International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

Identifying failure trends in a Belt Conveyor Control system

Mr. M. Vishnu Teja[1], Mr.N. Sri Chandrahas[2]

Mr. M. Vishnu Teja[1] Asst.Prof,, Dept of Mining Engineering, Malla Reddy Engineering College(Autonomous) Maisammaguda, Dhullapally post, via Kompally, Secunderabad-500100 India

Mr.N. Sri Chandrahas[2]Asst.Prof,, Dept of Mining Engineering, Malla Reddy Engineering College (Autonomous) Maisammaguda, Dhullapally post, via Kompally, Secunderabad-500100 India

Abstract:*Theconveyorbeltisoneofthemostoperationalcriticalequipmentintheminingindustry,theyaremostlyusedinthe transportation of crushed materials from the crushing station to where there'll be further processed. Due to the increasingcomplexity of belt conveyor systems, managing their integrity has become even more difficult, as they are now used acrossvarious industries, environments and carry materials of different weight variations, leaving them susceptible to failures (1). Thispaperprovidesanindustryspecificknowledgeonbeltconveyorsystems,theirrespectivecomponents,andhowtheyareconfigured using fault tree analysis to predict the different branches of event that can contribute to the failure of a belt conveyorsystem. The use of fault tree analysis sheds more light on how cascading failures can occur, where the failure of one componentleadstothefailureoftheoverallsystem. (2)*

Keywords:*RCFA,FMEAOpex,FTA,Capex,Eca,Ttf,Ttr.*

I. INTRODUCTION

In recent years, the mining industry has experienced various disasters worldwide, due to improper planning and lack of functionalreliability improvement programs being put in place. A vivid example of such is the recent dam disaster which occurred in Brazil, inJanuary 2019, which claimed the lives of over 270 people, where the company in question later settled for a compensation of $7billion, to be paid out to the families of those affected. This shows the direct cost implication of disasters, caused by unanticipatedfailures and how much disrepute it may bring to operating companies. Equipment failures are never taken likely by regulatorybodies, as it sometimes reflects how good or poorly, a company has prioritized safety and integrity management of her assets. Thatbeing said, to better manage assets and minimize disasters caused by equipment related failures, there are several cost and timeeffective ways of properly anticipating failures in systems, components and their sub-components, one of such techniques is faulttree analysis (FTA), which utilizes the failure data of an equipment to predict different branches of failure and cascading faults. FTAwas specifically chosen in this paper due to its relevance and improved accuracy in the domain of reliability and asset riskmanagement.In this paper, the common failure patterns of conveyorbelts are analyzed,and conclusions are drawn from theanalysis.

II. THECONVEYORBELTSYSTEM

Belt conveyor systems have been used for over 2 centuries across various industries (2), which include petrochemicals, mining,manufacturing & production. The belt conveyor system is mostly used in the movement of bulk materials from one station toanother, they have proven to be highly effective and time saving, they are also very easy to maintain, which makes them a cost-effective solution for several industrial applications.The focus industry of this paper is the mining industry, the subsequent sectionswill further describe the different components within the system and the common failure modes that contribute to system failure. Afault tree analysis will be drawn to represent all branches of component failure or events that could contribute to the total failure andunavailabilityoftheentiresystem.

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

Fig.1Thebelt conveyorsystem(3)

There are several components within the belt conveyor system that experience individual failures over time, due to factors such as,wear and tear, corrosion, overloading and stresses. Most times, finding the cause of failure may become increasingly complex untilthoroughresearch andfaultfindingisdone,usingreliabilitycenteredmaintenancetoolssuch as,rootcausefailureanalysis(RCFA),failuremodeandeffectanalysis (FMEA),faulttreeanalysis andotherknown reliabilityimprovementtools.

