could reduce bottom by 0.5-1.0 % as compared to benchmark additives. Currently this additive is scaled up to 25 tons and field trials are in progress in Vizag Refinery FCC unit.

Paper ID 223: Comparative performance evaluation of commercial and in house synthesized wax dispersant on wax deposition behavior of upper Assam basin crude oil

Manisha Sahai, Umesh Kumar, Aruna Kukerety, T. Senthilkumar, Bijan Mahanta, Rajarshi Panigrahi, Neeraj Mathur, Sanat Kumar, Sudeep K Ganguly, Anjan Ray

CSIR-Indian Institute of Petroleum, Dehradun, India

The presences of paraffins in crude oil results in the increase of the viscosity of the crude oil as well as deposition of waxes along the walls of the pipeline leading to restricted flow or even plugging of pipeline... A significant percentage of the crude oil from Indian oilfields are expected to be paraffinic in nature and one such oil resource is crude oil from the Upper Assam basin. This

crude oil has a wax appearance temperature (WAT) of 31℃, pour point of 15℃, and an API density of 28.6º. This crude oil though having a low pour point, still exhibits a high rate of wax deposition which poses a risk of the wax getting stuck in the pipeline and temporary shutdown of operations. Hence frequent pigging is performed, the frequency of which varies from two to fifteen days depending upon the weather conditions and properties of crude oil. Among all the techniques being utilized for mitigation of wax related problems encountered during pipeline flow of waxy crude oil, dosing of crude oil with the chemical additives, such as wax dispersants/ PPD, is the cost effective and most preferred method. Hence in the present work we have investigated the effect of three commercially available wax dispersant additives (CA-1, CA-2 and CA-3) and three lab synthesized wax dispersant additives (LA-1, LA-2 and LA-3) on their efficacy for reduction in wax deposition wax deposition behavior of Assam crude oil. (A-1, A-2 and A-3) wax dispersant for its. The rheological behavior of the Assam crude oil has been determined by rheometry and the wax deposition behavior has been studied using an in-house designed cold finger apparatus and a flow loop. It was observed that among the all screened commercial additives, CA-2 has shown the highest reduction in wax deposition at 15℃. CA-2 has shown a reduction of 32% as compared to neat crude oil at a dosage of 1000ppm while CSIR-IIP-developed wax dispersant, LA-3 showed a reduction of 69% in the wax deposition by flow loop at a dosage of 1000 ppm (0.1 wt%) and 52% at a dosage of 500 ppm at 15℃. This shows that CSIR-IIP designed wax dispersants can be the new aged additives that can provide cost-effective solution for the mitigation of wax deposition in the waxy crude oils compared to traditional crystal modifiers and wax dispersants.

Paper ID 242: Waste to BS-VI fuels as enabler for net zero

P.Naresh, Yash Yadav, Pravesh Kumar, K.Ramesh, Sarvesh Kumar, Madhusudan Sau

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

The energy transition scenario to achieve net zero targets as per COP-26 is changing the energy landscape from traditional fossil fuels to alternate sources. Waste to fuel and chemical is one of the emerging area for circular economy and sustainable fuels production. One of the objectives of net zero concepts is to offset the unabated carbon emission, which can be achieved by recycling the waste to valuable products. In the present work, process has been developed for the conversion of tyre pyrolysis oil to BS-VI fuels, which is currently used as a fuel oil in furnaces and boilers as a heating medium leading to higher emission due to presence of sulfur, nitrogen and metals in Pyrolysis oil.

Paper ID 254: Thermal co-carbonization study of petroleum residues and coal tar pitch for production of electrode material for aluminium industry

Prantik Mondal, Pradeep PR, Ravindra Kumar, Satyen K. Das, Sarvesh Kumar, J Christopher, Madhusudan Sau, SSV Ramakumar

