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Warning System and Automatic Engine Cut off Control Deveplopment for Heavy Machine; A Case Study on KOMATSU PC130F-7

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ABSTRACT

An alert and automatic engine cut-off system is an integrated device to prevent the machine from experiencing sudden damage while operating. This system works using feedback principles controller as one component of the regulatory system that functions to process the feedback signal and the reference input signal or error signal becomes a control signal. The purpose of this study is to design a preventive system as a form of controller development for the heavy machine. As a case study, the system is employed on Komatsu PC130F-7 Excavator for engine cut-off functions if there are errors or abnormal engine oil levels and pressures. Komatsu PC130F-7 Excavator is heavy equipment with the highest population in the area of plantations and industrial plantations, especially in Riau and surrounding areas. The controller created is the development of an existing controller on the Machine by adding the engine cut-off feature if there are abnormal oil levels and pressures, and also as an alternative solution to the current problems, that is for safety and preventing more serious damage to the engine. The oil level sensor will be active if the oil level is below the low on the H-L (high-low) measuring stick, and the oil pressure sensor will read if the oil pressure is below 0.49 kPa (0.5 kg / cm²). This design has two inputs, that is a voltage of ± 15 volts on the path of the engine oil level sensor and oil pressure sensor. This voltage is used as an input that activates the relay work to respond to lower engine speed from 1880 rpm to 950 rpm and continued by the timer work as a time lag regulator to cut off the electricity on the starting engine line so that the engine will automatically stop turning and shut down.

KEY WORDS: *Controller PC130F-7, Oil Level Sensor, Oil Pressure Sensor, Relay Timer*.

1.0 INTRODUCTION

Currently, the mining industry and forestry utilize heavy equipment such as excavators, wheel loaders, dump trucks for production operations (loading, hauling and dumping). The production operation is almost carried out every day without stopping (24 hours). This indicates that the role of heavy equipment is very important for the ongoing operation of a mining and forestry industry in Indonesia. Heavy equipment in the mining and forestry industry has a huge workload and a high level of damage. From these considerations, every mining and forestry industry has specific strategies to reduce the rate of damage that occurs, that is through maintaining each unit of heavy equipment [1].

Figure 1: Hydraulic Excavator PC130F-7, Komatsu

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An early warning indicator system and an automatic engine shutdown system based on the level of lubricants in the engine room can be selected for the purpose of avoiding damage to the machine. Automation design "Engine Cut Off" on the PC130F-7 Excavator is activated when a problem appears due to the abnormal oil levels and pressures which can lead to fatal engine failure. There were 299 problems on PC130F-7 which were recorded for two years (2016-2017) in the data system of PT. United Tractors Pekanbaru Branch. The data shows from the 88 problems that appear on the engine, 44 of them are problems with reduced oil quantity. The highest percentage recorded (30%) goes to problems on the engine, followed by problems in the hydraulic system (22%). The cause is initially small, but when it is not noticed it will be fatal and leads to machine damaged.

The condition of oil levels and pressures that can be directly monitored by heavy equipment operators is apparently not enough as a reminder of the dangers. This is because indeed the effect that occurs is not felt directly. Using a circuit to shut down the engine when there are abnormal levels and oil pressure, it will be very helpful to reduce the risk of further damage. Graph of the damage on PC130F-7 in 2016-2017 Riau Province area can be seen in figure 2 and damages on engine PC130F-7 can be seen figure 3.

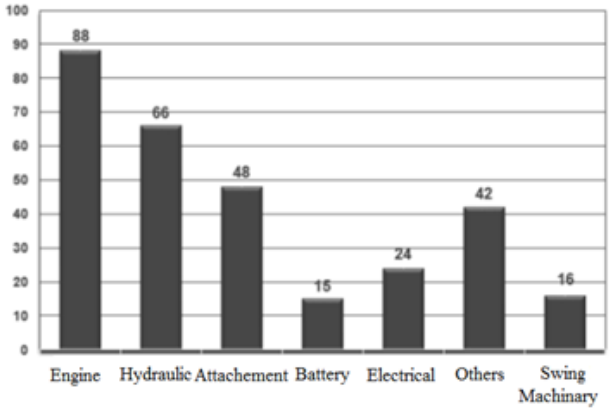

Figure 2: Graph of damage data for PC130F-7 2016-2017.

