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Programmable Logic Controller based Monitoring System for Oil Filling of Heavy Vehicle Rear Axle Assembly

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ABSTRACT:

In the chassis assembly shop, there are instances when the rear axle oil was not filled. During the period from January to December, there were ten such instances that were reported. Out of the 10 cases, 6 cases seized after handing over the vehicle to the customer and 4 cases were identified when the vehicles left the assembly process. The reason for the seizing of the trucks was predominantly due to the absence of the oil in the rear axle or in some cases, due to the discrepancy that occurred. This problem can be rectified by introducing the concept of interlocking, wherein the conveyor stops from proceeding to the next stage in case the rear axle oil is not filled. To prevent any further chances of error, a system was suggested where a code is scanned, which gives details of the bill of materials used to assemble the truck. This bill of material includes the axle model number which is cross referenced with a traceability matrix to determine the quantity of oil required and confirming the oil filling process with a sticker.

KEYWORDS:

Programmable Logic Controller; Rear axle; Inspection; Oil filling; Interlocking; Truck; Seizing

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1. Introduction

The two rear wheels are mounted on to the rear axle of an automobile. The axle is not a rotating component but a shaft is a rotating component. Axles are purely designed for static loadings and not dynamic loading (like shafts). In case of a rear wheel drive vehicle, the rear axle also allows the differential casing together with differential in it, to be mounted on it. The two half shafts pass through the rear axle for independent suspension rear wheel drive vehicles. The two ends of the rear axle are fitted into the wheel hubs of the two rear wheels. Axles are the most important part in the chassis of the heavy duty vehicles [1]. The oil which is required for the working of the axle should be monitored properly and should be taken care of. In the absence of the axle oil, the axle seizes.

The main purpose of this paper is that whenever the vehicle is manufactured and sent to the customer, there should be a wholesome contentment. So if at all there appears to be an error the manufacturer should rectify them. The causes of error are schematically shown in Fig. 1. The first objectives of this work is to study the existing process of axle oil filling in the chassis assembly operation so-as to determine the presence of oil in the rear axle for eliminating the defects Parts Per Million (PPM). The second objective of this work is to automate the existing oil filling process to eliminate the redundant errors.

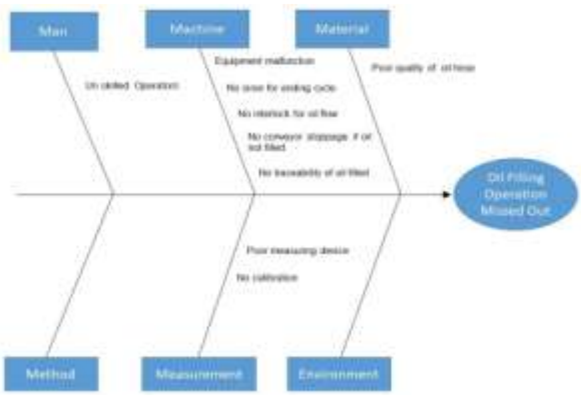

Fig. 1: Causes of error

2. Concept development

Based on the survey of the product catalogues from the instrumentation suppliers across the world for a non-contact type measuring sensor to check and confirm the oil quantity in vehicle, it was conclude that there is no such item(s) was not found on the market to suit the dealer requirement. In the existing machine there is no provision to record the quantity of oil filled for each vehicle. If there were technical feasibility to record the oil quantity in PC, the actual filled quantity of oil in each vehicle, can trigger an alarm in case of discrepancy. But in this case, the comparison starts based on operator selecting the model. If the model is not selected, alarm will not trigger and chances of error may happen. Also, this concept is not cost effective.

To develop concept to compare the oil filled in confirmation with preceding stage. Stage 10 is axle oil filling process. Stage 11 is CAB mounting. It is not possible to pass the chassis without CAB mounting. By utilizing this reference, the oil filling of axle can be confirmed for every vehicle as shown in Fig. 2. So at any point of time before CAB mounting, the oil filling confirmation is required to close the loop, otherwise it will be alarmed automatically. This concept is technically feasible and found to be cost effective [2].