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

With deteriorating crude oil quality worldwide, generation of vacuum residue (VR) from petroleum refineries is increasing. On the other side, with growth in steel industry, availability of coal tar pitch (CTP) generated from coke oven batteries is also increasing. Up-gradation of VR to distillates and processing of CTP through thermal cracking route is a valuable proposition to refineries in the future scenario. It is proposed to produce electrode materials from co-carbonization of VR & CTP for use in Aluminum industry. This will indirectly help in meeting future demand of Aluminium for manufacturing of Aluminum-Air batteries – which are projected to be a key segment of EV Battery industry.such as XRF, ICP-OES, NMR etc. Processing of neat CTP in residue conversion unit is a challenging task due to presence of very high content of aromatic, CCR, and asphaltene compounds which may lead to coking in thermal cracking furnace. To overcome the above issues, blending CTP with VR can be a good solution due to the reduced content of polyaromatic hydrocarbons. In this study, thermal cracking behavior of VR and CTP and blends were studied to observe at any possible chemical interactions between them in a thermal cracking refinery process unit like Delayed Coker.In the present study, non-isothermal pyrolysis of VR, CTP and their asphaltene and maltene fractions and blends of different compositions were studied using a thermogravimetric analyzer (TGA). Using TGA data, activation energy of VR, CTP, and their asphaltene and maltene fractions and blends of different compositions were estimated using model-free isoconversional Ozawa–Flynn–Wall method. Thermal decomposition behavior and interaction between VR and CTP in blends were also investigated during the pyrolysis study. Micro-Coker reactor experimentation of VR, CTP, and blends were also carried out at Delayed Coking process conditions for estimation of product yields and quality. The coke products obtained from the Micro-Coker reactor were calcined in a lab calciner unit at high severity conditions. The calcined coke samples were analyzed for XRD, XRF etc for coke quality. The results showed that blending of CTP in VR improved coke quality with lesser impurities and higher crystalline features which can be used as an anode for aluminum industry VR and CTP contains high molecular weight components (asphaltenes) which may create many problems during refining such as fouling, deposition, and catalyst deactivation, etc. Therefore, it is utmost important to study the thermal cracking behavior of VR and CTP for process optimization and smooth operation in

residue conversion units. In this work, asphaltene and maltene fractions from VR/CTP were separated using suitable aliphatic solvent. Physico-chemical characterization of VR, CTP, and their asphaltene and maltene fractions were carried out using different analytical techniques

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Paper ID 295: Evaluation of heavy metals in north Gujarat crude & their toxic effect in treated industrial effluent water

Bhawana Srivastav, Heer Tahiliani, Ashutosh Mishra

Quality Control Deptt. Gujarat Refinery, Indian Oil Corp. Ltd., Vadodara, India

North Gujarat Crude oil extracted from oil fields of Gujarat, India have a considerable amount of heavy metals such as cadmium, nickel, zinc, manganese, vanadium, copper, chromium, lead, arsenic and mercury etc. as part of the impurities present. Some of the dominant methods of metal removal from crude oil include: deasphalting, hydrocracking and hydrotreating .Other methods under investigation include; oxidation, adsorption, acid attack, solvent extraction etc. The presence of metals in crude oil during subsequent processing may cause corrosion, environmental pollution, and may poison the catalysts used in the secondary units. The metals may also interfere in oil refining processes by causing excessive coke formation. Operations and waste products associated with metal extraction and processing are the principal causes of environmental concerns about metal mining.

Concerns include: Physical disturbances to the landscape; Soil and water contamination. These toxic discharges which are the heavy metals and other trace elements can be uncontrollably percolated and penetrated to the industrial effluent. Heavy metal-contaminated water is the threat for living organisms as well as to the environment that instigates climate change. These heavy metals need to be removed from the industrial effluent using cost- effective bio-based adsorbents before discharging it to the rivers.

This study provides an insight into the evaluation of heavy metals contribution in Treated Industrial Effluent Water because of North Gujarat crude.

Paper ID 296: A unique antifouling solution for refinery preheat exchangers to improve operational efficiency and reduce GHG emissions

Eswararao Doni, Sairamu M, K. R. Krishna

HPCL Green R&D Centre, Bengaluru, India

Fouling of refinery process equipment is a common problem resulting in severe economic penalties due to energy loss, throughput loss as well as significant safety concerns. Typical problem areas include crude and short residue/ vacuum residue preheat exchangers, furnaces, reactor beds etc. Multiple factors affect fouling including crude type, equipment design, flow rates, temperature, unit's operational severity and fluid characteristics. Fouling deposits can be categorized into two major types, inorganic and organic. Inorganic fouling is due to deposition of solid inorganic contaminants such as sand, silt and corrosion products of process equipment such iron sulfide, iron oxide in the heat exchangers. Organic fouling resulting from separation and deposition of asphaltenes at high temperatures is due to incompatible blending of crudes and polymerization of dienes and alkenes.