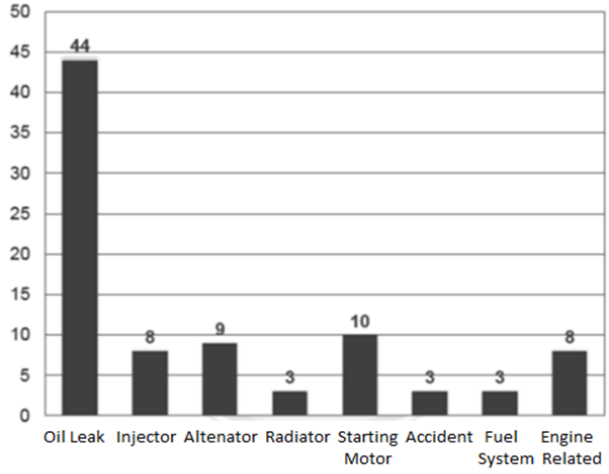

Figure 3: Problem Summary on PC130F-7 engine.

2.0 METHODOLOGY

The steps in designing this device system include: Read the circuit on the main controller of the machine, determine the signal capture point or input in the main circuit, measure the voltage on the sensor path to be taken, arrange the controller circuit, determine component specifications, prepare all tools and materials including components, manufacturing the controllers and testing the controller, for a complete flowchart methodology, can be seen in Figure 4.

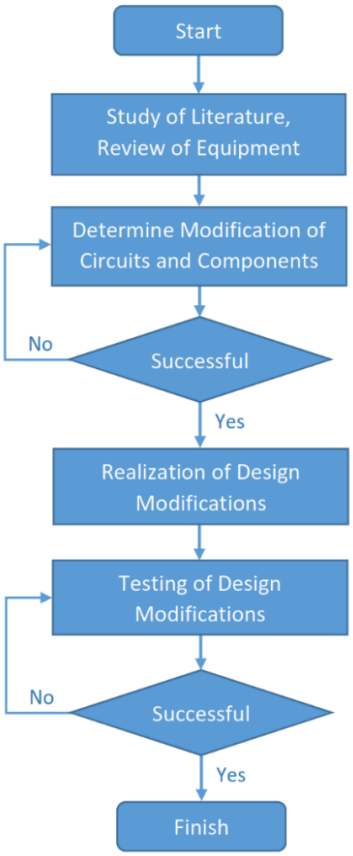

Figure 4: Flowchart Methodology.

3.0 RESULTS AND DISCUSSION

This controller is a simple controller which comes from the development of the unit's default controller to make the engine cut-off automation function based on oil pressure and level. The controller, in this case, is a device that aims to control when there are abnormal engine oil levels and pressures as a form of protection against the engine.

When the oil volume is below the low level, the sensor will read and give a signal to the monitor panel, then the controller gives a command to reduce the rpm and turn off the engine. The oil pressure sensor will also send a signal to the monitor panel so that the indicator light will turn on when the oil pressure is below 49 kPa (0.5 kg / cm²). [3]

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After determining the input and output devices of the controllers on the Komatsu Excavator PC130F-7 for the engine cut-off automation function, then the design results are immediately applied to the PC130F-7 Excavator so that the controller's output can be seen directly. The testing of the controller on the PC130F-7 Komatsu Excavator aims to determine whether the system is designed as expected. This study used an automatic control system. This system is a control system in which the manipulator variables and control variables work system is carried out by automatic control equipment, both in terms of observing data processing inputs and moving output equipment.

1. PC130F-7 Excavator voltage measurement
   In this section, the measured voltage is from the pressure and oil level sensors. The tool used for voltage measurement is avometer. The measurement of voltage on the oil pressure sensor is done when there is an oil pressure abnormality. The result of the measured voltage shows 14.42 volts. The purpose of this initial voltage measurement is for an input to be read by the controller. Meanwhile, the voltage measurement on the oil level sensor done when the oil level abnormalities occur. The result of the voltage shows 15.10 volt.
2. Compilation of Controller Series
   In compiling a development of controller series we refer to the controller set in the unit as a guide for taking the planned input and output. The electric diagram in the development of the PC130F-7 control system is shown in figure 3.

