ANALYSIS OF THE PROBLEM OF INTEGRATING AN ENGINE TECHNICAL CONDITION PREDICTION SYSTEM

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Abstract. *The report contains the introduction of the system of forecasting the technical condition of an internal combustion engine, the task of which is to adapt the service intervals prescribed by the manufacturer to the real operating conditions of the unit.*

Key words: *prediction of technical condition, gas composition, maintenance intervals, operation, operating modes, adaptive maintenance intervals.*

Introduction

Today in the world there is a huge number of stationary and transport power plants in operation, which are based on the internal combustion engine. The total capacity of internal combustion engines is five times higher than the capacity of all stationary power plants in the world compared to other types of engines, electric power plants of electric vehicles, hybrids, hydrogen engines, and other alternative fuels - the use of internal combustion engines remains almost unavoidable, both now and in the foreseeable future. On the other hand, engines are a source of heat, noise and chemical pollution, and when running on fossil fuels, they contribute to negative climate change on the planet, so the issue of improving the fuel, economic and environmental efficiency of operating engines in vehicles is relevant.

These power plants are rather complicated, responsible and expensive systems, which require high quality and timely maintenance. Also, for units which are not stand-by, but are involved in some kind of technological process, the question of minimization of their downtime related to routine and emergency maintenance or repair remains very relevant.

Usually, the manufacturers of internal combustion engines or service companies, lay down a clear schedule of maintenance of the unit [4]. In fact, the instructions clearly indicate which works at which operating hours should be performed. But in practice we see that there are different conditions of engine operation, these conditions include the quality of fuel and lubricants, operating conditions, place of work, etc. Thus, for example, for an engine that has worked its life to overhaul in favorable operating conditions, it is not quite reasonable to carry out this repair in time according to the instructions. Using the prediction system, it is possible to determine the real time for an overhaul, taking into account the technical condition of the engine. Essentially, the system makes it possible to maximize the life of the power plant. Or, on the contrary, when an engine is operated in unfavorable conditions, with low-quality consumables, with overloads, this all provokes premature wear of its parts and components, in which case the unit with high probability will not reach its operating life before overhaul even according to the recommendations given by the manufacturer.

Possibilities and tasks of the prediction system

The problem of predicting the technical condition of internal combustion engines is that the engine itself is a complex unit, which includes a big lot of systems and components, working under the influence of a large number of factors (temperature, pressure, friction, contact with aggressive media, etc.). Nevertheless, the ability to predict the technical condition of such a complex and expensive unit is a relevant and demanded idea.

The task is to use the forecasting system to assess the real technical condition of the engine and, based on this data, set the optimal maintenance terms, and prevent accidents which entail expensive repairs, or even complete replacement of the unit. Such a system would be relevant for large, expensive stationary machines involved in any technological processes, where the downtime of the unit entails financial losses associated with the termination of a particular production process. Representatives of this type of power plants are gas engines - drives for booster or wellhead gas compressors, gas generators operating on landfill gas or biogas.

For these plants a great influence on their technical condition affects the composition of the fuel gas. In turn, the composition of fuel gas dictates its physical, chemical properties, as well as detonation resistance [2]. This is especially critical for wellhead integrated motor-compressors, where the gas composition varies depending on what field the unit is used in, as well as engines that run on biogas, landfill or sewage gas. In the latter case, the gas composition is also unstable, and requires constant monitoring of its chemical composition in order to adjust the fuel system and ignition system to the current conditions. The properties of the fuel gas then directly affect the service life of combustion chamber parts such as valves, piston surfaces, piston rings and spark plugs. Under unfavorable conditions, when the gas properties have deviations from the specified standards, combustion chamber parts are subject to the following factors:

1. Excessive recession of the exhaust valve chamfers and seats;
2. increased wear of spark plug electrodes, or excessive deposits on electrodes, resulting to misfire;
3. Melting, chipping of piston firing ring edges, due to detonation or high temperature of exhaust;
4. Coking or destruction of piston rings;
5. Disturbance of properties of the engine oil (loss of viscosity properties), as a result of contact with crankcase gases [1].

