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Review Study on Failure and Performance Analysis of Fan Motor Adaptor and Stack Silencer for JCB Wheel Loader –A Practical Problem of Industry

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Abstract—*Today's industry demands versatile, efficient and cost effective equipment while at the same time providing more flexibility along with significant savings through increased productivity. Developing an industrial activity gives an exposure to the budding engineers to get familiar with the industrial area, in which they are supposed to work in future. Also the interaction happened during the development of an activity include investigation of available methodologies, finding the drawbacks in the existing system, creation of new innovative ideas, checking the feasibility of ideas, gathering of relevant information, application of theoretical knowledge for designing of system, verification using computer oriented technologies, finally implementation of best solution gives us the opportunities to two major problems one in cooling system and other in the exhaust system of JCB wheel loader. While operating, adaptor of fan motor of JCB wheel loader breaks down at its neck causing leakage of the hydraulic oil in the system and ultimately performance of the cooling system drops down. Also direct shear out of the screws of adaptor is observed. As per the major service concern issue and customer feedback, the generation of crack in the adapter result into the serious problem such as leakage of the hydraulic oil through the adapter which affects the performance of whole cooling system. These problems are selected for study, failure, performance analysis and finding the best solution to improve performance of the wheel loader. Presently this work is allocated as a problem task from JCB India Limited, which is located in Chakan MIDC, Pune. In this paper, Investigations for the problem currently in use was analyzed for various modes of time taken, time laps and then select methodology for the analysis to recover the problem of industry and the future work is the analysis and furthermore the results will be compared with FEA software- ANSYS.*

Keywords: *Industry problem, investigations, adaptor, silencer, analysis, ANSYS software etc.*

1. INTRODUCTION

Hydraulic fan drives have caught on as the most effective way to cool diesel engines. Traditional, belt-driven fans produce air flow that is dependent upon engine speed, not cooling demand. This means belt-driven fans usually deliver too high or too low an air flow, which not only causes wide fluctuations in engine temperature, but wastes power. Unlike traditional systems, hydraulic fan drives operate with variable speed. This means air flow through the radiator can be closely matched to the cooling requirements of the engine. In its simplest form, a hydraulic fan drive consists of a pump, pressure control valve, motor, sensors, and electronic control and, of course, all the hydraulic fan drives also allow mounting the radiator in a location that may be more practical than adjacent to the engine. The cooling system operates hydraulically i.e. fan motor is driven hydraulically. Various connections of the hydraulically driven fan motor as shown in block diagram of hydraulic system of JCB wheel loader. In JCB vehicles hydraulically driven fan motor is used instead of conventional belt driven fan motor. In JCB wheel loader's fan motor, there was a serious problem of breakage of the adaptor of the fan motor , used to connect inlet hydraulic oil hose to the fan motor, at its neck due to insufficient thickness of adaptor neck to bear stresses acting on it

