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“A REVIEW ON MULTI PLATE CLUTCH WITH DIFFERENT MATERIAL”

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ABSTRACT

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. A detachment between continually turning driving rod and the gearbox should be acknowledged to have the option to stop just as to switch gears. Among numerous standards in plan, the traditional grating plate clutch has set up it' position in vehicle plan. Three dimensional model of the contact surface of grip plate was fabricate dependent on limited component strategy to decide the warm conduct of erosion grasp framework. The contact pressure between the contact surfaces was assumed uniform during all commitment. It was tracked down that rehashed commitment impact the surface temperature.

Key Words: Dry friction clutch Successive engagements, Temperature distribution Finite element analysis.

I. INTRODUCTION

Friction clutches and brakes are considered to be the most common type used in automotive application. Two or more surfaces are pressed together by a normal force to create a friction torque. The friction surfaces could be flat and perpendicular to the axis of rotation. Figure 1 shows the main parts of typical single-disc clutch system during engagement and disengagement operations. The requirement for an accurate estimation of the surface temperature of the friction clutch increases for different applications in the mechanical engineering field to avoid the early failure or damage in the contact surfaces. Faidh-Allah [1] developed a thermolelastic finite element model of the friction clutch (single clutch disc). The effect of different friction materials (material properties) on the thermal and mechanical behavior was investigated intensely. Organic and Sintered friction materials was used as a friction facing of the clutch disc. The results showed the temperature distribution, the heat flux due to friction and the contact distribution on the contact surfaces of the friction clutch at any time during engagement. It was found that the highest temperature and contact pressure occurred when using Organic friction material.

II. ENERGY CONSIDERATIONS

Heat Transfer is a kind of energy transportation, where the heat will be transferred by conduction, convection and radiation. The relative motion that occurred between the clutch parts, due to this fact one can be neglect the effect of radiation [1-4]. The input and output powers to the clutch system are explained in Figure 2. It was clear from mentioned figure that the energy was classified into two categories. The first category was the mechanical energy (Pm. input and Pm. output) and the second one was the thermal energy (Pt. output).

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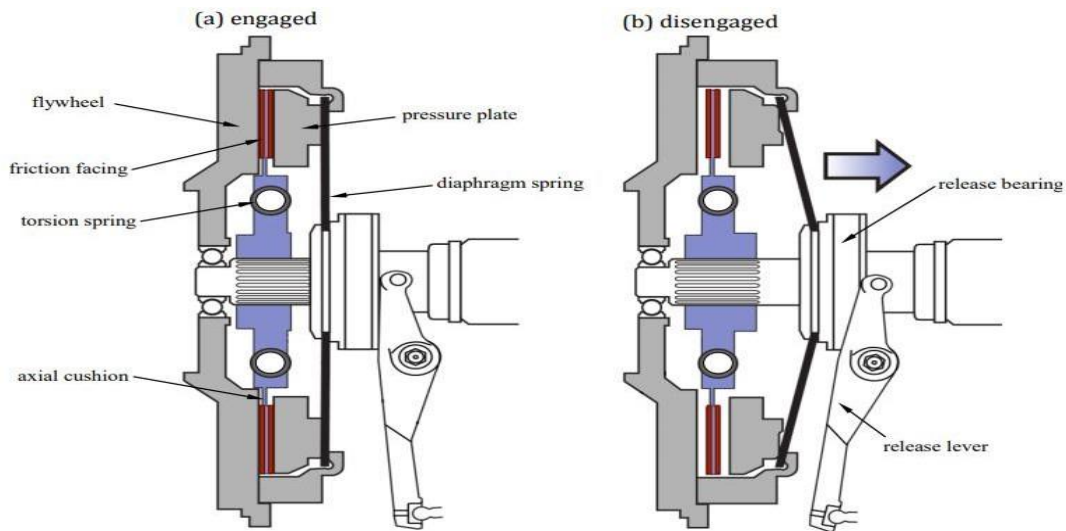


