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CENTRIFUGAL PUMP- FAILURE MODE EFFECTIVE ANALYSIS

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Abstract: Today the technological growth is un imaginable. Quality is an essential factor to be considered in every product or service. For the survival of any industry, quality is an essential requirement. Without adequate quality, it is not possible by any industry to compete in the present day market. Centrifugal pumps find a wide application, because of their capabilities to adapt to variable operating conditions, and their ability to discharge different kinds of fluids. Due to these reasons, it is vital to assure quality in the development of centrifugal pumps. One of the important areas of quality assurance is the, "assurance for failure free service". Failure mode and effects analysis (FMEA) is a very powerful and effective methodology for listing all the possible contributing factors of a quality problem. It is a method available for evolving good designs and processes taking inputs from various functions like design, assembly, services etc., It is an essential ingredient of Reliability Engineering. Also it is a mandatory requirement when the companies go for QS 9000. In this project is made to use FMEA for a centrifugal pump. In this investigation, failures in the centrifugal pump components are accounted, i.e., casing, shaft, impeller, bearing and stuffing box. The failure mode,causes, effects and current controls are studied by taking inputs from various pump-manufacturing industries, historical data's, customers and experts in this field. The rankings, occurrence, severity and detection are calculated to know the risk priority number of the failure mode. For each failure mode, the recommended action is given to reduce the effect of failure.

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INTRODUCTION

The concern for reliability and quality assurance is of increasing in mechanical industries in recent years. Product development teams need to build-in reliability at the early stages of design. Design engineers are under increasing pressure to produce correct, safe designs in shorter time frames. As complexity of mechanical systems has increased, it has become more difficult for designers to comprehend all the possible implications of component failures on a design.

Concurrent Engineering is a Management and Engineering philosophy for improving quality. This approach utilizes Failure mode and effects analysis to act as a Failure Consultant during the product design activities. FMEA is an Engineering technique used to define, identify and eliminate known and potential failures, problems and errors from the system design, or process before they reach the customer. In this project, an attempt is made to analyze the failures in Centrifugal Pump using Failure mode and effects analysis. This chapter presents the basics of FMEA and Centrifugal pump.

NEED FOR FMEA IN CENTRIFUGAL PUMP

There is other many conditions in which a pump, despite suffering no loss in flow or head, is considered to have failed and has to be pulled out of service as soon as possible. These include seal related problems (leakage's, loss of flushing, cooling, quenching systems, etc.), pump and motor bearings related problems, leakage's from pump casing, very high noise and vibration levels, or driver (motor or turbine) related problems.

The list of pump failure conditions mentioned above is neither exhaustive nor are the conditions mutually exclusive. Often the root causes of failure are the same but the symptoms are different. A little care while designing a pump can save the pumps from permanent failures. Thus the most important task in such situations is to find out whether the pump has failed mechanically or if there is some design deficiency, or both.

Thus the decision to pull a pump out of service for maintenance/repair should be made after a detailed analysis of the symptoms and root causes of the pump failure. Also, in case of any mechanical failure or physical damage of pump internals, the operating engineer should be able to relate the failure to the process unit’s operating problems. Effective troubleshooting requires an ability to observe changes in performance over time, and in the event of a failure, the capacity to thoroughly investigate the cause of the failure and take measures to prevent the

problem from reoccurring. The fact of the matter is that there are three types of problems mostly encountered with centrifugal pumps,

• Design errors

• Poor operation

• Poor maintenance practices

Hence it is important, the designers to know the different failure modes of the components, which are occurring most frequently and which will affect the system performance. The FMEA is an effective tool for this purpose.

Working Mechanism of a Centrifugal Pump

Fluid enters the impeller axially near the shaft and has energy, both kinetic and potential, imparted to it by the vanes. Whirling motion is imparted to the fluid by means of blades mounted on the disc known as impeller. Its purpose is to convert energy of a prime mover (a electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. The energy changes occur by virtue of two main parts of the pump, the impeller and the volute or diffuser. The impeller is the rotating part that converts driver energy into the kinetic energy. The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy. This is, of course, accompanied by a decrease in the velocity. After the conversion is accomplished, the fluid is discharged from the machine.