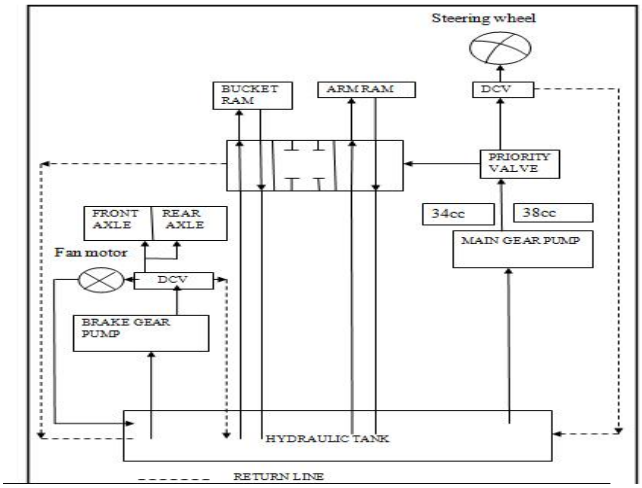

Fig. 1: Block diagram of hydraulic system of JCB wheel loader

The Fan Motor Adaptor Inlet port mounting screw head were also sheared off due to incorrect selection criteria. As per the major service concern issue and customer feedback, the generation of crack in the adaptor result into the serious problem such as leakage of the hydraulic oil through the adaptor which affects the performance of whole cooling system. Because of the above problem, modifications are proposed in the design such as in the adaptor design the few changes such as thickness of flange is increased by 3mm and the internal structure such as chamfer is extended to the flange end and also simple button head screws are changed in to tap screws with increased thickness which is further explained in detail in design modifications. While designing any Off-highway vehicle, it is most important to design it considering operator's safety and comfort. Hence every system of the vehicle must be designed with safety and comfort conditions of the operator. While considering exhaust system, an exhaust pipe must be carefully designed to carry exhaust gases away from the users of the machine. Indoor generators and furnaces can quickly fill an enclosed space with carbon monoxide or other exhaust gases if they are not properly vented to the outdoors. Also, the gases from most types of machine are very hot; the pipe must be heat-resistant, and it must not pass through or near anything that can burn or can be damaged by heat. Also this should meet the regulation norms maintained in each country In India BS-III etc. In JCB wheel loader all the above criteria get fulfilled but ultimately in cost of the operators safety and comfort because the silencer designed was all according to rules and regulations but as the distance between the silencer and drivers cabin was less, heat from exhaust gases in the silencer was passing in the drivers cabin and causing a feeling of uncomforting to him. In order to solve the problem of driver's comfort and safety , the distance between silencer and drivers cabin must increase and there should be such arrangement that driver does not feel discomfort.

2. STUDY- FAILURE ANALYSIS OF FAN MOTOR ADAPTOR IN COOLING SYSTEM OF WHEEL LOADER

2.1 Problem

In JCB vehicles hydraulically driven fan motor is used instead of conventional belt driven fan motor. Hydraulic fan drives have caught on as the most effective way to cool diesel engines. Traditional, belt-driven fans produce air flow that is dependent upon engine speed, not cooling demand. This means belt-driven fans usually deliver too high or too low an air flow, which not only causes wide fluctuations in engine temperature, but wastes power. In its simplest form, a hydraulic fan drive consists of a pump, pressure control valve, motor, sensors, adaptor and electronic control and, of course, all the hydraulic fan drives also allow mounting the radiator in a location that may be more practical than adjacent to the engine. Unlike traditional systems, hydraulic fan drives operate with variable speed. This means air flow through the radiator can be closely matched to the cooling requirements of the engine hence in JCB vehicles hydraulically driven fan motor is used instead of conventional belt driven fan motor.

In fan motor, oil comes from the gear pump through the hoses and supplied to the fan motor by connecting the hose through the adaptor. An **adaptor** is a device that converts attributes of one device or system to those of an otherwise incompatible device or system. But the problem with existing inlet port adaptor is that the adaptor a cracked at neck due to various reasons such as high pressurized oil force creates fluctuations in the hose due to sudden variations in pressure which pulls adaptor downwards. And due to insufficient thickness of adaptor neck to bear stresses acting on the adaptor resulting into crack in adaptor neck area. The Fan Motor Adaptor Inlet port mounting screw head are also sheared off due to wrong selection criteria. The generation of crack in the adaptor gradually increases and result into the serious problem such as leakage of the hydraulic oil through the adaptor which affects the performance of whole cooling system.

