A Literature Review on Failure in Single Plate Clutch System

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Abstract— Clutch system is among the main systems inside a vehicle. Clutch is a mechanical device located between a vehicle engine and its transmission and provides mechanical coupling between the engine and transmission input shaft. Clutch system comprise of flywheel, clutch disc plate and friction material, pressure plate, clutch cover, diaphragm spring and the linkage necessary to operate the clutch. The clutch engages the transmission gradually by allowing a certain amount of slippage between the flywheel and the transmission input shaft. However, the slipping mechanism of the clutch generates heat energy due to friction between the clutch disc and the flywheel. At high sliding velocity, excessive frictional heat is generated which lead to high temperature rise at the clutch disc surface, and this causes thermo-mechanical problems such as thermal deformations and thermo-elastic instability which can lead to thermal cracking, wear and other mode of failure of the clutch disc component.

Key words: Clutch system comprise of flywheel, clutch disc plate and friction material, pressure plate, clutch cover.

I. INTRODUCTION

The clutch is a mechanical device, which is used to connect or disconnects the source of power from the remaining parts of the power transmission system at the will of operator. The clutch can connect or disconnect the driving shaft and driven shaft. An automotive clutch can permit the engine to run without driving the car. This is desirable when the engine is to be started or stopped, or when the gears to be shifted. Clutch is a mechanism for transmitting rotation, which can be engaged and disengaged. The clutch connects the two shafts so that they can either be locked together and spin at the same speed (engaged), or be decoupled and spin at different speeds (disengaged). Depending on the orientation, speeds, material, torque produced and finally the use of the whole device, different kinds of clutches are used. The clutch in itself is a mechanism, which employs different configurations. The friction clutch is an important component of any automotive machine. It is a link between engine and transmission system which conducts power, in form of torque, from engine to the gear assembly. When vehicle is started from standstill clutch is engaged to transfer torque to the transmission; and when vehicle is in motion clutch is first disengaged of the drive to allow for gear selection and then again engaged smoothly to power the vehicle. Generally there are two types of clutches based on type of contact

- Positive clutch
- Friction clutch

Single plate comes under the category of friction clutch.

Desirable properties for friction materials for clutches:

- The two materials in contact must have a high coefficient of friction.
- The materials in contact must resist wear effects, such as scoring, galling, and ablation.
- The friction value should be constant over a range of temperatures and pressures.
- The materials should be resistant to the environment (moisture, dust, pressure).
- The materials should possess good thermal properties, high heat capacity, good thermal conductivity, withstand high temperatures Able to withstand high contact pressures
- Good shear strength to transferred friction forces to structure.

II. WORKING PRINCIPLE OF CLUTCH SYSTEM

The clutch principle is based on friction. When two friction surfaces are brought in contact with each other and pressed they are united due to friction between them. If one is revolved the other will also revolve. The friction between the two surfaces depends upon. Area of the friction, Pressure applied on them.

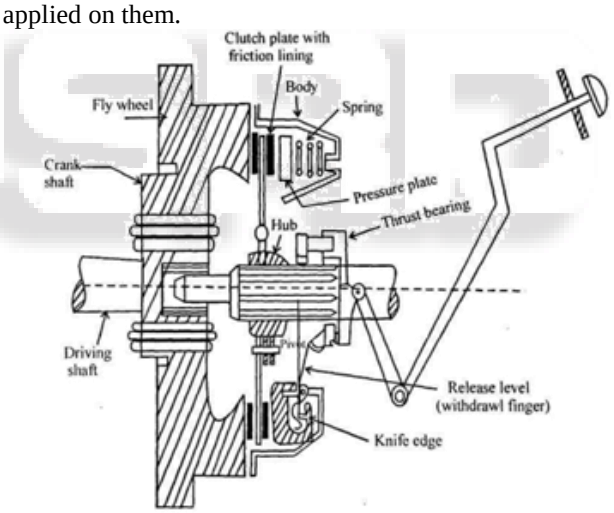

Fig. Single Plate Clutch

III. LITERATURE REVIEW

Static And Dynamic Analysis of Clutch Plate With Crack By N.V.Narasimharao [2] has Done Research Work On Investigate How A Crack Propagates And Grows In A Clutch. A Clutch Plate Is Analyzed For Crack Propagation For Different Materials Aluminum Alloy 6061, Aluminum Alloy 7475, Composite Materials S2 Glass And Kevlar. Theoretical Calculations Are Done To Determine Stress Intensity Factor, Crack Extension Force, Crack Opening Displacement. . From Dynamics And Fracture Mechanics, It Is Well Known That Accelerated Crack Nucleation And Micro-Crack Formation In Components Can Occur Due To Various Reasons, Such As Transient Load Swings, Higher Than Expected Intermittent Loads, Or Defective Component Materials. Normal Wear Causes Configuration Changes That Contribute To Dynamic Loading Conditions That Can

Cause Micro Crack Formation At Material Grain Boundaries In Stress Concentrated Regions (Acute Changes In Material Geometry).