Fig. 2: Architecture of the proposed system

3. Implementation of the proposed system

By studying the existing process as shown in Fig. 3, it is observed that the time required for chassis to pass from stage 10 to 11 is around 6 minutes. This time is between the moment axle oil start push button pressed to cab mounting start push button actuation in continuous conveyor run.

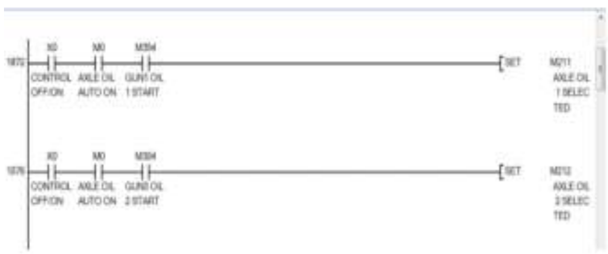

Fig. 3: The existing system for rear axle oil filling

A programmable logic controller (PLC) based monitoring system is established by the following steps:

1. Though conveyor is continuous run mode, chances of getting stopped by pull cord due to various reasons is a mere possibility. So to measure the time between the two stages a special type timer called Retentive Timer used in logic [3].
2. After oil filling of axle starts, the logic will accumulate the time only when conveyor is ON. If it is OFF, the old value is kept retentive in the PLC memory, which starts accumulating from previous value when conveyor is ON.
3. Similarly, in axle oil filling machine an output is generated as a confirmation to indicate oil filled for each vehicle.
4. Logic developed in CAB EMS to generate an output at starting of every auto cycle to indicate that CAB mounting is started.
5. Now with combinational comparison of axle filled confirmation from axle oil filling machine, conveyor ON time of 6 minutes and CAB loaded confirmation from CAB EMS are interlinked together to conclude a logical decision of whether axle oil is filled or not.

3.1. Visual indicators & float switch usage

Previously, there were no visual indicators and Siren at end of the oil filling cycle. These modifications were added onto the system as shown in Fig. 4. A float switch is a device used to detect the level of liquid within a tank. The switch may be used in a pump, an indicator, an alarm, or other devices. The power rating of the float switch is 15Watts. The oil pump has been stopped whenever the oil is empty then alarm triggered to stop the conveyor by logic modification in the PLC ladder diagram by using float switch [4].

Fig. 4: Visual indicators and float switch usage (bottom)

3.2. Interlocking in PLC & axle oil control panel

In the old case, if the oil is not filled in the oil filling stage, the conveyor does not stop. Also, there was no interlock system with the conveyor hence there is no indication in the axle oil control panel. With the new modifications, visual indication provided for the confirmation of axle oil filling process (Relay Q1 and Q2) and completion of CAB loading. In case of missed out condition we can check the oil filling status in control panel (Relay Q4 and Q5).The improvements were seen once the modifications were done and the errors seen to drastically reduce [5].

4. Automation of oil filling checking system

When a customer creates a purchase order, the vehicle manufacturer generates a bill of material for the various parts required for the assembly of the truck. The bill of materials has the vehicle identification number (VIN) number for the chassis and V-Part number of all the other parts required. The VIN and V-Part number are used to identify the chassis and part respectively using a bar-code scanner. A bar-code scanner is composed of three parts: the illuminator, the decoder, and the sensor/convertor. The barcode scanner illuminates the barcode with red light using the illuminator system. The sensor/convertor part of the scanner then detects the reflected light. Once the light is detected, an analogue signal is generated. This signal contains varying voltage based on the intensities of the light reflection. The analogue signal is converted by the sensor into a digital signal. The digital signal is then interpreted by the decoder. The decoder then sends the information to the computer attached to the scanner. Once the assembly process reaches the oil filling stage the worker has to scan the V-Part number using a barcode scanner and the specifications of the rear axle are generated using a traceability matrix programmed into the system. Table 1 gives the traceability matrix which compares the part number to axle model and selects the quantity of oil to be filled and then show it in the PLC panel [6].

