CASE STUDY OF DAMAGE ANALYSIS OF HT BEND PULLEY ON OLC4A COAL CONVEYOR PT BUKIT ASAM TBK

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ABSTRACT

HT (High Tension) bend pulley is one of the components in the conveyor system which functions to redirect the conveyor belt and provide tension on the conveyor belt when there is a bend in a conveyor belt system. The HT bend pulley on the OLC4A conveyor line at PT Bukit Asam Tbk (PTBA) has been damaged and after an investigation into the damage, it is known that on the right side of the HT bend pulley there is a broken shaft. This damage also has an impact on damage to other machine component components that are around the HT bend pulley such as bearings, surrounding construction. Visual inspection is carried out by taking pictures of damaged shaft parts and analyzing the shape of the shaft fracture. Material identification is used to determine the strength of the material, namely the strength to withstand the tension that occurs on the shaft. The inspection results show that there is crack initiation. This failure mode assumes that the shaft is subjected to rotational loads which causes the tensile stress to exceed its ultimate strength and on the surface of the shaft there are also traces of rewelding which may be aimed at the hard-facing process on the surface of the shaft. The hard-facing welding process will affect changes in the microstructure and the hardness value of the pulley shaft. Judging from the shape of the shaft fracture, brittle fracture occurred on the left side and ductile fracture on the right side of the shaft. It is possible that a crack had occurred at that point before the shaft fracture occurred, and the condition of the broken shaft pulley has been hard faced (repaired). The C45 Steel shaft material can be equivalent to P265GH although the P265GH material tends to have lower specifications than C45 Steel. For certain operating conditions it is better to stick to the original material, namely C45 Steel.

Keywords: *pulley shaft*, *tensile stress*, *ultimate strength*, *material identification*.

1 INTRODUCTION

In the conveyor belt system, the HT (High Tension) bend pulley is one of the main components that play a role in running the system. HT bend pulley serves to redirect the conveyor belt and provide tension on the conveyor belt when there is a bend in a conveyor belt system. [1]

The components of the machine elements on the HT bend pulley used in conveyor systems are generally the same as other types of pulleys such as the drive pulley, tail pulley, take-up pulley and snub pulley which generally consist of drums, bearings, shafts, lagging and locking element as can be seen in figure 1.

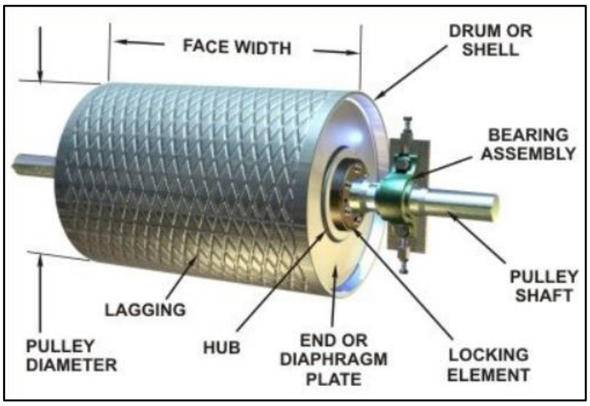

Figure 1 Anatomi of pulley conveyor

In February 2023 there was damage to the HT bend pulley of the OLC4A conveyor line at PT Bukit Asam Tbk (PTBA) which resulted in a cessation of coal shipments on that line for quite a long time. This, of course, from the company's

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point of view, has a significant impact on losses both in terms of costs, time, material aspects and other resources. After carrying out an investigation of the damage, it was found that on the right side of the HT bend pulley there was damage to a broken shaft. This damage also has an impact on damage to other machine component components that are around the HT bend pulley such as bearings, surrounding construction and also the belt as can be seen in Figure 2..

