Finite Element Analysis of the Oldham Coupling by using ANSYS

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Abstract— Proper alignment for a rotating shaft has been identified long ago as a precondition to safe and trustworthy uses. High noise levels, frequently vibrating device, failure of bearings and lubrication are the types of machine rupture that are the results of the shaft misalignment. To get the sufficient torque and efficient power transfer, proper alignment plays a crucial role. Oldham coupling is one of the couplings which is properly aligned and transfers the power to one another shaft without any physical joint. One of the major advantages of Oldham coupling is that it can use for shafts which are non-coaxial. In this work, a simulation model set up is constructed in a CATIA for a driver and a driven shaft which are connected with each other by Oldham coupling. Proper shaft alignment is done with the help of Oldham coupling alignment and performance readings of ANSYS are leading us to the understanding the efficiency of the power transmission. The objective of this work is to study the performance of the Oldham Coupling using CATIA and ANSYS. In this manner, finite element analysis was performed. It was found that the simulation of Oldham Coupling is too time consuming to be used in everyday engineering work. However, Oldham Coupling can successfully be predicted with simplified models.

Keywords: Oldham Coupling; Finite Element Analysis; Regression Analysis; Driving Shaft; Driven Shaft

I. INTRODUCTION

The main function of coupling is transmitting torque from one shaft to the other are classified in two group: (1) Rigid coupling (2) Flexible coupling.

The rigid coupling cannot adapt to misalignment. A rigid connection is usually used when the load transfer takes place at very low speed. In a flexible coupling they have the ability to absorb misalignment. This ability is achieved thanks to the flexible coupling element.

A flexible coupling is a component that transfers torque between the two axes, while allowing some misalignment between the two axes. When the propeller shaft and rotor axes are not on the same axis, they are considered to be misaligned.

Couplings are often the cheapest part of a system, but they protect the most expensive and most valuable components when they are designed to break before the harmful forces pass through the system.

In each direct mechanical drive system, it is necessary to combine various drive elements that can be considered. Most drive components, including gearboxes, feed screws and many other components, are driven by rollers supported by multiple bearings

Thanks to this, the pins remain extremely simple and rigid during rotation, thus avoiding problems with maintaining balance and support. Because of this rigid support, it is practically impossible to avoid slight misalignments between the wheel and the wheel when they are connected. The restoring forces that occur when two engaged axles compete to maintain their original positions can cause undesirable stresses in the shaft bearings, causing premature wear. Additional axial loads are also exerted on the bearings as the temperature on the shaft increases during operation.

Mechanical components are driven by rotary shafts are widely used in all machines that perform different processes and functions of modern industry. Perfect alignment of the axes and rotating elements is desirable, but it is almost impossible to build a real machine in which the ends of adjacent axes are perfectly aligned.

The ends of the shaft may be unevenly angular or angular, have an axial displacement or a combination of the three. Misalignment will cause stresses on the axles and related parts of the assembly, such as bearings, which can lead to premature failure of both. Drive couplings can be used to compensate for shaft misalignment, whether the misalignment is an intentional or an unintentional part of the design.

When designing or modifying the system, important factors should be taken into consideration when selecting the appropriate coupling for the application.

Oldham coupling is used where the power transmission shafts are having the non-parallel axis. One of the major advantages its mechanism is not having any backlash during the operation. Actually is it specially design for the backlash purpose. It is efficient than the straight jaw coupling meanwhile in terms of the performance. The Oldham coupling having the three discs for its arrangement. When the centre disc designed in tongue and groove formation, it is used to sandwich each other both disc. The disc made from material such as plastics. Then other both disc are used to connect the drive and made from stainless steel (or) aluminium material.

