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EVALUATION OF FTC - 1 COMBUSTION CATALYST IN MINE MOBILE EQUIPMENT

AT

BHP UTAH COAL LTD'S

NORWICH PARK MINE

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ABSTRACT

During the period October, 1989 - January, 1990, a trial was conducted at BUCL'S Norwich Park Mine to measure the effects of introducing a recognized combustion catalyst into the fuel for mine mobile equipment. The catalyst is known to produce a faster and more complete burn of all liquid hydrocarbon fuels.

The effects of the catalyst on the following were measured:

1. Engine efficiency
2. Engine wear rates
3. Oil consumption
4. Black smoking

Engine efficiency was shown to increase by 7.1%, indicating a net (after treatment) saving of $125,000 p.a. Soot production (black smoking) was shown to markedly decrease in all units tested - an average reduction of 27% on the Bacharach scale.

Oil consumption was reduced to approximately half in the Cummins units. This is evidence of improved piston ring cleanliness and better oil control.

Analysis of laboratory oil reports revealed a pattern of substantially reduced engine wear in many units. In a few units wear rates were approximately halved. A conservative 15% extension on engine life can be expected, bringing further savings of some $75,000 p.a.

With total savings of $200,000 p.a. (the equivalent of 4-5 wages) this represents a 350% return on investment.

2. INTRODUCTION

FTC-1 is a recognized combustion catalyst based on ferrous picrate. Ferrous picrate has long been known to promote a faster and more complete burn of petroleum fuels, providing fuel efficiency improvements of some 5-8% for high speed diesels typical of mine mobile equipment (SAE Technical Paper Series - 831204).

The more efficient burn also results in reduced soot accumulation in lube oil and gradual erosion of hard carbon deposits throughout combustion surfaces, turbochargers, and exhaust systems. Abrasive carbon deposits are eventually eliminated. The incidence of bore polish, ring sticking, exhaust valve burning and high oil consumption is reduced. From a enviromental standpoint, black smoking and noxious exhaust emissions (NOx, CO and hydrocarbons) are also reduced.

The purpose of this trial was to quantify the approximate annual savings (fuel and maintenance costs) to Norwich Park Mine due to use of this catalyst.

3. METHOD

3.1 Fuel Consumption Measurements

A specially adapted Australia standards (AS 2077 - 1982) procedure was used to measure fuel efficiency. This method is based on measuring the amount of "burnt fuel" leaving the exhaust as CO_2, CO and hydrocarbons, under static load conditions.

By comparing initial baseline measurements with those on treated fuel at the end of the 4 month trial, a percent change in fuel efficiency was established.

Seven Coal haulers were selected for evaluation. At the end of the trial, 4 were available for final measurements. (One had an engine replacement and two were undergoing preventative maintenance). All trucks were operated at a steady 1500 rpm. Trucks TKD 1772 and TKD 1774 were operated with transmissions locked in 5th gear and brakes applied. Truck TKD 2251 was operated at no load and truck TKD 3630 in reverse gear with brakes applied.

Gas samples were taken via a pitot tube inserted into the exhaust stacks, and the components were measured by a Horiba gas analyser. There are several variables of relevance to this procedure -
Barometric Pressure
Ambient Temperature
Exhaust Pressure
Exhaust Temperature
and these were monitored on each occasion.

3.2 Maintenance benefits

3.2.1 Iron wear rate: This information was gained from BUCL's oil analysis data and expressed in the units "ppm/hour", after corrections had been made for make-up oil used. This represents a rate of wear that is meaningful in terms of overall engine life. The contribution to abrasive wear by soot in the lube oil and hard carbonaceous deposits on rubbing surfaces is the factor of interest here.

3.2.2 Blacking Smoking: A Bacharach Smoke sampler was used to draw a standard volume of exhaust gas through a filter paper under the same test conditions as AS 2077-1982. Comparison of the discoloured patch with Bacharach Smoke Scale allowed a value assigned to each sample. The higher the value the higher the smoke level.

This was performed on a monthly basis for the following reasons:
* A visual evidence of a change in combustion efficiency.
* To check the progress of engine conditioning.
* To assess the rate of soot production both in exhaust gas and lube oil (since it comes form the same source).

3.2.3 Oil Consumption: Norwich Park Mine's own data was again used for comparision here. Care had to be taken to distinguish between oil consumption and make-up due to filter changes.

4. RESULTS

4.1 Fuel Consumption Measurements

Complete results for Australia standards 2077-1982 measurements appear in Appendix.

The summary of findings are shown in Table 1.

Table 1

Unit No	ENGINE RPM	LOAD	CARBON FLOW RATE		% CHANGE
			Untreated	Treated	
TKD 1772	1500	5th Gear Lock	12.814	11.813	-7.8
TKD 1774	"	" " "	5.305	4.994	-5.8
TKD 2251	"	NIL	1.857	1.717	-7.5
TKD 3630	"	REV; GEAR BRAKE	4.289	3.965	-7.6
AVERAGE			6.066	5.622	-7.1 -7.3

Note: Because of the elbow at the end of each exhaust stack, laminar gas flow does not exist. Carbon flow rates are directly proportional to actual fuel consumption. The factor however is peculiar to each exhaust system. This makes it impossible to compare fuel efficiency between different units.

4.2 Maintenance Benefits

4.2.1 Iron wear rates: Although a clear trend was not observed in every case (variables such as dust and coolant entry, fuel dilution, etc are common) there are quite a few units where reductions in iron wear rate would appear significant. In these cases reductions of 18.1% - 45.7% were noted. These are graphically represented in Figure 1 and summarized in Table II.

