

Design Optimization of Industrial and Automobile Clutches- A Review Study

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Abstract— Industrial and automobile clutches are one of the important components of any mechanical assembly. It provides the link between gears and engines. Clutches are prone to get fail regularly causing it to be replaced. This replacement leads to financial losses and undue interruption in working of the components, a clutch is fitted with. Hence in order to minimize these losses, rigorous amount of research is required in the field of industrial and automobile clutches. A lot of research has already been done in this field. Current research paper investigates and analyses the work and research analysis which has already been performed. The results of the literature review (Current state of the art situation) have been presented as the part of conclusion.

Keywords: Design Optimization, Industrial and Automobile Clutches

I. INTRODUCTION

Engineering optimization is the subject which uses optimization techniques to achieve design goals in engineering. It is sometimes referred to as design optimization. The optimization stage of the engineering design process is a systematic process using design constraints and criteria to allow the designer to locate the optimal solution. In an engineering design approach, both analysis and optimization are employed before any prototype work is started.

A clutch is a mechanical device that engages and disengages power transmission, especially from a drive shaft (driving shaft) to a driven shaft. The clutch acts as a mechanical linkage between the engine and transmission; and briefly disconnects, or separates the engine from the drivetrain, and therefore the drive wheels, whenever the pedal is depressed, allowing the driver to smoothly change gears.

In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts). In these devices, one shaft is typically attached to an engine and other to power unit (the driving member). While the other shaft (the driven member) provides output power for work and typically the motions involved are rotary, linear clutches are also possible.

II. LITERATURE REVIEW

Abhishek Borse et al. [1] The automatic transmission in automobiles is a unit which supplies the power from the clutch to the differential. There are some types of gear transmission system. These transmission systems help to improve the economy and efficiency of the work transfer. some machines with limited speed ranges, such as few forklifts and lawn mowers only use torque convertor. Besides the traditional automatic transmission, there are also other types such as continuously variable transmission, dual clutch transmission and automated manual transmission system.

gear shifting strategy is the core of intelligent control of any automatic transmission used in modern vehicles. It directly influences the vehicle performance; drivers feel and fuel economy separately. the comparison between automated manual transmission and automatic transmission system is essential. The strategy of the gear shifting in manual transmission system is specified.

Amir Hussain Idrisi et al. [2] Clutch is the most important component of any automotive machine. It is a mechanism which is used to transmitting the rotation from one shaft to another shaft by engagement and disengagement of the same. It is a connection between engine and transmission system which transmit power in the form of torque from engine to the gear assembly. When vehicle is in motion clutch is first disengaged for the drive to allow for gear selection and then again engaged smoothly to power the vehicle to transfer torque to the driving wheels. In the present work SolidWorks software is used for modelling of two different types centrifugal clutch and ANSYS 14 workbench for static analysis then comparison is made for the maximum principal stress developed and maximum deflection in the three-shoe clutch and rigid body type clutch which can be used in automotive vehicles.

Antonio Della Gatta et al. [3] single and dual dry clutches are widely used in automotive transmissions because of their reliability and efficiency paired with low fuel consumption and reduction of pollutant emissions. A prerequisite to attain these goals in automated manual transmissions is the adoption of a “good” clutch model and the design of a robust control strategy. Several papers have been dedicated to modelling and engagement control of dry clutches, both in mechanical and control engineering literature. The wide practical interest of the application and the maturity of the research field motivate the need for a state-of-the-art analysis on the topic. This paper aims at exploring clutch transmissibility models and engagement control strategies proposed in the last decades. An overview of dry clutch torque modelling is proposed together with a discussion on the main factors which affect the torque transmission, such as temperature, sliding speed, contact pressure, wear. Then, the prevalent clutch actuator architectures and control strategies are analysed by discussing pros, cons and open issues. The survey is concluded by suggesting some topics of interest for future research.

C. M. Meenakshi et al. [4] This project work titled “Electro Magnetic Clutch” has been conceived having studied the automatic clutch mechanism in vehicles. Now the project has mainly concentrated on a suitable control unit has been designed for automatic clutch. The fabrication part of it has been considered with almost case for its simplicity and economy, such that this can be accommodated as one of the essential tools on automobile garages. In our project, the switch is fixed below the braking pedal of the four-wheeler.