Fig. 1. Major parts of a single-disc clutch system

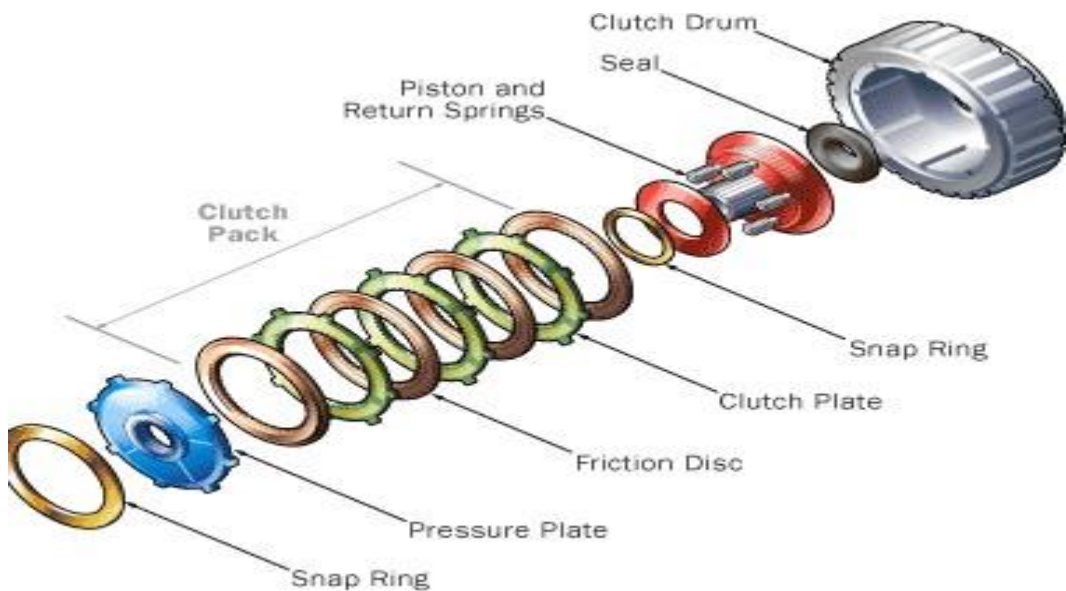


Fig. 2. Input and output powers of the clutch system

III. LITERATURE REVIEW

The Friction plate used right now part of a Wet Multi-Plate grasp System which is conventionally used in business Motor vehicles. The hold Friction plate is arranged between the Clutch Center and the Pressure plate. The grip ingest the vibration sway during hold duty similarly as interfacing the grip counter mate plate and the grasp circle base together.

Abdullah et al [2010] investigated the temperature field and the essentialness scattered from dry pounding handle during a single and reiterated responsibility under uniform pressure and uniform wear conditions. They furthermore analyzed the effect of weight between contact surface while fluctuating with time on the temperature field and within essentialness of handle plate using two strategies heat fragment extent approach to manage register the glow delivered [http:// www.ijrtsm.com](http://www.ijrtsm.com) © International Journal of Recent Technology Science & Management

for each part solely however the second applies the total warmth made for the whole model using contact model.[1]

Hua Fu [2010] In request to developed the appropriate rubbing materials of Tunnel Boring Machine (TBM) grasp plate, the temperature field of contact interface was set up by Finite Element Analysis (FEA) programming ANSYS. The recreation results shows that the most elevated temperature at the grinding interface is roughly 370-. At the sliding interfaces, the warmth influenced area of grating facings is far not as much as that of counter circle. With the gripping time is drawn out, the distinction of warmth influenced zone in sliding framework turns out to be progressively particular, and the warmth influenced zone of the partner is a lot bigger than that of the grating materials.

El-Sherbiny and Newcomb [1976] the temperature dissemination in the erosion circle, flywheel and weight plate was determined utilizing thermo-versatile limited distinction technique so as to explore the impact of contact zone on temperature rise. They anticipated temperatures of 100–120 °C for a solitary commitment and 280–300 °C for numerous commitment that included sliding occasions of up to 2 s.