Figure 2 The condition of the HT bend pulley falls over the take-up pulley and counterweight

2 METHODOLOGY

The methodology for investigating the fracture of the HT bend pulley shaft is carried out with the steps below, namely:

1. Visual inspection and inspection
2. Material identification

Visual inspection is carried out by taking pictures of damaged shaft parts and analyzing the shape of the shaft fracture. Geometry and crack modes were identified and analyzed. In the material identification step, the shaft refers to the HT bend pulley specification document and is supported by testing the chemical composition of the shaft material which is carried out using a portable Spectro Analyzer tool. Material identification is used to determine the strength of the material, namely the strength to withstand the tension that occurs on the shaft.

3 RESULTS AND DISCUSSIONS

3.1 Visual inspection and inspection

A visual inspection is performed to analyze the failure mode.[2] One of the pictures can be seen in Figure 3. The former shaft fracture is in the direction of the shell, the shaft fracture is in an area close to the locking element pulley component and is on the inside of the shell. The shape of the shaft fracture leads to the hypothesis that brittle fracture occurs on the left side of the shaft and ductile fracture on the right side of the shaft.

Figure 3 Shaft fracture condition.

Then seen in Figure 4, that is, on the former shaft fracture in the direction of the bearing, there are traces of rewelding work on the surface of the broken shaft. Visually, the shape of the shaft fracture is seen as brittle fracture on the left side and ductile fracture on the right side of the shaft.

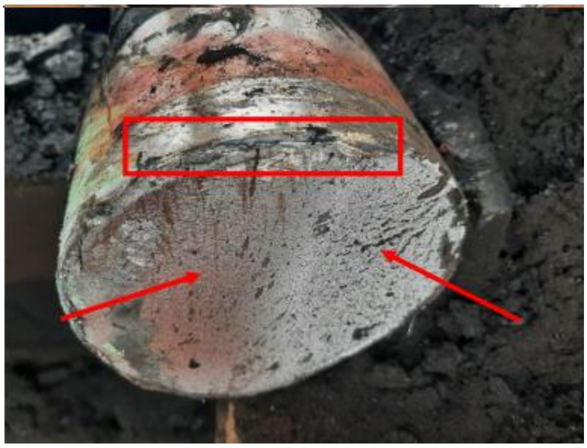

Figure 4 Shaft fracture condition

The two pictures above show that there is crack initiation. This failure mode assumes that the shaft is subjected to rotational loads which causes the tensile stress to exceed its ultimate strength and on the surface of the shaft there are also traces of rewelding which may be aimed at hard-facing processes on the surface of the shaft.

Hard-facing welding (build-up welding or over-laying) is a surface welding process that uses an arc, arc and plasma to melt the base metal and form a wear-resistant, corrosion-resistant and heat-resistant layer on the surface of the workpiece. Hard-facing has a function as surface repair and reinforcement. The hard-facing welding process will affect changes in the microstructure and the hardness value of the pulley shaft.[3]

Figure 5 There are traces of hardfacing on the shaft.

If seen in Figure 4, there are three parts to failure, the part where large plastic deformation occurs, the brittle fracture part and the rotational bending fatigue characteristic part. Most failures are flat and creeping. This surface condition is considered to be due to the crack initiation process that has occurred before coupled with the process of fluctuation or dynamics of the operating stress of the conveyor system which increases the rate of cracking in the shaft. Figure 3 shows that there is also a fatigue zone. Fatigue zones can be described as follows: smooth rubbed and velvety appearance, presence of waves known as clam shells or oyster-shells, stop mark lines, beach marks and there is also a herringbone pattern or granular traces indicating the origin of the crack. In general, stop marks show variations in crack propagation rates due to variations in stress amplitude in cycles that vary with time. [4]

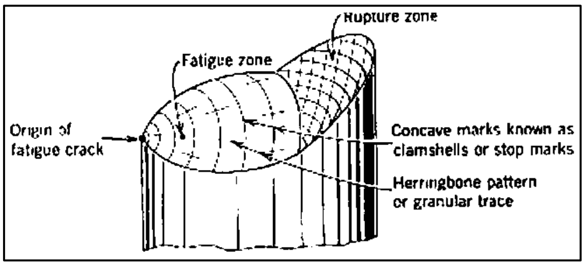

Figure 6 Failure zone

Another cause of failure is the wear of the shaft at the support location, which can be seen in Figure 5 and Figure 7. This wear causes the shaft cross-sectional area to decrease and it is less able to withstand tensile stresses. Voltage is the high voltage level caused by the fluctuating voltage supplied by the operating pattern since the start and stop cycles of operation. The shaft is subjected to fluctuating bending loads and torsional loads during operation. In this area, excessive plastic deformation can occur resulting in significant local stress, which will cause fatigue cracking.

