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Subj: THE EFFECT OF MILITEC-1 SYNTHETIC METAL CONDITIONER ON THE PERFORMANCE OF A DIESEL GENERATOR SET.

REPORT

The U.S. Merchant Marine Academy agreed to test Militec-1 metal conditioner by adding it to the engine lubricating oil of a marine diesel generator set that it uses for student laboratories.

A demonstration of Militec -1 was witnessed by Professor Jose Femenia, the Head of the Department of Engineering at the U.S. Merchant Marine Academy, and several faculty members of the Academy at a joint meeting of SNAME and the Society of Marine Port Engineers in New York City. After the demonstration, Professor Femenia offered the Academy's diesel generator set as a test facility. Militec-1 was subsequently added to the engine lubricating oil of the diesel generator set and the change in the engine performance was analyzed. The purpose of this report is to state the findings of this analysis.

The results of the analysis, the opinions, and the conclusions stated in this report are strictly those of the author and are not the official position of the United States Merchant Marine Academy, the Maritime Administration, or the Department of Transportation.

RESULT

The affect of Militec-1 on the performance of the engine as compared to its historical performance is a decrease in the specific fuel consumption of up to 3 percent.

INSTALLATION

The U.S. Merchant Marine Academy has in its possession a 300 kW diesel generator set. The diesel generator has been used for a diesel engine heat balance laboratory with the Academy engineering majors for many years. The objective of the laboratory is to familiarize the students with the instruments and procedures followed when conducting a diesel engine heat balance and to familiarize the students with diesel engine performance trends.

INSTALLATION (Cont.)

The unit consists of a V-12 four-stoke cycle Waukesha marine diesel engine directly coupled to a 300kW General Electric generator. The engine has a displacement of 1616 in^3 and is rated at 525 hp at 1800 rpm. It is equipped with two turbochargers and burns No. 2 diesel fuel. The engine has attached fuel oil, lube oil, jacket water and raw water pumps. The raw water cools the jacket water and the jacket water cools the lubricating oil.

The engine is instrumented so that the mass flow rate of the fuel oil, intake air and raw water can be determined. The engine is also instrumented so that raw water temperature in and out of the jacket water cooler and the air intake and exhaust gas temperature can be determined. The flow rates and the temperatures are the basis of the heat balance. The generator can be connected to an electrical load bank so that load can be placed on the engine. The brake power output of the engine is determined by converting the kilowatt output to horsepower and dividing by the generator efficiency.

HEAT BALANCE

In a diesel engine, fuel is cornbusted inside the cylinder and the chemical energy of the fuel is released as thermal energy. The objective of the heat balance is to determine where the energy of the fuel is going. This gives a better understanding of the engine and is the basis for making improvements in engine efficiency.

Unfortunately, not all of the energy that is released in the combustion process can be utilized to push down on the piston and drive the load. Some of the energy is conducted through the walls of the cylinder and is picked up by the jacket water. Some of the energy leaves the engine in the exhaust gas. Some of the energy is lost overcoming friction in the engine and some is used to operate the intake and exhaust valves, fuel injectors, and engine driven pumps. The diesel engine heat balance allows for the determination of what percentage of the energy in the fuel is going to useful work and what percentages are lost to the cooling water, the exhaust gas and other losses.

EXPERIMENT

After agreeing to utilize the Waukesha diesel generator set as a test vehicle, the engine lubricating oil and filters were changed and the correct amount of Militec-1 was added to the oil. The engine was run on a number of occasions to allow the Militec-1 to bond to the surfaces of the engine.

The engine was then run on three different occasions with the power output set at 150kW and 250kW. The first two occasions were student laboratories and third occasion was a test run conducted by the author. The heat balance data was recorded at both loads on all three occasions creating six sets of performance data. The brake specific fuel consumption (bsfc), brake thermal efficiency, and heat balance were calculated for all six runs. These values were then compared to the data and calculated values from student laboratories prior to the addition of Militec-1. The pre-Militec data is presented in Enclosure (1) entitled “Historical Laboratory Data.” The post-Militec data is presented in Enclosure (2) entitled “New Laboratory Data, Sept.‘98 & March ‘99.”