Maucher [1990] examined the impact of frictional execution of the grasp lining material on the created torsional vibrations. He reasoned that rubbing actuated torsional vibrations of the grip framework show up with low drivetrain damping and especially with a negative angle for the coefficient of grinding variety with grasp confronting slip speed, while the clasp load, torsional firmness and mass snapshot of dormancy of the grasp indicated slight impacts.

Anderson [1990] presented and talked about four car erosion framework problem area types. These are ill temper, central, distortional, and provincial. Grating material and metal counter surface wear outcomes are talked about, as they identify with the diverse hot spotting types. Central problem areas are stressed. These may shape marten site on the cast iron drum or circle scouring surface. Such problem areas, if not forestalled, can give an underlying driver to unsuitable exhibition or strength in car contact frameworks. PC contemplates, utilizing a two dimensional model, are utilized to supplement the exploratory investigations of basic problem areas and decide problem area warm motion limits. Surface liquefying and known prerequisites for the development of marten site are utilized to build up limits from the PC investigation.

Sawanobori and Suehiro [1995] detailed their consolidated exploratory test apparatus and dynamic displaying for the examination of the grasp judder marvel. They inferred that the significant reason for judder is the variety in pivotal (brace) load coming about because of any misalignment of the driveline framework. Also, judder was demonstrated to be affected by the grip rubbing attributes, the commitment time and the situation of the base of the downturn in the contact sliding rate variety. The reproduction results showed that judder happens at a position, where the hub load arrives at its most extreme worth, and the flywheel speed drops only before the full commitment.

Bostwick et al. [1998] utilized a devoted grasp dynamometer to explore oneself energized vibrations during grip commitment. They established that judder emerges due to the thermo-flexible twisting of reaching surfaces, or misalignments in the drivetrain, just as a negative coefficient of erosion of grasp fixing material with interfacial slip speed.

Velardocchia et al. [2000] likewise considered the warm conduct of grasp frameworks, utilizing a basic direct warm model to foresee the temperature ascend in the grip circle. Their model depended on protection of vitality applied to the grating circle and ignoring different segments of the grip get together, for example, the flywheel and the weight plate. Their model created results quicker, from a computational perspective, when contrasted and FEA. The exactness of their model and the anticipated outcomes are, be that as it may, indistinct as no approval information were given.

Crowther et al. [2005] utilized lumped parameter displaying to explore grip judder. Two models were created, one with four degrees of opportunity (4-DOF) and another with 12 degrees of opportunity, including a programmed transmission, differential outfitting, and the driveline. It was indicated that the grasp confronting frictional qualities assumes a key job in the age of grip torsional vibrations.

Al-Shabibi [2009] explored elective strategy to tackle the thermo versatile contact issue with frictional warmth age. Two-dimensional axisymmetric limited component model worked to examine the temperature field and weight dissemination of two sliding plates. Steady and shifting velocities were considered in this examination. The outcomes demonstrate that the underlying temperature is demonstrated to be vital since it speaks to the specific arrangement, which can have very unpredictable structure, this circumstance particularly evident when the framework works over the basic speed.

Shahzamanian et al. [2010] utilized numerical recreation to consider the transient and contact examination of practically evaluated (FG) brake plate. The material properties shift in the spiral course from full metal at the inward span to that of full-ceramic at the external sweep. The coulomb contact grinding is considered between the cushion and the brake disk. Two-dimensional limited component model utilized in the work to acquire the weight dissemination, absolute burdens, cushion entrance, rubbing stresses, heat motion and temperature during the contact for various estimations of the contact firmness factor. It found, that the contact weight and contact absolute pressure increment when the contact solidness factor increments and the degree of the metal-clay has huge impact on the thermo mechanical reaction of FG brake circles. Additionally, it tends to be finished up when the thickness of the cushion builds the contact status among cushion and circle changes from adhering to contact and afterward to approach contact.

Menday et al. [2010] created point by point multi-body dynamic models, including estimated grip interfacial frictional attributes. They indicated that notwithstanding the grasp lining negative coefficient of erosion slant qualities with interfacial slip, loss of cinch load because of rushed arrival of grip pedal expands the affinity to judder.

