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Case Study and Critical analysis to find the FMEA in Hydraulics System

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Abstract: *The Fluid power system is primarily designed to perform work. These systems use pressurized fluids to produce some useful mechanical movements. The major advantage of fluid controlled hydraulic system is multiplication of small forces to achieve greater force. Thus hydraulic powers are used for heavier load application like hydraulic press, Scissor lift, automobiles etc. The hydraulic system also shows several malfunctioning during operation and this will affect the performance of the system. Most of the problems are Pressure Fluctuation, leakage, overheating etc. The main aim of this paper is to find out the root cause of these problem using 5-WHY Analysis and each of the problem are assign based on its Severity, Occurrence, and Detection. An FMEA Evaluation is performed for both global & local problems and Risk priority Number (RPN) for improper functioning in Hydraulic systems is determined and solution is also recommended. Most of the problem like Pressure Fluctuation, leakage, overheating etc. can be reduced by using an Accumulator Unit.*
Keywords -5*-WHY Analysis, Severity, Occurrence, Detection, FMEA, Accumulator.*

I. Introduction

A hydraulic circuit is a group of components such as pumps, actuators, control valves and conductors arranged so that they will perform a useful task. Fluid power is transformed to useful work by the means of hydraulic fluid. The hydraulic fluid act as lubrication for the moving parts absorbs, carry & transfer heat generated within the circuit. Fluid power Technology has advanced considerably since 1926, when the self-contained packaged systems are developed for industrial equipment, including a reservoir pump, controls and actuators. During the past 50 years, fluid power technology rose to an important industry. With the increasing emphasis on automation, quality control, safety and more efficient energy systems, fluid power technology should continue to expand many industrialized nations. The basic principle of fluid power was developed by Pascal. He stated that the pressure generated at one point in a confined liquid acts equally in all directions. Fluid power is used for different applications like Farm equipment, Earth-moving equipment, controllable pitch propellers, hydraulic retractable landing wheels, Missile launching system, navigation controls, hydraulic elevators, Material handling purposes, Automations etc.

The main advantage of hydraulic equipment is accuracy in controlling, multiplication of forces, fluid drives are more compact than mechanical drivers, and constant force is possible. All these operations are performed using hydraulic fluids. There is no universal or ideal hydraulic fluid for all applications. One major reason is the imposing list of fluid characteristics considered important by users, system designers and manufacturers. So selection of a proper fluid for a given application is always very important factor. The hydraulic system also shows several malfunctioning during operation and this will affect the performance of the system. Most of the problems are Pressure Fluctuation, leakage, overheating etc. Almost all major problems are related to hydraulic fluid.

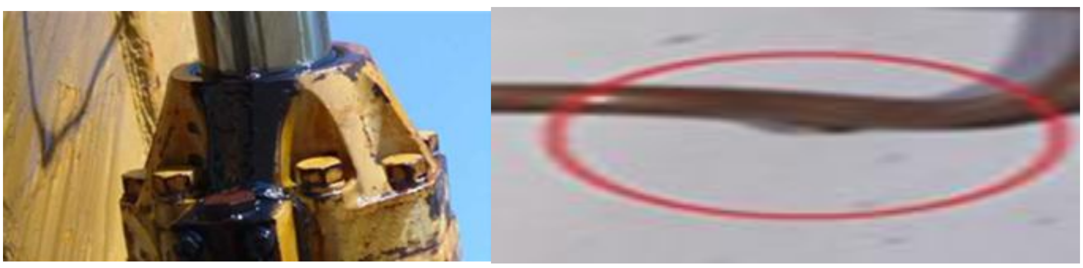

Figure.1.1 Fluid leakage from cylinder & Connectors

This work is done to find out the major problems found in hydraulic systems and there causes, also suggesting the remedial actions. Failure mode effect analysis is performed to determine the RPN values for the problem and suggested the solution for that.

II. Aim and Objective

The main aim of this work is to find out the cause of improper functioning of hydraulic system. The most common problems like overheating, Excessive Noise, Insufficient Power, leakage etc. are analyzed using FMEA and Solutions are recommending to overcoming these problems.

III. Data Collection

Various techniques are used to identify the mode of failure of a part or component. Following are some of the major techniques used, (1) Field inspection, Several hydraulic operated systems are investigated. (2) Online discussion in hydraulic forumsis the major sources for data collection. All data collected are classified as global as well as local problems and documented for performing FMEA analysis.

