Automatic Operation Of Gas Engines

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INTRODUCTION

There must be a good reason for considering automatic operation of any machine. It has been said that a man will work a life time to make a machine to do his work. The reward may be wealth or just plain self satisfaction. In any event, the goal is compensation in some way. In the business world, survival depends upon profit. Competition keeps the price of the products at the maximum level and costs of production sets the minimum level.

Seldom can the prices be raised to gain or increase profits. That leaves the cost of production to be considered. Obsolete and inefficient machines are discarded. Replacements require very little maintenance and operate as nearly automatic as possible. We will discuss here automatic operation of only one machine — the gas engine.

THE OPERATING CYCLE

Since we are interested in the production of oil, let us take a look at the counterweighted well pump as a possible automatic operating installation. We will assume that the pump is in good condition and will operate many days without servicing. However, it normally operates for a limited time each day. The automatic control must perform the same functions and in the same sequence that the operator performs in starting, loading, unloading and stopping the engine. To get the complete picture, let us go through the cycle step by step.

Assume the engine is at rest with the ignition turned off and the clutch disengaged. To put the machine back into operation, the man will proceed as follows — turn on the ignition, cock the safety switches, operate the choke and press the start switch. He continues cranking until the engine starts or until he knows that continued cranking will cause some damage. When the engine fails to start, he waits to cool the starter, then tries again. If unsuccessful after several attempts, he will investigate and correct the trouble. When the engine does start, he will let it warm up, then engage the clutch. Now he finds that he must disengage the clutch because the engine is faltering from overload.

If the counterweight will swing back, he waits until it starts its forward motion, then engages the clutch again. This clutching procedure may have to be repeated. When he has the pump in operation, he will go on to his other duties. When the system has operated the desired number of hours, he must return to disengage the clutch, let the engine cool, then turn off the ignition to stop it. This installation is automatic in one respect — protection for the engine from overheating and low oil pressure.

What controls and equipment are necessary to make this installation automatic? A separate device is required for each operation performed by the attendant. The control must operate each of these devices in the same sequence as in the manual operation. A preset time switch would control the complete operating cycle. The length of time that this machine can operate automatically will be limited by the maintenance requirements of the engine and pump.

Except for the switches required to disengage and engage the clutch when the engine becomes overloaded in getting the pump into operation, the same controls might be used on other installations such as salt water disposal, gathering systems, booster stations, etc. The time switch may be replaced with some other type signaling device to control the running period.

The controller for an automatic system is a programming device designed to sequence a series of operations in response to a given signal. This signal may be from a remote switch or switches sensing temperature, pressure, level, etc., or the signal may be given by a time switch incorporated in the controller.

To get a better understanding of the complete operating cycle, let us examine each function of the controller.

Starting

Upon receiving the signal to operate, the controller will open the fuel valve, operate the choke, actuate the ignition system and begin cranking. We are assuming the protective circuits were made inoperative when the engine stopped.

Opening the fuel valve and activating the ignition system are single operation functions, since they will remain the same from start to stop. Choking may vary, depending upon warmup at full choke. If full choke warmup is not desired, the choke will operate only during cranking.

To prevent overheating or burn-out of the starter, intermittent cranking is required. Continuous cranking should be limited to about 30 seconds and the minimum to about 10 seconds. The rest period should be approximately double the cranking period. Experience has dictated that short and frequent crank-rest cycles are the most desirable.

Crank Termination

Cranking must be terminated as soon as the engine starts. Four means of termination are possible — speed, intake manifold vacuum, oil pressure and generator output voltage.

The speed switch is very good if a place for mounting is available. It may be part of a dual element switch, half of which is used for overspeed protection. It will be set to actuate at a speed above the maximum possible cranking speed and below the low idle or full choking speed.

Results when using the vacuum switch can be extremely good with the proper setting. Manifold vacuum at maximum cranking speed is well above the vacuum with the engine running at full choke.