In addition, the mass of the pulley is a factor that induces a fluctuating bending stress. This stress is distributed evenly along the shaft between the bearing supports. At bearing supports, the reduced cross-sectional area induces local stress gradients and these stresses can contribute to shaft failure.

Figure 7 Condition of the pulley shaft on the bearing side.

3.2 Shaft Material Identification

According to the specifications contained in the HT bend pulley specification document where the shaft material used is C45 Steel with material code number 1.0503, the classification of Non-alloy steel. This material has mechanical properties as seen in table 1.

Table 1. Mechanical Properties C45 Steel

Parameter	Value
Tensile Strength (MPa)	**560**
Yield Stength (MPa)	**275**
Elongation (%)	**16**

Meanwhile, the chemical composition of this material can be seen in table 2.

Table 2. Chemical Composition C45 Steel

Composition	Value

C	**0,43 – 0,5**
Si	**max 0,4**
Mn	**0,5 – 0,8**
Ni	**max 0,4**
P	**max 0,045**
S	**max 0,045**
Cr	**max 0,4**
Mo	**max 0,1**

The identification results of the broken shaft material can be seen in Figure 8.

Element		Concentration [%]	Stddev. [%]
Aluminium	Al	0.02	0.01
Silicon	Si	1.55	0.31
Chromium	Cr	0.33	0.06
Manganese	Mn	1.18	0.11
Iron	Fe	96.46	0.80
Nickel	Ni	0.08	0.05
Niobium	Nb	0.03	0.01
Molybdenum	Mo	0.19	0.02

Figure 8 Chemical Composition Results with a portable Spectrum Analyzer

Figure 8 shows that the identification of the shaft material is P265GH, the classification of Non-alloy steel with code number 1.0425. While the shaft material according to standard specifications is C45 Steel. The two materials are compared chemically and mechanically. The comparison can be seen in Table 3 and Table 4.

Table 3. Comparison of Mechanical Properties

Parameter	Value	
	C45	**P265GH**
Tensile Strength (MPa)	**560**	**400 – 530**
Yield Stength (MPa)	**275**	**200**
Elongation (%)	**16**	**22 - 23**

Table 3 shows the values of tensile strength and yield strength which have quite a slight difference even though the value of P265 GH tends to be lower than the value of the material that should be used, namely C45 Steel.

Table 4. Comparison of Chemical Compositions

Composition	Value	
	C45	**P265GH**
C	**0,43 – 0,5**	**Unidentified**
Si	**max 0,4**	**1,55**
Mn	**0,5 – 0,8**	**1,18**
Ni	**max 0,4**	**0,08**
P	**max 0,045**	**-**
S	**max 0,045**	**-**
Cr	**max 0,4**	**0,33**
Mo	**max 0,1**	**0,19**
Al	**-**	**0,02**
Fe	**-**	**96,46**
Nb	**-**	**0,03**

Table 4 shows the value of the chemical composition of the two materials in which the two materials have in common, namely belonging to the Non-alloy steel classification which tends to be medium carbon steel.

4 CONCLUSIONS

1. If seen from the shape of the shaft fracture, brittle fracture occurred on the left side and ductile fracture on the right side of the shaft, it is possible that a crack occurred at that point before the shaft fracture occurred, and the condition of the broken shaft pulley has been hardfacing (repaired).
2. The failure mode assumes that the shaft is subjected to a rotational load which causes the tensile stress to exceed its ultimate.
3. The C45 Steel shaft material can be equivalent to P265GH although the P265GH material tends to have lower specifications than C45 Steel. For certain operating conditions it is better to stick to the original material, namely C45 Steel.

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