International Journal of Scientific Modern Research and Technology
(Volume: 7, Issue: 1, Number: 2)
ISSN: 2582-8150

A Survey of a Machine Shaft in Various Failures

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Abstract- Shaft is a rotating machine element, circular in cross-section which supports elements like rollers, gears, pulleys & it transmits power. The shaft is always stepped with maximum diameter in the middle and minimum at the ends, where Bearings are mounted. Overload failures are caused by forces stress, strain and deformation of a shaft for that FEM analysis has been performed by using ANSYS 14.5.Here it also calculates the effect of principle stress and strain on the fatigue life of shaft and the vibration effect and frequency of shaft.
Keywords- FEM, Deformation, Fatigue, Fracture.

1. BACKGROUND

Human consumption of the Earth's resources increases the need for sustainable development as an important ecological, social, and economic theme. Re-engineering of machine tools, in terms of design and failure analysis, is defined as steps performed on an obsolete machine to return it to a new machine with a warranty that matches the customer's requirement. To understand the future fatigue behavior of the used machine components, it is important to investigate the possible causes of machine parts failure through design, surface, and material inspections. Failure analysis is an indispensable tool that is used widely by the industry sector to develop or improve product design. The failures of machine elements are studied extensively by scientists to find methods in order to identify their causes and to prevent them from reoccurring. To determine the failure modes, analytical, experimental, and finite element analysis methods can be used.

A structure as a whole, and each individual member, must be designed with reference to the three 'Ss': strength, stiffness and stability:

Strength is the ability to carry the applied loads without yielding or breaking. Examples of strength failures are a cable that snaps, a vehicle body which' crumples, and a glass panel being smashed.

Stiffness is the ability to carry the applied loads without too much distortion. A material can only sustain stress at the expense of some strain ($\sigma = E\varepsilon$). Sometimes the strain, even though very small, maybe the limiting factor. For example, a machine tool must be stiff enough to produce the required accuracy in machining, and a camera tripod must be stiff enough to prevent camera shake.

Stability is the ability to carry compressive loads without collapsing or buckling out of shape. For example, a metal rod in compression longitudinally will suddenly bow out of shape under compressive stress which is well below the compressive yield stress.

The importance of the different types of failure, in considering any particular member, depends on how the loads are applied to it.

ie: A member in tension. Strut: A member in compression

*Beam: A member with loads that causes *bending.*

II. THEORIES OF FAILURE

Unfortunately, there is no universal theory of failure. Instead, over the years several hypotheses have been formulated and tested, leading to today's accepted practices. Being accepted, we will characterize these "practices" as theories as most

designers do. Structural metal behaviour is typically classified as being ductile or brittle.

Theories have been developed for the static failure of metals based upon the two classes of material failure:

Ductile metals → yield
Brittle metals → fracture

The various theories are as follows:

- Maximum Principal Stress theory also known as **RANKINE'S THEORY**
- Maximum Shear Stress theory or **GUEST AND TRESCA'S THEORY**
- Maximum Principal Strain theory also known as **St. VENANT'S THEORY**
- Total Strain Energy theory or **HAIGH'S THEORY**

Maximum Distortion Energy theory or **VONMISES AND HENCKY'S THEORY**

III. LITERATURE SURVEY

Various review papers have also been published periodically by various researchers like:

Li-Hui Zhao et.al. (2019), This paper investigates the failure mode and root cause of drive shaft failure in a vehicle through examination of the macroscopic and microscopic morphologies of the fracture surface, the chemical composition, metallographic analysis, and mechanical properties of the material, and theoretical finite element calculations of the drive shaft. The results show that fatigue was the dominant mechanism of drive shaft failure due to obvious benchmarks on the fracture surfaces. Fatigue cracks initiated from the root fillet region of the spline gear.

Jae-ung Lee et.al.,(2018) Since selecting a case ship subjected to the damage on the stern tube bearing, it investigated the actual cause of the damage, thereby finding a practical way to enhance the sustainability of the propulsion shaft system using the single stern tube bearing. Results of the analysis suggested that the degree of slope be taken into account when estimating the effective supporting point of the bearing. Finally, this paper pointed out that the establishment of a shaft installation guideline considering the effect of the shaft slope, thereby preventing wiping damage of the aft stern tube bearing would be an urgent task.

Mahmoud T.El-Sayed (2017) The objective of the present work was to estimate the effect of internal torsional resistance in shafts which is caused by deflection, for the reason that it has the upper hand on misalignment problem. With the aim of fulfilling this objective, an experimental rig has been constructed to verify the existence of the torsional resistance in deflected shafts and its variation with the rotation angle.

Samuel O. Afolabi et.al.(2017) In materials engineers, it is important to determine the cause of failure of a machine component, to prevent prospect occurrences and increase the performance of the component structure. In this study, the parameters of the fatigue life of machine shafts are investigated.

K.R Rushton (2016) A detailed investigation into the stress concentration factors arising in the torsion of grooved shafts is described. The results were obtained on an electrical analogue, which solves the finite difference form of the governing differential equation. The method was first tested by a comparison with the analytical solution for shafts containing deep hyperbolic grooves, and was then used to provide numerous numerical results for solid and hollow shafts containing parallel-sided and "V" grooves

M.J. Miller (2015) As with any technology, progression of the product application has adapted to the needs of the vehicle driveline layout. We discuss the fundamental layouts where propshafts are applied, the key enablers for propshaft design, critical calculations, variations of propshaft products, and current trends for propshafts and the interfaces with the torque products they interact with.

M.Banuta, I. Tarquini(2013) The drive shaft in the propulsion system of a boat broke, while the vessel was sailing along the Western Canadian coast. This part was made from a low-alloy steel grade 4340 quenched and tempered. Fractographic investigation at macro scale revealed that the shaft failed under low rotating-bending variable stress. Fatigue propagation occurred on about 95% of the total cross section of the shaft, under both low-cycle and high-cycle fatigue mechanisms.

M. Savković, M. Gašić,(2011) The common design of the bucket wheel drive mechanism in some bucket wheel excavators (BWE) consists of a gearbox and a hollow shaft, while the bucket wheel is supported by the axle passing through the hollow shaft. Improper maintenance and inadequate elimination of axis misalignment of the hollow shaft and the bucket wheel axle are the main causes of excavator failure and axle fracture.

IV. PROBLEM IDENTIFICATION

A shaft, which has a circular cross-section, is a rotating machine element used in mechanical equipment and machines to transmit rotary motion and power. Bearings, flywheels, gears, clutches, and other machine elements are usually mounted on the shaft, and help in the power transmission process. Shaft failures do not happen every day, but when they do, it can be a challenge to determine the cause of failure. In diagnosing which mechanism caused the failure, a critical point to remember is that overload failures are generally caused by a single load application, while fatigue failures are always the result of a load applied repeatedly over many cycles. This means if the shaft failed as a result of an overload, the force that caused the failure has applied the instant before the shaft broke. Conversely, if fatigue was the culprit, the initial force may have been applied millions of cycles before the final failure occurred.

Scope of Proposed work

- Different materials can also be tried for better performance and surface refinement can be done for better and more accurate results.
- The study can be taken up for different configurations of a shaft.
- The results provided in this work can be experimentally verified

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