A. MajorSubsystems withintheBeltConveyorSystem

The typical belt conveyor system used in open pit and underground mines consist of the idler which have bearings, the drive unitwhich houses the gearbox, the pulleys, the scraper and the skirt board, as some the main subsystems. The complete diagram of thedriveunitisshowninthefigurebelow.(4)

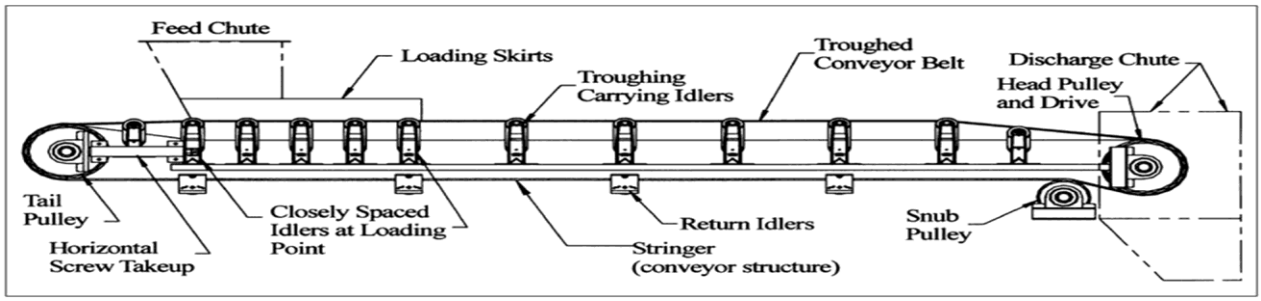

Fig.2Abasicdiagramshowingthebeltconveyorsystem(5)

B. ThePulley

The pulleys are a major component of belt conveyors, they are usually made of steel and are frequently used in deflecting andproviding support along the conveyor structure. Pulleys also help in the process of training the conveyor belt to properly run alongtheidlers(6).

The location of pulleys may vary along the structure, while some can be found at the begging of the structure, during take-up, someare situated around the end of the structure. Pulleys help inboosting the transmissionof drive powerthroughthe belts (6). Ingeneral, belts require a significant amount of thrust to kick-off the system and remain in motion, the thrust is useful in overcomingfrictionalandgravitationalforces (5)

Thediagrambelowshowsthebasiccomponentswithinthepulley,withthebearingassemblyandpullyshaftasmajorsubcomponents whosefailurecancontributetothetotalfailureofthecomponent(6).

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

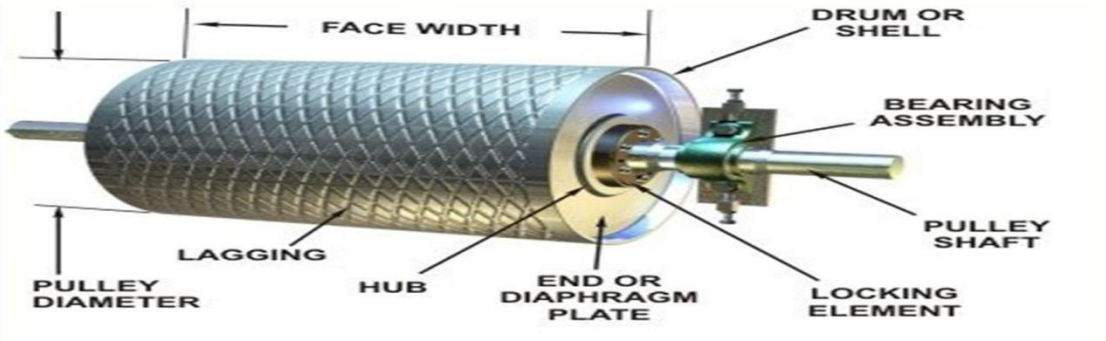

Fig.3Showingthevarious subcomponentsofthepulley(6)

C. TheConveyorBelts

The belt is known to be the primary component of the system, it is the major components that makes transportation of materials toseveral stations possible, without the belts, there would be no base or ridged body to place materials on. Therefore, keeping the beltsin good condition has always been a priority to maintenance personnel (4). Most belts require additional preventive maintenancechecks,dependingonthenatureofmaterialstransported(4).

Maintenance personnel's must be mindful of spillage, if materials transported is liquid in nature.In mining, bulk materialstransported are usually heavy solids, which leaves the belts prone to wear, due to their weight. Belts are of different types, some ofthemostcommonlyusedonesarethecoated,coveredandreinforcedbelt(4)

D. TheIdler

The Idler is an assemble of steel tube rolls which are situated in the pulley head with shafts, bearing and seals. The most commonlyused idler are the Impact idler, return idler and the toughing idler alongside the toughing trainers (4). Idlers act as support providersto belts during transportation of materials, there are close similarities between the pulleys and Idler, therefore they fail in similarways, just like the pulleys, worn out bearings in idlers will result to an upsurge in the external load that the drive unit carries, whichinturncancontributetoanincreaseinpowerconsumption(4).