IV. Fish Born Diagram

Most of the problem associated with a hydraulic system is Excessive noise, Fluid leakage, Insufficient Power, Excessive Temperature which was considered as global Problems. And the cause of theses Global problems are find out using 5-WHY analysis which is known as local problems. Local Problems are selected randomly. These problems are represented in the form of a fish born diagram as shown in Fig.4.1.

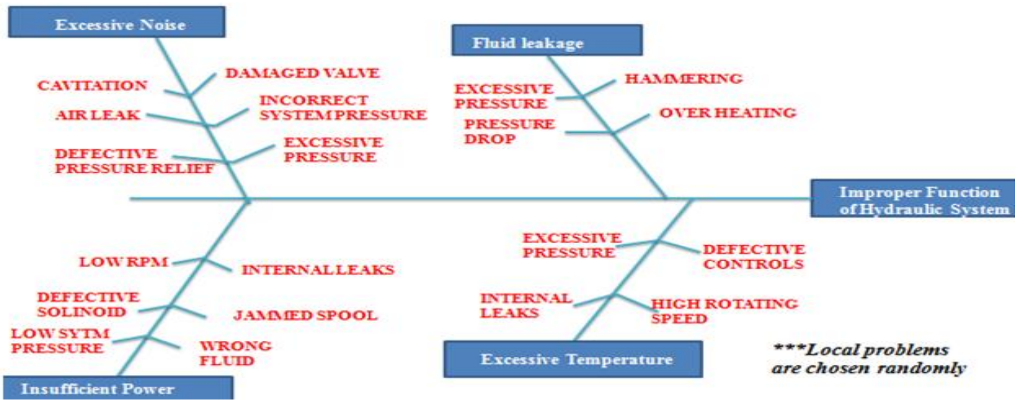

Figure.4.1 Fish Born Diagram

V. Failure Mode Effect Analysis

A failure modes effects analysis (FMEA) is a process used to identify and the evaluate the failure modes for a hydraulic system. This is done by considering the severity and likelihood of the failures. A systematic approach is adopted for FMEA activity to identify potential failure mode, its causes, impact of these potential failures and then prioritizing actions to reduce or eliminate these failures. Failure modes are faults in component, or system, those that affect the proper functioning. Effects analysis refers to studying the consequences of those failures. The underlying principle of FMEA is to resolve potential problems before they occur, enhancing safety, and increasing customer satisfaction. Different types of FMEA analysis is using like DFMEA, PFMEA etc. For this analysis PFMEA analysis is used.

5.1 STEPS OF FMEA

5.1.1 Review the process

The reviewing of the process is to identify all of the components of the system and determine the function or functions of each of those components. Many components have more than one function. In this step the data are collected through field inspection, hydraulic forums and those problems are classified as global as well as local problems.

5.1.2 Brainstorm potential improper functioning modes.

Brainstorming is done in order to identify failure modes for each component/system. Typically there will be several ways in which a component can fail. A potential failure mode represents any manner in which the component or process step could fail to perform its intended function. Brainstorm the potential failure modes for each function for each of the components identified. The 5 WHYS technique is used to get the root cause of a problem. It is based on the premise that it is not enough to just ask why one time. Each global problem is brainstorm by FIVE-whys and the exact root cause is determined.

5.1.2.1 Five whys for Excessive Noise.

Five whys analysis is performed for Excessive noise in order to identify root cause of the problem is shown in Table 5.1.

Table.5.1 5-WHYS for Excessive Noise

PROBLEM	WHY	WHY	WHY	WHY	WHY
EXCESSIVE NOISE	Damaged valve	Sudden pressure variation	hammering	Not absorbing pressure oscillation	Accumulator not used.
	Air leak	Catastrophic pump failure	cavitation	Improper suction	Suction pipe not fully immersed to fluid
	Incorrect System Pressure	Jerk	Excessive Heat Generation	System Pressure Rise Or Lower	Defective Valve
	Defective Solenoid	Sudden Pressure Variation	Hammering	Not Absorbing Pressure Oscillation	Accumulators Are Not Using
	Excessive Pressure	Pressure Drop	Fluid Blockage	Filter Get Blocked	Contamination
	Cavitation	Formation Of Air Bubbles	Vacuum Is Created	Pressure Drop	Sudden Hammering

5.1.2.2 Five whys for insufficient power.

Five whys analysis is performed for Insufficient power in order to identify root cause of the problem is shown in Table.5.2.