We developed a novel, cost effective Antifouling formulations by characterizing and studying the fouling deposits collected from various preheat exchangers and understanding the various fouling mechanisms. Our Antifoulant formulation is a unique combination of active chemical components, which can effectively control all types of fouling mechanisms. A series of novel in-house formulations have been developed and evaluated against various crudes, crude blends, DHDS feed and short residue using Refinery Process Fouling Simulator (RPFS). The in-house developed formulations exhibited superior performance in comparison with the commercial benchmarks. Importantly, one single formulation (HP THERMOPRO) was working well for all types of crudes, crude blends, DHDS feed and short residue. The formulation has been scaled up to multi-tonnage and field trials were conducted successfully for one year at both HPCL Visakh and Mumbai refineries and proved the sustainable performance over long time against varying crude processing. Moreover, the use of this product improved the preheat temperature; reduced the fuel oil burning; and improved the environmental aspects by reducing GHG emissions. HP THERMOPRO is being continuously used in HPCL refineries. Indian and Singapore Patents have been granted on this invention. We were also awarded "Product Innovator of the Year" from FICCI Chemicals and Petrochemicals Awards-2021 for HP-THERMOPRO.

Paper ID 350: Microwave-based economical biodiesel production in India

Amit Pal, Naveen Kumar Garg

Delhi Technological University / G B Pant DSEU, New Delhi, India

The current study used microwave transesterification, a crucial technique in the development of biodiesel production, to investigate the expenses of the conversion of cottonseed oil to biodiesel and the returns from the byproducts. The costs of converting feedstock into biodiesel would include capital expenses and variable costs. Initial equipment purchases are susceptible to capital expenditures as well as variable expenses such chemicals, labour, fuel, power, and ongoing maintenance. The estimated processing has been measured for a 500 litre daily output. Clean cottonseed oil has been suggested as a feedstock in this study. The unit is operational for 8 hours, with a 15% cost for transportation, insurance, and taxes. According to calculations, the conversion cost for producing pure biodiesel using a microwave-assisted method is around INR 3.35/litre. For the purposes of microwave assistance in biodiesel manufacturing, this paper would be helpful.

Paper ID 308: HP DWA: A cost effective and novel dewaxing aid polymer for lube refinery – A make in India initiative

Ch. Siva Kesava Raju, Kottari Naresh

HPCL Green R&D Centre, Bengaluru, India

Petroleum Lube refinery produces niche grades of lube base oils such as Spindle oil, 150 N, 500 N and Bright stock. Solvent dewaxing process is one of the important processes in lube refinery, which is used to remove wax from lube raffinates in order to improve Pour point. Dewaxing aid is important and process is not feasible without dewaxing aid. Dewaxing aid polymer is a chemical that assists and enhances the dewaxing process. Some of the functions of DWA are, helps to form proper crystals, improve filtration rate, improve DWO yield and reduce oil content in wax. The performance impact of DWA affects the quality and yields of dewaxed oil in lube refinery, which influences the refinery margins. Dewaxing aid polymers are difficult to screen and synthesize as the polymer chain, branching and molecular weight of the polymer plays important role in proper lube oil production. At present all dewaxing aid polymers are being imported and vulnerable for geo-political conditions. Hence, there is a need for the development of cost effective high performance DWA polymers to reduce the operating cost of refinery.

HPGRDC under the make in India initiative, developed a novel dewaxing aid polymer, in-house. The developed polymer was characterized by GPC, IR, NMR and TGA techniques. The performance of the synthetic DWA polymers has been evaluated by standard test method and the performance of in-house developed polymer is superior to the commercial sample in terms of yield of the dewaxed oil and dewaxed oil properties, such as, pour point and VI. The performance has been evaluated for different base oils, such as, 150 N, 500 N, SPO and Bright stock and the corresponding dewaxed oil is meeting all the specifications. The best DWA polymers from lab trials were synthesized in tonnage scale and supplied to HPCL Mumbai refinery. The in-house developed HP DWA was superior in terms of performance, economical in terms of cost and long unresolved issues with commercial DWA were resolved. The product is handed over to HPCL Direct Sales Division and marketed to refineries on regular basis. IPR of the product is protected by Indian and International patents1-2 and FTO is obtained for the same.