So, Finally They Conclude That If The Crack Propagates In The Composite Materials, They Tend To Fail Faster Than Aluminum Alloys Thereby Reducing Their Life. So Care Should Be Taken For Composite Materials Not To Get The Crack.

Analysis Of Multidisc Clutch Using Fea By Ganesh Raut [3] presents The Structure Analysis Of Multi Plate By Varying The Friction Surfaces Material And Keeping Base Material Aluminum Same.

Structural Analysis Is Done On The Friction Plates To Verify The Strength. Friction Materials Used Are Lo31and Hybrid Sf-Bu.

By Observing The Analysis Results, The Maximum Shear Stress, Von-Mises Stress And Total Deformation Values For Hybrid Sf-Bu Are Less Than Lo31 Respective Values. So That For Multi Plate Clutches Using As Hybrid Sf-Bu Friction Material Is Advantageous Than Using Lo31 As Friction Material.

Static Structural Analysis Of Multi Plate Clutch With Different Friction Materials This Paper By. Anil Jadhav [3] Is Concerned The Structure Analysis Of Clutch Plate Is Done Over Cork, Copper And Sa92 As Friction Lining For Pulsar Dtsi Model.

The Intensity Of Axial Pressure Was Calculated By Using Uniform Pressure Theory And Uniform Wear Theory. As The Structural Behavior Of The Friction Lining Of Multi Plate Clutch Can Be Studied By Analyzing Just A Single Clutch Plate, Hence In This Study, Structural Analysis Of A Single Clutch Plate Has Been Carried Out In Ansys Workbench.

The Von Mises Stress, Von Mises Strain And Total Deformation Values For The Three Materials Obtained From The Analysis Were Compared And The Best Friction Material Was Selected. From Analysis It Can Be Concluded That, On The Strength Basis, Sa92 Is More Suitable And Quite Better Friction Material Than Copper And Cork For Same Rated Torque.

Dynamic Analysis Of Single Plate Friction Clutch This Paper By Shrikant V. Bhoyar [3] is Published To Find Duration Of Engagement Period Is Calculated For The Selected Power Transmission System And Energy Dissipated During Engagement. The Effect Of Excitation Torque And Damping Coefficient On The Amplitude Of Vibration Is Plotted For Various Values Of Excitation Speeds.

The Effect Of Excitation Torque And Damping Coefficient On The Amplitude Of Vibration Is Plotted For Various Values Of Excitation Speeds.

For Different Values Of "T" Energy Dissipated In The Clutch During Engagement Period Is Calculated And Tabulated. From Analysis They Concluded

- Duration Of Engagement Period Is Calculated And Found To Be Equal To 0.063 Sec.
- For Various Values Of „T", Energy Dissipated W.R.T. Engagement Period Is Plotted And Graph Shows That During Engagement, Energy Dissipated Goes On Decreasing.
- Amplitude Of Vibration Depends On Damping Coefficient And It Decreases With Increase In Damping Coefficient.

Vibration Analysis Of Dry Friction Clutch Disc By Using Finite Element Method By Prashil M. Mhaiskar [3] is on A Numerical Technique (Finite Element Method) Is Used To Model A Disc Of Friction Clutch And Compute The Natural Frequencies And Mode Shapes Are Computed For Dimensionless Radius Ratio (R) And Also For Thickness (Tp). The Modal Analysis Has Been Done Using Ansys 14.5 Software For Vibration Characteristics Determining The Natural Frequencies And Mode Shapes Of The Designed Structure. In All Computations For The Dry Clutch Disc, It Has Been Assumed Homogenous And Isotropic Materials, And All Parameters And Materials Properties.

So Finally They Conclude That That The Values Of Natural Frequencies Increase When The Dimensionless Radius Ratio (R) Increase. The Reason For This Result Is Due To The Change In The Mass Of Frictional Lining (When R Increases The Mass Of Frictional Lining Decreases And R Decreases The Mass Of Frictional Lining Increases).And The Values Of Natural Frequencies Increase When Thickness (Tp) Of Disc Increases. The Reason For This Is Increase In Thickness Increases The Stiffness Of Disc. Therefore The Natural Frequency Of Disc Increases.