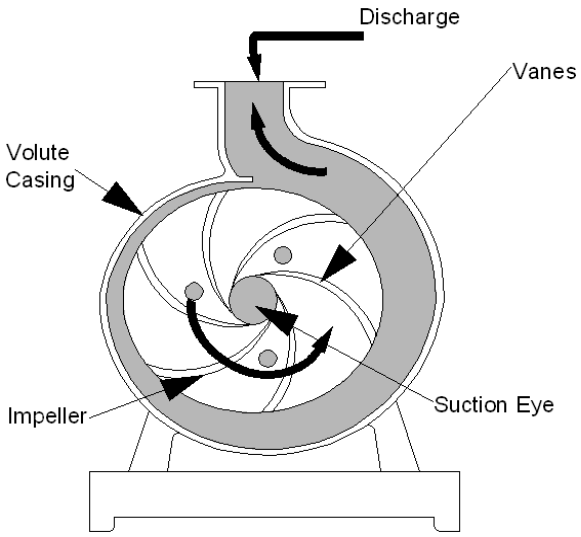

Fig Liquid flow path inside a centrifugal pump

IDENTIFICATION OF PARTS AND FAILURE AREAS

From the literature survey and customer survey, it is clear that, in centrifugal pumps the following parts are frequently failed,

(i) Impeller

(ii) Shaft

(iii) Bearing

(iv) Stuffing Box

(v) Wearing ring

Potential Effects of Failure

A potential effect of the failure is the consequence of its failure on the next higher design, system, and product. The consequences may be to the design itself, the product and the customer. Often, the failure effect is evaluated from a customer's perspective or experiences.

The customer may be an internal customer as well as the ultimate end user. The effects should be in terms of the specific system, subsystem or component being analyzed.

The following are, reviewed to identify the potential effects.

- Customer complaints
- Field service data
- Warranty documents
- Similar current or past FMEA

Some of the potential effects of failures are given below for centrifugal pump,

- Heat generated
- Fluid Leakage
- Noise and Vibration
- Not enough water flow
- Pump will not start

Potential Causes for Failure

The cause of a design failure mode is the design deficiency that results in the failure mode. Most probable causes associated with potential failure modes. For each failure mode, the possible mechanisms and causes of failures are listed on the table. This is an important element of the FMEA since it points the way toward preventive/corrective action.

For example, the cause for the failure mode " unspecified surface finish" could be "improper surface finish" and for the failure mode " fluid leakage" of a pump might be "corrosion resulting in body structure". Other design causes are,

- Improper choice of materials
- Improper tolerance
- Improper stress calculations
- Improper use of processes

Occurrence

Occurrence (frequency) is the rating value corresponding to the estimated number of frequencies and/or cumulative number of failures that could occur for a given cause over the life of the design. To identify the frequency for each of the causes cumulative number of component failures (CNF) per 100 components is used over the design life of the component under study.

If expected frequencies and/or cumulative number of failures cannot be estimated, it is acceptable for design FMEA to examine similar and/or components for similar information.

For calculating the occurrence value of the component failures of centrifugal pump, the failure data for each mode of failure is collected from the service section of a leading pump manufacturing company. From collected data, the occurrence value of each failure mode of centrifugal pump component failure is calculated

The occurrence ranking calculations are based on the standard guidelines given for design FMEA (US MIL-STD -1629-A).

Detection

Detection is rating corresponding to the likelihood that the proposed design controls will detect a specific root cause of a failure mode before the part is released for production. To identify a detection rating, the ability for each of the controls identified needs to be estimated, to detect

the failure before it reaches the customer. If the ability of the controls to detect the failure is unknown, of the detection cannot be estimated, then the detection rating should be 10. Detection rankings are calculated for each failure mode of pump component failure based on the standard guidelines for design FMEA (US MIL-STD-1629-A).