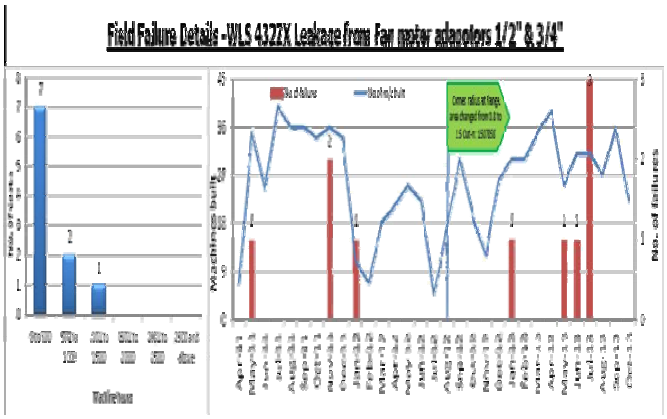

Fig. 2: Field failure details of fan motor adaptor s

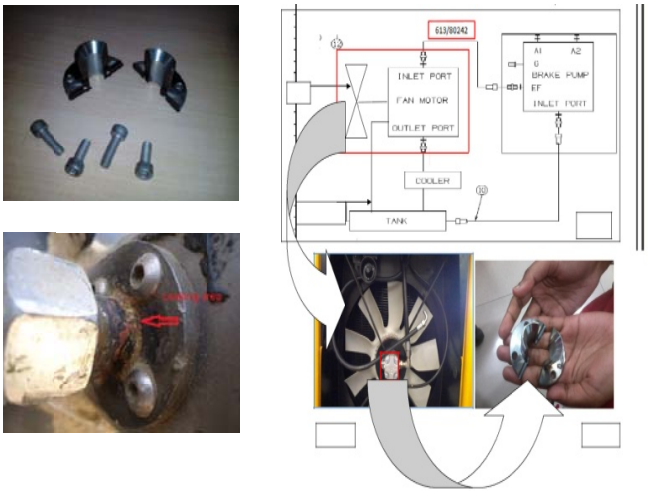

Fig. 3.The hydraulic system and fan motor adaptor failure

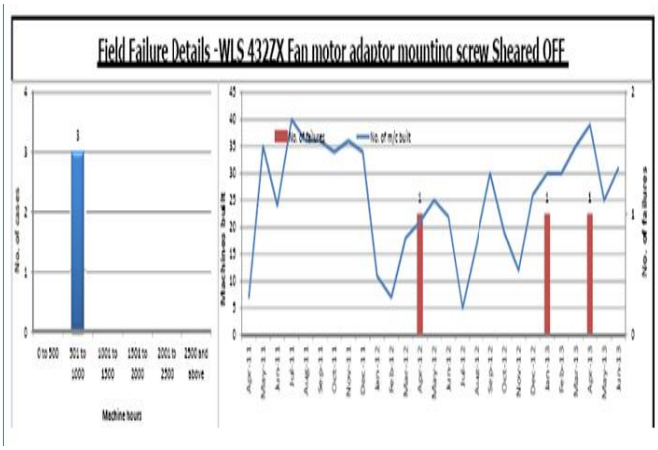

Fig. 4: Field failure details of fan motor adaptor mounting screw shear off

2.2 Suggested solution to avoid the fan motor adaptor failure-

The torque applied should be within limit-The insufficient or excess of the torque applied can also be the reason of the given failure of adaptor hence while solving issue of the failed adaptor , torque application is also an important parameter and must be considered. For better performance of the adaptor without failure and for improving the cooling efficiency the torque applied must be within tolerable limit i.e.50N. It must be within given range of torque suitable for this application.

Flange thickness should be increased-The breaking may cause due to insufficient thickness to withstand the stress generated or force applied. In order to diminish this possibility of breaking due to insufficient thickness flange thickness should be increased.

The direction of flow should be changed- As in case of current model the oil flows through the hose forming U-shape and due to gravity pressure would concentrate at the lowermost point in hose pulling hose and adaptor at its neck and adaptor breaks at its neck hence direction of the hose should be change in order to avoid pressure concentration and ultimately breaking. Hence hose direction is changed i.e. taken from upward direction instead of taking from downward direction as in case of old model.

Simple screws should be replaced by tap screws-As wrong selection of screws shear off the screws from nut. It is very crucial to change the button head screws to cap screws which are suitable for the given application

3. STUDY-PERFORMANCE ANALYSIS OF STACK SILENCER OF WHEEL LOADER

3.1 Problem

The old design shown in the Fig. deals with the problem that the distance of the silencer from the cabin is very less and the exhaust gases heats the cabin. To eliminate this problem the new design shown in the Fig. that shielding is provided to the outer side and the inner diameter of the silencer is reduced and given the curvature to the inner pipe to avoid the sharp edges which can result in the turbulence of the exhaust gases and generation of the noise. The existing silencer has the problem that it has the notch at the inner side of the silencer which is given to avoid the sharp edges so that the exhaust gases were coming back by attacking to that notch. Due to this there are many chances of pollution and it is not permissible according to the regulation norms maintained In India BS-3 etc. also there is appearance of the black smoke which is coming out of the two side grill holes of the wheel loading shovel machine of JCB when observed from backside of the machine when machine is running in the field this was the very prompt issue reported by the operators of the machine in the field. Due to backflow the exhaust gases engine is also heated to great extent and it also causes the carbon formation on the inner side of the top panel assembly components of the wheel loading shovel on which the silencer is fitted. To prevent this backflow of the exhaust gases proposed design is suggested as shown in the Fig. .