Paper ID 361: CO combustion promoter in FCC unit: Influence of metal dispersion on performance

P. Manjunathan, V. Chidambaram, K.O. Xavier, A.V. Karthikeyani, Alex. C. Pulikottil and Madhusudan Sau

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

CO combustion promoter is additive used in Fluid Catalytic Cracking Unit (FCC) to assist combustion of CO to CO_2 in the regenerator. In a quest to reducing the concentration of air pollutants, such as CO, in FCC waste gas streams, more active and stable CO combustion promoters to be used to meet the requirements of refiners. Platinum based alumina supported catalysts are being used as catalyst additive for CO-combustion. The efficacy of CO combustion promoter is known to depend on various parameters such as metal content, metal dispersion, the type of catalyst support employed, and physical characteristics of additive such as attrition resistance and bulk density. The main challenge in the development of this additive is to achieve desired performance with a catalyst having lower metal loading and thereby offer cost effective additive to refiners. The present paper describes the influence of metal dispersion on the performance of CO combustion promoter additive. The metal dispersion in additive is measured by CO-chemisorption method. The paper also discusses the methodology of CO-chemisorption measurement and estimation of Pt-dispersion. The lab developed CO combustion promoter is found to have improved performance above 98% under simulated regenerated conditions at 0.02–0.03wt% concentration of CO promoter.

Paper ID 362: Lab studies for assessing the energy efficiency of the industrial gear oils

Sandeep Singh, Rahul Meshram, Sanker Bhadhavath, Kavita Rai, Rajendra Mahapatra, A K Harinarain, Mukul Maheshwari

Indian Oil Corp. Ltd., R&D Centre, Sector-13, Faridabad, India

In this study, the effects of some physio-chemical and tribological properties (such as Pressure-Viscosity coefficient (α), Viscosity Index, friction, etc.) on the Energy Efficiency (EE) characteristics of the transmission oils were investigated. Power losses in the gear drives comprise primarily of losses due to viscous drag / oil churning, boundary metallic friction and at the sealing. Gears drives operate predominantly in the EHL regime. The film thickness in the EHL regime depends upon the Oil Pressure–Viscosity Coefficient and its viscosity at normal pressures, whereas the EHL friction is related to its limiting shear stress. These key characteristics of pressure viscosity coefficient and the limiting shear stress of the oil are influenced by its molecular structure.

In this study, the energy efficiency of the various gear oils in gear contacts was assessed on the FZG test rig. The energy efficiency of the gear oils is also assessed from the temperature rise experienced during the long duration tests on the FZG rig. An attempt was made to quantify the above physico-chemical/ tribological properties to calculate the losses encountered during the gear meshing and correlate these with the energy efficiency tests on the FZG Gear tester

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Paper ID 241: Experimental study of in-cylinder flame characteristics of butanol-gasoline blends in SI engine using endoscopic visualization system

Kumaravel S, Saravanan C.G, Vikneswaran M, Velavan A, Saravanan M.S

Annamalai University, Annamalai Nagar, Chidambaram, TN, India

As two-wheeler segment is already being dominated by gasoline powered vehicles, the implementation of BS-VI norms extends the application of gasoline vehicles to light and medium duty vehicle segments. Due to these, the demand and usage of gasoline are increasing every day. Therefore, it's a need of the hour to find a suitable supplement to gasoline fuel. This work focused on investigating the in-cylinder flame characteristics of butanol-gasoline blends. Experiment was conducted on a MPFI spark ignition engine fuelled by butanol-gasoline blends prepared in the ratio of 10:90, 20:80, and 30:70 by volume. The in-cylinder flame was captured using endoscopic visualization system with camera. The flame characteristics such as spatial flame distribution and

temperature contour distribution were evaluated from the captured flame images for butanol blends and compared with sole gasoline. Further, combustion, emission and performance characteristics were investigated for the same blends. The result revealed that the percentage of flame spread region was found to be higher for butanol blends when compared to gasoline. The combustion characteristics such as in-cylinder pressure and heat release rate were increased due to the blending of butanol in gasoline. The brake thermal efficiency of the engine increased with increasing butanol concentration in the blend. Furthermore, HC and CO emission of butanol-gasoline blends were lesser compared to gasoline. Whereas, NO was higher for butanol blends. Finally, it is concluded that butanol has the potential to be used as supplement to gasoline and can be used in the conventional gasoline engine without any major engine modification.