It is useful to know that most Idlers are already factory lubricated (7) and are set to go into operation. How long an idler remains inservice is largely attributed to the care given to them when in service, maintenance personnel must put addition care into scheduledandperiodicroutineinspectiononthеIdlers,takingintoconsideration,theirworkingandenvironmentalconditions (7).

E. TheDriveUnit

The drive unit is one of the major components of the belt conveyor system, it consists of the 2-3 stage gearbox that is responsible forconnecting the outer shaft to the pulley, it also has an electric motor. However, the safety critical subcomponent within the system isthe gearbox. There is a high probability that about 25% of gearboxes would require yearly replacement due to catastrophic failures(4).Belowis adiagrammaticrepresentationofthedriveunitanditsvarioussubcomponents.

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

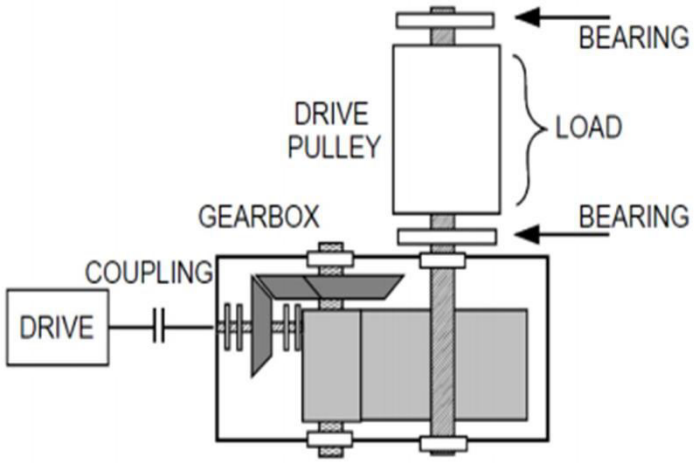

Fig.4 Representingthedriveunit(5).

As shown in figure 4 above, the parts individually contribute to the continuous operation of the drive unit. The bearing is usuallyresponsible for rotational efficiency within the system. In general, when it comes to the provision of rotation support to the beltconveyorsystem,thedriveunitisregardedastheprimarysource.

F. Scraper

The primary function of the scrapper at the discharge pulley is to provide cleaning action to the conveying portion of the belt and toensure that the return idlers do not wear out. In general, the scrappers are positioned to clean the innermost surface of the belt, toserveasabarrierthatpreventsmaterialsfromfallingintothegapbetweenthetailpulleyandthebelt(4).

III. RESULT

A. AnalysisofaBeltConveyor systemusingFTA

Belt conveyor systems are known to be highly reliable, how much they would last, greatly depends of the maintenance strategy putinplace forthem.Irrespectiveof how wellthey are maintained,some components withinthe systemare prone to normalwearduring the useful life of the equipment, therefore it is necessary for duty holders to pay a great deal of attention to the most failureprone components. In most cases, maintenance teams would organize yearly plant shutdown, where total overhauling of equipmentis done. The fault tree diagram is sometimes used to visualize cut sets and combination of subsystem failures that can contribute tothe main event. **Fig. 5** is a representation of the different branches of events that can contribute to the failure of the entire beltconveyorsystem,inthisanalysis,moreemphasisisplacedonthefixedunit(8).

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

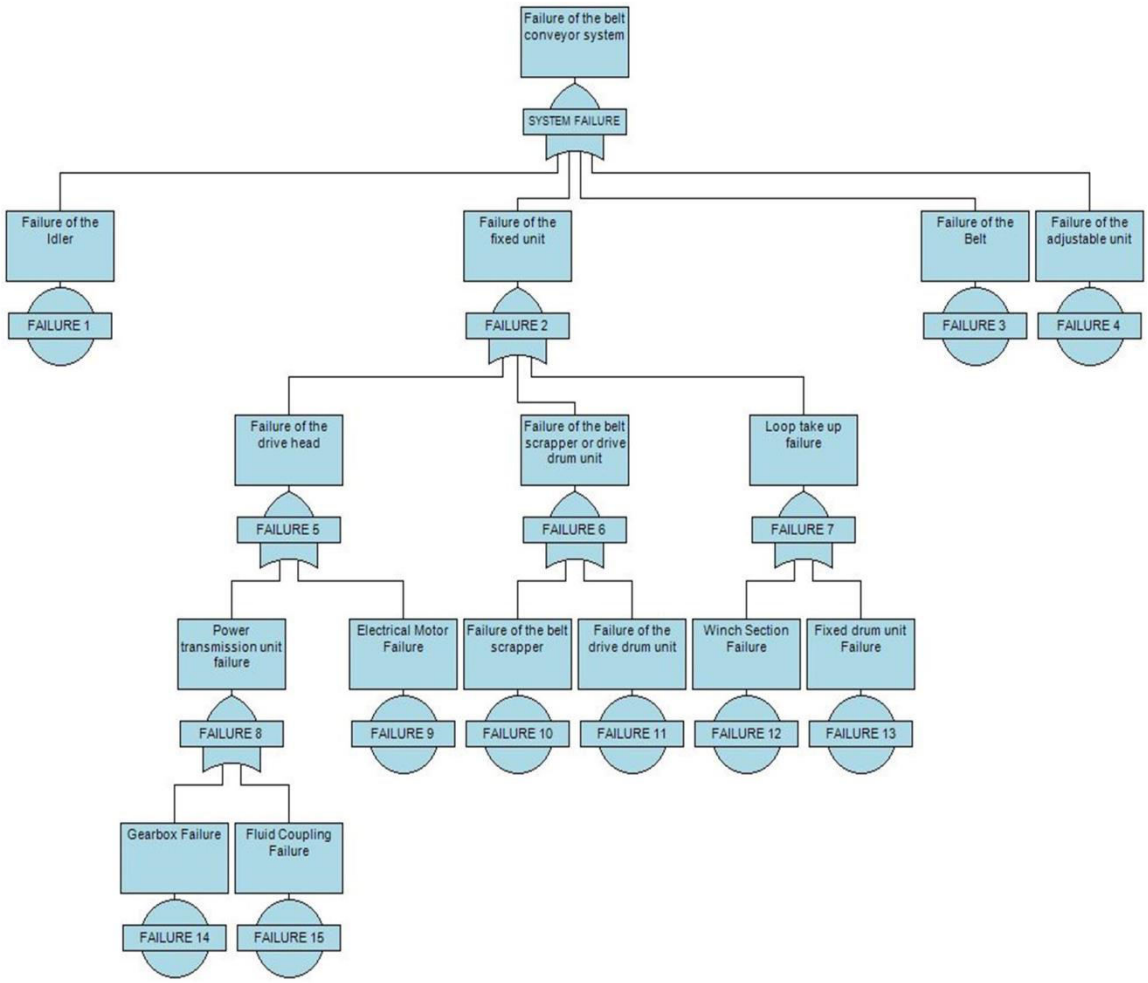

Fig.5Representingthefaulttreeoftheconveyorbeltsystem(8).

Fig. 5 Above was done using isograph software tool,it shows aboutfourteen (14) differentindividual single pointof failures thatcan potentially lead to the failure of the entire system, which is the greatest nightmare of several companies, as it would directlyaffect operations, operating and capital expenditure (Opex and Capex). To help in better understanding how belt conveyors work,somecommonfailuremodeswillbediscussedinthefollowingsections.

B. BeltFailure

The failure of the belts inner structure, side and top covers are one of the common belt failures, when this happens, the belt loses itstension retention ability due to the belt being ripped. The top covers also get worn out over time, which makes it less possible tothemtoguardtheinnerstructure.Lastly,thesidecovers getwornoutovertime,leavingtheinnerservicevulnerable(2).