Muhammad Mumtaz et al [2013] Abdullah and Josef Schlattmann delineated about transient thermoelastic assessment of dry grasp system. The high warm weights, made between the arriving at surfaces of handle system (pressure plate, hold circle and flywheel) on account of the frictional warming during the slipping, are seen as one of the standard reasons of handle frustration for contact surfaces. A restricted segment methodology has been used to consider the transient thermo adaptable wonders of a dry handle system. The effect of sliding speed on contact pressure dispersal, temperature field and warmth progress made along the frictional surfaces is inquired about.

Mamta G. Pawar et al [2013] depicted about arrangement and assessment of handle using sintered iron as a disintegration material. At the present time, exhibiting of grasp is done in point by point using showing programming. After that the FEM assessment is cultivated for sintered iron contact material. The weights and misshapening got for this scouring material is then diverged from examination programming result. The assessment is practiced for annihilated grinding plate.

Shrikant V. Bhoyar [2013], a basic transmission framework comprising of motor, grasp, gearbox and burden is intended for the heap lifting application. Solidness of all the three shafts have been determined and equal firmness is determined. Proportional mass snapshot of dormancy is additionally determined. From this information, utilizing the ideas given by Prof. DOW, span of commitment period is determined for the chose power transmission framework and vitality scattered during commitment is additionally plotted as a component of time.

P.Naga Karna [2013] 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. Furthermore, 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.

Anil Jadhav [2013] 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.

Ganesh Raut [2013] presents The Structure Analysis Of Multi Plate By Varying The Friction Surfaces Material And Keeping Base Material Aluminum Same. Basic Analysis Is Done On The Friction Plates To Verify The Strength. Rubbing Materials Used Are Lo31 and 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.

N.V.Narasimharao [2013] 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. Hypothetical 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. Ordinary 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).

B. Nivas [2014] 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 Gray Cast Iron. These Materials Also Have Similar Properties Of Gray Cast Iron. From Analysis They Conclude D That Maximum Deformation In Mm (Pressure Plate).

Rajesh Purohit[2014] 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.

Hard Chrisol Joseph et al. [2014] Multiplate handle is one of the critical parts in the power transmission structures. Incredible structure of hold gives better system execution. Multiplate grasp is commonly used in hustling cars and unshakable vehicles which have space hindrances and require high torque transmission. At the present time multiplate handle has been arranged by using precise formulae. The multiplate handle has been shown using SOLIDWORKS 2013 and imported in ANSYS workbench for performing helper examination. The Von Mises pressure has been constrained by changing the grinding surfaces material-SFBU and Kevlar 49. The SFBU grinding material and Kevlar 49 pounding material are considered subject to the hard and fast contorting of the grasp plate to find the better covering material.

Oday I. Abdullah et al [2014] depicted about thermoelastic assessment of multidisc handles using restricted segment system. A restricted part strategy has been used to think about the transient thermo adaptable miracles of a multi-plate dry handle. The results present the contact pressure transport, the temperature appraisal, and the glow movement made along the frictional surfaces. Assessment has been done using two-dimensional axi symmetric model to imitate the multi-plate handle. ANSYS programming has been used to play out the numerical figuring at the present time.

Prashil M. Mhaiskar [2014] is on A Numerical Technique (Finite Element Method) Is Used To Model A Disk 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 Disk, 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 Disk Increases. The Reason For This Is Increase In Thickness Increases The Stiffness Of Disk. Accordingly The Natural Frequency Of Disk Increases.

Rajesh Purohita [2014] The motivation behind a grip is to start movement or increment the speed of a body for the most part by moving active vitality from another moving body. The mass being quickened is commonly a turning inertial body. The current paper manages structuring an erosion grasp gathering utilizing Solid Works Office Premium programming. The get together includes the grasp plate, the weight plate and a stomach spring. Static basic investigation was finished utilizing ANSYS programming. The plots for comparable pressure, complete distortion and factor of wellbeing were gotten and the plan was ceaselessly improved till a protected structure was acquired. Uniform wear hypothesis was utilized for the investigation. The material task is as per the following: grip plate-basic steel, pressure plate-cast iron GS-70-02 and stomach spring-spring steel. The grating material accepted that is shaped asbestos restricting cast iron/steel surface.