Schematic circuits generated based on input signal capture points in the main series PC130F-7 include:

1) Line engine oil level sensor
2) Line engine oil pressure sensor
3) Line switch (ACC terminal ignition)
4) Alternator path (terminal R)
5) Power supply (battery) line
6) Coolant temperature sensor path

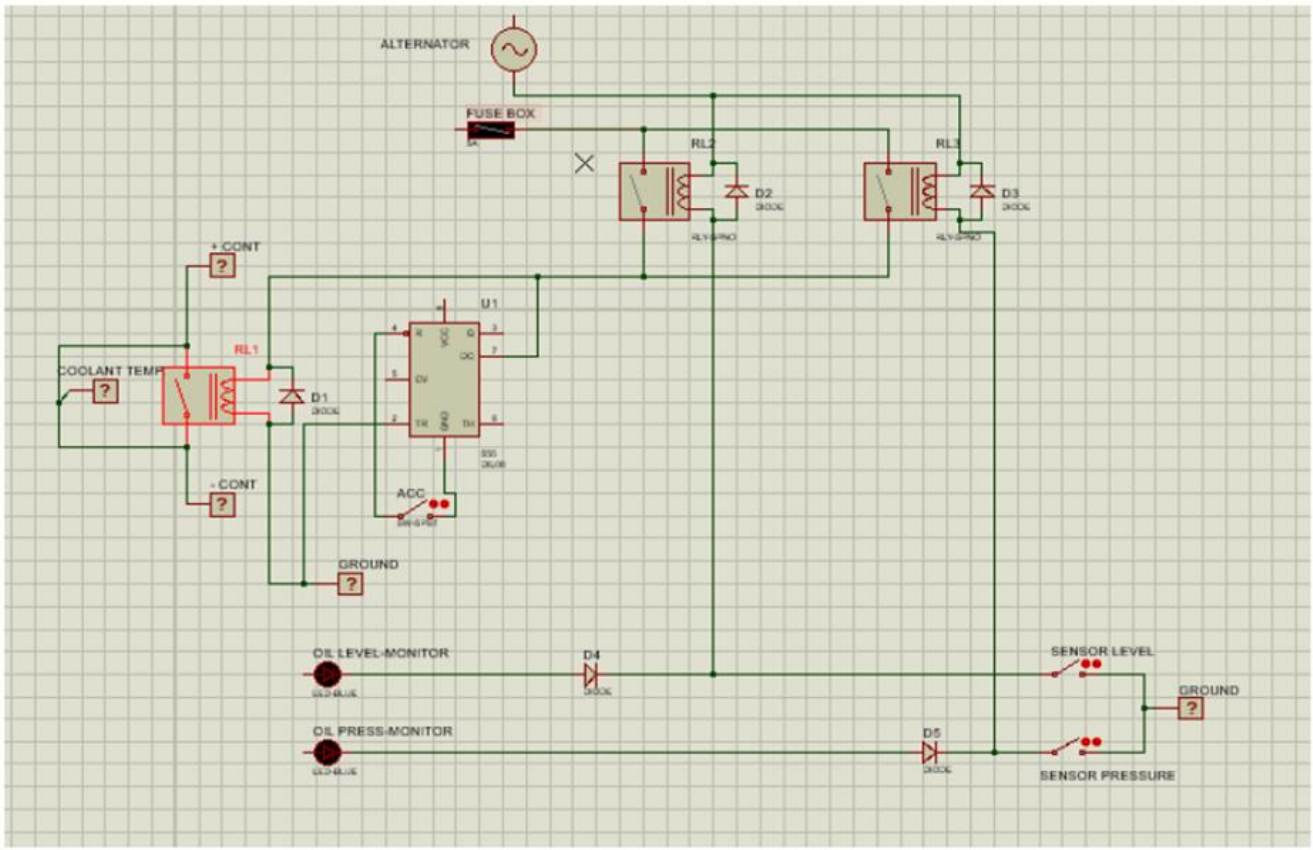

Figure 3: Schematic of Control System Circuitry

In control theory, the controller is designed to monitor the output and compare it with the reference. The difference between the original output and the desired output is called the error signal, which is fed back to the input from the system so that it affects the controller to produce an output that is close to the reference. [4]

In the controller system diagram is shown in figure 4, it can be explained that when the oil level sensor and pressure show abnormalities, it will send a signal in the form of an indicator light that lights up on the monitor panel in the operator's cabin. The signal from the indicator light is taken as input to the controller which then functions to lower the rpm and turn off the engine. This controller consists of a collection of relays and timers equipped with several supporting components such as diodes and fuses that function as safety. [5].