C. DriveSystemFailure

The motors find it difficult to freely rotate, the bearings get easily worn out, causing low friction. The gear-box loses some of itstooth,makingitextremelytotransferpower.Ingeneral,thefailureofthedrivesystemhappensinsuchawaythat,theyareunableto supply sufficient power to the belts, this reduced efficiency directly affects the entire component and would usually require urgentcorrectiveactions(2).

D. IdlerFailures

The Idlers are known for their ability to help align the belt, however, when they lose the ability to provide support, the belts run withuncontrolledfriction. Typically,theyareunabletocontinueprovidinghighrollingresistance (2).

E. TheBrakeSystem

The brake system is used for intervention in the case of an emergency, it helps in reducing the speed of the belts, when the

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

brakesystem fails, it becomes practically impossible for it to slow down the belts. Duty holders most ensure to carry out adequatepreventivemaintenancechecks onthesystem,ensuringthattheyarelubricatedatalltime(2).

IV. CONCLUSION

The belt conveyor system remains a critical equipment in open pit and underground mining. In this paper, FTA has been utilizedusing real life belt conveyor set-ups and scenarios obtained from several mining companies and individual subject matter expertise,and results have been used to draw useful conclusion. Regardless of the maintenance strategy put in place by mining companies,addressingunexpectedfailures has remainedaconcern, whichmakes currenteffortinsufficient.Priority mustbeplacedonidentifying bad actors and organizing a total review of current preventive, predictive and corrective maintenance plans, with earlyfailure detection being the main determinant factor for improvement. Predictive maintenance technology is certainly the wayforward,as the technology is capableof identifying failure contributors such as, temperature,pressure and vibration changes infixedandrotatingassetsbeforefailureoccurs.

It is imperative that more concern is directed towards improving maintenance task for key components, such as the rollers, thepicking belts, Idlers and the pulleys, which are failure prone components within the belt conveyor system. Duty holders must alsotakeintoconsiderationthattheoverallsystemreliabilityof theconveyorbeltcanbecompromisedifonly onecomponentfails,thisis duetotheirseries arrangement,whichmakeseveryindividualcomponentofequalimportance.

Finally, effort must be put into minimizing repair times, as every minute lost during downtime would cost thousands of dollars,whichaffectsrevenuegenerationandtheoverallreputationofthecompany.

REFERENCES

[1] Ortmeier F, SchellhornG.FormalFault TreeAnalysis-PracticalExperiences. Vol.185,ElectronicNotesinTheoretical ComputerScience.2007.p.139–51.
[2] ZeeuwVanDerLaanB.Systemreliabilityanalysisofbeltconveyor.2016;(March):73.Availablefrom:http://mararchief.tudelft.nl/file/45179/
[3] ABB.Miningconveyorsystems _ABBconveyorsolutions- Beltconveyorsystems (Crushing andconveying)[Internet].ABB;2021. Availablefrom:https://new.abb.com/mining/crushing-conveying
[4] VelmuruganG,PalaniswamyE,SambathkumarM.ConveyorBeltTroubles(BulkMaterialHandling).2014;2(3):21–30.
[5] ZimrozR,KrolR.Failureanalysisofbeltconveyorsystems forconditionmonitoringpurposes.StudiMater.2009;(36):255–70.
[6] Pulleys_Basicsofconveyorpulleys[Internet].CKIT;2020.Available from:https://www.ckit.co.za/
[7] TheseR, CarefullyI, StartingB. ReadTheseInstructionsCarefullyBeforeStartingInstallationBeltConveyorIdler. :1–8.
[8] Gupta S, Bhattacharya J, Barabady J, Kumar U. Cost-effective importance measure: A new approach for resource prioritization in a production plant. Int J QualReliabManag.2013;30(4):379–86.
[9] Dwi-weibullBST.SOMEPROPERTIESOFBI-WEIBULLDISTRIBUTIONS.2008;4(April):2003–4.
[10] SimpsonFM.TheUseofWeibull AnalysisMethodsinAssessingFieldFailureProblems.1994.
[11] TechnologyC.WeibullReliabilityAnalysis=⇒.1999;Availablefrom:http://www.rt.cs.boeing.com/MEA/stat/reliability.html
[12] Engineeringstatisticshandbook.8[Internet].NIST&Sematech;Availablefrom:https://www.itl.nist.gov/div898/handbook/apr/section1/apr162.html