K.S.Aravindh et al [2015] The critical piece of any vehicle machine is the disintegration grasp. Handle is a framework for transmitting insurgency which can be secured and pulled back. It is an association among engine and transmission structure which practices power as torque from engine to the apparatus get together. Right when vehicle is moving handle is first isolated for the drive to think about apparatus assurance and a while later again associated effectively to control the vehicle to move torque to the driving wheels. In the present work, an undertaking is made on wet multi plate handle with varying disintegration material. The lead of the grip or brake is influenced by the scouring mix when being secured and pulled back, the sensible warm stacking and the direct in regards to mileage should be considered.

Guruprasad Shriwas et al [2015] A grip is a significant machine component which assumes a principle job in the transmission of intensity starting with one segment then onto the next. A typical and notable application for the grip is in car vehicles where it is utilized to interfaces the motor and the gearbox. As the grasp is working condition it experiences the effect of erosion power and warming of surface and subsequently wear happens, which decreases the life of grip. In this paper softly center the grinding grasp configuration is unequivocally needy upon the frictional warmth created between contact surfaces during the slipping at start of commitment. The absolute wears regarding the variable (time, burden and speed) by the assistance of pin on circle strategy to assess the property of material for relative investigation of them.

Gkinis et al. [2016] likewise made a 4-DOF grasp commitment model, consolidating the deliberate grip erosion lining attributes through utilization of pin-on-circle tribometry in accordance with SAE (Society of Automotive Engineers) and ASTM (American Society for Testing and Materials) gauges additionally indicated that stick-slip rubbing, brought about by a negative slant of coefficient of grinding variety with slip at the grip plate interface, is the fundamental driver of grasp take-up judder. They likewise indicated that the judder reaction range is more extensive than that recently announced yet is increasingly perceivable with higher amplitudes of wavering in the range 8–20 Hz.

Joel Martinsson [2016] Controlled Start Transmissions can be portrayed as a mechanical transmission joined with a water driven grasp for controlled torque yield. CSTs are generally used to fire up substantial loads for instance mining

transports and delivers heat during fire up. Models for CST grasp heat age along with warm conduct has been created and examined. This incorporates a temperature model along with a motor model of the gearbox and a torque model of the grip. Approval of discrete model segments and affectability investigation of parameters are directed. The created models are then contrasted by examining estimations and reenactments with research produced heat during customary use.

Dr.Ch.S.Naga Prasad [2017], In this proposition, the general preface to the strategy, structure and some major thought of multi plate wet sort handle. Fluid accept a huge activity right presently hold so a part of their properties are analyzed. A couple of incidents in light of structure parameters are in like manner analyzed. To meet the necessities of low fuel use, incredible driving execution and amassing feasibility. This paper will give a structure diagram of the transmission plan, major characteristics, key subsystems and control strategies. This gives better cognizance about working guideline of handle, material used for making the grasp plates. Effect of structure thought can be furthermore considered during its application in various conditions. At the present time, plan a multi plate hold by using trial plans. A 2D drawing is drafted for multi plate handle from the checks and a 3D model is made in the exhibiting Software Pro/E for Automobile Applications. We have coordinated fundamental examination by fluctuating the contact surfaces material. By evacuating the results Comparison is cultivated for the two materials to support better covering material for multi plate catch to find which material is best for the covering of grinding surfaces. Examination is done in ANSYS programming.

Guguloth Ravi [2017] A grip is a mechanical gadget which accommodates the transmission of intensity (and along these lines typically movement) from one segment (the driving part) to another (the determined part). The contrary part of the grip is the brake. A multi plate grip might be utilized when an enormous torque is to be transmitted. Within plates are secured to the determined shaft to allow hub movement. The materials utilized for coating of contact surfaces are Asbestos, Cork, Rubber, Cast iron, Powder metal. The point of the undertaking is to structure a multi plate grasp by utilizing observational equations. A 2D drawing is drafted for multi plate grasp from the computations and a 3D model is made in the 3D displaying programming Creo. Auxiliary, modular and exhaustion examination is accomplished for multi plate grip utilizing the properties of the three materials. External material is steel and Materials utilized for contact plate are differed Cast iron, Cork and Asbestos. Correlation is accomplished for above materials to approve better grating material for multi plate grip under the heap conditions while switching the gears. Investigation is done in Ansys software.