II. WORKING PRINCIPLE OF OLDHAM COUPLING

Oldham coupling have three discs, one of which is coupled to the input shaft and another with to output shaft and the third disc is the Centre disc joined the each disc. The tongue and slot has one side is perpendicular to other side of tongue and slot. This coupling is specially used to reduce the coupling backlash in mechanism. During the torque and power transmission through one drive to other, the centre disc is slides on the surface of other disc for every rotation with the help of tongue and slot of discs. The sliding motion also include small amount of angular and axial motion. They are useful in application with parallel motion.

Vibration analysis of the rotating shafts has been studied since the 19th century [1]. As tools have become available through the advancement of technology, more mathematically complex models have been developed to study vibrations in rotating equipment. Misalignment of the shafts across a coupling is one of the reasons which have been studied in rotor-dynamics it also have the impact on vibration analysis. A flexible coupling is an element that transmits torque between two shafts while allowing for some misalignment between the two shafts. When the axis of both the shafts in not similar it will be considered as misalign. Flexible coupling connects the drive shaft of a motor to the shaft of a gearbox.

Misalignment has been a long-time problem for engineers. Jackson [2] confirmed that at least 60% of the analysis related to vibration problems he had solved in the field was caused by misalignment. Mancuso [3] described three types of possible misalignment in a machine train: parallel, angular, and a combination of both parallel and angular misalignment. Parallel misalignment means to an in between distance of the parallel centrelines of the shafts connected by the coupling, and angular misalignment refers to the angle of the centreline of one shaft with respect to centreline of the other shaft.

In the past, gear couplings have been commonly used in turbo-machinery, but their lubrication requirements and lack of flexibility have presented users with problems. Most turbine manufacturers have switched to dry and flexible couplings. There are different types of dry clutches and flexible couplings. Disc couplings and diaphragm couplings are often used in turbo-machinery gearboxes. They use a flexible metal element to transmit torque and correct misalignment. Both disc-pack and diaphragm couplings generate smaller reaction forces and moments under misalignment when compared to a gear coupling under the same amount of misalignment. There are other types of dry flexible couplings that use an elastomer element instead of a metallic one to transmit torque. The tire coupling uses a rubber component to transmit torque between two hubs, and it can withstand a large amount of misalignment while imposing small reaction forces on the bearings because of the rubber element. The “Croset” coupling uses rubber or urethane blocks to transmit torque although it does not accommodate much misalignment. The spider coupling, commonly known as the “jaw” coupling because of the shape of its hubs, transmits torque through the spider elastomer component that is in between the two coupling hubs. These couplings are the Special-purpose couplings utilized in high performance applications, which usually imply high-speeds, use metallic flexible elements to withstand the large stresses; therefore, couplings with elastomer elements are not used in high-speed applications [4]. The application for which the coupling will be used dictates the type of coupling that should be selected.

There are many mechanisms which are used to transmit the power between the traversing shafts. In all of them Hooke’s joints are the commonly used [5]. Hooke’s joint also known as the spherical joint. These joints have the intersecting angles of 15^o to 45^o, respectively. These types of joints are used where the high power transmission is required. However, one drawback is there angular velocity is not constant for the driven shaft. So, the angular velocity ratio is not similar for all the angular positions of output to input [6].

Bayrakceken, et al. [3] has done the rupture analysis of a universal joint for transmission system. They demonstrate that crack propagations are results for the highly stressed points and due to this fatigue failures are occurred which is the one of the major failure reason for the universal joints. They also suggest some minor modifications in the design of the U-joint, in order to control the types of failures.

Heyes [7] studied the some common types of failures in vehicles. He exposed many types of failures in the transmission system. Some common reasons for such failures are the manufacturing errors and the poor design. The poor maintenance and the wrong material selection are also the contributing factors.

There are also reports by some researchers on the failure of the power transmission systems [8-11]. Bayrakceken studied the failure of a transmission shaft of a differential system [12]. Kepceler et al. studied the stresses developed and the tool life of the elements for the power transmission system of a 4-wheel drive automobile [13].

