MARINE RESIDUAL FUELS, IMO2020 AND WHY CHEMISTRY MATTERS

By Kevin Cote

The effects of IMO2020 on the commercial shipping sector will include marine bunker supplies, quality of fuels, refinery outputs, compatibility concerns, pricing spreads, contamination issues of blends and scrubber effectiveness. *Pacific Maritime Magazine* file photo.

There is much noise these days surrounding IMO2020 and its effect on the commercial shipping sector moving forward. It appears that everyone has an opinion of which way the market will move regarding marine bunker supplies, quality of fuels, refinery outputs, compatibility concerns, pricing spreads, contamination issues of blends, scrubber effectiveness and the list goes on and on. One must filter out all the noise, perform a fleet analysis and then make a decision that is best aligned with your company's strategy while focusing on standard operating procedures, risk mitigation and crew training.

There is increased demand for lighter end products with a decreased demand for the heavy ends during the past few years. Several reasons for this change would include: increasing use of lighter end fuels by the transportation sector (cars, trucks and aircraft); and decreasing use of residual fuels due to environmental and economic reasons under the forthcoming IMO2020 regulations.

If one analyzes it from an economic standpoint, the lighter products command higher prices while the residuals are sold at prices lower than the cost of the crude. Refineries end up purchasing the lowest priced crude to meet their market demand. Since crude is purchased under various timed contracts, the refinery will not be running the same crude at all times. In regards to the marine market, there will be changes in the properties of residuals as crude feedstock changes.

Refineries will have economic pressures to produce the higher margin light products which will create a more complex refining process to go beyond the simple atmospheric distillation process and will now include catalytic cracking and viscosity breaking. This secondary refining has resulted in some marine operational problems such as: incompatibility due to mixing in the same storage tank; heavy sludge formation due to precipitation of asphaltenes; fouling of filters and centrifuges; poor atomization; poor ignition and combustion; damage to equipment due to catalytic fines; and high-temperature deposits and erosion of exhaust valves to name a few.

This secondary refining along with the introduction of fuel specifications have caused the refiners to adjust the way they prepare marine fuels. As a result, the main source of residuals supplied in the marine market is now highly viscous residue from the secondary refining. These residues are blended with cutter stocks on extraction to reduce the viscosity for improved handling.

Cutter stocks tend to be lower value, low viscosity cycle oils from the catalytic cracker and at times higher value kerosene or vacuum gas oil from the atmospheric and vacuum distillation towers. The cutter stocks not only reduce viscosity, but are added to meet appropriate International Standards Organization (ISO) specifications and market requirements. The quantity of light products extracted during vis-breaking can be adjusted so the greater amount extracted results in a more "severe" process.

The economic pressures within refineries are to maximize the quantity of light, high value products while minimizing the amount of low value residue, which results in more severe extraction. The greater the severity, the greater the tendency for the resulting residue to become unstable. "Instability" under this context means that the asphaltenes may tend to precipitate out of the residue, or be caused to precipitate when blended with a cutter stock. This severe vis-breaking also increases the density and carbon residue value.

The increased operational problems aboard ship over the years have resulted in the end users receiving more information on a fuel's properties than the typical parameters of viscosity and density given on a bunker delivery receipt. As a result, fuel oil analysis now contains many of the following characteristics such as: density; specific gravity; viscosity; ignition quality; flashpoint; pour point; carbon residue; water; sulphur; vanadium; sodium; alumina and silica; ash; asphaltene stability; total sediment existent; total sediment accelerated; total sediment potential; and compatibility.

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There are more than a dozen grades of residual fuel distinguished by three letters and two numbers. The first two letters are common to all residual grades where "RM" denotes "Residual Marine", while the third letter refers to the maximum permissible density at 15 degrees Celsius, and the two numbers are the kinematic viscosity of the fuel at 50 degrees Celsius. The current international fuel specification limits are covered under ISO8217, which is constantly being updated and revised. The analytical laboratory results conducted of the bunker sample will provide a reasonable indication as to how the operator should treat or handle the fuel during shipboard use or if there could be combustion problems.

There are three regions aboard ship where fuel is used which include: the pre-combustion; combustion; and post-combustion processes. The pre-combustion process involves fuel storage, handling and treatment. There are generally two types of fuel storage tanks installed aboard ship, which include double bottom and wing tanks, however the number and positioning of the tanks is a function of the vessel type, ballast requirements and of course, required fuel capacity. Double bottom tanks tend to be shallow with a large surface area that will assist in the separation of water and sediment whereas wing tanks are a high, narrow design due to cargo and space restraints. As a result, double bottoms are more susceptible to sludge accumulation due to the difficulty in completely emptying the tanks, whereas wing tanks typically have little ullage due to the tank heights and a positive head of oil on the transfer pump's suction. A common problem arising in storage tanks comes from unstable and incompatible fuels. Unstable fuels will degrade in storage over time and cause stratification and/or sludge precipitation. Incompatible fuels will cause excessive sludging when different fuels are mixed in the same tank. When the asphaltenes agglomerate, they form sludge and as a result, will entrap water and "cat fines" making separation extremely difficult. This excessive water contamination can produce water/oil emulsions and based upon the fuel characteristics, form stable emulsions difficult to "break".