The electro-magnet with brake pedal mechanism is used to pushing/pulling of the clutch automatically, when the braking pedal is pressed (Full brake time or gear engaged time).

Dr. Porag Kalita et al. [5] The coupling of two working parts, for example two shaft, in such a way as to permit connection or disconnection at will without the necessity of bringing both parts to rest, and when connected to transmit the required amount of power without sign is known as Clutch and or, the friction or hydraulic actuated mechanism used for coupling two shafts or similar parts, one of which drives and the other of when is driven by the Clutch. Clutch plate assembly has three principal components i.e., Flywheel, Clutch plate and Pressure Plate. The device used is the Clutch which transmits the rotary motion of the engine to the transmission, which required by the driver and located between the engine and the gear box and which it connects and disconnects the two units smoothly without shock. As per the theory of the Clutch, first assumption is used in case of problems involving power absorption by friction. Second assumption is used in case of problems involving power transmission by friction between the surfaces.

Gowtham Modepalli [6] In this project dynamic analysis of clutch assembly will be carried out. Clutches are useful in devices that have two rotating shafts. In these devices, one of the shafts is typically driven by a motor or pulley, and the other shaft drives another device. The clutch connects the two shafts so that they can either be locked together and spin at the same speed, or be decoupled and spin at different speeds. In evaluating the stresses and strain in the part, modelling and simulation are used. The modelling of the clutch assembly is modelled using 3D software. Here we will be using Pro E for modelling. The simulation part will be carried out using the Analysis software, ANSYS. The created model is exported to ANSYS by converting it to IGES format. The imported model is meshed in ANSYS and boundary constraints are defined. With the Boundary constraints, the stresses and strain of the clutch assembly can be determined and the values are tabulated. Thus, the investigation of stress and strain is carried out using ANSYS. This project will also help to learn Pro E and also ANSYS.

Hailemariam N. Hailu et al. [7] A study on green vehicle was introduced and promoted to minimize the problem of air pollution caused by emissions of conventional vehicle. Green mobility are vehicles with low fuel/energy consumption and low/zero exhaust gas emission, these vehicles are like hybrid, battery powered, and fuel cell electric vehicle that can be enhanced to be more efficient than the conventional vehicles through a new design and development of power transmission system. Power transmission system for green and lightweight vehicles consists of different components like gear box, propeller shaft, differential and final drive. In this review more emphasis is given to gear box due to some reasons: firstly, it is one of the heaviest components of the power train system and as a result weight reduction is critically needed to increase the efficiency of the vehicle. Secondly, gearshift takes place therefore, torque interruption needs to minimize. The use of simulation software's i.e., Mat lab, AME sim, cruise software and other similar programs can simulate high-efficiency power transmission system. The results from the simulation software will be validated by experimental tests

on test rigs. One way of minimizing fuel consumption is to reduce the weight of the gearbox by 10% reduction in vehicle weight can improved fuel economy by about 5-7%. As different researchers confirm that to have high vehicle efficiency the type of the transmission, they used matters. A vehicle using automated manual transmission (AMT) and dual clutch transmission is more efficient in terms of less energy loss and gearshift comfort.

J. ANDO et al. [8] This paper describes the development of the new third-generation electronically controlled all-wheel drive (AWD) coupling that achieves drastically improved drag torque performance and torque accuracy at low temperatures and contributes to higher fuel efficiency through weight reduction in the driveline. One issue for electronically controlled AWD couplings is an increase in torque due to higher lubricant viscosity at low temperatures, especially below 0°C because of clutch slide with the lubricant sealed inside the couplings. The developed third- generation electronically controlled AWD coupling addresses this issue by focusing on the surface texture of the electromagnetic clutch. The third-generation coupling also restricts the torque increase by actively utilizing the dynamic pressure between the clutch plates and increasing the clearance of the clutch plates at low temperatures where viscosity increases. This enables further weight reduction in the driveline. In order to reduce drag torque at low temperatures, a macroscopic sliding surface profile in the order of tens of micrometers is provided on the electromagnetic clutch under fluid lubrication. In addition, to reduce control torque at low temperatures when electric current is applied, the microscopic sliding surface profile on the electromagnetic clutch, which is in the order of several micrometers, was optimized under boundary lubrication. This results in stable torque accuracy at both low and high temperatures.