If the engine is equipped with a battery charging generator, the generator output voltage may be used as a reference for cranking termination. The initial output voltage of the generator is determined by speed and the field residual magnetism; hence, this voltage may be too low to actuate a relay or switch with the engine running at full choke or low idle. In short, the battery charging generator is not always a good reliable source if the speed of the engine is limited immediately after the start.

Although it is used to some extent, the oil pressure method of crank termination also has its problems. It is possible during long cranking periods to build up enough pressure to actuate the switch before the engine starts. Result: rapid crank-rest cycling without a start. The other extreme, occurring with cold heavy oil, is continued cranking after the engine starts because the pressure builds up slowly.

Protection For The Engine

The engine should always be protected against loss of lubricating oil pressure, overheating, and in many cases, overspeeding.

To protect against loss of oil pressure, a pressure switch set to actuate just above the minimum safety operating pressure should be installed in the header supplying oil to the bearings. It is not good practice to locate this switch ahead of filters and coolers. Compensating for pressure drop is impossible. Since there will be little or no pressure at the switch when the engine is cranking, this protective circuit must remain inactive until cranking is terminated.

The setting of the temperature switch will depend upon the location and whether it is the wet or dry type. Both types should be located as near as possible to one of the hot spots in the engine head. Of course, the location must also depend upon the available openings in the engine. The switch must be set to actuate at a few degrees below the maximum safe operating temperature of the engine.

In some types of installations it may be desirable to have duplicate switches sensing oil pressure and engine temperature, to sound a warning before a failure occurs. Failures may be avoided by using this system.

When the engine is operating on a fixed throttle, the regular engine governor may be serving as the overspeed protection. Many multicylinder engines on well pumps are controlled in this manner. In other cases, this regular governor is controlling for the desired operating speed. If overspeed protection is required here, an overspeed governor with an electrical switch can be used to stop the engine. This switch will be in the circuit during the cranking and running periods.

Engine Warmup

This is generally necessary to guarantee lubrication to all parts of the engine and to guard against faltering when the load is applied. Time and temperature or a combination of the two can be used to control this period. If a specific minimum temperature is desired before applying the load, a switch sensing engine temperature must be used. However, we must be sure that this temperature can be attained in low temperature operations.

A time controlled period will be satisfactory in most cases. It has the advantage of always guaranteeing a warmup period. Ambient temperatures may be high enough to keep a temperature switch actuated during the off period; consequently, the load could be applied before the engine reached normal operating speed. This can be avoided with a timer.

On engines where warmup is made with full choke, choking must be terminated with this period.

Loading

A means of partial or complete unloading is necessary before starting the engine. The characteristics of some driven machines such as centrifugal pumps and generators, or installations using fluid couplings or torque converters, are such that it is not necessary to disconnect them to crank and warm up the engine. The additional load imposed by each may be small enough to allow good cranking speed. Each installation of this type must be judged on its own merits.

In the case of the well pump, reciprocation pump and similar loads, disconnecting the load from the engine is necessary. There are several possible ways to do this. Electrically controlled pneumatic and electromagnetic clutches are types where the actuating mechanism is a part of the clutch. Where the clutch is the type intended for manual operation, it may be operated by an electromechanical actuator, or a hydraulic or pneumatic cylinder, each with electric control. Each of these would be disengaged before the engine stopped and engaged after the engine started and completed the warmup period.

Stopping The Engine

Since the signal device — pressure temperature, level, time switch, etc. — controls the complete running period, it will signal the engine to stop when the work is completed. The controller must reverse the sequence of some of the previous operations when the stop signal is received. At that time, the load will be removed by disengaging the clutch or reducing the speed, and the timer controlling the cooling-off period will assume control.

When this period expires, the timer interrupts the remaining circuits, which will close the fuel valve, inactivate the ignition system to stop the engine, and disconnect all of the protective circuits. Where the cycling of the system is controlled by a time switch built into the controller, this circuit will remain connected and active.