Seyoum Kebede [2018] Able multi-plate holds to use in twin grasp transmission (TCT) structure for green and Light Weight Vehicle. The static and dynamic assessment were created for a grip plate by using restricted part examination (FEA). The 3D solid model was done using SOLID WORK 2016 and imported to ANSYS work seat 16 for model assessment. The logical showing was similarly done using unmistakable interminably open materials (for instance Aluminum compound 6061, EGlass Epoxy, and Gray Cast iron); by then, by viewing the results, connection was carryout for materials to favor better covering material for multi plate holds using ANSYS workbench 16 in conclusion gathered that composite material E-Glass Epoxy has an unrivaled grinding material for structure of multi-plate gets a handle on in TCT framework.

M.H. Faidh-Allah [2018] Realistic applications to arrive at the alluring pace. The customary hypothetical strategy to process the temperature field explicitly the most extreme temperature showed up in the surfaces of the grating grip plate just during the single commitment is bootlicker to get an effective structure which fulfills the needs today. The temperature fields were processed during 6 back to back commitment when the full commitment time frame was 5s. Three dimensional model of the grating surface of grasp plate was manufacture dependent on limited component method to decide the warm conduct of grinding grip framework. The contact pressure between the contact surfaces was assumed uniform during all commitment. It was discovered that rehashed commitment impact the surface temperature.

Liping Li [2018] Car judder is a sort of back-forward vibration during vehicle beginning which brought about by the torsional swaying of the driveline. This paper presents a precise report on the dynamic reaction attributes of the grasp driven plate for concealment of the judder during vehicle beginning. Self-energized vibration conduct of the grasp

driven plate is investigated dependent on the created 4DOF non-direct multi-body dynamic model of the grip driving procedure considering stick-slip attributes and utilizing Karnopp grinding models. Physical parameters of a grasp deciding the ages of the judder practices are examined and the changed structures of the determined circle of a grip for concealment of the judder are subsequently explored and approved with tests for two genuine vehicles.

Gkinis et al. [2018] built up a grip warm system model and utilized a warmth parcel strategy to decide the temperature of grasp interfaces with rehashed commitment. They additionally indicated that exhaustion of warmth leading components in the contact lining material (e.g., copper) influences its frictional attributes and influences the judder.

ZHENGFENG YAN [2019] The attributes of the grasp commitment procedure would have significant influences on the torque transmissibility and activity comfort. Be that as it may, some significant segments are simplified in numerous past writing, which would cause imprecision. In this way, it is essential to fabricate a nitty gritty numerical model of these parts and review the entire procedure of grip commitment. Moreover, models of the pivotal parts, for example, the stomach spring, which associates the ties and pad plate, are assembled and the comparing mechanical properties are broke down. In view of the assembling resilience, the existence cycle, and the wear properties, stomach spring rectification equation is proposed by alluding to Almen-Laszlo technique. On the framework level, the entire commitment process is separated into four phases on account of the contrasts between the drawing in and withdrawing forms, which would influence the pedal discharging solace in the manual transmission framework and the moving quality in the robotized transmission framework. To exhibit the viability of the proposed technique, point by point mathematic models are assembled and the relating tests are directed.