Severity

The severity always applies to the effect of a failure mode. In fact, there is a direct correlation between effect and severity. For example, if the effect is critical, the severity is high. Conversely, if the effect is nuisance, the severity is very low. Severity is reviewed from the perspective of the system, design itself, other systems, the product and the customer.

The severity ranking for each failure mode is calculated based on the guidelines. A typical design guideline for design FMEA is shown in Table.4.3. In the design FMEA the severity rating should be based on the worst effect of the failure mode. For the pump failures, the severity rankings are calculated for each and every component failure mode.

Risk Priority Number (RPN)

This number is the product of severity, occurrence, and detection. The RPN defines the priority of the failure. By themselves the RPN's have no value or meaning. They are used only to rank (define) the potential design deficiencies.

In the design FMEA one must always remember that the goal is to reduce the RPN, but in a specific way. The specific way is through a reduction in severity, occurrence, and detection. The severity can be reduced only through a change in design. If that is attainable, then the failure is eliminated.

Improving engineering specifications and/or requirements with the intent of preventing causes or reducing their frequency can reduce the occurrence.

In the case of centrifugal pump, the risk priority number for each failure mode of pump component failure is calculated.

Recommended Action

No FMEA should be done without a recommended action. The recommended action may be specific action(s) or it may be further studying. The idea of the recommended action in the design FMEA is to reduce the severity, occurrence, detection, or all of these elements. In

essence, the design FMEA is done to eliminate design deficiencies and therefore eliminate failures.

To facilitate this, the failure modes are prioritized with the highest RPN, the highest severity, and the highest occurrence. Typical recommendations may be

- No action at this time
- Add build-in detection devices
- Provide alternatives to the design
- Design experiments
- Reliability Testing
- Finite Element Analysis

Finite element analysis

In, FEM, the computational domain is discretized into elements. The element characteristic equation is developed in the local element coordinate system. The elemental equations are assembled to form the global equations. The sets of algebraic equations are modified to incorporate the boundary conditions. The final set of simultaneous equations is solved for the nodal values, which are the unknowns for which the solution attempted. The modeling of the geometry, discritizing the domain into the elements, element selection and its characteristic, proper specification of the boundary condition, and solver used for the solution of the simultaneous equations determine the correctness and accuracy of the final solution.

CONCLUSION

Failure Mode and Effects Analysis is a specific methodology to evaluate the designs, and to identify failure mode, causes and effects of all failure modes in order to improve the Quality and Reliability of the Centrifugal pumps.

The technique of FMEA has been applied to centrifugal pump for the purpose of improving the quality and reliability of the centrifugal pump. During the process of application of FMEA technique, the following observations are made,

1) Occurrence, Detection, Severity and Risk Priority Number for all failure mode of Centrifugal pump is calculated. It has been found Risk Priority Number for Shaft and Bearings are very high, which is not recommendable and hence design review has been performed.

2) Productivity and Quality of the centrifugal pump is improved.

3) Percentage of rejection during the process is reduced by anticipating the failures, effects and causes during the design stage itself.

4) The possibilities of failure are reduced at the manufacturing stage as well as at the customer end.

REFERENCE

1. Nwaoha Chikzie “Centrifugal Pumps: preventing cavitation problems”

2. Anikori Furukawa And Hisada Takahara “ Pressure flyctuation in a vanned diffuser downstream from a centrifugal pump impeller”

3. Akharas, M.Elhajem “The Internal of centrifugal pump”

4. Ranier nordman, Martinaeins “Fault diagnosis in centrifugal pump using active magnetic bearings”

5. R.Franz, A. J. Acosta “The Roto-Dynamic Forces on a centrifugal pump impelles in the presence of Cavitation”