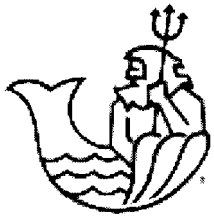
Technical Paper

MODERN MOTOR VESSEL EXHAUST GAS STEAM GENERATOR (GAS SIDE) PROBLEMS AND CURES



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MODERN MOTOR VESSEL
EXHAUST GAS STEAM GENERATOR
(GAS SIDE)
PROBLEMS AND CURES

The exhaust gas steam generators on modern vessels are an integral part of the system for efficient utilization of the fuel energy. The exhaust gas from the combustion process in the main engine passes through the turboblowers and ultimately through the exhaust gas steam generator before exiting to the funnel. Capturing as much of the heat energy as possible in the exhaust gas is highly desirable since it improves the overall efficiency of the vessel's energy consumption program.

The problem in this energy conservation process is the exhaust combustion gases from the engine carries with them deposit producing materials which are a combination of unburnable products such as ash as well as the hydrocarbons which have not been completely burned simply because the combustion process is not 100% efficient. In addition to these particulate materials the exhaust gases carry moisture from the combustion reactions and volatilized portions of the various contaminants which were present in the fuel. All of these materials tend to foul the heat transfer surfaces of the steam generator which, in turn, reduces its efficient generation of steam for shipboard process applications.

An example of the effect of deposit buildup on the gas side surfaces of the exhaust gas steam generator is that 0.5 mm of soot can reduce the generator's output by up to 20% at rated boiler load conditions. Another way of saying this is that 1 mm of soot is equivalent to the insulating effect of 5 mm of asbestos. Therefore, minimizing deposits especially those from unburned hydrocarbons is a necessity if the system's efficiency is to be maintained at optimum levels.

In addition to the particulate formations, the problems with respect to acid corrosion cannot be overlooked. Low temperature corrosion is caused by the presence of sulfur in the fuel which is converted in the combustion process in the presence of oxygen to sulfur dioxide (SO_2). This sulfur dioxide and a secondary product sulfur trioxide (SO_3) combine with moisture (H_2O) in the exhaust system to form sulfurous (H_2SO_3) and sulfuric acid (H_2SO_4). In addition to this reaction, the presence of other fuel contaminants such as vanadium act as catalysts in combustion and further the formation of sulfur trioxide from the sulfur dioxide. This means that additional quantities of highly corrosive sulfuric acid are formed in the exhaust system.

If the gas side heat transfer surfaces are coated with particulate material of any type and the gas temperature is such that the dewpoint (approximately 140°C) of the gas stream is reached, the water and acids which are generated are absorbed on the particulate material and held to the metal surfaces of the unit. This exaggerates the already severe corrosion effects.

With all of these undesirable conditions which can occur, it is imperative that corrective action is taken to reduce the deposits and the acid generating characteristics to the lowest levels possible in the combustion process of the main engine. It is also possible to treat the exhaust gas steam generator with a special soot release product designed for the unit's low temperature areas.

Minimizing deposit formations and the acid generating potential of a diesel combustion process involves the optimization of the engine operations in burning the fuel and the treatment of the fuel with combustion improvers and deposit modifiers if necessary. When these approaches have been taken, the next course of action is the use of a low temperature soot release product on a regular schedule to burn off the unburned hydrocarbons That may be present which then minimizes the potential for acid attack, since there will be no surfaces on which the acid can be absorbed. Of course, the utilization of effective soot blowers to remove loosened particulate material is of prime importance. While, the application of a low temperature soot release product can go a long way towards minimizing deposits and acid attack conditions, it cannot take the place of good soot blowing capability and proper orientation of the soot blowing nozzles.

The heat exchange elements in an exhaust gas steam generator are usually fitted with studs or gills to increase the heat transfer absorption characteristics of the surfaces. Deposits and acids which accumulate on these surfaces can be minimized by the low temperature soot release catalytic action. This catalyst reduces carbon buildup by promoting the "controlled burning" of the hydrocarbons. While steam ship boiler systems have used regular soot release products for many decades, these same chemical materials are not effective in diesel engine exhaust gas systems because of the lower temperatures encountered. These temperatures can be as low as 200°C or lower and, as such, require special chemical formulations to become activated.

The criteria for the amount of a low temperature soot release product required for treatment of an exhaust steam generator's gas side involves the type and degree of fouling, the equipment's design, the vessel's operating conditions, the exhaust gas temperature ranges and, finally, the burnability characteristics of the bunker being burned in the engine. All of these criteria are important and can play a major role in the success of the treatment program. Once these considerations have been evaluated, the amount of the low temperature soot release product required will probably be in the order of 1 kilogram/day for each 400-500 square meters of heat transfer surface. If exhaust gas temperatures at the entrance to the unit are much below 250°C the dosage level should be increased approximately 50%.

The recommended method of dosing a low temperature soot release formula is by means of a chemical pot fitted with plant air to propel the product into the entry duct work. The desired treatment quantity is placed into the pot and the plant air pressure (approximately 7 kg/cm^2) will be adequate to inject the treatment which is in a powder form. The injection piping places the soot release powder just at the entrance to the exhaust gas steam generator to take full advantage of the gas flow to carry the treatment throughout the generator. The low temperature characteristic of the soot release product permits it to be activated by the gas temperature and its position on the heat transfer surfaces and the deposits commences with a controlled burning process of the unburned hydrocarbon. This "controlled burning" is in the form of a "glowing ember" rather than an open flame. When the burning process is complete (approximately 15-30 minutes) the system should be air or steam blown in the normal manner to remove all loosened material. With this process, air or steam the cleanliness and efficiency of the heat transfer generator tube banks should be restores and optimum steam generation should be realized.

SUMMARY

In summary, all practical combustion systems create particulate material, moisture and acids in the exhaust gases. If these products are allowed to remain and solidify on the metal surfaces of the gas steam generator the efficiency of heat transfer is dramatically reduced and the corrosive action of the acids formed in and after the dewpoint areas is enhanced. Special low temperature soot release products are available to help correct the unburned hydrocarbon conditions in deposit formations but, in many instances, it is necessary to examine and correct off- specification operation of the engine as well as the quality of precombustion handling of the fuel.

Low temperature soot release products are injected into the flowing exhaust gas. They promote the burning of the unburned hydrocarbons in the deposit formations which are then loosened so as to permit proper soot blowing procedures to remove them from the system. Once the deposits have been removed, the corrosive effects of acids are minimized since there are no surfaces on which they can be absorbed.

In closing, it is important to remember that the proper application of a low temperature soot release product on a regular schedule can maintain the system's efficiency. However, the operation of the main engine and the quality of the fuel being consumed should not be ignored. Optimizing these areas will minimize the deposit problems in the exhaust system and improve efficiency while minimizing the harmful effects of acid accumulations and potential stack fires.

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