Preventative Medicine for Pumping Engines

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INTRODUCTION

Our entire economy is sick. The illness is generally diagnosed as over-production or underconsumption. The disease has become epidemic in the oil producing industry. Some very drastic curative measures are being advocated. The medicine generally prescribed is hard to take and very expensive. Actually, the causes of the malady cannot be eradicated. Barring unthinkable catastrophe, we can expect low allowables and proration for a number of years. Available cheap foreign crude makes prospects for higher crude prices quite unlikely.

The cure for our economic ills is maximum efficiency. Every item affecting production costs must be held to an absolute minimum. Cost of power is a big item and of particular interest to us. The practical man in the field plays a very important part in the realization of minimum power costs.

Usually, the men in the field have a direct or an indirect part in the original selection of power source. It is vital that the most efficient selection be made. No curative measure, short of costly replacement, can correct the ills that result from errors in choice of power. A short review of the fundamentals should serve as the preventive medicine for improper prime mover selection.

POWER SOURCE SELECTION

The myth of cheap electric power is rapidly being exploded. Any power bill supplies the required information. Divide the dollars billed by the kilowatts consumed to get the real picture. Contrary to propaganda emanating from some quarters, the cost per kilowatt hour will go up in the future. Our rapidly increasing population, with its normal energy requirements, necessitates greatly increased investments in utility facilities. Most of the hydro-electric possibilities have been developed.

Atomic power, in spite of its enormous popular appeal, cannot be expected to be an important source of electrical energy in this country until available conventional fuels double their present relative cost. Coal will generate increasingly greater percentages of our electricity. The coal industry has made enormous advances in mechanization with the result that further cost reduction will be minor. Likewise, further improvement in power generating efficiency is not expedient. Consequently, Redy Kilowatt's price tag will spiral in company with increased costs of material, labor and fuel.

Natural gas accompanies most crude oil production. Conservation agencies and sound economics demand that it be used, not wasted. This gas has its highest well head value when used to fuel the engines used in production operations.

A vast network of gas pipe lines gathers excess gas produced from our oil fields and from the gas wells in gas fields adjacent to the oil patches. Gas companies are increasingly anxious to sell gas as fuel for gas engines where lease gas supplies do not furnish all the fuel needed. Oil field fuel gas can be sold at attractive rates because it is transported over shorter distances and the demand is constant, in contrast with the long haul and seasonal demand requirements of the domestic market.

Gas companies will be increasingly interested in obtaining oil field fuel loads in the future because attractive gas markets are nearly satisfied and large additional supplies of gas will become available with return of reasonable Federal Government regulations and logical development of the tremendous Canadian gas production potential.

Natural gas must compete with other fuels in every market. This competitive situation means that gas will be priced to sell at prices competitive with other fuels that may be used to produce power.

ELECTRIC MOTOR APPLICATION

Electric power should be utilized to pump oil wells where the loads are small and a considerable number of wells can be economically served through a single meter. Most of these applications are in comparatively shallow fields, particularly when production has declined to the stripper stage and the wells pump a few hours each day. Time clock operation should be prescribed for these conditions. Careful observation of properly electrified installations reveals that a great majority of the motors have small horsepower ratings. Relatively few are larger than 10 horsepower. Most of the well loads involved require less than 7 horsepower, if calculated by the formulae used for gas engine application.

GAS ENGINE APPLICATION

Horizontal gas engines, specifically designed for oil well pumping, are what the doctor orders in practically every instance where the actual load is in excess of 6 or 7 horsepower. These heavy duty engines use the very minimum of parts. Their design is uncomplicated. They use a heavy fly-wheel for high inertia effect. Ability to operate over a wide range of load requirements is an inherent characteristic. Thousands of these engines have been operating around the clock for 25 or 30 years and are still in the pink of condition. They have proved their ability to handle rod pumping installations with the absolute minimum of down time and maintenance.

Modern heavy duty horizontal engines are superior in every way to the older models. Scientific advances and modern precision machine tools have created completely self-contained gas engines. Very simple accessories make them self-operating. These advances have been accomplished at costs so low that gas engine powered pumping installations require the minimum capital investment, and are completely salvageable. Gas engines do not require expensive extraneous paraphernalia such as wire, poles, transformers, capacitors, switch gear and what-have-you, requiring high installation costs and possessing little salvage value.

Not to be overlooked is the very important consideration that modern horizontal gas engines use fuel so very efficiently that utility gas rates are reasonable, where all the gas must be purchased. In other instances, where all or part of the fuel gas is obtained with the crude oil production, this gas has a bonus value which further reduces operation costs.