Design And Finite Element Analysis Of An Automotive Clutch Assembly By Rajesh Purohit[3] The Static Structural Analysis Was Done Using Ansys Software Of The Assembly Of The Clutch Plate, The Pressure Plate And A Diaphragm Spring. The Plots For Equivalent Stress, Total Deformation And Factor Of Safety Were Obtained And The Design Was Continuously Optimized Till A Safe Design Was Obtained. Uniform Wear Theory Was Used For The Analysis.

They Said That It Is Possible To Predict Clutch Wear. The Front Surface Temperature Of A Clutch Pressure Plate Is Studied For Clutch Wear Prediction. A Combined Deterministic Plus Stochastic Modeling Approach Is Used To Fit The Front Surface Temperature Data.

The Material Assignment Is As Follows: Clutch Plate- Structural Steel, Pressure Plate- Cast Iron Gs-70-02 And Diaphragm Spring- Spring Steel. The Friction Material Assumed Is Molded Asbestos Opposing Cast Iron/ Steel Surface.

So Finally They Conclude From The Finite Element Analysis Was Carried And Find Equivalent Von-Mises Stress, Total Deformation And Stress Tool (Factor Of Safety) Were Calculated And Analyzed. The Finite Element Analysis Showed That The Designed Friction Clutch Assembly Is Safe.

Design And Analysis Of Clutch Using Sintered Iron As A Friction Material This Paper By Mamta G. Pawar[3] The Modeling Of Clutch Is Done In Detailed Using Modeling Software. After That The Fem Analysis Is Done For Sintered Iron Friction Material. The Stresses & Deformation Obtained For This Friction Material Is Then Compared To Analysis Software Result. At High Sliding Velocity, Excessive Frictional Heat Is Generated Which Lead To High Temperature Rise At The Clutch Disc Surface, And This Causes Thermo-Mechanical Problems Such As Thermal Deformations And Thermo-Elastic Instability Which Can Lead To Thermal Cracking, Wear And Other Mode Of Failure Of The Clutch Disc Component.

By Analysis They Concluded The Stresses Using Kevlar As A Friction Material & Sintered Iron Is Near About Same. Torque Transmission Capacity Of Sintered-Iron Friction Material Is 350 To 400n Which Is More Than Kevlar. Total Deformation In Kevlar Material Is Less Than Sintered-Iron Friction Material. Sintered-Iron Material Can Sustain Higher Temperature.

Analysis Of Friction Clutch Plate Using Fea By P.Naga Karna[2] Present Work Is To Observe The Stress Distribution And The Temperature Distribution Of The Clutch Plate By Changing The Material. It Is Observed That The Same Required Out Put The Dimensions Of Clutch Plate Are Various With Respect To The Material. And For That We Are Taken One Existing Clutch Plate Dimensions And Modeled It By Using Pro-E After Analysis Is Done By Using Ansys.

They Concluded Is That For The Steel Material The Stress Intensity And Displaced Shape Results Are Better Than Aluminum In Static Analysis And In Thermal Analysis Also For The Steel Material The Thermal Flux And Thermal Gradient Are Better Than Aluminum. They Came To Know That Steel Is The Best Material For Clutch Plate And It Will Be Replaced By Any Other Composite Material Or An Alloy Or A Reinforced Material.

Design And Analysis Of Clutch Plate Using Steel Material [En –Gjs-400 -15steel] By B. Nivas [4] To Reduce The Cost Of Clutch Plate Material Without Affecting The Life And Effectiveness Of The Clutch Plate, We Modify Other Material Low Carbon Steel For Clutch Plate. The Advantage Of This Project Is To Reduce The Cost Of Clutch Plate Without Affecting The Function And Life Of Clutch Plate. They Use Steel En Gjs-400-15 As Optional Material To Grey Cast Iron. These Materials Also Have Similar Properties Of Grey Cast Iron. From Analysis They Conclude D That Maximum Deformation In Mm (Pressure Plate).

After analyzing the materials, we found out von misses stress in MPa (overall component) that the suitability of EN GJS-400-15 steel for the production of clutch plate is better than Grey Cast Iron (FG300). En 15 steel reduces the Stress on the support link is 167.911 MPa, where as the yield stress of FG300 is 181.033, so the life of the material should be high. Stress on the pressure plate is reduced to 46.937MPa, whereas stress on grey cast iron is 52.145MPa.

IV. CONCLUTION

Clutch failure and damaged due to excessive frictional heat and heat fluctuations to the clutch counter mate disc often happens to any type of automotive clutches. These situations contribute to thermal fatigue to the component which causes the clutch counter mate disc to crack and deform. This later will create problems such as clutch slip, clutch drag or failure of clutch to disengage properly and clutch rattling as well as shortening the lifecycle of the component.

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