iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: X Month of publication: October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38569

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Establishing failure patterns of a Belt Conveyor System configuration

Olutayo Opeyemi Ogunmilua[1], Isaque Moyses Guimaraes[2], Efe Peter Iyomi[3]
[1]*Reliability Availability & Maintainability Engineer, Canadian National Railway, Montreal, QC, Canada*
[2]*Reliability Engineer. EIT, Vale Canada Limited, Sudbury, Ontario, Canada*
[3]*Reliability Engineer. P. Eng., Vale Canada Limited, Sudbury, Ontario, Canada*

Abstract: The conveyor belt is one of the most operational critical equipment's in the mining industry, they are mostly used in the transportation of crushed materials from the crushing station to where there'll be further processed. Due to the increasing complexity of belt conveyor systems, managing their integrity has become even more difficult, as they are now used across various industries, environments and carry materials of different weight variations, leaving them susceptible to failures (1). This paper provides an industry specific knowledge on belt conveyor systems, their respective components, and how they are configured using fault tree analysis to predict the different branches of event that can contribute to the failure of a belt conveyor system. The use of fault tree analysis sheds more light on how cascading failures can occur, where the failure of one component leads to the failure of the overall system. (2)

Keywords: RCFA, FMEA Opex, 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 functional reliability improvement programs being put in place. A vivid example of such is the recent dam disaster which occurred in Brazil, in January 2019, which claimed the lives of over 270 people, where the company in question later settled for a compensation of $7 billion, to be paid out to the families of those affected. This shows the direct cost implication of disasters, caused by unanticipated failures and how much disrepute it may bring to operating companies. Equipment failures are never taken likely by regulatory bodies, as it sometimes reflects how good or poorly, a company has prioritized safety and integrity management of her assets. That being said, to better manage assets and minimize disasters caused by equipment related failures, there are several cost and time effective ways of properly anticipating failures in systems, components and their sub-components, one of such techniques is fault tree analysis (FTA), which utilizes the failure data of an equipment to predict different branches of failure and cascading faults. FTA was specifically chosen in this paper due to its relevance and improved accuracy in the domain of reliability and asset risk management. In this paper, the common failure patterns of conveyor belts are analyzed, and conclusions are drawn from the analysis.

II. THE CONVEYOR BELT SYSTEM

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 to another, 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 sections will further describe the different components within the system and the common failure modes that contribute to system failure. A fault tree analysis will be drawn to represent all branches of component failure or events that could contribute to the total failure and unavailability of the entire system.

Fig. 1 The belt conveyor system (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 until thorough research and fault finding is done, using reliability centered maintenance tools such as, root cause failure analysis (RCFA), failure mode and effect analysis (FMEA), fault tree analysis and other known reliability improvement tools.

A. *Major Subsystems within the Belt Conveyor System*

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

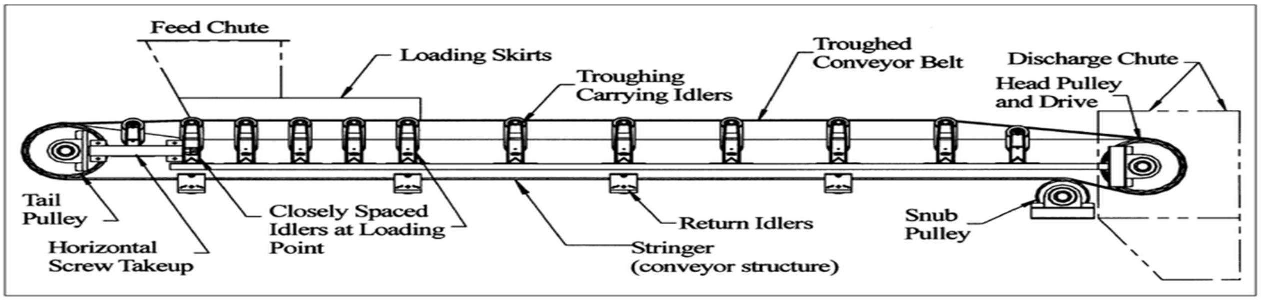


Fig. 2 A basic diagram showing the belt conveyor system (5)

B. *The Pulley*

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

The location of pulleys may vary along the structure, while some can be found at the begging of the structure, during take-up, some are situated around the end of the structure. Pulleys help in boosting the transmission of drive power through the belts (6). In general, belts require a significant amount of thrust to kick-off the system and remain in motion, the thrust is useful in overcoming frictional and gravitational forces (5)

The diagram below shows the basic components within the pulley, with the bearing assembly and pully shaft as major subcomponents whose failure can contribute to the total failure of the component(6).