III. PROBLEM DEFINITION

- The failure of the part happens because of several reasons which can be producing and design fault, raw material faults, maintenance faults, material process faults, etc.
- Oldham Coupling in power transmission process wears due to the presence of standard frictional thrust force. Sometime, absence of proper design of Coupling or lubrication is also responsible for low strength.
- In power transmission process cross section area of shaft is less; therefore, the strength of rotating shaft is also less.
- Shearing happens at the point of friction wherever coupling disc will mate with rotating shaft discs. Oldham Coupling is going through under the tension, it may shear and causes shear failure.

IV. ANALYSIS IN ANASYS SOFTWARE

- ANSYS is a broadly useful programming, used to mimic collaborations of all controls of physical science, basic, vibration, liquid flow, warmth exchange and electromagnetic for architects.
- Therefore, ANSYS, which regenerates test or working conditions, allows you to test in virtual environments before collecting element models. In addition, 3D reproduction in virtual environments can design and improve impotent homes, determine life, and predict practical problems.
- Material use for manufacturing of Oldham Coupling is EN-24 material.

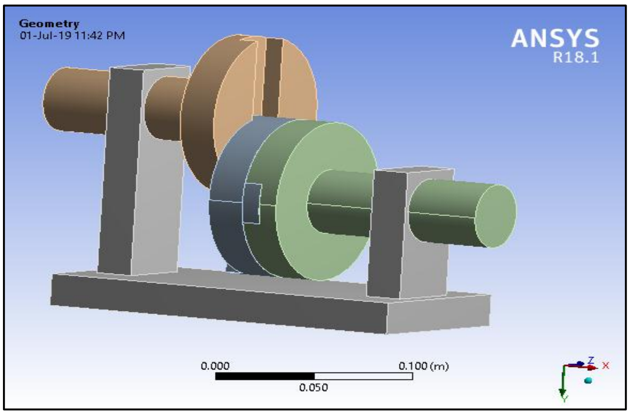


Fig. 1: Oldham coupling after the modelling in CATIA software

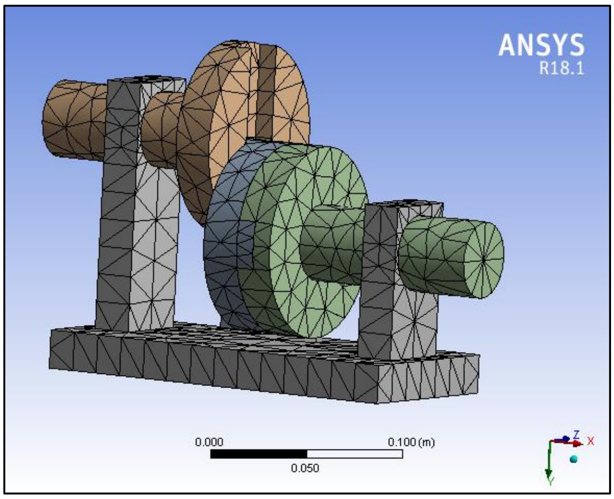


Fig. 2: After modelling in CATIA software, triangular type of meshing of Oldham Coupling is done in ANSYS software