Table.5.2 FIVE-Whys for Insufficient Power

PROBLEM	WHY	WHY	WHY	WHY	WHY
INSUFFICIENT POWER	Low Rpm	Pumpis Not Getting Sufficient Power	Motor Is Not At Recommende d Rpm	Motor Are Not Installed Properly	
	Internal Leak	Defective Component	Sudden Pressure Rise	Damping Of Fluid Is Not Done	Accumulators Are Not Used
	Defective Solenoid	Sudden Pressure Variation	Hammering	Not Absorbing Pressure Oscillation	Accumulators Are Not Used
	Low System Pressure	Loss Of Motor Power	Reduction Of Pressure St Hyd.Motor	Frequent Checking Of System Pressure May Not	May Be No Frequent Problem Reported
	Jammed Spool	Valve Partially Shift/Sticky	System Contaminatio n Issue	Filter Get Blocked	Filter Quality Is Not Monitoring
	Internal Wear	Fluid Viscosity Changes	Excessive Heat Generated	Due To Friction	Hyd.Motor Part Contact

5.1.2.3 Five whys for fluid leakage & Excessive Temperature

Five whys analysis is performed for Fluid Leakage & Excessive Temperature in order to identify root cause of the problem is shown in Table.5.3.

Table.5.3 FIVE whys for Fluid Leakage & Excessive Temperature

PROBLEM	WHY	WHY	WHY	WHY	WHY
FLUID LEAKAGE	Hammering	Pressure Rise	System Difficult Withstand The Pressure	Not Absorbing Pressure Oscillation	
	Overheating	Fluid Property Changes	Excessive Temperature	Pressure Drop	Accumulators Are Not Using
	Cavitation	Formation Of Air Bubbles	Vacuum Is Created	Pressure Drop	Sudden Hammering
	Pressure Drop	Hammering	Sudden Pressure Variation In The System	Pressure Oscillation In System Isnotdamping	Accumulators Are Not Using
EXCESSIVE TEMPERTURE	Pressure Drop	Hammering	Sudden Pressure Variation In The System	Pressure Oscillation In System Isnotdamping	Accumulators Are Not Using
	Defective Control	Sudden Pressure Variation	Hammering	Not Absorbing Pressure Variation	Accumulators Are Not Using
	Internal Leak	Defective Component	Sudden Pressure Variation	Damping Of Fluid Is Not Done	Accumulators Are Not Using
	High Speed Rotation	Produce Excessive Heat	Notoperating At Recommended Rpm		

5.1.3 List potential problems effects

Determine the effects (both locally and globally) associated with each failure mode on the system. The effect is related directly to the ability of that specific component to perform its intended function. An effect is the impact a failure could make if it occurred.

5.1.4 Assigning Severity, occurrence, detection.

Likelihood of Occurrence (O): This evaluates how likely a failure mode is to occur, with one being least likely and ten being most likely. Potential Severity (S): This evaluates how severe a failure would be, with one being no effect and ten being great effect of product function. Likelihood of Detection (D): This evaluates how easily a failure can be detected, with one being most detectable and ten being least detectable.

5.1.5 Calculate RPN

The RPN is the Risk Priority Number. The RPN gives us a relative risk ranking. The RPN is calculated by multiplying the three rankings together. Multiply the Severity ranking times the Occurrence ranking times the Detection ranking. For example,

Risk Priority Number (RPN) = (Severity) X (Occurrence) X (Detection).

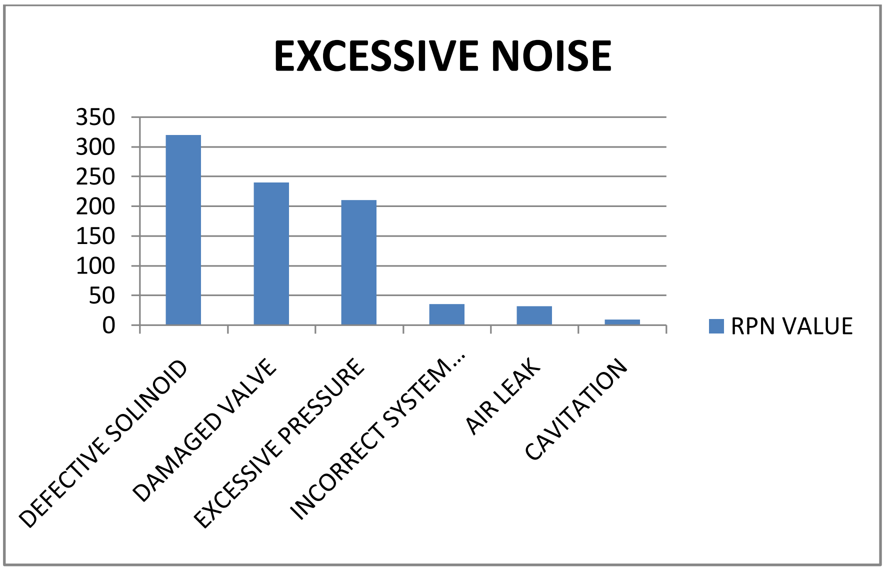

Figure 5.1 Excessive Noise

Excessive noise Shown in Fig.5.1, of a hydraulic system is occur due to defective solenoid, damaged valve and excessive pressure are the main cause and RPN value for those are higher.