REFERENCES

- [1] El-Sherbiny, M.; Newcomb, T.P. Temperature conveyances in car dry grasps. *Proc. Inst. Mech. Eng.*, 190, 359–365, 1976
- [2] Maucher, P. Grip prattle. In *Proceedings of the fourth International Symposium on Torsional Vibrations in the Drive Train*, Baden-Baden, Germany, 20 April 1990.
- [3] A.E. Anderson: "Hot Spotting in Automotive contact Systems", *J. of Wear*, Vol. 135, No. 2, pp. 319-337, 1990
- [4] Sawanobori, T.; Suehiro, T. An Analysis of Clutch Judder; SAE Technical Paper, No. 95131; SAE:Warrendale, PA, USA, 1995.
- [5] Bostwick, C.C.; Corp, C.; Corp, E. Self-energized vibrations during commitment of dry contact grasps. *SAE Trans.*, 107, 689–701, 1998
- [6] Velardocchia, M.; Amisano, F.; Flora, R. A Linear Thermal Model for an Automotive Clutch; SAE Technical Paper, No. 2000-01-0834; SAE:Warrendale, PA, USA, 2000.
- [7] Crowther, A.R.; Zhang, N. Torsional limited components and nonlinear numerical displaying in vehicle power train elements. *J. Sound Vib.*, 284, 825–849, 2005
- [8] Abdullah M. Al-Shabibi and James R. Hair stylist: Transient Solution of The Unperturbed Thermo versatile Contact Problem, *J. warm anxieties*, Vol. 32, pp. 226-243, 2009
- [9] M.M. Shahzamanian, B.B. Sahari, M. Bayat, Z.N. Ismarrubie and F. Mustapha: Transient and warm contact investigation for the versatile conduct of practically reviewed brake plates because of mechanical warm loads, *J. Materials and Design*, Vol. 31, Issue 10, pp. 4655–4665, 2010.

- [10] Menday, M.; Rahnejat, H. Rubbing arranging qualities and the grasp take judder wonder with manual transmission. In Tribology and Dynamics of Engine and Power train: Fundamentals, Applications and Future Trends; Rahnejat,H., Ed.;Woodhead Publishing: Cambridge, UK,; pp. 680–702, 2010
- [11] Abdullah M. Al-Shabibi, "The Thermo-mechanical Behavior in Automotive Brake and Clutch Systems," in New Trends and Developments in Automotive System Engineering, 2010.
- [12] Hua Fu, Li Fu, Ai-ping Liu, Guan-Lei Zhang "Constrained Element Analysis of temperature field of handle in Tunnel Boring Machine" WASE International Conference on Information Engineering, IEEE, 2010.
- [13] Muhammad Mumtaz Jamil Akhtar, Oday I. Abdullah, Josef schlattmann "Transient Thermoelastic Analysis Of Dry Clutch System", Department of System Technology and Mechanical Design Methodology, 2013.
- [14] Mamta G. Pawar, Monarch K. Warambhe, Gautam and R. Jodh "Plan and Analysis of Clutch Using Sintered Iron as a Friction Material", International Journal of Innovative Technology and Exploring Engineering., 2013.
- [15] Dr. J. P. Modak, Shrikant V.Bhoyar, Dr. G. D. Mehta, —Dynamic Analysis Of Single Plate Friction Clutchl, IJERT, Vol. 2, Issue 7, July – 2013.
- [16] Mr. P.Naga Karna, Tippa Bhimasankara Rao, —Analysis of Friction Clutch plate using FEAl ,IJERD, Volume 6, Issue 2, March 2013.
- [17] Prof.P.Baskar, Anil Jadhav, Gauri Salvi, Santosh Ukamnal, —Static Structural Analysis of Multi plate Clutch with Different Friction Materialsl IJERT, Volume 2, Issue 11, November 2013.
- [18] Mr.Ganesh Raut, Anil Manjare, P Bhaskar —Analysis of Multidisc Clutch Using FEAl IJETT, Volume 6, Dec 2013.
- [19] Mr.N.V.Narasimharao.L, Ch.Chandrarao —Static and Dynamic Analysis of Clutch Plate With Crackl, IJRMET, Volume 4, Issue Spl - 1, Nov 2013.
- [20] Mr. B. Nivas, M. Nithiyanandam, S. Tharaknath, A. AvinashKumar, —Design and Analysis of Clutch Plate Using Steel Material [En – Gjs-400 - 15steel]l,IOSR-JDMS, Volume 13, Issue 5, May. 2014
- [21] Mr.Rajesh Purohit, Pooja Khitoliya and Dinesh Kumar Koli, —Design and Finite Element Analysis of an Automotive Clutch Assemblyl, ScienceDirect, Procedia Materials Science 6, 2014.
- [22] Bony Chrisol Joseph , M Vasundara Structural Analysis of Multiplate Clutch using ANSYS ' worldwide journal of programming and hardware building vol 2 issue 05, 2014
- [23] Oday I. Abdullah, Wassan Abd AL-SAHB and Abdullah M. Al-Shabibi , "Thermoelastic examination of multidisc Clutches using constrained segment procedure", 2014.
- [24] Mr.Prashil M. Mhaskar, Nitin D. Bhusale, Mayur D. Pastapure —Vibration Analysis of Dry Friction Clutch Disk by Using Finite Element Methodl, IJERT, Volume 3, Issue 1, January – 2014.
- [25] Rajesh Purohita, Pooja Khitoliyab and Dinesh Kumar Kolic "Plan and Finite Element Analysis of an Automotive Clutch Assembly "Procedia Materials Science 6 science direct (2014) 490 – 502