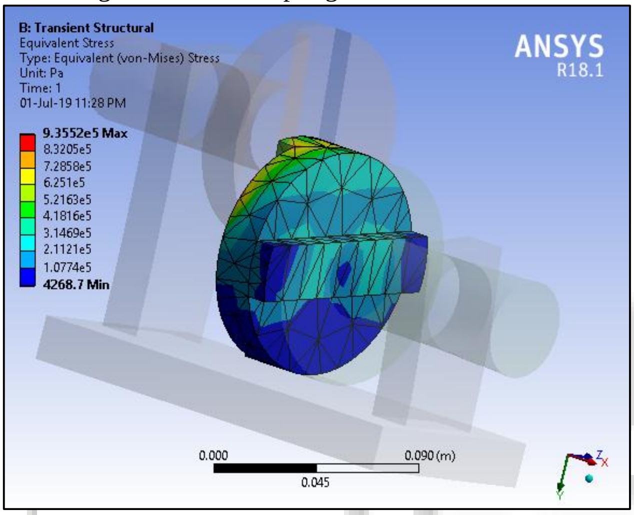
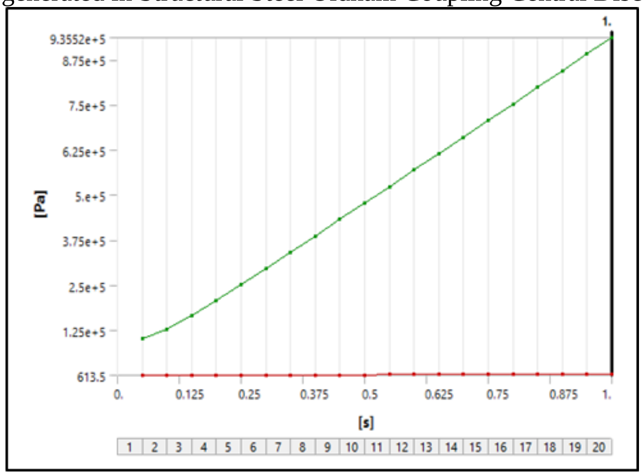


Fig. 3: By analysis in ANSYS software, Equivalent stress generated in Structural Steel Oldham Coupling Central Disc



Graph 1: Equivalent stress maximum generated in Structural Steel Oldham Coupling Central Disc is of 9.355×10^5 Pa & minimum is of 613.5 Pa

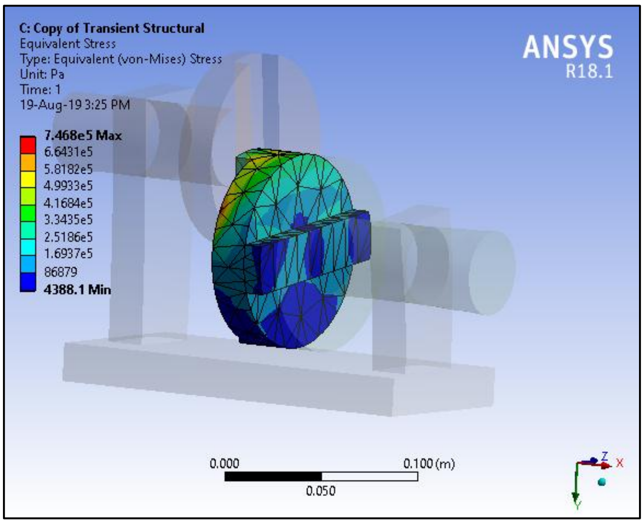
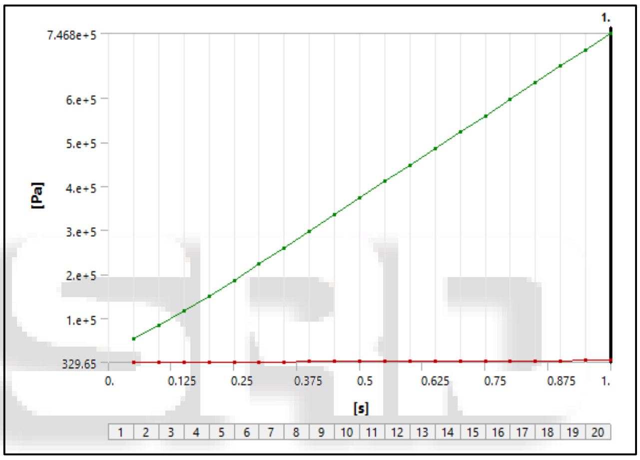


Fig. 4: By analysis in ANSYS software, Equivalent stress generated in Aluminium Alloy Oldham Coupling Central Disc