Protection For The Driven Equipment

To guard against operating the equipment beyond safe limits, it is necessary to provide safety switches on the driven machines. High or low pressure may occur, indicating a blocked or broken line. Or perhaps a certain level must be maintained to prevent running a pump dry. These safety devices must be connected to stop the equipment only if a failure occurs and not from a false condition.

For example, low pressure may exist on the discharge side of a pump on startup and gradually build up to normal pressure. If a low pressure safety switch is used, a means of locking out this switch for a suitable length of time must be used to prevent a false shutdown. Also, it may be desirable to protect against loss of lubrication or overheating just as the engine is protected.

TYPES OF INSTALLATIONS

We cannot drive an automobile or operate a drilling rig automatically. The human element is needed when the unpredictable takes place. To make any machine operate automatically, the course and sequence of events must be predictable.

Naturally, all new installations will be equipped to operate automatically whenever possible. Many existing installations in good condition can be converted to automatic operation. Equipment that could operate continuously for many days without maintenance, but must be started and stopped at certain intervals to meet production demands, could possibly operate automatically.

The feasibility of equipping for automatic operation will be determined by the predicted net gain. Each type of installation must be judged on its own merits. Since there are several kinds of well pumps, each will require some equipment peculiar to each type.

For example, getting the counterweighted pump into operation requires a means of swinging the counterweights or gradually moving them over the top. Also, if the pressure in the air-balance type is lost during the down period, it must be restored before pumping can begin.

The gathering system presents entirely different operations to be performed after the engine is started. With this system operating on tank level switches, protection may be required to guard against breaks or stoppage in the discharge line. Excessive pressure should stop the pump immediately while low pressure shutdown must be delayed for a reasonable length of time after pumping starts to permit the pressure to rise above the switch set point. Also, communications must be maintained. Failing to operate with a full tank could be disastrous.

Booster stations require still other devices for control and operation. Motorized or pressure operated valves may be needed to direct the flow. Some high and low pressure switches may be used for protection, while others are used for control.

In any type of installation where continuous operation is essential, standby equipment is necessary. The standby set will operate from a failure signal on the prime operating unit. When electric utility power is used for normal automatic operation, a standby engine powered system can be used for protection. Rather than duplicate all the pumps and controls of the electric system, it may be more economical to use an engine driven generator set. This generator set will start when a power failure occurs and continue to operate until complete restoration is achieved.

COMMUNICATIONS

Do we need communications between automatic sets and a central station? This depends upon the installation. The greatest need for the communications, of course, is to be able to detect failures. If we can somehow determine that the equipment is operating satisfactorily, then failures become apparent. There are many installations operating on a manual basis where communications are absolutely essential. Results could be disastrous if some failures were not detected promptly.

Radio or direct wire must be used to have continuous contact. Unless the distances are limited to a few miles, both are expensive to install.

Direct wire is probably the most positive means to maintain contact and keep control. Circuit interruptions can easily be determined. Unit operation can be controlled and malfunctions can be detected.

All radio communications are controlled by the Federal Communications Commission. About one year ago, the FCC opened up what is called the "Citizens Band" in the 27 megacycle band. It permits operation of a transmitter by organizations or any citizen 18 years or older after a permit has been issued. Maximum output is 5 watts; therefore, transmission is limited to a few miles in a direct line or ground plane. Signals are limited to pulses.

Since the operating frequency is not limited to one station within definite areas, several transmitters operating on the same frequency could be operating within range of the receiver, making it impossible to maintain control of the machine. Model planes, boats and garage door openers operate on several channels at 27.255 megacycles.

If an engine is isolated and depends on battery power for cranking and control, radio contact will be limited to that time when the engine is running. Continuous operation of the receiver from the battery may drain the battery to a point where starting would be impossible.