Loads greater than 6 or 7 horsepower represent a constantly greater percentage of total oil field installations because average producing well depths are increasing and because secondary recovery operations are accounting for mounting proportions of our total crude production. These secondary recovery operations create injection pump loads perfectly suited to horizontal gas engines. The resulting produced fluid loads require continuous operation and are rarely small enough to be economically powered with anything but gas engines. Luxury power can be fatal in secondary recovery operations. There are many cases where the cost of purchased electric power prohibits lifting the high water/oil ratios encountered in the final stages of depletion. The oil produced during this high water/oil phase may mean the difference between a successful flood operation and a failure.

GAS ENGINE OPERATION

The economic facts of life dictate that gas engines will occupy an increasingly important place in our work-a-day world. The heavy duty horizontal work horses seldom get sick. They are truly rugged individuals. Power units which are modifications of engines designed for mobile equipment cannot be placed in the same category. These multiple cylinder engines lack the fundamental requisites for rod pumping.

Multicylinder babies really do get sick. Their case histories reveal short life and high maintenance costs. Unfortunately, cost records from operations using these misapplications have been used to justify luxury electrification. Fortunately, less of this kind of misapplication is likely in the future. Time will take care of those now in service.

Mobile equipment emphasis on minimum weight and high specific output has led to the development of vertical and V-type multiple cylinder engines operating at speeds too high for proper application to pumping units. If the rotative speeds are reduced, their torque characteristics are unsuited to well pumping. Greatly reduced flywheel effect severely limits their capacity for absorbing the heavy peak loads encountered in rod pumping. These deficiencies more than offset lower initial price.

With the foregoing in mind, we can devote our attentions to gas engines designed specifically for oil field applications. Most of the troubles encountered in their operation can be broadly associated with:

1. Air gas mixtures
2. Lubrication
3. Ignition
4. Exhaust systems
5. Cooling systems

A brief examination of these items may suggest corrective measures for curing troubles and definitely can help avoid future difficulty. Certainly these items should provide ample material for discussion.

Air Gas Mixtures

The proportions of the air/gas mixtures are important. Gas engines should always be operated on lean mixtures. The mixtures should be as lean as possible without quenching. Lean mixtures require large quantities of air to pass through the cylinder and thorough scavenging is accomplished. Lower surface temperatures result and stress failures disappear. Lubrication is easily achieved and deposits of partially burned fuel will not be formed. Absence of deposits or glowing carbon particles eliminates autoignition. Detonation also is eliminated with complete scavenging. Since detonation is largely dependent upon high temperature of the mixture at the end of compression, the problem is eliminated when surface temperatures are low and the cycle starts with a cylinder filled with a fresh, cool charge.

Unrestricted supplies of clean air and clean gas at constant pressure must be available if we expect to establish and maintain the desired air/gas mixtures.

Adequately sized air filters will meet the air requirements if they are clean and if the oil level is maintained with light motor oil -- SAE 20 in summer and SAE 10W in winter. Obviously, all connections between the air filter and the air intake on the engine must be air tight. Air filters that are not in working order allow dust to enter engine cylinders.

Small quantities of sand wear rings and cylinders very rapidly. Dirty, plugged air filters choke the engine to death. Heavy bodied oil will cause filter plugging and should never be used. Some sections of the country experience "bug seasons" when bugs cause dirty air cleaners. This trouble can be minimized by hanging a mosquito netting sack below the air filter inlet. The netting prevents bugs entering the filter and an occasional "flip of the sack" gets rid of the accumulation.

Gas requirements too frequently are not properly met. Failure to fulfill adequately this essential need is perhaps responsible for more deficient operation and actual grief than any other single factor involved with heavy duty gas engine operation.

If the fuel supply is dry sweet residue gas, difficulties should not be tolerated. With this duel a standard gas hookup fills the requirements perfectly. A standard hookup consists of a high pressure regulator, scrubber tank, low pressure or sensitive regulator, volume tank and the necessary piping. A suitable high pressure regulator is installed at the engine location to reduce the gas pressure to a maximum of 25 or 30 psi.

Down stream from the high pressure regulator, the gas passes through a scrubber containing lube oil through which the gas is bubbled to remove any rust, scale, sand or other solid material picked up from the piping. The scrubber design should provide means for checking and maintaining the oil level in addition to a large entrance for easy cleaning. "Scrubbed" gas should be carried through a short and direct run of ample sized pipe to a low pressure regulator. This sensitive regulator must be of ample capacity and be equipped with the right orifice for the pressure/volume requirements. The regulator should be mounted close to and just upstream from the volume tank. It will be adjusted to deliver gas at the minimum pressure the engine requires for its loading. The volume tank should never be smaller than the engine builder recommends and should include provision for draining and interior inspection. This volume tank must be located as close to the engine gas valve as practical.