Kunal Saurabh et al. [9] This paper reveals the fabrication of electromagnetic clutch and braking System. An electromagnetic clutch is a device used to make and break contact from the transmission operate electrically but transmit torque mechanically. An electromagnetic braking system uses magnetic force to engage the brake but the power required for braking is transmitted manually. The disc is connected to a shaft and the electromagnet is mounted on the frame. In this paper when electricity is applied to the coil a magnetic field is developed across the armature. The eddy current is created by the relative motion between a magnet and a metal (or alloy) conductor. The reverse magnetic field is induced which results in the deceleration of motion. This proposed the mechanism which implements this phenomenon in developing an electromagnetic clutch and braking system. This reduces complication to control of clutch and brakes. The operating temperature is limited, because at high temperature insulation of the electromagnet gets damaged.

Mahendra Sahu et al. [10] A Clutch is a machine member used to connect the driving shaft to a driven shaft, so that the driven shaft may be started or stopped at will, without stopping the driving shaft. A clutch thus provides an interruptible connection between two rotating shafts. The present used material for friction disc is Cast Iron and aluminum alloys. In this thesis analysis is performed using composite materials. The composite materials are considered

due to their high strength to weight ratio. In this thesis composite material Kevlar and aluminum Metal Matrix Composite are taken. A single plate clutch is designed and modelled using Catia V5 software. Static analysis is done on the clutch to determine stresses and deformations using materials Grey Cast Iron, sintered iron, Kevlar and aluminum Metal Matrix Composite. Analysis is done in Ansys 16.0. Theoretical calculations are also done to determine stresses.

Mr. Amol A. Parihar et al. [11] A Dual clutch transmission (DCT) is a type of automatic transmission featured with a dual-clutch module and two input shafts. A DCT is able to provide a high-quality gear shifting with a gear pre-selection procedure and overlapping of clutch engagement. The gear pre-selection procedure means that the synchronization of the oncoming gear has been completed before the actual gear shifting procedure starts. And due to the overlapping mechanism of the two clutches, torque is transferred from the engine to the driving wheels without interruption during gear shifting. Therefore, it provides a rapid gear shifting without sacrificing fuel efficiency and riding comfort. In addition, with a precisely computed and accurately controlled slippage of the dual-clutch module, the DCT is able to provide a fast and smooth gear shifting. The performance of a DCT during gear shifting relies on a well-designed clutch engagement controller. A good clutch engagement controller should be able to achieve (1) a fast clutch-to-clutch shifting and (2) a smooth gear shifting without noticeable torque disturbance. This research work proposes a newly designed clutch-to-clutch shifting controller that satisfies both objectives mentioned above. The presented control law is implemented in a linear 9 control method that explicitly separates the controlling of the two clutches. The presented control method can be applied to a wide range of applications with easy implementation and a good robustness. Computer simulations in Simulink proved that the control objectives were realized with a robust and relatively simple controller. According to the simulation results, the average magnitudes of the output torque were reduced by 32.5% with the help of the proposed clutch-to-clutch control law. Also, by observing a couple of contrast simulations, we found that the output torque difference grew larger as the clutch actuator time constant became larger. In addition, simulation results showed that smaller clutch pressure changing rate contributed to a smoother gear shifting.

Mr. K. Venkatesh et al. [12] This design modification is implemented in manual transmission automobiles to reduce the use of human power because of its potential applications as manipulating and managing two pedals (new pedal, brake) is easier than manipulating and managing three pedals (accelerator, brake, clutch). This system can eliminate the clutch pedal and by modifying the accelerator pedal (new pedal) we can make the clutch to engage and disengage itself according to the new pedal. This system has many advantages like it's very easy to operate, to avoid accidents which are due to application of wrong pedals in panic situations and increases the mileage in light traffic conditions. While changing gears and stopping the vehicle we need to release the accelerator and press the clutch. So, the report puts forward a kind of operation that can activate the clutch first and then the action of accelerator in a single pedal.

The main objective of this project is to attach that system to an automobile so that the driver can control with 2 pedals. The action of the clutch is reversed with the spring. If we press the new pedal, at first the clutch is activated and after that the accelerator is activated and if we release the new pedal then at first the accelerator releases and then the clutch disengages simultaneously.