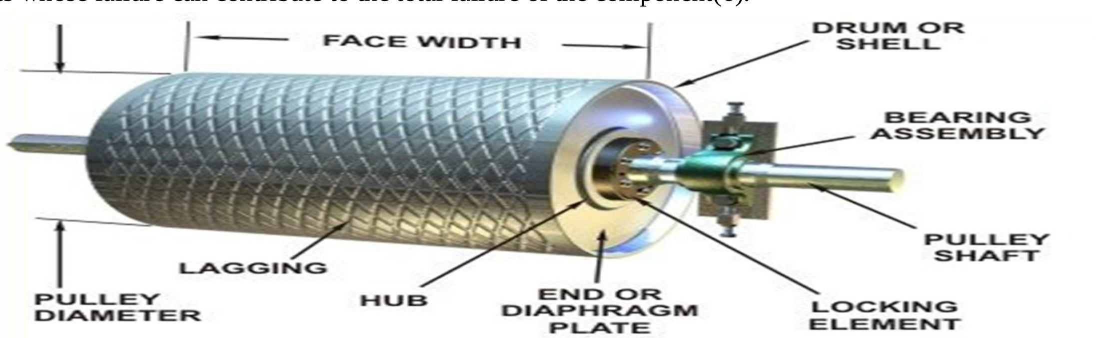


Fig. 3 Showing the various subcomponents of the pulley (6)

C. *The Conveyor Belts*

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

Maintenance personnel's must be mindful of spillage, if materials transported is liquid in nature. In mining, bulk materials transported are usually heavy solids, which leaves the belts prone to wear, due to their weight. Belts are of different types, some of the most commonly used ones are the coated, covered and reinforced belt (4)

D. The Idler

The Idler is an assemble of steel tube rolls which are situated in the pulley head with shafts, bearing and seals. The most commonly used idler are the Impact idler, return idler and the toughing idler alongside the toughing trainers (4). Idlers act as support providers to belts during transportation of materials, there are close similarities between the pulleys and Idler, therefore they fail in similar ways, just like the pulleys, worn out bearings in idlers will result to an upsurge in the external load that the drive unit carries, which in turn can contribute to an increase in power consumption (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 in service is largely attributed to the care given to them when in service, maintenance personnel must put addition care into scheduled and periodic routine inspection on the Idlers, taking into consideration, their working and environmental conditions (7).

E. The Drive Unit

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 for connecting the outer shaft to the pulley, it also has an electric motor. However, the safety critical subcomponent within the system is the gearbox. There is a high probability that about 25% of gearboxes would require yearly replacement due to catastrophic failures (4). Below is a diagrammatic representation of the drive unit and its various subcomponents.

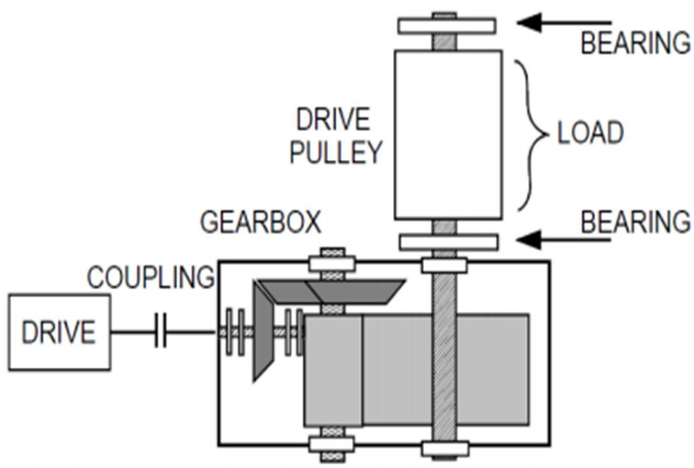


Fig. 4 Representing the drive unit (5).

As shown in figure 4 above, the parts individually contribute to the continuous operation of the drive unit. The bearing is usually responsible for rotational efficiency within the system. In general, when it comes to the provision of rotation support to the belt conveyor system, the drive unit is regarded as the primary source.