Graph 2: Equivalent stress maximum generated in Aluminium Alloy Oldham Coupling Central Disc is of 7.468×10^5 Pa & minimum is of 329.65 Pa

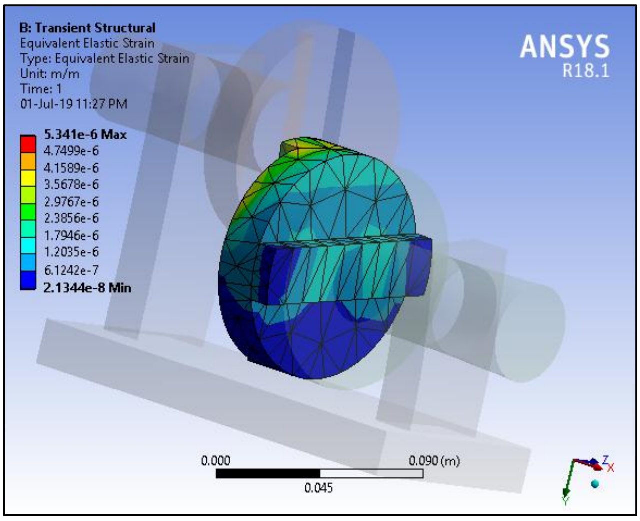
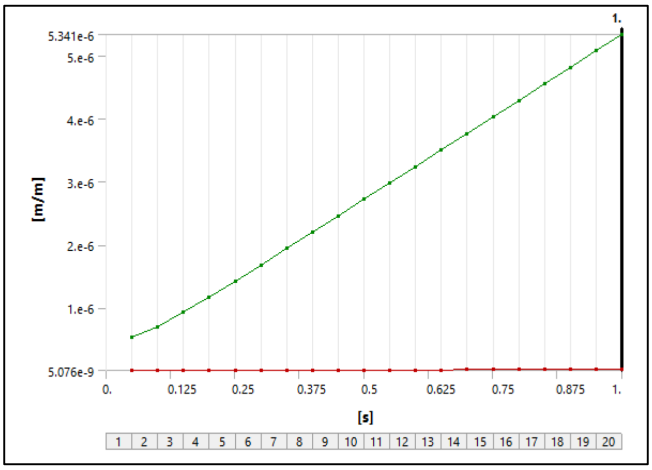


Fig. 5: By analysis in ANSYS software, Equivalent elastic strain generated in Structural Steel Oldham Coupling Central Disc



Graph 3: Equivalent elastic strain maximum generated in Structural Steel Oldham Coupling Central Disc is of 5.34×10^{-6} & minimum is of 5.076×10^{-9} m/m

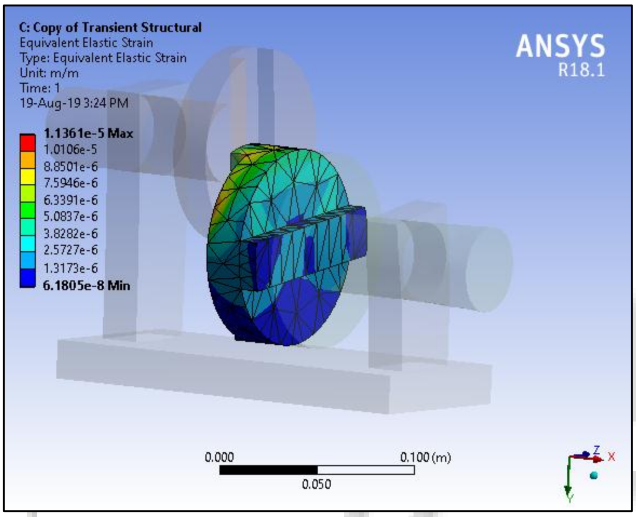
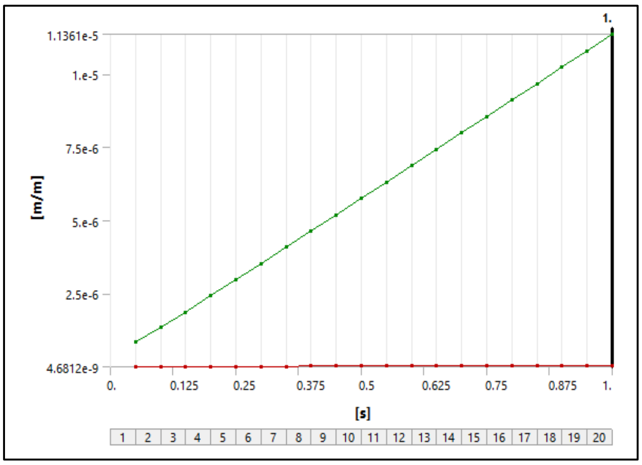


