Belt Conveyor Pulley Failure and Maintenance at Pilbara Iron

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Abstract

The aim of this thesis is to examine the maintenance and reliability of Pilbara Iron's Conveyor Belt Pulleys at Mount Tom Price in order to assess the current maintenance strategy and suggest changes for improvement. Failure mode and effect analysis and risk assessment will be used to identify the critical sources of failure. From this recommendations will be made to improve maintenance and reliability.

1.0 Introduction

Each year, well over 40 million tonnes of material is excavated and sorted resulting in the production of approximately 20 million tonnes of iron ore from the Mount Tom Price mine site. The task of transporting this amount of material around the mine site is done by a network of 63 conveyor belts.

The operation involves mining, crushing and dry processing of high grade iron ore as well as wet processing of low grade ore to produce lump and fines ore with conveyors between each section. Due to the nature of plant and its design, most of the conveyors are in series, and if one fails, then a whole section has to be shut down. Any failure in either the High-grade flow or the Low-grade Flow could shut down the entire flow as there is limited buffer capacity between the main stockpiles and the train loading piles.

The thesis examines the maintenance and reliability of conveyor pulleys at the Mount Tom Price mine site. The approach involves both qualitative and quantitative analysis of the available data. Quantitative analysis uses the statistical information from the historical records, analysing it in terms of availability, Mean Time To Failure (MTTR), Mean Time Between Repair (MTBR), and Mean Time To Repair (MTTR). Qualitative analysis is based on a process called Failure Modes and Effects Anaysis (FMEA).

2.0 literature review

There already has been extensive research work done on the individual compents of belt conveyor pulleys. For instance Jones (1995) undertook an extensive study into the fatigue failures that can occur in the pulley drum. Schmidgall (2004) examines the issues and failures relating to the pulley lagging. The issue of lagging and specifically ceramic lagging to reduce wear is covered in an article in Power Engineering Anon. (1996). Shaft design and failure was looked at by Laughlin (2004). There is a large amount of material on general bearing failure and tribology. Despite the literature on failure of the individual components, I was not able to find in the literature a study on conveyor belt pulley reliability as a whole.

3.0 Method

The boundaries of the system to be analysed will be conveyor pulleys and associated equipment. Data sources include historical data from the plant such as maintenance work orders, discussions with operators, engineers and maintainers and records from the pulley-refurbishment contractor (RCR Tomlinson).. A project database integrate these data sources to allow a selection of a subset of data for detailed analysis. This will encompass both quantitative and qualitative aspects.

3.1 System Boundary

In the Rio Tinto SAP system, each conveyor has its own functional location, the pulley code '.PU', and a two digit pulley number, for example: '2C .PU .01' (Pulley 1 on Conveyor 2C). This functional location includes the physical pulley (pulley drum, shaft, lagging) as well as the bearings and the grease lines. For the purposes of this project the system boundaries will be based on the SAP functional location classification. The system will include: the bearings, the shaft, the drum and the lagging, and lubrication as shown below in Figure 1.

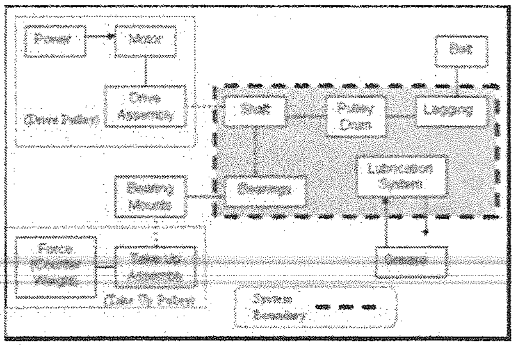

Figure 1. Definition of Boundary for Pulley

3.2 Data Sources

The data sources include the historical records for the plant found in SAP (SAP is Pilbara Irons Enterprise Resource Planning(ERP) software system which integrates all their core business processes and stores maintenance work order and cost data). It will also include the informationn from site maintenance planners and personnel, and information from Rio Tinto Mine Operations & Mine Maintenace in Perth, as well as RCR Tomlinson, who supply and repair all Pilbara Iron's pulleys.

3.3 Integrated Project Database

The data sources are combined into a project database as illustrated below in Figure 2. This will facilitates the initial analysis and selection of a subset of data for detailed analysis.