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 to ensure that the return idlers do not wear out. In general, the scrappers are positioned to clean the innermost surface of the belt, to serve as a barrier that prevents materials from falling into the gap between the tail pulley and the belt(4).

III. RESULT

A. Analysis of a Belt Conveyor system using FTA

Belt conveyor systems are known to be highly reliable, how much they would last, greatly depends of the maintenance strategy put in place for them. Irrespective of how well they are maintained, some components within the system are prone to normal wear during the useful life of the equipment, therefore it is necessary for duty holders to pay a great deal of attention to the most failure prone components. In most cases, maintenance teams would organize yearly plant shutdown, where total overhauling of equipment is done. The fault tree diagram is sometimes used to visualize cut sets and combination of subsystem failures that can contribute to the main event. **Fig. 5** is a representation of the different branches of events that can contribute to the failure of the entire belt conveyor system, in this analysis, more emphasis is placed on the fixed unit (8).

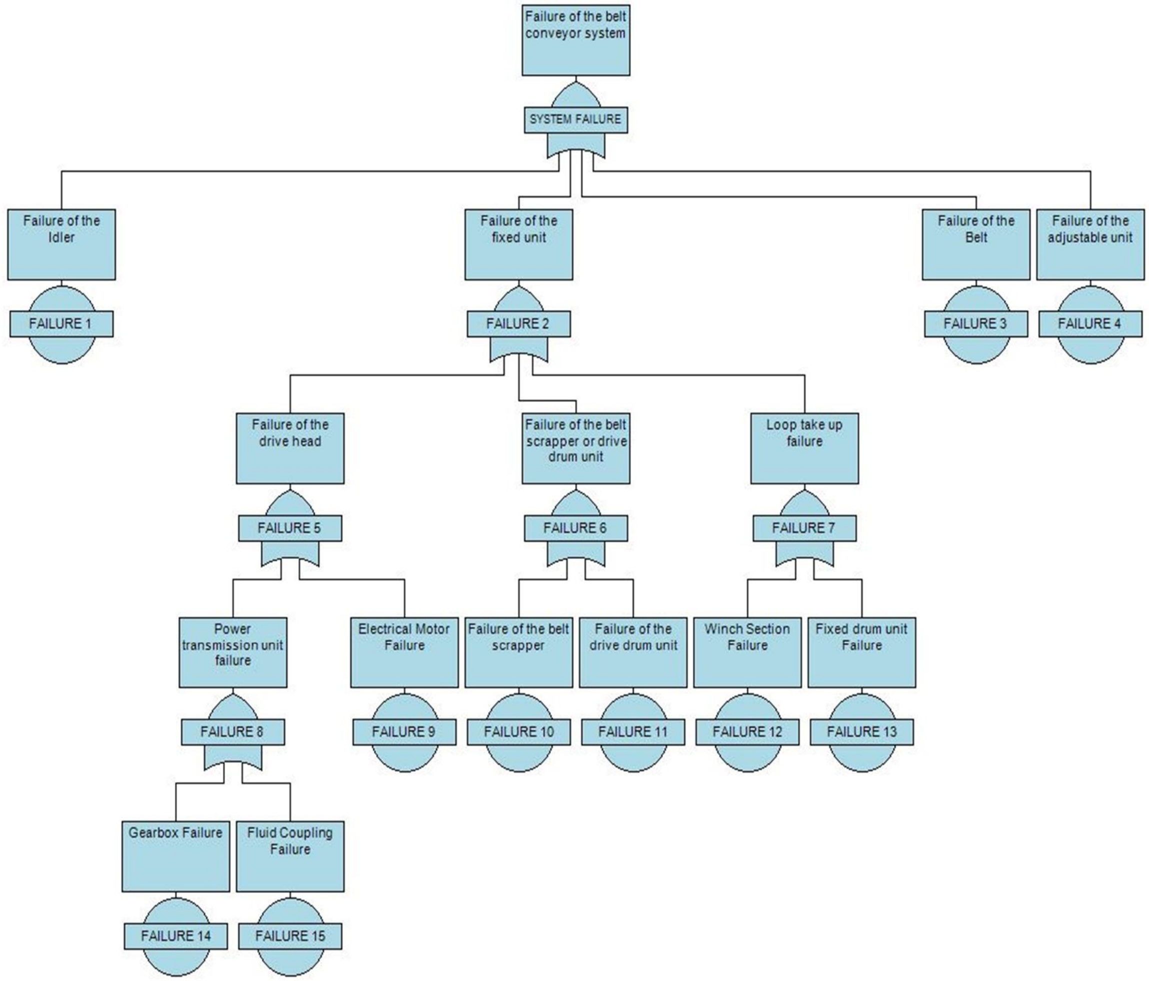


Fig. 5 Representing the fault tree of the conveyor belt system (8).