Table II

Unit No	Wear rate (ppm iron / hour)		% change
	Untreated	treated	
TRD 91	.340	.205	-39.6
TRD 93	.334	.224	-32.9
TRD 151	.166	.135	-18.7
TRD 1772	.079	.042	-46.8
TRD 1773	.106	.058	-45.7
TRD 2250	.327	.194	-40.7
TRD 3569	.103	.081	-21.4
TRD 3630	.035	.029	-18.1
AVERAGE			-33.0

4.2.2 Black Smoking: Black smoke emissions were significantly reduced throughout the trial. The results are summarized in Table III.

Table III

Unit No	BACHARACH Smoke No	
	Untreated	Treated
TKD 1772	9.5	6.0
TKD 1774	9.5	8.0
TKD 2251	8.5	6.0
TKD 3630	5.5	4.0
AVERAGE	8.25	6.0

The complete series of smoke patches appear in Figure II.

4.2.3 Oil Consumption: Average figures of oil consumption before treatment and after treatment are compared in Tables IV & V.

Table IV

CUMMINS ENGINES

Unit No	OIL CONSUMPTION (L/Hour)		
	Untreated	Treated	% CHANGED
TKD 1772	.023	.013	-43.5
TKD 1773	.009	NIL	-100
TKD 1774	NEGLIG	NIL	-
TKD 1775	.075	.028	-62.7
TKD 1776	.012	.017	+41.7
TKD 1777	.053	.014	-73.6
TKD 1778	NEGLIG	NEGLIG	-
TKD 2250	.036	.004	-88.9
TKD 2251	.041	.006	-85.4
TKD 3569	NEGLIG	NEGLIG	-
TKD 3572	.171	.082	-52.0
TKD 3630	.081	.030	-63.0
AVERAGE			58.6%

Table V

CATERPILLAR ENGINES

Unit No	OIL CONSUMPTION (L/Hour)		
	Untreated	Treated	% CHANGE
LOW 73	.115	.108	-6.1
LOW 78	.040	.042	+5.0
LOW 113	.065	.068	+4.6
TRD 115	.032	.039	+21.9
TRD 150	.015	.011	-26.7
TRD 151	.067	.040	-40.3
TRD 157	.056	.030	-46.4
AVERAGE			-12.6

Note: Oil consumption for the Caterpilla is inherently more variable, presumably due to variations in work duties. Therefore although there appears to be an overall trend towards reduced oil consumption, further oil change data would be required before this can be varified.

5. DISCUSSION

5.1 Fuel Savings

The fuel savings slightly over 7% as measured in the static load tests will closely reflect those actually occurring in the field. Based on a current annual fuel usage rate of 10 million litres at 26 cents/litre, fuel savings will total $182,000.

At a treatment cost of approximately 0.61 cents/litre of diesel, the catalyst will cost $56,730.

5.2 Maintenance Savings

Engine life of units at Norwich Park is very good and a credit to the preventative maintenance staff. With reference to the Cummins engines, black smoke emissions were extremely high prior to fuel treatment, suggesting deposit formations on combustion surfaces, ring grooves, turbo-chargers, etc, could be effecting engine performance. The fact that generally, oil consumption has approximately halved is evidence of reduced blow by and better oil control through cleaner ring grooves.

With less exhaust soot and less oil consumption on treated fuel, it follows that soot contamination of lube oil and subsequent abrasive wear should be considerably reduced.

Anaylsis of laboratory oil reports requires more care and understanding. The first samples after an oil change typically show high contaminant levels, due to residual contaminants and relative low hours on that change. Therefore these values have not been considered in any comparisons.

Response to the catalyst is not always immediate. In the case of TKD 1773, the engine has had a history of high insoluble contamination (presumably soot). This rapidly depletes an oils detergency/dispersancy capacity, and with negligible oil consumption it was not being replaced. Aftersome 350 hours and two filter changes, a new low wear rate was reached - a reduction of some 45%.

Reductions of this order are typical of sooty engines, however this does not reflect your fleet situation. The average wear reduction of the eight units graphed is 33%. Because of background variations (caused by a variety of reasons) clear trends could not be identified in many units.

The catalyst has been proven to extend engine life by 15-100%. Assuming an average engine life of 15,000 hours, replacement cost of $50,000 with 40 major plant averaging 3800 hours pa, approximately 10 engines are replaced each year. A 15% extension on engine life would seem conservative and reduce maintenance cost by $75,000.

Fuel savings and projected maintenance savings represent a net (after treatment) saving of $200,000 (the equivalent of 4-5 mens wages) and a return of 350% on investment.

6. RECOMMENDATIONS FOR CONTINUED USE

The dosing system supplied by us and installed at the day tank adjacent to the service bay was quite satisfactory for the duration of the trial period. It does, however, rely on mine staff to regularly check and change over drums of catalyst as required. It is also calibrated to an average flow rate of fuel into the 12,000L day tank. The actual flow rate varies with the head in the bulk fuel tank, and has been measured varying from 135 to 155 L/min.

For these reasons, the following type of system is recommended:

1. Installation of 1000L stainless steel bulk catalyst tank with contents gauge.
2. Installation of fuel flow meter on entry line into day tank.
3. Installation of dosing unit calibrated for flow meter.

Our engineers can design and build these systems to your requirements.