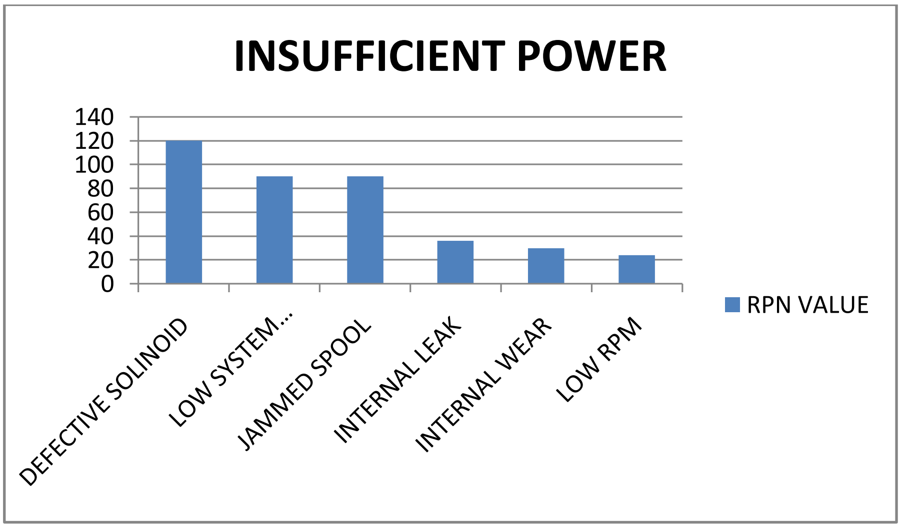

Figure 5.2Insufficient Power

Insufficient Power shown in Fig.5.2, of a hydraulic system is occur due to defective solenoid, low system pressure and jammed spool are the main cause and RPN value for those are higher

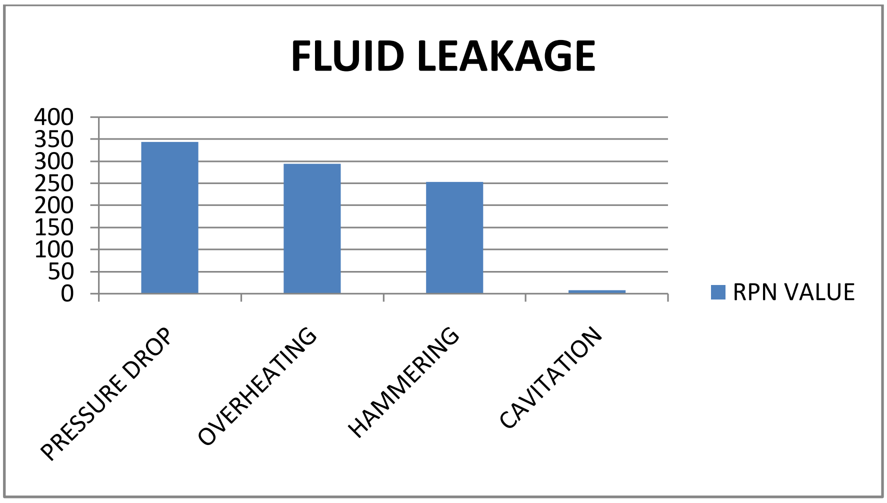

Figure 5.3Fluid Leakage

Fluid leakage shown in Fig 5.3, of the major problem faced by all type of hydraulic equipment and the main causes for those problems are pressure drop, overheating and hammering.