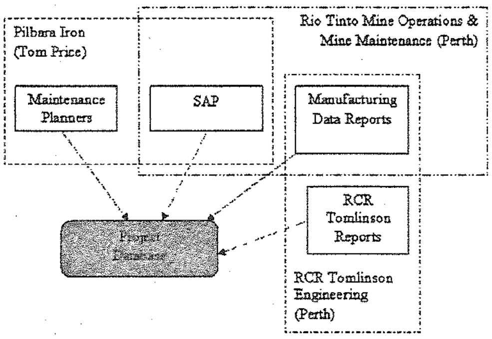

Figure 2. Project Database Data Sources

3.4 Selection of Data Subset for detailed Analysis

The selection of the data sub-set is influenced by a recent criticality review by Pilbara Iron undertaken at Mount Tom Price. In this review each piece equipment was given a numerical criticality rating and a criticality category, with 25 the highest rating, and high the most severe category. This review broke down the system to the level of individual pulleys and separate idler sets with reference to conveyor belts and from this, conveyors 48AC, 69C and 11M were all rated as high criticality.

3.5 Quantitative & Qualitative Analysis

3.5.1 Quantitative Analysis

The quantitative analysis will be statisitically based reliability engineering analysis using the historical failure records to caclulate MTTF, MTTR, MTBF. MTTF is determined from Weibull plots using the formula shown in Equation 1. Where F(t) is the probability density function, beta(β) is the shape parameter, and eta (η) the characterstic life.

$$\ln \ln \{1/[1-F(t)]\} = \beta \ln (t) - \beta \ln(\eta) \quad .....(1)$$

3.5.2 Qualitative Analysis

The qualitative component of the analysis includes a FMEA study, of the components within the system boundary as shown in Figure 1. The level of analysis detail and depth of analysis for the FMEA study will not be exhaustive and the main aim will be focus on dominant failure modes which have the greatest impact. Each of these failure modes can have follow on effects within the defined system, and to the greater conveyor belt system and the mine operation. For each significant failure mode means of preventing, means of detecting and the means of limiting the impact of the failure mode will be determined.

4.0 Results

4.1 Quantitative Analysis

Figure 3 shows the historical conveyor pulley and pulley bearing change outs for the Mount Tom Price mine site. For the purposes of Figure 3, a pulley change out includes replacement of the bearings (it is operational procedure due to relative costs, and time efficiency to replace bearings whenever a pulley gets replaced), while a bearing change out refers to an instance when only the bearing was changed.

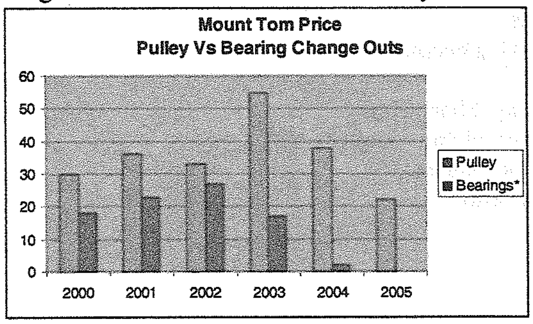

Figure 3 Pulley Vs Bearing Replacements

4.2 Reliability Engineering

The reliability analysis results will be reported in the main thesis.

4.3 Qualitative Analysis

Conveyor 11M was selected for analysis in this project due to the high incidence of pulley and bearing failure. Conveyors 48AC and 69C were selected due to failure records, and because the two conveyors have very similar design and layout which will be useful for comparative purposes.

The Conveyors 11M, 48AC and 69C will be analysed in more detail using Failure Modes Effects Analysis (FMEA) and Failure Mode Effects & Criticality Analysis (FMECA). The FMEA scope will be limited to the defined system boundary and categorised into the systems maintainable sub-units as defined below in the Figure 4.

The design and operational parameters of these conveyors will also be analysed to determine possible causes of failure. The analysis will be assisted by the pulley inspection data available from RCR Tomlinson

Combining this qualitative with the quantitative data and follow on effects will allow for the additional criticality aspect found in FMECA to form a risk matrix.

Equipment Unit	Belt Conveyor Pulley System			
Subunit	Bearings	Shaft	Drum	Lagging
Maintainable Items	Housing Seals Bearing Lubricant	Shaft Locking element(s)	Disc(s) Shell Center plate(s) Locking element	Method of attachment Grooving/Tread

Fig 4. Belt Conveyor System Sub-Units

5.0 Conclusion

Due to delays in obtaining data, at the time of writing this paper, much of the analysis for the thesis is still to be completed. While the analysis is not complete, there have been some findings. It is apparent that the SAP system has more potential which is not being fully utilized. There is also more scope for utilization of valuable vendor knowledge, working with RCR Tomlinson, and this has already been recognised by Mine Operations & Mine Maintenance. Some of the conclusions from the reliability analysis may just confirm what is already suspected.This work will lead to recommendations for maintenance strategies and practices.

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