Large diameter pipe with the minimum of connections should be used between the volume tank and engine gas valve. This standard hookup requires little attention. The scrubber tank oil must be maintained at its proper level and accumulated solid particles should be removed occasionally. The volume tank should be drained regularly as a check against possible entrained fluids. Gas pressure should be checked as a matter of routine and regulators adjusted or repaired when changed pressures are encountered.

If the fuel gas supply is green or wet gas from casingheads, separators or traps, moisture removal equipment must be added to the standard gas hookup. Drips must be installed at low spots in the field line between the fuel source and the high pressure regulator on the engine location. These drips must be drained regularly to prevent fluid slugs passing through the system. The scrubber tank, downstream from the high pressure regulator, must have a mist extractor incorporated in its design.

This mist extractor may consist of a layer of loosely packed glass wool through which the gas passes just before it leaves the scrubber. The glass wool presents considerable surface area to collect fluid vapor particles into drops. The drops fall down into the scrubbing oil where the accumulation is easily removed. The extractor area must be large in order that gas velocity be so low that reintrainment of liquid is impossible. The combination scrubber/-extractor must include an additional opening to facilitate cleaning or replacing the glass wool.

Some fuels will give up additional vapor after passing through the low pressure regulator. A second mist extractor in the line between the sensitive regulator and the volume tank usually removes this moisture. The most stubborn cases can be cured if both mist extractors are used and the volume tank is heated by the engine exhaust. This heat raises the gas temperature above the dew point of the extrained vapors to produce dry gas.

If the gas contains any hydrogen sulphide, heated volume tanks should be used. Heating seems to reduce sour gas attack even when no signs of moisture are visible.

We must realize that this type of moisture removal does not change the composition of the gas. Residue gas, which is largely methane, is the ideal fuel for gas engines. We know that green or wet gas usually includes heavier hydro-carbons such as ethane, propane, butane and pentane, not to mention water vapor or complex vapors from the crude oil. Unfortunately, very little is known about the ignition qualities or the burning rates of the various gases at temperatures and pressures comparable to those obtained in a gas engine cylinder. Test experience has demonstrated that considerable variation in mixture and ignition requirements do exist when various single gases are used to fuel an engine. We cannot hope that one air/gas ratio or one ignition timing setting will meet the requirements for all the components which make up the mixture of many raw oil field gases. We should expect higher maintenance when mixed gases are used to fuel gas engines.

Hydrogen sulphide contained in any fuel gas does cause additional maintenance. Trunk piston four cycle engines can tolerate less hydrogen sulphide than ported two cycle crosshead engines for reasons too obvious for discussion. Hydrogen sulphide troubles are reduced when:

1. The gas is vapor-free and heated.
2. Water jacket temperatures are above 180 F.
3. Cylinder lubricants contain no ash burning additives.
4. Spark plugs are adapted to the service.
5. Exhaust systems are free from excessive accumulation of the deposits peculiar to sour gas combustion.

Lubrication

So much has been written and said about lubrication that we logically should expect considerable confusion to exist. Frequently the subject is further confused as a result of personal experience with automobiles. If we consider this problem intelligently, we find that crosshead type gas engines have no lubrication problems. The stuffing box used in these engines completely isolates the crankcase from the cylinder. The lube in the crankcase is not contaminated by combustion products. It does not come into contact with parts heated by the combustion process. This oil has the simple task of separating cool, lightly loaded parts with a resilient oil film. Since there is no contamination, heat or heavy loading, a wide variety of stable straight mineral oils will fill the requirements for very long intervals without renewal.

Cylinder lubrication on crosshead engines is simplified because only fresh oil is used. The quantity required to maintain an oil film is automatically supplied by a force-feed lubricator. All that is required is an oil of suitable quality to maintain an oil film on rings and walls at operating temperatures existing within the cylinder. Many straight mineral oils meet these requirements and leave no deposits to stick rings or plug exhaust ports. Cylinders should not be overlubricated. Adequate lubrication requires approximately one pint in 24 hours for each 25 horsepower of rated output -- rated at the speed at which the engine is operating. Too much oil will lead to ring sticking and port plugging.

Trunk piston engines do require much more than lubrication from the oil in the crankcase. In addition to the primary function of providing the necessary film between moving parts, this oil must cool heated parts and resist the contamination of acid, varnish, sludge, oxidation, soot, and water from the combustion chambers. Various additives are included in the lubricating oils to fulfill these additional requirements. Frequent oil renewal or changes are needed. Obnoxious residue and additive ash difficulties in the combustion chambers and piston ring grooves may be associated with high additive concentration. The cylinders on these engines depend upon oil splash. Oil rings scrape contaminated oil from the cylinder walls. This contamination causes wear and plugging. Excess oil consumption results. The only cure for this excess consumption is new rings.