Fig. 5 Above was done using isograph software tool, it shows about fourteen (14) different individual single point of failures that can potentially lead to the failure of the entire system, which is the greatest nightmare of several companies, as it would directly affect operations, operating and capital expenditure (Opex and Capex). To help in better understanding how belt conveyors work, some common failure modes will be discussed in the following sections.

B. Belt Failure

The failure of the belts inner structure, side and top covers are one of the common belt failures, when this happens, the belt loses its tension retention ability due to the belt being ripped. The top covers also get worn out over time, which makes it less possible to them to guard the inner structure. Lastly, the side covers get worn out overtime, leaving the inner service vulnerable(2).

C. Drive System Failure

The motors find it difficult to freely rotate, the bearings get easily worn out, causing low friction. The gear-box loses some of its tooth, making it extremely to transfer power. In general, the failure of the drive system happens in such a way that, they are unable to supply sufficient power to the belts, this reduced efficiency directly affects the entire component and would usually require urgent corrective actions(2).

D. Idler Failures

The Idlers are known for their ability to help align the belt, however, when they lose the ability to provide support, the belts run with uncontrolled friction. Typically, they are unable to continue providing high rolling resistance (2).

E. The Brake System

The brake system is used for intervention in the case of an emergency, it helps in reducing the speed of the belts, when the brake system fails, it becomes practically impossible for it to slow down the belts. Duty holders most ensure to carry out adequate preventive maintenance checks on the system, ensuring that they are lubricated at all time(2).

IV. CONCLUSION

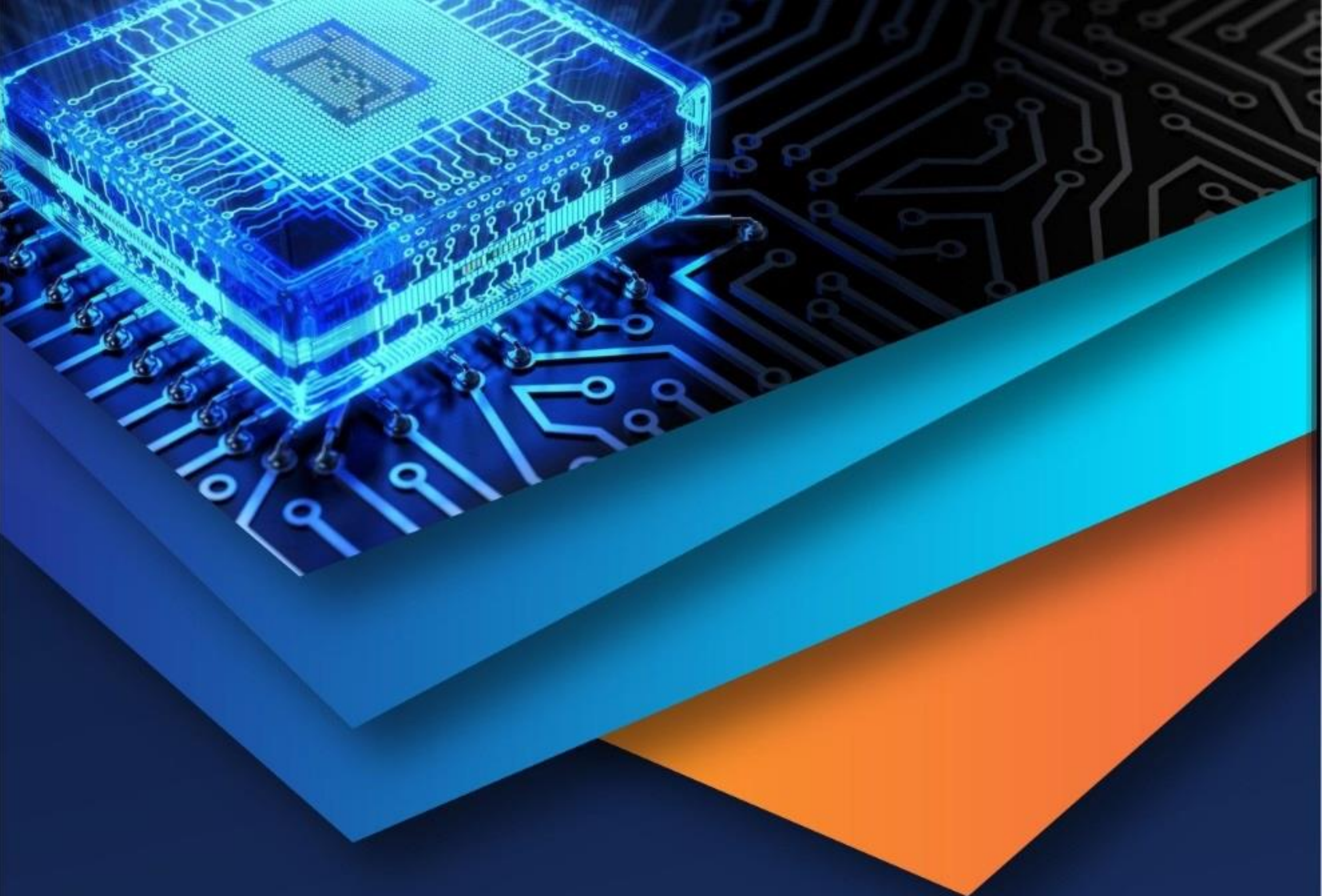
The belt conveyor system remains a critical equipment in open pit and underground mining. In this paper, FTA has been utilized using real life belt conveyor set-ups and scenarios obtained from several mining companies and individual subject matter expertise, and results have been used to draw useful conclusion. Regardless of the maintenance strategy put in place by mining companies, addressing unexpected failures has remained a concern, which makes current effort insufficient. Priority must be placed on identifying bad actors and organizing a total review of current preventive, predictive and corrective maintenance plans, with early failure detection being the main determinant factor for improvement. Predictive maintenance technology is certainly the way forward, as the technology is capable of identifying failure contributors such as, temperature, pressure and vibration changes in fixed and rotating assets before failure occurs.