Nishant Dhengre et al. [13] Clutch plays an essential part in automobile transmission in modern high-speed vehicle. Clutch are devices which are highly required as it used to control comfort, economy and sportiness Clutch are mainly use to engage and disengage the engine input shaft to output shaft, so that the vehicle shaft may be stopped or start without affecting the driving shaft. It can be used in any machine where power is being transmitted and subjected to variable loading like in automobile. In this study, an attempt is made to investigate the behaviour of clutch plate under different loading. Currently used material of friction disc used in analysis are cork and Kevlar fiber. During engagement and dis engagement of clutch plate deteriorate and get erode at every cycle. The aim of the research is to study the effect of axial force offered by the spring for engagement using theories based on uniform pressure and uniform wear. Clutch plate of CT-100 was designed in solid works and for its finite element analysis has been performed.

Pankaj et al. [14] Tractors are indicative application of technology in the agriculture field and tractors cover a very large sector of agriculture industry. Housings which form the basic structure of the tractor, experiences internal loads due to transmission line and external load due to agricultural implements attached to it. Clutch housing and gear box housing are important component of the tractor transmission system. Thus, the strength of clutch housing and gear box housing is an important parameter to be taken into account while designing of housings. The study here represents an approach to analyses clutch housing and gear box housing of 65 HP tractor and conclude that the same design of clutch housing and gear box housing can be used that are currently in use for 50 HP tractor under the load developed by 65 HP tractors.

Pappuri Hazarathaiah et al. [15] Clutch plates are usually made of cast iron and high carbon steels. The properties of cast iron have high compressive strength, low tensile strength and no ductility. It can be easily machined. Due to this reason, it is suitable for the clutch plate but its cost is high. In order 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. Comparison can be done for deformation, stresses etc. form the three materials to check which material is best. NX/UG is a 3d modelling software widely used in the design process. HYPERMESH is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user designated size) called elements.

Peng Han et al. [16] The clutch control in the starting process is a main core and difficulty of control technology of dual clutch transmission (DCT). Without a hydraulic torque converter, the DCT achieves a smooth start only by the slipping of clutches and the DCT slipping control in the starting process becomes a key point. The torque transfer

characteristics of the wet clutch is very complex and affected by many factors. An intelligent starting control strategy of DCT is introduced in this paper. The method of determining the starting gear is illustrated and it induces the control strategy with two forward gears involved in the starting process. The control flow of the starting process is used to illustrate the DCT operation. Some vehicle tests are carried out to verify the strategy effectiveness. The result shows that the strategy has good robustness and adaptability, and can also response to various changes in parameters quickly, which can increase the clutch life and ensure the ride comfort.

Prof. Jignesh J. Patel et al. [17] This research paper has been related to the friction lining material in clutch plate. There are many materials available in market like, Asbestos, Ceramic-metal, organic fabric, cast iron, sintered metal etc. but According to market survey ASBESTOS is normally used as a friction lining material in clutch plate. But there are few problems in asbestos friction plate like, high heat-generation and low co-efficient of friction. So, there is requirement of change the material in clutch plate. Firstly, change the friction lining material and redesign the clutch plate and after that different experiment will be carried out with the different material in clutch plate. Here mainly focus on increasing torque transmission capacity of clutch plate. According to results of different experiments, choose the best material for friction lining of clutch plate.

Pulavarthi Krishram Raju et al. [18] Clutch is one of the essential components in automobiles. It is located between the engine and the gear box. The main function of the clutch is to initiate the motion or increase the velocity of the vehicle by transferring kinetic energy from the flywheel. Multiplate clutch is one of the important parts in the power transmission systems. Good design of clutch provides better system performance. Multiplate clutch is widely used in racing cars and heavy-duty vehicles, which have space limitations and require high torque transmission. In this paper a pressure plate of multiplate clutch has been designed by using empirical formulae. This work depicts a solid modelling of pressure plate with CREO package that is employed for varied automotive applications. The structural analysis of clutch plate is done over different materials. The analysis is carried out on FEA package to get the foremost appropriate material for pressure plate of clutch. From the analyzed results, stress, strain and total deformation values were compared for all the three materials and the best one was taken out and the best material with good model will suggest to the company.