Ignition

Magnetos, ignition cables and heavy duty spark plugs have been greatly improved in the last few years. Careful attention to magneto timing, electrical connections and spark plug condition will reduce ignition problems to a minimum.

The engine builder's instructions for magneto timing should be carefully followed. Timing lights are quite useful for this detail and will quickly detect faulty impulse coupling setting. All cable terminals should be carefully soldered, with rosin solder, to the ignition cable. Terminals must be tight in their receptacles. Spark plug electrodes must not be allowed to become fouled.

Magneto and spark plug life will be much extended if the spark plug gap is set at .015 inch and regapped when the electrodes have eroded to produce approximately .018 inch gap. Copper spark plug gaskets and clean gasket surfaces are necessary to prevent pressure leaks and to transfer spark plug heat to the water jacket in the cylinder head.

Exhaust Systems

We all know that the valve mechanisms on four cycle engines must be maintained in very good condition and operating clearances held within recommended limits. We know that the ports in the cylinder walls of two cycle engines must not be filled with lube-fuel decomposition deposits. Some operators still do not recognize the important part that exhaust lines play in overall gas engine performance and, as a result, often handicap their engines.

Proper exhaust conditions require the pipe to be of the size indicated by the exhaust flange on the engine. The piping system should contain the minimum turns and all directional changes should use long radius bends. The exhaust piping should be supported to prevent dibration and at the same time allow creep, so that stresses will not develop with temperature changes. The exhaust pipe must be of the proper length for the engine speed. Your engine builder can or should be able to provide you with this proper length for your engine. Some four cycle engine manufacturers evade this issue: proper exhaust length does promote thorough scavenging which leads to lower surface temperatures and reduced operational costs.

There is one right length for a specific operating speed for any engine -- 2 or 4 cycle -- 1 or 16 cyclinders. Because oil well pumping involves change in speed, the exhaust length should be chosen for the average speed. Some engines are located where exhaust silencers are needed. This muffler should be sized according to the engine builder's recommendations. The silencer should be installed with the right length of exhaust pipe between the engine exhaust flange and the muffler inlet flange. This muffler must be supported with ample provision for temperature creep.

Many exhaust systems accumulate large quantities of carbon from the fuel and lubes. Analysis of this "carbon" generally reveals a great proportion of elements other than carbon but regardless of content the deposits must be removed if the system is expected to operate without choking the engine. It is very good practice to design the exhaust system so that it can be broken down for easy cleaning.

COOLING SYSTEMS

Modern heavy duty horizontal gas engines are quite immune to fever and related ailments. Water pump troubles are nonexistent because water pumps are not used. Oil and grease deposits in the cooling system disappear with the pumps. Rust is eliminated because water pumps contribute the entrained air responsible for the rust. These cooling systems require practically no makeup water, thus eliminating scale formation. Tight connections and properly functioning pressure caps (or vent holes on vapor phase engines) retain the original filling of clean coolant. Obviously, anti-freeze in sufficient amounts must be added to the cooling water to contend with cold weather conditions. Fan bearings should be lubricated (never overlubricated) in accordance with the engine builder's instructions. Fan belts on truly modern horizontal engines have a minimum life expectancy in excess of seven years.

Common sense suggests that fan belts be renewed when the clutch is pulled to repack, to inspect, or to replace the clutch pilot bearing. Generally, overheating of these engines can be traced to bugs, dust, leaves and other trash on the face of the radiator. It should be unnecessary to insist that the radiators be cleaned of this litter or to suggest that removable screens greatly simplify this housekeeping chore. Occasionally, we may find an engine located in a position where winds may blow counter to the blast from the fan and cause heating. A simple duct, directing the fan blast vertically after the air has passed through the radiator, cures this heating problem.

CONCLUSIONS

Reduced allowables, proration and low crude prices force every operator to use the most economical source of power as a logical method of cost reduction. Gas engines specifically designed for oil well pumping are the most economical power source for most of our wells requiring in excess of six or seven horsepower. Wells in the specified horsepower range will constitute a greater percentage of the total in the future. Oil field operating personnel must possess gas engine know-how if they are to fill their job requirements. A thorough understanding of the functions and requirements of air/gas mixtures, lubrication, ignition, exhaust systems and cooling systems should be included in this know-how, if maximum performance from gas engines is to be realized.