It is imperative that more concern is directed towards improving maintenance task for key components, such as the rollers, the picking belts, Idlers and the pulleys, which are failure prone components within the belt conveyor system. Duty holders must also take into consideration that the overall system reliability of the conveyor belt can be compromised if only one component fails, this is due to their series arrangement, which makes every individual component of equal importance.

Finally, effort must be put into minimizing repair times, as every minute lost during downtime would cost thousands of dollars, which affects revenue generation and the overall reputation of the company.

REFERENCES

[1] Ortmeier F, Schellhorn G. Formal Fault Tree Analysis - Practical Experiences. Vol. 185, Electronic Notes in Theoretical Computer Science. 2007. p. 139–51.
[2] Zeeuw Van Der Laan B. System reliability analysis of belt conveyor. 2016;(March):73. Available from: http://mararchief.tudelft.nl/file/45179/
[3] ABB. Mining conveyor systems _ ABB conveyor solutions - Belt conveyor systems (Crushing and conveying) [Internet]. ABB; 2021. Available from: https://new.abb.com/mining/crushing-conveying
[4] Velmurugan G, Palaniswamy E, Sambathkumar M. Conveyor Belt Troubles (Bulk Material Handling). 2014;2(3):21–30.
[5] Zimroz R, Krol R. Failure analysis of belt conveyor systems for condition monitoring purposes. Stud i Mater. 2009;(36):255–70.
[6] Pulleys_ Basics of conveyor pulleys [Internet]. CKIT; 2020. Available from: https://www.ckit.co.za/
[7] These R, Carefully I, Starting B. Read These Instructions Carefully Before Starting Installation Belt Conveyor Idler. :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 Qual Reliab Manag. 2013;30(4):379–86.
[9] Dwi-weibull BST. SOME PROPERTIES OF BI-WEIBULL DISTRIBUTIONS. 2008;4(April):2003–4.
[10] Simpson FM. The Use of Weibull Analysis Methods in Assessing Field Failure Problems. 1994.
[11] Technology C. Weibull Reliability Analysis = ⇒. 1999; Available from: http://www.rt.cs.boeing.com/MEA/stat/reliability.html
[12] Engineering statistics handbook. 8 [Internet]. NIST & Sematech; Available from: https://www.itl.nist.gov/div898/handbook/apr/section1/apr162.htm



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY