The Oilfield Gas Engine—Automation—Extended Service—Economics

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INTRODUCTION

The end of World War II marked the entrance into a new era in domestic oil production. Full capacity production gave way to curtailment and pro-ration. The necessity for drastic economies resulted in close scrutiny of all costs and practices.

The Gas Engine which had long been the "work horse" in the oilfields began to feel the inroads of electrification. Wider availability of electric power and the obvious ease of automating electric motors were compelling reasons that led to wholesale electrification.

Although much of the heavy duty engine industry during this same period was preoccupied with expanded markets for engines in other industries, there were a few who remained dedicated to the purpose of providing engines, accessory equipment, and controls that would meet the requirements of the changing economics in domestic oil production.

PHASE I: DAILY ATTENTION AUTOMATION

The first and most obvious step in the elimination of excess costs chargeable to gas engine operation was the elimination of the daily attention required by the engine for the simple task of checking and filling cooling systems and engine crankcases. Automatic oil level regulators provide the answer to the problem of maintaining a constant level of oil in the crankcase. These devices are specially designed float valves which attach to the engine crankcase and deliver oil from an external oil supply tank as required by the engine. The tanks vary in capacity of oil storage from 5 gallons to 55 gallons and are selected to provide sufficient oil to last for whatever period of time the particular economics dictate.

Several important benefits developed from this application of automation. Substantial savings in oil consumed by the engine resulted from the maintenance of a low but safe oil level. The elimination of manual filling eliminated the almost universal tendency to overfill crankcases. Trouble from contamination of the oil manually poured was eliminated. In addition, the period of time between engine overhauls was materially extended.

The problem of maintaining a proper water level in the engine cooling system has found a unique solution. This consists of a condenser mounted on the engine, utilizing a portion of the engine exhaust gas from which sufficient water for cooling system make-up is condensed and automatically delivered to the engine as required.

Again, as in the case of the application of the oil level regulator, not only was the necessary automation of the water supply provided but important contributions to the engines extended service and over-all life resulted. The water condensed from natural gas combustion products contains no minerals. Thus the problems of engine scaling, radiator clogging, and corrosion, commonly created by the use of native water, were eliminated.

These two means of eliminating daily attention have been justified on their own merit without additional modification of engines. Tens of thousands of engines so equipped are presently operating with uniformly good results and a satisfactory pay-out of the cost of the equipment.

PHASE II: "EXTENDED SERVICE"

"Long Run", "Long Life", "Extended Service" are terms applied to engines not only equipped to eliminate daily attention but also additionally modified. These engines are now capable of running unattended for extremely long periods of time. Some have been purposely run continuously for a year at a time with no services of any kind being provided and with no damage resulting to the engine.

In reality, this phase is just a continuation of the goal engine manufacturers have been working toward for a long time, and with which they have had a large measure of success. The basic natural gas engine has long been known for its service free potentiality. The "too frequent" services heretofore performed were usually justified to check accessories or component systems applied to the engine. In addition, uncontrolled environmental factors such as wide variations in ambient temperature, dirty fuel, atmospherically carried abrasives, and the use of unsuitable cooling water commonly caused engine service trips and contributed to expensive engine operation.

Ignition

Two lines of development have resulted in two successful extended service ignition systems. The first borrows liberally from aircraft practice. Aircraft type magnetos

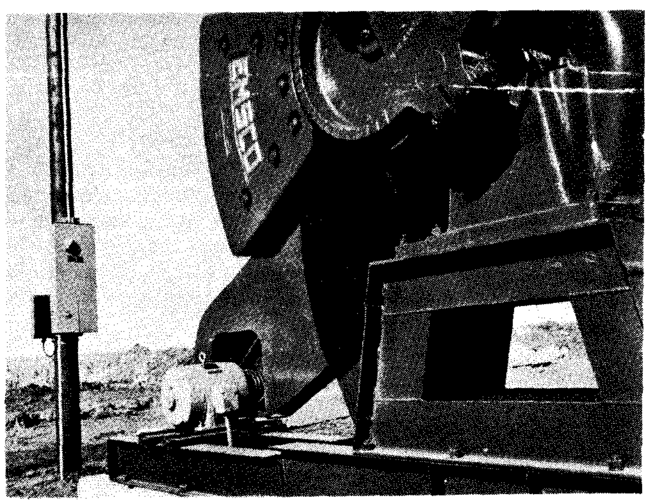

FIG. 1 - Daily Automated Pumping Engine Eliminating Necessity for Daily Service Checks in Andrews County, Texas.

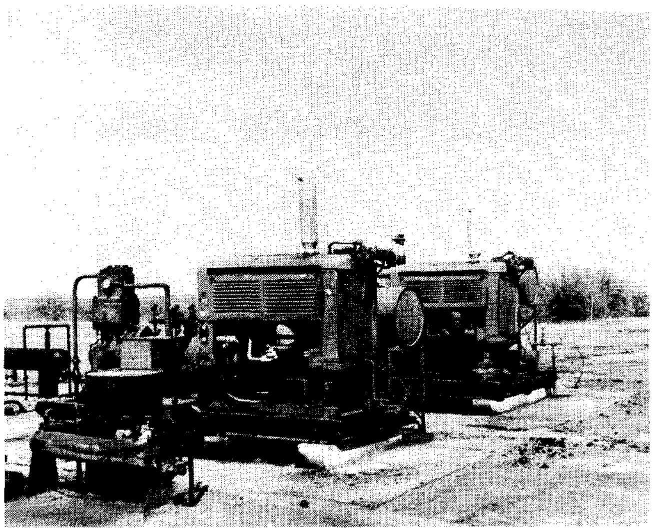

FIG. 2 - Two Extended Service Triplex Drive Engines in Texas Panhandle Requiring Very Infrequent Mechanical Service Checks. (Photo Courtesy Oil & Gas Journal)

with platinum breaker points replace the standard magnetos. Aircraft type spark plugs with platinum electrodes are used to insure that the proper spark gaps will be maintained for an indefinite period of time. Equally service free ignition is also provided by the use of low tension magnetos with high quality alloy spark plugs and individual coils for each cylinder.

Lubrication

Extended service lubrication usually involves the "permanent packing" of the fan and clutch bearings with synthetic or lithium-base greases. These have a high melting point, "stay-put" when retained by good seals, and maintain good lubrication qualities for prolonged periods. One clutch manufacturer has made modifications in design to apply extended service lubrication more easily. Most extended service engines employ oversize (by old standard) oil filters of either a "by-pass" type or a "full-flow" type to provide for adequate contaminant removal for prolonged periods.

Miscellaneous Refinements Generally or Optionally Applied

Many of the remaining changes usually made to extended service engines involve the use of high grade materials. Ordinary fan belts are replaced by higher quality reinforced fan belts. Ordinary radiator hoses are replaced with reinforced hoses with a greater life-expectancy.

Since all mechanical devices, regardless of how well they are made and applied, may at some time fail, it is necessary to provide reliable safety shut-down switches. These switches respond to conditions indicative of immediate or impending troubles such as: high water temperature or low water level, low oil pressure or low oil level, severe unbalance of load caused by failure of the driven equipment.

It is sometimes thought necessary to provide for supplemental crankcase breathing or ventilation. There appears to be justification of this if the engine is going to be required to operate for extended periods with very light loads.

Protection Against Environmental Factors

Temperature Control:

In some areas such as the Northern Rocky Mountain states and Canada, ambient temperatures will vary from 100 degrees F. to minus 60 degrees F. Engines operating under these extremes must be provided with the best possible means of stabilizing overall engine temperatures. Most single or dual-cylinder engines inherently provide for this temperature control by continuously operating at or near the boiling point of water. This is accomplished by using either thermosyphon or condensor cooling systems.

Multi-cylinder engines operating under these same extremes generally employ one of two systems. The first is the use of automatic radiator shutters and in some cases water-oil heat interchangers as well as thermostatically controlled radiator by-passes. The second system involves the complete water jacketing of the engine from top to bottom including the oil pan and the use of large, thermostatically controlled radiator by-passes.

Regardless of the means of temperature stabilizing used, extreme underloading (which is obviously undesirable for other reasons) will result in inadequate control of temperature.

By way of contrast, in tropical or sub-tropical areas, wholly adequate means of temperature control may involve only standard thermostatic control of engine temperature.

Fuel and Air Cleanliness

Uninterrupted engine service and minimal engine wear depends vitally on fuel and air cleanliness.

Unless an engine is using fuel directly from, and in close proximity to a fuel processing plant it is usually necessary to provide for a fuel "scrubber" and/or gas filter to remove solid particles, water, and heavy liquid

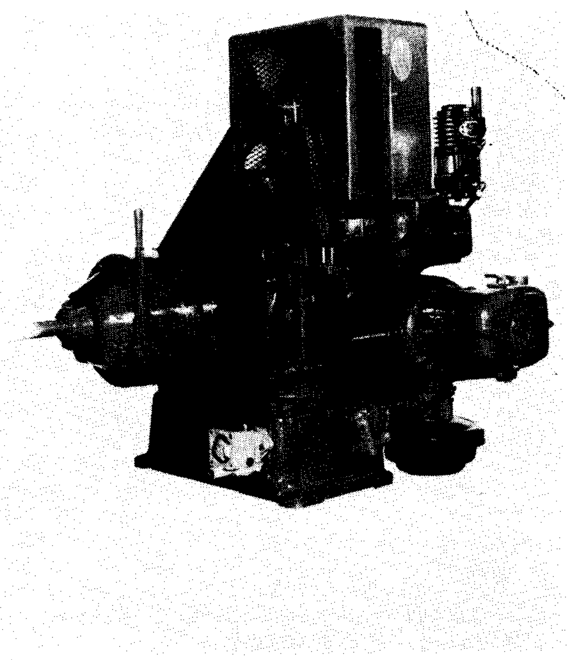

FIG. 3 - Extended Service Single Cylinder Engines for Use in Oilfield Pumping. Note Exhaust Condenser for Cooling System Water Make-up and Oil Level Regulator on Crankcase. (Photo Courtesy Witte Engine Works)

hydrocarbon fractions entrained in the fuel gas stream. Very little of such contamination may destroy the sensitive balance of the carburetion system and cause power loss, excessive fuel consumption, and engine failure.

Extended service depends on extended life. Neither is possible if even small quantities of abrasives from the air become entrained in the air-fuel mixture. Oversize oil-bath cleaners and dry pre-cleaners are generally used, but after the most adverse atmospheric conditions (prolonged dust storms) have existed for a period of some duration, good judgment would dictate the breaking of the extended service rule to the extent of intermediate servicing of air cleaners. Some promise is shown for the use of "service-free" cyclonic air cleaners, but their efficiency depends on a rather precise selection of unit size and a steady engine running displacement.

The Use of Good Cooling Water

It is almost a rule that the water native to oil producing areas is generally unsuitable for use directly in engine cooling systems without refining or treating. If the location or application of the engine does not permit the use of an exhaust condensor, as is the case where sour gas is used as a fuel, then some other automatic supply must be provided. In this event it is essential that either properly treated and inhibited water be added or that an adequate treating and filtering unit be incorporated in the engine cooling system.

With engines equipped with water softening filters and using native mineralized (hard) water for make-up, provisions must be made to protect against electrolytic corrosion. To localize this corrosion, most of these filters employ a "sacrificial" bi-metal system, elements of which must be replaced from time to time. Failing this, corrosion will take place in a bi-metal system (of a lower order of electrolytic potential) existing in the engine's own cooling system.

Analysis of Costs

Altogether much has been accomplished and just as surely more improvements and better controls will follow. But if one is tempted to be sceptical of the progress to date he must then, in all fairness, try to explain away the growing success of the commercial application of the extended service concept.

Evidence of the advances of the extended service engine may be found in an analysis of the costs of guaranteed maintenance or of outright engine leasing now commercially available.

Engines are offered to users on what amounts to a virtual guarantee of cost to the user. They can be bought outright and all necessary services and overhauls contracted for on a fixed monthly service charge. Or, for a fixed monthly lease charge, involving no capital expenditure, the producing company buys gas engine power directly at the point of connection to the driven equipment.

Although it is not the purpose of this paper to discuss the competitive aspects of gas engines to electric power it will be evident from the following analysis that engine power with no capital investment, and no lessee responsibility for certified performance, is now offered at rates that invite comparison. The following tabulation is derived from an average of schedules, currently available, now being commercially offered. To this composite of rates a charge of $2.00 per hp. per month has been added to cover the cost of fuel gas consumed and lubricating oil used, both of which are supplied by the lessee.