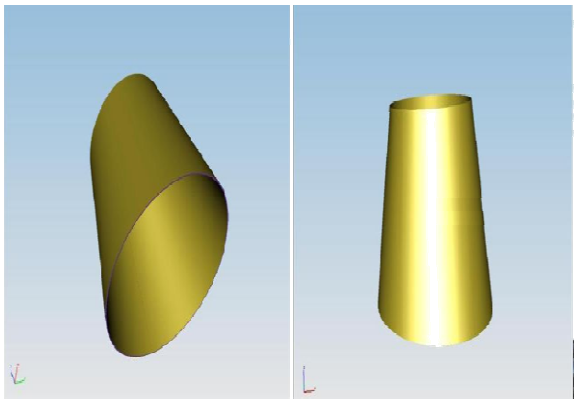

Fig. 5: Design of Stack in CATIA

The proposed design consists of the shielding in case of the current design and the shape as per the old design the new invention in this case is that the part **STACK** provided at the bottom side up to the shielding so that the exhaust gases are directly thrown into the exhaust pipe and exhausted which results in reduction of the backflow of the gases to the engine.

Fig. 6: Showing Silencer WLS with problems failure

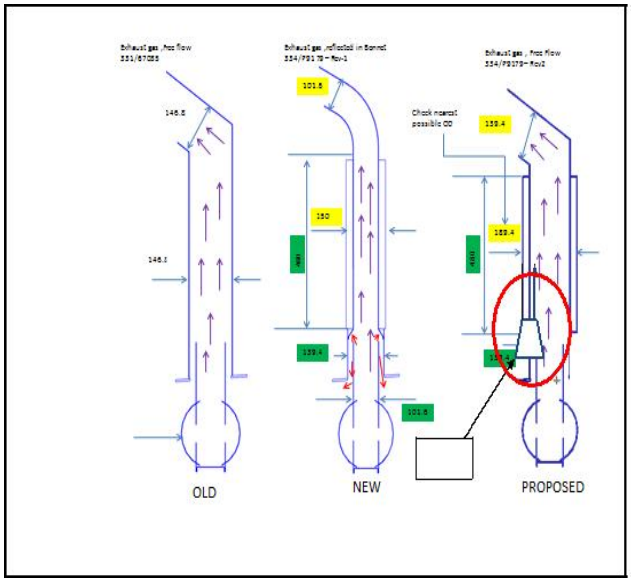

Fig. 7: Problems with Silencer

That is as shown in above Fig. only shields are added to outer side of exhaust pipe to absorb some amount of heat to reduce cabin heating as by minimizing inner diameter of exhaust end pipe the curvature is given at the bottom side to avoid the sharp edges. But by testing a silencer in a field or by testing a exhaust system in a field we have found a new problem with this silencer. In this silencer due to inaccurate design total exhaust gases are thrown on the surface of the cabin and due to heating of outer side of cabin, temperature of internal side of cabin also increases gradually and driver's feels uncomforting in the cabin .To avoid the cabin heating of WLS glass wool shields are added to outer side of the exhaust pipe to absorb the heat but with this solution only cabin heating issue is solved but another new issue is created that backflow of exhaust gases in to bonnet due to striking of the exhaust gases on the curvature given at the bottom side of the exhaust pipe. These gases can be viewed from the backside when the machine is running in the field. By analyzing these faults in the silencer and studying it by approximately we have suggested some changes in design of silencer to avoid the cabin heating issue and backflow of exhaust gases in the bonnet.

In this design of silencer one new part is attached to silencer that is the stack shown in Fig. 7 by red encircled, therefore it is called as stack silencer. As we discussed earlier to avoid the cabin heating problem we have added glass wool shields to the silencer by minimizing the inner diameter of exhaust pipe. But due to this solution new problem to exhaust system of WLS is arise. That is the backflow of exhaust gases in to the bonnet through clearance between the exhaust end pipe and outer pipe of silencer. The exhaust system can become damage due to various problems which can group into three categories rust, vibration and incorrect use. All three categories will eventually generate failure of the exhaust system components by creating backpressure problem. Back pressure is the term used to describe the effort required for exhaust gases to flow through the exhaust system and out to the atmosphere. But with current scenario in WLS type of wheel loader it's not happen properly due to incorrect design of silencer. Therefore we have need to change the design of silencer according problem came in exhaust system of WLS. To avoid backpressure in engine as well as exhaust gases entered in to a bonnet, internal side of bonnet is totally black and due to this maintenance of system as well as engine is challenging task for service engineers. To solve these above two issues in silencer it has to design such kind of silencer that solved simultaneously both issue and efficiency of exhaust system also increases with this solution. In field if exhaust system not perform its operation properly its total effect on product sales in market as exhaust system as well as intake of engine is the main two system of engine. In market, comparison with other companies of off-road vehicles, efficiency of exhaust system surely focused by others.

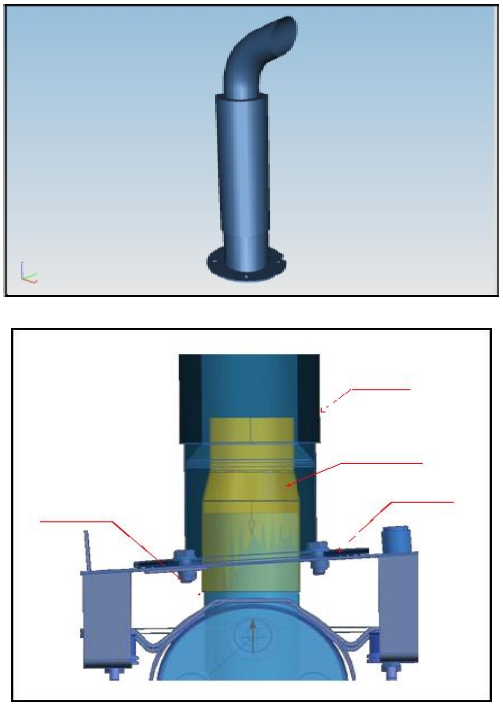

Fig. 8: Proposed Model of Stack Silencer and Silencer in CATIA

3.2 Suggested Modification to avoid the failure of Silencer

To improve the exhaust system of WLS, it is suggested addition of stack -In order to avoid backflow of the gases there should be an arrangement which will gives the proper way to the exhaust gases and prevent them from back flowing into the engine. Hence a new additional part called stack is added to the silencer to serve for the same. Due to specific shape of the stack backflow is avoided and in turn efficiency of the silencer increases. Therefore addition of stack results in improvement of efficiency of the exhaust system.

Shield should be added outer to the exhaust pipe-Because of the small distance between silencer and driver's cabin hot gases from exhaust system were heating the driver's cabin and causing very uncomforting to the driver, As hot gases from exhaust were heating the driver's cabin, shield should be added to avoid this. Shield would act as a insulator preventing large amount of heat passing to the cabin.

Diameter of silencer pipe should be reduced-It is require to add shielding to the silencer in order to prevent heat passing to the driver's cabin but if we will add shielding without reducing the old diameter again the distance between driver's cabin and silencer would reduce. This would not suitable distance according to standards maintained by JCB India Ltd. Hence in order to maintain sufficient distance between driver's cabin and silencer shielding is added with reduction in diameter of the silencer.

4. CONCLUSION

Failure analysis of fan motor adaptor has played very crucial role in the solving the issue of the breaking of fan motor adaptor. Due to failure analysis of fan motor adaptor suitable changes are made in the existing model which would in turn avoid the further breaking of the silencer. By performance analysis of stack silencer and existing silencer of WLS by improving a design of silencer, efficiency of stack silencer increases. By introducing a stack in proposed model of silencer backflow of exhaust gases in to bonnet reduced and increases performance of silencer. Also by adding shields into the silencer cabin heating issue get solved. Ultimately by deigning this new silencer both issue, cabin heating as well as back flow of exhaust gases into bonnet solved. By implementing the various ideas on the JCB wheel loader, the line efficiency and productivity is increased. The major outcomes of the implementation are time saving, Effective space utilization, Quality improvement, Cost saving, Operator fatigue elimination and comfort increases that is ergonomic benefit.

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