Fig. 6: By analysis in ANSYS software, Equivalent elastic strain generated in Aluminium Alloy Oldham Coupling Central Disc



Graph 4: Equivalent elastic strain maximum generated in Aluminium Alloy Oldham Coupling Central Disc is of 1.1361×10^{-5} & minimum is of 4.681×10^{-9} m/m

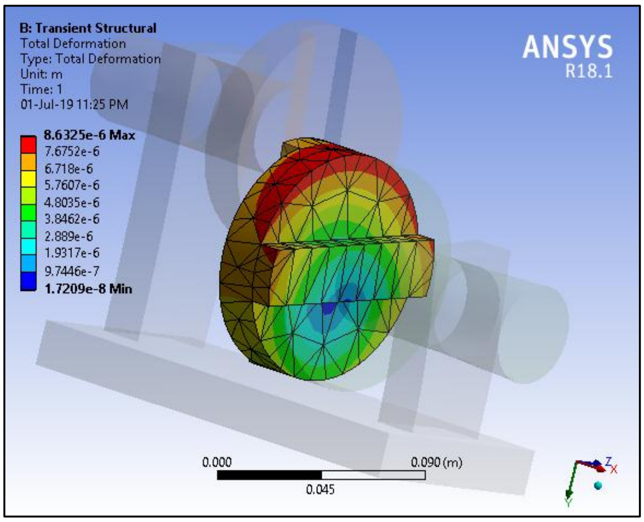
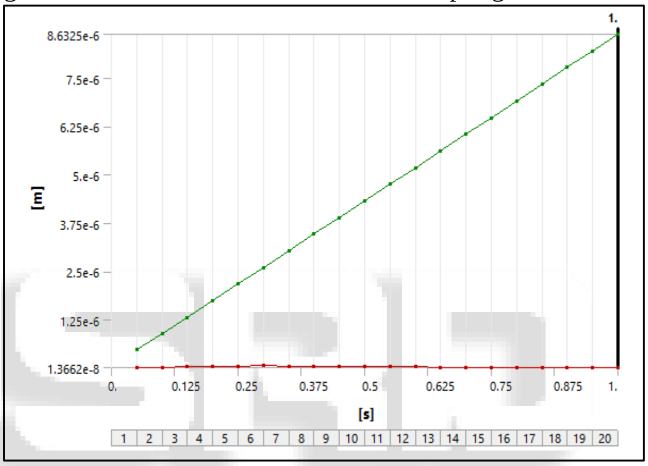


Fig. 7: By analysis in ANSYS software, Total Deformation generated in Structural Steel Oldham Coupling Central Disc



Graph 5: Total Deformation maximum generated in Structural Steel Oldham Coupling Central Disc is of 8.63×10^{-6} m & minimum is of 1.366×10^{-8} m