Table 1: Traceability matrix

Model	Raspec	Part No.	Axel model	Qty.
2516IL/XL	BA22	FD135800	149.7	18
2516IL/XL twin speed	BA31	FD144900	149.7	18
3518 tractor	BA201/15	FD100500	149.7	18
CT1616 tipper	BA415	V6736272	142	18
4019 tractor	BA204/01	FD104000	160	22.5
CT2516MT	BA211/20	FD138400	MT148 1st axle	19
CT2516MT	BA229/19	FD138500	MT148 2nd axle	14
3116/3118	BA207/3	FD134300	149.7	18
3116/3118 twin speed	BA310/1	FD145000	149.7	18

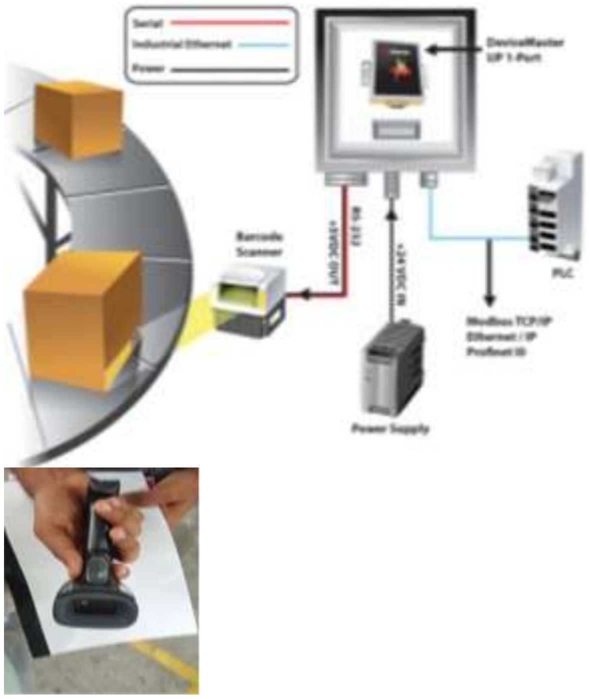

Fig. 6: Interfacing barcode scanner

Barcode scanner is connected to the PLC through serial (RS232, device net, profibus) to transfer the data to the PLC in ASCII format. Incoming ASCII data from an USB device that is mapped to user defined tags or registers in the data table of the PLC. A schematic view and a photograph of the bar code scanner is shown in Fig. 6. The ideal requirement is two tags. One for incoming data and another one for a message counter. For a given logic, the value of the scan is read whenever the message count increments. Then PLC ladder rungs are written to read the bar code data into the PLC memory [7]. Once a bill of materials is formed to assemble a particular model of truck, all these individual components get aggregated to get an A-Part number. When it reaches the oil filling stage the operator has to scan the A-Part number and the proposed monitoring system cross references the given A-Part number to a traceability matrix to find the axle model and the quantity of oil required. Once the value of oil has been identified, the worker has to insert the nozzle into the rear axle and begin the oil filling process. This method can be used to prevent any errors that occur in the oil filling process. Finally, the oil gun is inserted to the rear axle to fill the oil where the quantity of oil filled is found by using an inline flow meter to determine the flow rate of oil from the gun into the rear axle.

6. Conclusions

The implemented PLC based system for checking the status of oil filling for rear axle of heavy vehicle assembly was successful. The main idea was to increase the productivity and reduce the machine down time during missed out oil filling cases. The proposed PLC based automation has helped to prevent the errors caused due to manual labour and improved the efficiency of the oil filling process. This process also prevents seizing of trucks after the assembly process thereby ensuring that there are no cases of oil filling being missed.

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