Typical problems found in the pre-combustion process include: excessive sludging from unstable and/or incompatible fuels; filter blocking; centrifuge overload; water removal from emulsions; cat fine removal; fuel heater fouling; fuel injector tip fouling; poor atomization; and abrasive wear.

Pre-combustion solutions would treat the fuel for problems of instability and incompatibility during storage and residence time in fuel storage tanks. Dispersants and stabilizers will address the following: stabilizing secondary refined residues to keep asphaltenes in suspension when blended with cutter stocks; dispersing existing asphaltene agglomerations; reducing incompatibility problems when various fuels are mixed; reducing filter blockage and fuel heater fouling; improving efficiency of centrifuging and filtration since fuel sludge is reduced and the useful fuel to the engine is increased; allowing easier removal of cat-fines in fuel due to centrifuge efficiency; and ensuring good atomization through a homogenous fuel condition.

The combustion process involves atomization, combustion air, ignition, and ignition delay. Fuel will pass through several phases during this combustion process and include: beginning of injection then start of ignition; rapid fuel combustion with a rise in pressure; steady combustion as fuel injected; and finally an after-burning period where remaining unburned fuel mixes with oxygen and combustion is complete. Typical problems found in the combustion process include: poor atomization; slow burning fuel; incomplete combustion; piston fouling/crown erosion; premature piston ring failures; high cylinder liner wear; and scavenge air port/valve fouling with increased under piston deposits.

Combustion solutions would treat the fuel with a combustion catalyst or a combination of a catalyst and dispersant/stabilizer product to mitigate or eliminate problems. These products will improve the following issues: maintaining fuel in a homogeneous condition to ensure good atomization; reducing thermal cracking of cylinder liners from irregular/distorted spray patterns; reducing piston crown erosion; improving combustion by promoting more complete and earlier completion of combustion; reducing piston fouling due to less unburned fuel deposits; improving piston ring integrity by reducing deposit ingress into ring grooves; preventing the burning of the cylinder lubricant oil film; improving cylinder liner condition by minimizing scuffing or polishing effect from piston crown deposits; and reducing under piston-space deposits with the potential for scavenge fires.

The post-combustion process includes exhaust/particulate emissions, soot, coke, ash, NOx, SOx, system/cylinder lubricating oil, cold/hot corrosion, turbochargers and exhaust gas economizers. Typical problems found in the post-combustion process include: high and low temperature corrosion; exhaust valve pitting/corrosion; piston crown corrosion; turbo-charger fouling from carbon/ash deposits; economizer fouling and corrosion; soot fires; funnel emissions; rapid degradation of the sump oil from combustion by-products; and excessive acid production causing high depletion of total base number (TBN) in cylinder oils.

Post combustion treatments would include a combustion catalyst or some combination of a combustion catalyst and ash inhibitor product to reduce or eliminate post combustion problems. A combustion catalyst will typically assist by effecting the following actions: improving combustion through more complete and earlier completion of combustion; improving exhaust valve sealing by reducing carbon particulates; maintaining cleanliness of turbo-chargers; improving cleanliness of economizer thereby minimizing any risk of soot fires; reducing particulate matter by more than sixty percent; and preventing overloading of sump oil with carbonaceous debris in 4-stroke engines.

An ash inhibitor, on the other hand, will assist with effecting change in the following areas: inhibiting further deposition and removing existing high temperature corrosive deposits on various components by raising the melting temperatures of ash forming compounds; reducing low temperature corrosion by reducing and neutralizing sulphuric acid formation; and maintaining adequate TBN levels of cylinder oil while burning high sulphur fuels thereby reducing liner wear in 2-stroke engines.

Now for the coffee house and camp fire discussions regarding IMO2020, since everyone has a perspective on the direction and outcome of the forthcoming regulations, whether you're a refiner, blender, legal entity, class society, someone within the supply chain or a vessel operator. Whether you choose scrubbers, LNG or the use of 0.5 percent compliant fuel, it is a difficult decision based upon unknown future events. A strategy needs to be developed for whichever solution you choose and there have been a few recommendations from marine class and others for ship owners' preparedness which include:

1. Fuel systems on board ships – segregation of high sulphur and low-sulphur fuel oil systems
2. Engine Room fuel sampling points
3. On board documentation/approval for changes to fuel systems
4. HAZID and mitigating measures
5. On board Operational manual including:
   a. change over @ compliance date
   b. bunker tank cleaning – preparation for compliance
   c. renew on board calculators for time needed to switch between 0.5 and 0.1 percent fuels
6. Procedure for fuel oil purchase and testing
7. Procedure how to document and report fuel non-availability
8. Crew training

Any preparation for the fuel change when it comes to tank cleaning might include:

1. All current heavy fuel oil transfer, distribution and tanking systems being cleaned before loading of 0.5 percent sulfur fuel
2. Dispersants to be used for a time period (3-5 bunkers) prior to change in system allocation, to allow an "in-service" cleaning of the system at low cost, no down time and most importantly, limit the need to enter the tank and clean (enclosed space entry).

The primary two parts of your IM02020 strategy would be mitigating the effects of contaminated bunkers and planning for tank cleaning. Please feel free to reach out to me to discuss in further detail any of the topics covered here.

Wishing everyone fair seas and following winds moving forward, but always remember "Chemistry Matters". PMM

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