EXPERIMENT (Cont.)

The experiment was to see if there would be immediate performance improvements to the engine due to the Militec-1 reducing friction on the bearing, gear, and cylinder surfaces of the engine. A reduction in friction in a diesel engine would increase its mechanical efficiency. This should show up in the heat balance as an increase in the brake thermal efficiency and a corresponding decrease in the energy loss to the cooling water and to other losses. The energy loss to the exhaust gas should not be effected.

ANALYSIS

The calculated values of the historical data reveal that the engine's brake thermal efficiency increased steadily from 28% at an output of 130kW to just under 36% at an output of 250kW. The corresponding brake specific fuei consumption (bsfc) decreased from a value of 0.50 lb/bhp-hr at 130kW to a value of 0.393 lb/bhp-hr at 250kW. This is typical of what one would expect to see in efficiency and fuel consumption as the engine output is increased. Diesel engines are most efficient at around 80% of their rated output.

The post-Militec data reveals that at an output of 150kW, the brake specific fuel consumption is averaging 0.45 lb/bhp-hr. This is lower than what the trend in the historical data would suggest even though the value of the bsfc at the 148kW run was also 0.45 lb/bhp-hr. This would lead one to conclude that the engine is running with a lower specific fuel consumption than it was before. At an output of 250kW, the average bsfc is now 0.381 lb/bhp-hr. Comparing this to the historical value of 0.393 lb/bhp-hr reveals a decrease of 3% in fuel consumption.

The heat balance results are not conclusive. The "Percent of 'Heat In' to BHP" is the same as brake thermal efficiency. It experiences an increase of about one percent from 35.7% to an average of 36.8%. The "Percent of 'Heat In' to Exhaust Loss" is essentially unchanged at 22%. The "Percent of 'Heat In' to Cooling Water Loss" has experienced a decrease but it is all showing up as a corresponding increase in the "Percent of 'Heat In' to Other Losses." The measurement of the raw water flow rate could be the source of the problem.

CONCLUSION

The addition of Militec-1 to the engine lubricating oil of the Waukesha marine diesel generator set at the U.S. Merchant Marine Academy has produced a reduction of specific fuel consumption of three percent at an output of 25OkW. This result is based on the average of the three readings taken after the addition of Militec-1 to the lubricating oil and one reading taken before. In conclusion, the data shows that the engine is experiencing a decrease in its specific fuel consumption due to the reduction of friction by the addition of Militec-1.

DIESEL ENGINE HEAT BALANCE
WAUKESHA DIESEL GENERATOR SET

HISTORICAL LABORATORY DATA

DATE	8/24/93	Unknown	8/24/92	8/24/93	8/24/92	Unknown
WITH OR W/O MILITEC-1	W/O	W/O	W/O	W/O	W/O	W/O
DATA						
LOAD (kW)	130	148	170	200	237	250
GENERATOR EFF.	0.912	0.915	0.917	0.92	0.924	0.925
INTAKE AIR TEMP (“F)	95	80	78	95	78	90
EXHAUST AIR TEMP (° F)	440	460	485	510	565	570
MANOMETER (inches of water)	13.4	12.6	13.5	15.9	158	16.6
AIR FLOW RATE (CFM)	925	895	925	1005	1010	1030
COOLING WTR INLET (“F)	87	72	88	87	100	72
COOLING WTR OUTLET (° F)	93	82	100	100	113	89
CLG WTR FLOW RATE (gpm)	134	100	135	132	135	95
FUEL CONSUMED (lbs.)	10	16.25	IO	10	10	23.75
DURATION OF RUN (minutes)	6.25	10	5.23	4.78	4.27	10
CALCULATED VALUES						
FUEL FLOW RATE (lb/hr)	96.00	97.50	114.72	125.52	140.52	142.50
BRAKE HORSEPOWER (bhp)	191.1	216.8	248.5	291.4	343 8	362.3
BSFC (lb/bhp-hr)	0.502	0.450	0.462	0.431	0 409	0.393
BRAKE THERMAL EFF. %	27.96%	31.23%	30.42%	32.61%	34.37%	35.71%
HEAT BALANCE						
HEAT IN (Energy of Fuel) (BTU/hr)	1739520	1766700	2078776	2274477	2546136	2582100
HEAT EQUIV. OF BHP (BTU/hr)	486292	551810	632453	741637	875035	922035
HEAT LOSS TO C.W. (BTU/hr)	389528	484487	784869	831380	850275	782447
HEAT LOSS TO EXH. (BTU/hr)	377557	402828	447389	495731	586451	589368
% OF “HEAT IN” TO BHP	28.0%	31.2%	30.4%	32.6%	34.4%	35.7%
% OF “HEAT IN” TO C.W. LOSS	22.4%	27.4%	37.8%	36.6%	33.4%	30.3%
% OF “HEAT IN” TO EXH. LOSS	21.7%	22.8%	21.5%	21.8%	23.0%	22.8%
% OF “HEAT IN” TO OTHER LOSSES	27.9%	18.5%	10.3%	9.0%	9.2%	11.2%