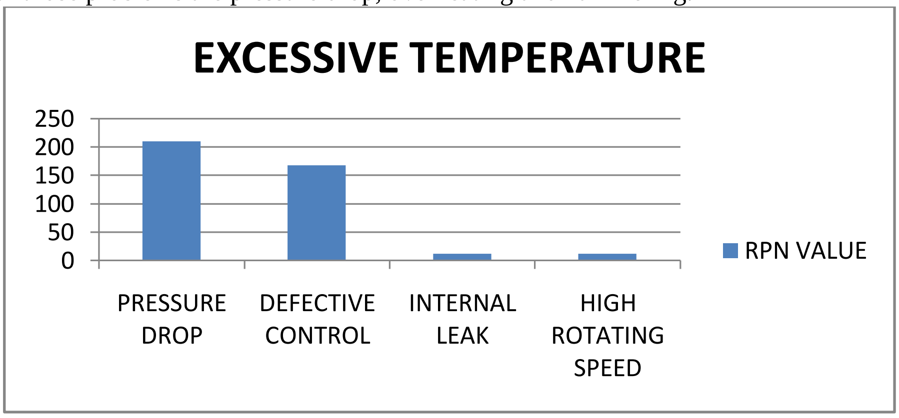

Figure 5.4. Excessive Temperature

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Excessive temperature shown in Fig.5.4 shows the main problem and this is occurring due to pressure drop and defective controls.

From the average calculated data it is come to know that the Risk Priority Number for the fluid leakage is more sever and the recommended action Plan is required.

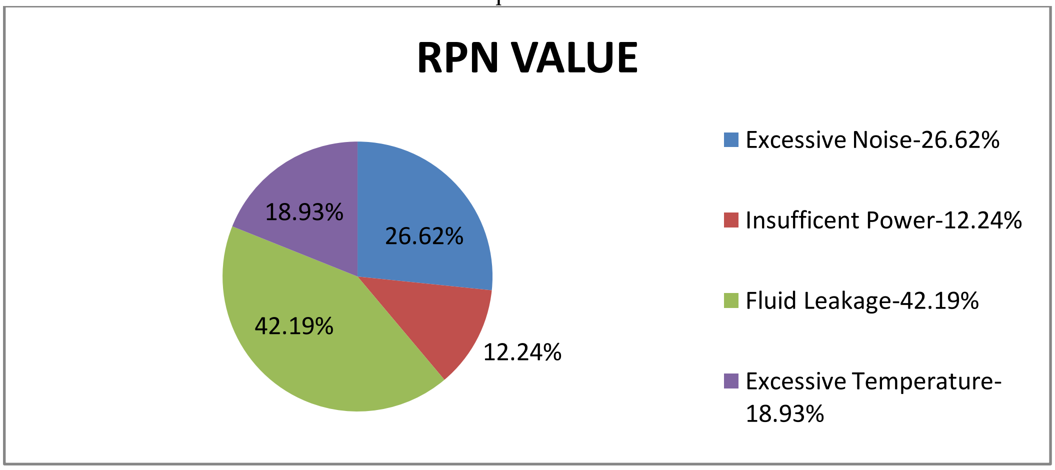

Figure 5.5Global RPN

VI. Recommended Action

Most of the problem can be reduced by placing an Accumulator. Accumulator in a hydraulic system helps to Reserve Energy, Store Fluid, Emergency Operate, Damp Mechanical Shock, Absorb Pressure Oscillations, Compensate Leakage Losses, Stabilize Pressure, Compensate the Effect of pressure Drop.The recommendation for local problems like Excessive Noise- Check the system Relief Valve to ensure that are not defective, Correct the system is operating at Recommended Pressure Setting, Piping of the Hydraulic system should be done carefully in order to avoid Air Leak thus to avoid Cavitation, Provide Accumulators thus it will Reduce the Effect of Hammering and dampening in the Hydraulic Circuit during Operation, Accumulators will Act as a Surge tank to supply fluid whenever necessary.Insufficient Power- Internal leak due to Overheating and pressure drop can be reduced by Placing Accumulator Unit, Correct the Relief Valve Pressure Setting.Excessive Temperature- Reduce the pressure Variation due to Hammering Can Be reduced by Installing the Accumulator, Overheating can be controlled by Reducing the Pressure Variation.Fluid Leakage-Reducing the Causes of Overheating, Reducing the Cause of pressure Variation and these Factors can be controlled by implementing the Accumulator Unit.

VII. Conclusion

The Failure Modes Effects Analysis (FMEA) procedure is a tool that has been adapted for identifying the potential causes for improper functioning of hydraulic system. 5 WHYS analysis is carried out to find out the root cause of problem. The major cause of improper function is Excessive Noise, Insufficient Power, Fluid Leakage and Excessive Temperature. About 42.19% of problem arises due to fluid leakages. And these problems can be reducing by implementing a Hydraulic accumulator. Accumulator act as Emergency Operate, Damp Mechanical shock, absorb pressure oscillation, compensate leakage losses, stabilize pressure and compensate the effect of pressure drop. The use of Accumulator will also reduce the RPN number and it is clear from the FIVE why analysis the root cause. And remedial actions also suggested in order to improving the performance of hydraulic systems while operating.

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