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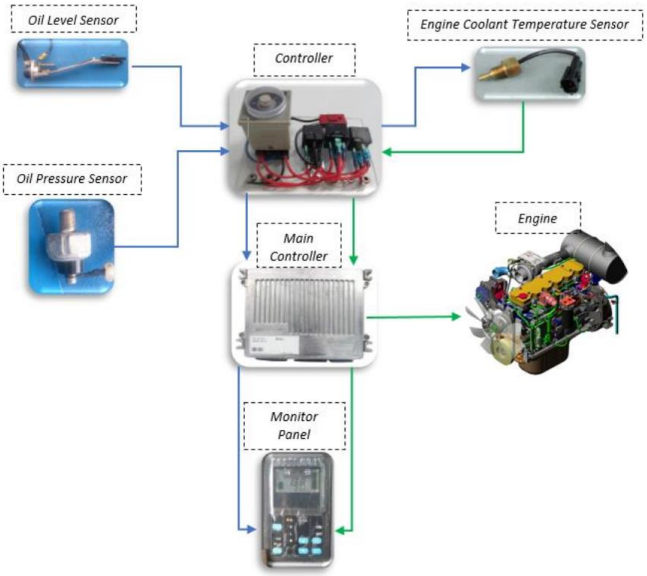

Figure 4: Controller working system diagram

This controller is made for the purpose of protection or safety because the Komatsu SAA4D95LE-3 engine system is not equipped with a system that can protect when there are abnormal oil levels and pressures. As a result, if the oil level is too low and the pressure is not achieved, the occurrence of an error that is not immediately handled can cause the engine to jam and leads to fatal damage. This controller is equipped with a timer as a function to adjust the time lag when an abnormality (error) occurs with the engine shut off. The engine cannot be immediately turned off during high engine speed (1880 rpm), because it can cause damage to the turbocharger which is no longer lubricated by engine oil [6]. Thus, the way to reduce engine speed (rpm) is by manipulating signals from the coolant temperature sensor, because in the sensor coolant system, the coolant in overheating conditions will make the engine speed automatically decrease at idle low conditions (950 rpm).

Thus, the time lag when the timer is working and the engine is at low rotation position automatically the operator cannot continue operating the unit. When the rpm goes down, the existing time lag can be used by the operator to position the unit for further handling of the troubleshooting that occurs. The time lag from the first abnormal occurs until the process of decreasing the rpm and the engine shuts off is 5 minutes. Because the engine time limit in low rpm rotation is only 5 minutes, its function is to wait for the turbocharger rotation to below. More than 5 minutes is not recommended because, at low rpm, the turbocharger does not get enough oil supply as a lubricant since the pressure has dropped. If in low engine rpm the engine turns on too long it can cause the turbocharger to be damaged.

Besides that, in the 5 minutes lag time, it can be used by the operator to position the unit if the operating field is tilted. Figure 5 shows the shape of the controller that has been completed in the coupling process and is ready for testing. The steps for testing are as follows:

Figure 5: The Controller system.

1) Position the controller above a pad, so there is no short circuit.
2) On the ignition key, make sure the monitor is on, then continue the Start Engine and set the monitor on the digital display to show the rpm.
3) Begin to set the FCD (fuel control dial) to the maximum position so that the engine speed is at high position rpm (1880)
4) Testing on the level sensor and the pressure sensor, it tries to connect the cables alternately with the ground (negative) to make sure the relay works respectively. Make observations on the timer, make sure the light on the timer turns yellow as a sign that the input power is connected.
5) Make observations on the monitor panel, when the ground (negative) on the sensor cable line is connected then relay 2 will work waiting for input from the coolant temperature sensor. Observations made on the monitor panel will ensure the line on the temperature indicator lights is working.
6) Approaching the position of the temperature rise indicator lights at the high position we make observations on the engine and on the timer. The moment the coolant seems to overheat, that is the time the engine speed will decrease, and the timer starts working according to the time we set.
7) Observe the indicator light on the timer, when the setting time we set is up, the engine rotation will automatically drop, and the yellow indicator light will disappear and the red indicator light will light up as the response time setting is complete, and the engine speed will stop (shut off).
8) Repeat the steps above with setting the time on a different timer.

4.0 CONCLUSIONS

The conclusion the writer can take from the development of the controller on the Komatsu PC130F-7 Excavator for the engine cut-off function is:

1). Oil level and pressure abnormalities are indicated on the light indicators lights that are lit on the monitor panel. By ensuring oil is below the low level on oil level gauges and oil pressure abnormalities if the pressure is below 49 kPa (05 kg / cm²).
2). The engine cut-off process is to cut off the flow in the engine starting system either in the electrical system or in the fuel supply system, so the engine cannot be started (starting).

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3). The controller circuit using relay components and diodes is used as a protection of the PC130F-7 Excavator engine if there is abnormality in the level and pressure of engine oil by turning off the engine.
4). Controllers equipped with timers set the system safely and securely on the PC130F-7 Excavator engine when there are abnormal oil levels and pressures by adjusting the time lag to reduce engine speed from 1880 rpm to 950 rpm before the cut-off occurs.

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