EQUIPMENT SELECTION

The decision to equip an installation for automatic operation will be determined by the net gain. The engine power unit may cost less than the equipment necessary for automatic operation. However, the saving in operating costs may demand it. This can be determined only by comparing costs of manual against automatic operation. For those who will become involved with that problem, this outline of six parts for selecting the equipment is offered:

1. Sequence of operations
2. Environmental conditions
3. Power source for system control and engine cranking
4. Controller and accessories
5. Communications
6. Cost analysis

The sequence of operations will enable you to determine what devices and controls are needed. In the simplest of installations, the engine must be started at little or no load, the load applied, then removed and the engine stopped. Some of the necessary controls which are needed for programming beyond the engine are incorporated in some of the available engine controllers.

Consideration of environmental conditions is necessary in every installation, whether it is under manual or automatic control. Since there is no room for error in the automatic system, appraisal of extremes must be made. Low ambient temperatures make starting aids mandatory. Providing heaters for the engine coolant and lubricating oil may suffice.

In other instances, it may be desirable to have the engine in a heated enclosure. Fungus resistant treatment of equipment may be necessary. Not to be overlooked is the need for greater capacity in air cleaners and oil filters where heavy concentration of dust and sand may be a problem.

The most readily available sources of power are gas pressure, air pressure, utility electric power and electric storage battery. For the controls, either A. C. or D. C. electric power is the most versatile. The storage battery is a good source of power for cranking of most engines. On the larger sizes, extra large batteries and dual starters can give satisfactory results. When using batteries for cranking, one of the biggest problems is the loss of power at low temperatures.

When considering electric utility power, the possible loss of this power must not be overlooked. Of course, failures may occur in any system with any other type power. However, restoration of operations may be made much sooner by the owner, and the failure limited to one installation. Combinations of pressure for cranking and electric power for controlling are quite common.

Selection of the controller will depend, in part, on meeting the requirements dictated by the preceding subjects of this chapter, namely, sequence of operations, environmental conditions and power source. In addition, some controllers are built to control clutching operations, and have circuitry for line pressure protection. All additional accessories, such as valves, solenoids, switches, etc., which are required to obtain the desired sequence, must be determined. Controllers and accessories built with good components and designed for specific installations will be the most reliable and economical to use.

The subject of communications has been covered in a preceding chapter. In some installations they are essential. In others, they may be omitted. Where needed, the most reliable and economical will be used.

All of the preceding parts in this chapter should lead to making a fair estimate of material costs. Add to this labor for installation and any anticipated additional maintenance costs to arrive at a final figure.

MODULATED CONTROL

Although modulated control of engine speed or load has limited applications, it is discussed here as it concerns automatic operation. The majority of engine driven installations operate on an intermittent basis, or continuously with at least partial load. Continuous operation under no load conditions can have an adverse effect on the engine by fouling spark plugs and building up carbon deposits. Temperature, engine condition, and fuel are some of the things that can determine idle running time. Continuous engine operation with intermittent loading is good where the no load period is short; for example, the air compressor with the ever changing demand.

Varying the engine speed to meet the load demands, as in refrigeration systems, is a method of modulation that has been used extensively. We have built many gas engine driven refrigeration condensing units, incorporating speed modulation, with automatic start and stop control. By this method, short-cycling was virtually eliminated.

In other refrigeration systems, the engine operates at a constant speed, with the load being modulated by making some of the compressor cylinders inactive.

Where line pressure is being controlled within a certain range, it may be possible to apply a modulating device to the engine governor which would respond to this pressure, to control the pumping rate and minimize the number of starts and stops.

These examples are being cited here, since they could affect the automatic system by their inclusion. A running engine will not be a starting failure.

CONCLUSION

Automatic operation can provide a means to increase profits, and the success of the installation will be measured by the net gain. This gain must come from a reduction in operating costs. Then the key to reaching this goal must be reliability.

Simplification and improvement of methods and equipment used in automation are continually being made. The demand for automatic operation is increasing, and with it the demand for trained men. These men must not be overlooked and they should not overlook automation.