Average of Rate Schedules Currently Available For Gas Engine Leasing with $2.00 / HP / MO for Fuel and Lube Oil Added

Continuous HP.	Cost/HP/MO.	Cost/HP/HR.
10	6.75	.0094
15	5.33	.0074
20	4.59	.0064
25	4.44	.0062
30	4.38	.0061
40	4.00	.0056
50	3.82	.0053
60	3.73	.0052
70	3.63	.0050
80	3.50	.0049
90	3.44	.0048
100	3.56	.0049

It is fair assumption that the engine leasing companies will earn a fair profit as well as interest on the substantial investments required. Why can't oil producers do the same thing?

The answer is that they can, and some do. To the writer's knowledge, one large oil company operates several thousand engines at total costs per HP/HR that compare very favorably with the above composite rate schedule.

This company has "daily automated" their engines and has applied other extended service features selectively to eliminate troublesome service points and to protect the engine from whatever hazards exist in its environment.

PHASE III: COMPLETE ENGINE AUTOMATION

Completely automatic engines, including automatic starting and stopping, are now a reality. At this time, the writer knows of three complete automatic engine systems that are commercially offered. These engine packages will automatically start on any desired signal. A warm-up period is provided of sufficient duration to

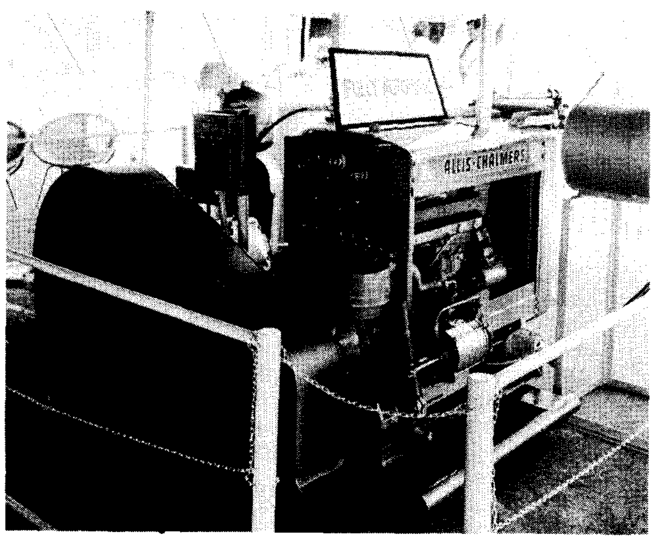

FIG. 4 - Completely Automated Shipping Pump Engine. This Engine Will Automatically Stop and Start Responding to Tank Level Switches or Any Other Signal. (Photo Courtesy Gaso Pump & Burner Co.)

protect the engine from the damage caused by cold engine loading.

After the engine has reached the desired temperature the clutch is automatically engaged by one of three types of clutch engagers being offered: compressed air powered, electrically powered from the engine starting batteries, and hydraulically powered from the engine pressure lubricating system. Engine shut-down is accomplished after the load is de-clutched and the engine has been allowed to "cool-down" while running under no load for a short period of time.

A gas engine may now be as completely automatic as an electric motor. It can be made to respond to a large number of signals or combinations of signals indicating: tank level (either high or low), line pressure, temperature, time, telephone relay, radio relay, voltage drop, etc.

These completely automatic engines show great promise for use in Automatic Custody Transfer applications that would otherwise require large automated electric motors with energy costs far in excess of that of gas engines.

CONCLUSIONS

Low cost natural gas is available nearly everywhere that oil is produced. Properly selected and applied gas engines can convert this low cost source of energy to useful horsepower at very low costs. But this can only be done if charges against the engine for maintenance and attention previously considered normal are largely eliminated.

Engine leasing, made practical by the development of the extended service engine, seems certain to find wide application. Budget and tax conscious companies will be attracted by the "no capitalization" feature of engine leasing as well as the guarantee of low energy costs.

Complete engine automation, now relatively new, should lead to wider use of gas engines in the growing trend toward complete oilfield automation.