- [26] K.S.Aravindh1, P Uma Mahesh2, K Mohan Krishna3, J "FEM ANALYSIS OF WET MULTI PLATE CLUTCH BY VARYING FRICTION SURFACE MATERIAL" SaiSandeep4International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 06 | Sep-2015.
- [27] Guruprasad Shriwas Prakash Kumar Sen Gopal Sahu A Review on Wear Analysis and Heat Generation in Dry Friction Clutch IJSTE - International Journal of Science Technology and Engineering | Volume 2 , Issue 3 ,2349-784, September 2015
- [28] Humphrey, E.; Gkinis, T.; Morris, N.J.; Leighton, M.; Rahmani, R.; Rahnejat, H. Grip lining frictional qualities under warm tribodynamic conditions. In Proceedings of the third Biennial International Conference on Powertrain Modeling and Control , Loughborough, UK, 7–9 September 2016
- [29] Joel Martinsson , Bin Liu "Controlled Start Transmission Hydraulic Clutch Disk Temperature Modeling and Applications" Proceedings of IEEE International Conference on Mechatronics and Automation August 7 - 10, Harbin, China, 2016
- [30] Dr.Ch.S.Naga Prasad "Structure and Fatigue Analysis of a Multi Plate Clutch International Journal for Modern Trends in Science and Technology" Volume: 03, Issue No: 04, April 2017
- [31] Guguloth Ravi , Thurai Sharat and Maloth Heeralal "Structure EVALUATION OF A MULTI PLATE CLUTCH" March 2017 | IJIRT | Volume 3 Issue 10 | ISSN: 2349-6002.
- [32] Vehicles Seyoum Kebede1, Hailemariam Nigus Hailu2 "Showing, and FEA of Multi-Plate Clutches by Varying Materials for Optimum Torque Transfer Capacity of TCT System of Green, And Light" International Journal of Advanced Engineering Research and Science (IJAERS) [Vol-5, Issue-1, Jan- 2018
- [33] M.H. Faïdh-Allah a "The Temperature Distribution in Friction Clutch Disk under Successive Engagements" Tribology in Industry, Vol. 40, No. 1 (2018) 92-99,
- [34] Liping Li a, b, Zhaijun Lu a, *, Xue-Lai Liu b, Tao Sun b, Xingjian Jing c, Wen-Bin Shangguan b, " Modeling and assessment of contact handle at a driveline for smothering vehicle starting judder" Journal of Sound and Vibration science direct 424 (2018) 335e351 .
- [35] Gkinis, T.; Rahmani, R.; Rahnejat, H.; O'Mahony, M. Warmth age and move in car dry grasp commitment. J. Zhejiang Univ. Sci. A 19, 175–188, 2018 .
- [36] ZHENG FENG YAN, FUWU YAN, JIEJUNYI LIANG , AND YALIN DUAN" Detailed Modeling and Experimental Assessments of Automotive Dry Clutch Engagement" Received April 8, 2019.