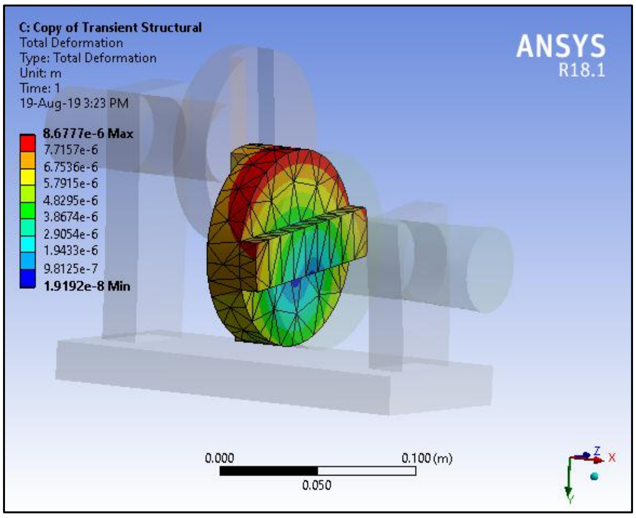
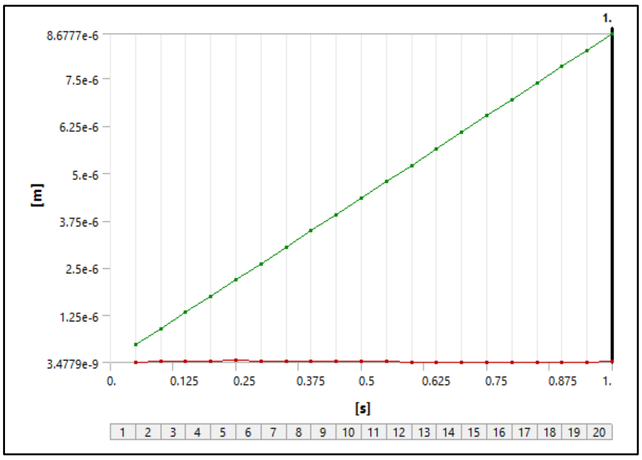


Fig. 8: By analysis in ANSYS software, Total Deformation generated in Aluminium Alloy Oldham Coupling Central Disc



Graph 6: Total Deformation maximum generated in Aluminium Alloy Oldham Coupling Central Disc is of 8.6777×10^{-6} m & minimum is of 3.477×10^{-9} m

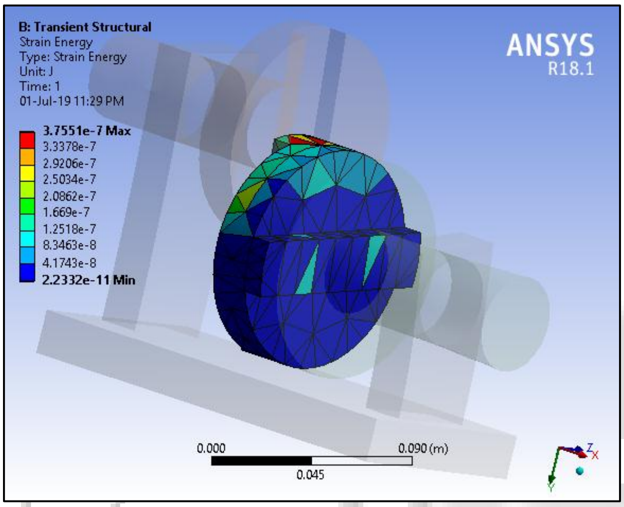
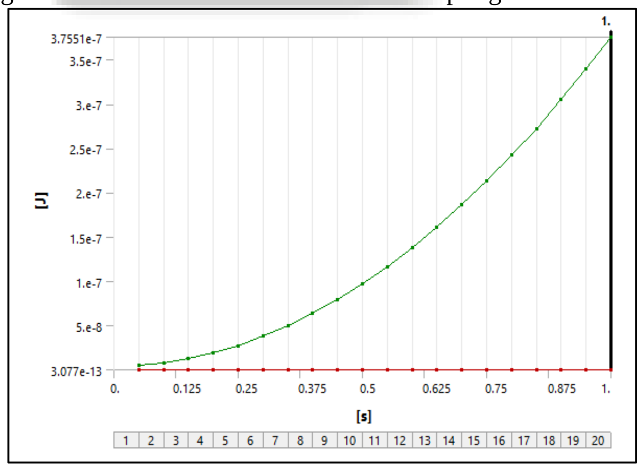