DIESEL ENGINE HEAT BALANCE
WAUKESHA DIESEL GENERATOR SET

NEW LABORATORY DATA, SEPT '98 & MARCH '99

DATE	9/3/98	9/10/98	3/3/99	9/3/98	9/10/98	3/3/99
WITH OR W/O MILITEC-1	WITH	WITH	WITH	WITH	WITH	WITH
DATA						
LOAD (kW)	150	150	150	**250**	250	250
GENERATOR EFF.	0.915	0.915	0.915	**0.925**	0.925	0.925
INTAKE AIR TEMP ("F)	78	71	82	**78**	71	89
EXHAUST AIR TEMP (°F)	424	353	451	**500**	422	560
MANOMETER (inches of water)	14.1	13.3	12.5	18.3	17.6	15.5
AIR FLOW RATE (CFM)	345	940	895	1085	1065	995
COOLING WTR INLET ('F)	73	74	73	74	77	83
COOLING WTR OUTLET (°F)	79	81	82	83	87	97
CLG WTR FLOW RATE (gpm)	55	52	60	60	53	60
FUEL CONSUMED (lbs.)	10	10	10	10	10	10
DURATION OF RUN (minutes)	5.9	5.95	6.25	4.42	4.32	4.3
CALCULATED VALUES						
FUEL FLOW RATE (lb/hr)	101.69	100.84	36.00	135.75	1 38.89	139.53
BRAKE HORSEPOWER (bhp)	219.8	219.8	219.8	362.3	362 3	362.3
BSFC (lb/bhp-hr)	0.463	0.459	0.437	0.375	0.383	0.385
BRAKE THERMAL EFF. %	30.35%	30.61%	32.15%	37.49%	36.64%	36.47%
HEAT BALANCE						
HEAT IN (Energy of Fuel) (BTU/hr)	1842712	1827227	1739520	2459729	2516667	2528372
HEAT EQUIV. OF BHP (BTU/hr)	559267	559267	559267	922035	922035	922035
HEAT LOSS TO C.W. (BTU/hr)	165132	182146	270216	270216	265212	420336
HEAT **LOSS** TO EXH. (BTU/hr)	387164	313857	391023	544245	444849	558895
% OF "HEAT IN" TO BHP	30.4%	30.6%	32.2%	37.5%	36.6%	36.5%
% OF "HEAT IN" TO C.W. LOSS	9.0%	10.0%	15.5%	11.0%	10.5%	16.6%
% OF "HEAT IN" TO EXH. LOSS	21.0%	17.2%	22.5%	22.1%	17.7%	22.1%
% OF "HEAT IN" TO OTHER LOSSES	39.7%	42.2%	29.8%	29.4%	35.1%	24.8%

AVERAGE BSFC @ 150kW 0.453
AVERAGE BSFC @ 250kW **0.381**