In the above case, it is necessary to revise the timing of engine maintenance, namely in their reduction and carrying out before the deadline. This will prevent emergencies and minimize downtime of the unit. It is also worth considering the case, when the engine is working in favorable conditions at constant modes, at average load modes. In such a case, there is a possibility to extend the service intervals, which will not negatively affect the technical condition of the unit, but will give an opportunity to save on service and rationally use spare parts and consumables.

As a sample we consider an example of operation of gas engine Waukesha L36GSI running on natural gas. In the instruction manual of this engine, the timing of replacement of spark plugs every 1500 engine hours, when working at rated power [4]. In practice, however, we have the situation when the engine is working at 75-80% of nominal capacity, and under these conditions the spark plugs run out up to 2000 hours. The cost of this part at the moment ranges around $ 150-180 USD. Total per year having 12 spark plugs to replace each time they are replaced every 2000 hours saves $1800-2160.

A similar example can be seen with oil changes for the same engine. The standard oil change interval for a gas engine is available in the Operation and Maintenance Manual. In some applications, the oil drain may need to be reduced. Some factors that can reduce an oil drain are fuel type, fuel contamination, operating conditions and environment. In other applications there could be additional life available in the oil. In both cases, the oil drain can be adjusted through the use of Services oil analysis. In an oil drain optimization program, it is strongly suggested that oil drain extensions be limited to 250 hour intervals. For example, if the standard oil drain is 1000 hours, and the oil appears to have additional life, the first extension should not exceed 1250 hours. The 1250 hour oil drain interval should be evaluated for three service periods, before another extension is considered. One of the basic characteristics of an oil evaluation program is consistent oil sampling and frequent oil sampling. For gas engines, oil samples should be taken every 250 hours. This consistent rate of sampling is especially important if an engine is operating on an inconsistent gas supply. In figure 1 the initial oil change was performed after 1000 service hours. The interval was increased in 250 hour increments. At oil change number 8, the oil had reached the condemning limit after 1750 service hours. Therefore, the interval was reduced to 1500 service hours. The results of the oil analysis were acceptable when the oil was used for 1500 service hours [6].

Given the variability of operating conditions for this type of engine, the term **adaptive maintenance intervals** are proposed. Adaptivity proper consists in the fact that optimal service intervals can be adjusted on the basis of real engine operating conditions. Monitoring of real engine conditions is entrusted to a predictive maintenance system. Such a system can be integrated into the engine control unit, applicable as a separate system with its own sensors, and measuring devices, or as diagnostic equipment that can be used when necessary.

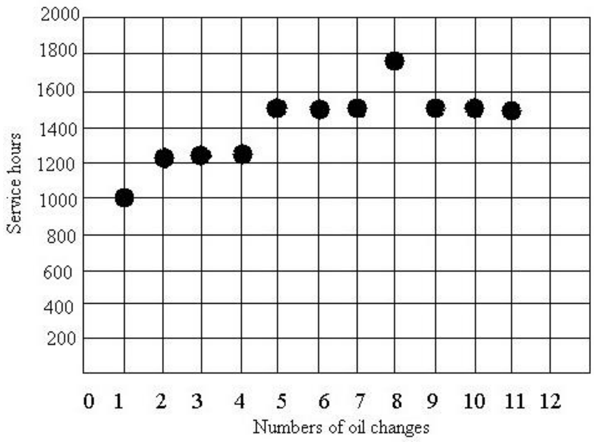

Figure 1. Adjustment of oil change intervals

The prediction system must collect all the information from the engine sensors, monitor its operating modes and give the operating time until an emergency or scheduled shutdown.

The system must collect all possible information on engine parameters from its measuring devices, such as: pressure, temperatures of fluids, exhaust, temperatures at critical points, maximum pressure in the combustion chamber, etc. In addition, there is a need to perform analysis of oil composition, coolant, fuel gas composition, ignition system monitoring.

The main task of the forecasting system is to adapt the service intervals specified by the manufacturer to the engine operating conditions, actually reduce or increase them in order to reduce the cost of emergency situations or prevent long downtime associated with costly repairs.

Conclusion

Fundamentally, a forecasting system would be relevant for large, powerful units involved in a continuous production cycle, the frequent shutdown of which causes great financial losses and destabilizes the production process, entailing failures, long set-up times, and recovery to the normal mode of a particular production process.

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