Fig. 9: By analysis in ANSYS software, Total Strain Energy generated in Structural Steel Oldham Coupling Central Disc



Graph 7: Total Strain Energy maximum generated in Structural Steel Oldham Coupling Central Disc is of 3.755×10^{-7} J & minimum is of 3.077×10^{-13} J

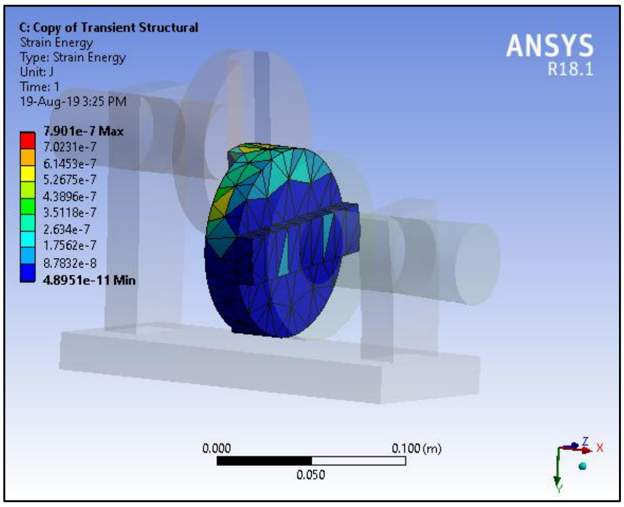
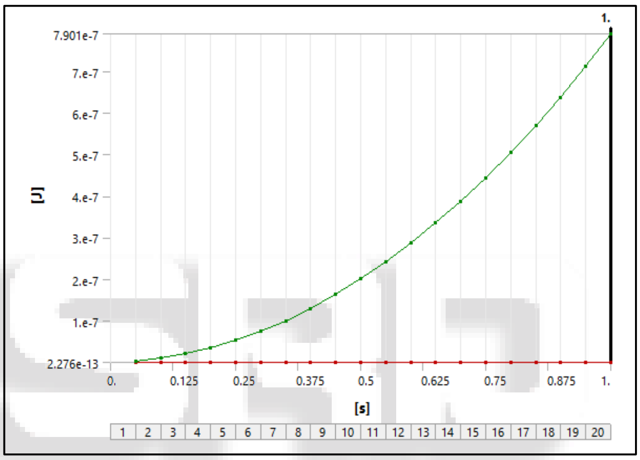


Fig. 10: By analysis in ANSYS software, Total Strain Energy generated in Aluminium Alloy Oldham Coupling Central Disc



Graph 8: Total Strain Energy maximum generated in Aluminium Alloy Oldham Coupling Central Disc is of 7.9×10^{-7} J & minimum is of 2.27×10^{-13} J

V. CONCLUSION

From the above graphs, it is found that Total Deformation, Equivalent Shear Strain, Equivalent stress & Strain Energy for Oldham Coupling Central Disc is well predicted by the Finite Element modal.

Hence, Finite Element Analysis Model is a good tool of ANSYS to predict the Different performance characteristic of any working mechanical model.

On the basis of the current work, it is concluded that:

Any Performance parameter can be efficiently predicted by the Finite Element Analysis. ANSYS is efficient Software to analyse the performance of Oldham Coupling working process and results accuracy is totally depends upon the perfection of the boundary condition. On the basis of results, we conclude that material of the central disc should be similar in nature. So, for the similar load and total deformation we got the better results for fluctuating motion.

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