S Murali et al. [19] Nowadays, recycling or regenerating the waste in to something useful is appreciated all around the globe. It reduces greenhouse gas emissions that contribute to global climate change. This study deals with provision of the automatic clutch mechanism in vehicles to facilitate the smooth changing of gears. This study proposed to use the exhaust gases which are normally expelled out as a waste from the turbocharger to actuate the clutch mechanism in vehicles to facilitate the smooth changing of gears. At present, clutches are operated automatically by using an air compressor in the four wheelers. In this study, a conceptual design is proposed in which the clutch is operated by the exhaust gas from the turbocharger and this will remove the usage of air compressor in the existing system. With this

system, usage of air compressor is eliminated and the riders need not to operate the clutch manually. This work involved in development, analyzation and validation of the conceptual design through simulation software. Then the developed conceptual design of an automatic pneumatic clutch system is tested with proto type.

S. Yuvaraja et al. [20] Compliant mechanisms and its systems are the focus of the active research. It describes a single elastic continuum used to transfer the motion and force mechanically. Their flexibility and stabilities are significant. Topology optimization Method is taken for designing the compliant mechanisms. It is a Material distribution approach for finding the optimum size and shape of the structure. The Author focused mainly on automotive application of Compliant Mechanism Design and implement of compliant clutch fork using topology optimization. Dimensional data is gathered in order to model the actual clutch fork. Compliant clutch fork designs are developed by reducing the weights compare to actual clutch fork with the help of topology optimization to get optimal compliant design. Experiments are directed to confirm the functionality of compliant clutch fork.

Sagar Chaudhari et al. [21] The paper presents the main features of a control-oriented model of a Dual Clutch Transmission (DCT) system that has been designed to support model-based development of the DCT controller. The model represents an innovative attempt to reproduce the fast dynamics of the hydraulic circuit while maintaining a simulation step size large enough for real time application. The model includes a detailed physical description of clutches, synchronizers and gears, and a simplified model of the vehicle and of the internal combustion engine, in order to simulate the behaviour of the entire system. As the oil circulating in the system has a large bulk modulus, the pressure dynamics are very fast, possibly causing instability in a real time simulation; the same challenge involves the servo valves dynamics, due to the very small masses of the moving elements. Therefore, the hydraulic circuit model has been modified and simplified without losing physical validity, in order to adapt it to the real time simulation requirements.

Sandeep Badlani et al. [22] A clutch is a very important machine element which plays a main role in the transmission of power from one component to another. A common and well-known application for the clutch is in automotive vehicles where it is used to connect the engine and the gearbox. As the clutch is working condition it undergoes the effect of friction force and heating of surface and as a result wear takes place, which reduces the life of clutch. Wear is a process of gradual removal of a material from surfaces of solids subject to contact and sliding. Damages of contact surfaces are results of wear. The objective is to calculate the coefficient of friction and total wear with respect to the variable (time, load and velocity) by the help of pin on Disc method to evaluate the property of the materials for the comparative study of them. To select the best material from the materials going to use in this test or enhance the properties of them to increase the life of clutch.

Seyed Reza Aghazadeh et al. [23] Background and Purpose: Clutch pedal is one of the most important controlling systems of car, and as a foot controller, it would

cause reduced comfort and fatigue in driver as well as vehicle safety decrease, because of the position and type of function mechanism, in case of inappropriate design. In current research, the clutch pedal comfort is investigated ergonomically in a few models of common cars within taxi service lines in Tehran. Method: in this sectional and applied study, 120 drivers from Tehran taxi lines were selected for study using stratified random sampling and an objective method (push and release force, frequency and duration of clutch pressing) as well as a subjective method, were used to investigate the fatigue and discomfort degree of clutch pressing. In the objective method, the push and release force were recorded using a piezoelectric dynamometer, while the duration of clutch pressing were noted using a micro switch called Data-logger. Results: According to results, there were significant difference in perceived discomfort after a work shift in all parts of the body involved in clutch pressing. Meanwhile, the highest discomfort was reported for lumbar (3.97) and knees (3.86) and the lowest one was for upper thigh muscle (1.45) and upper leg (1.98). Moreover, highest stated discomfort was for drivers of Peykan and Roa. About the force and frequency of clutch pressing, it was observed that the highest value was for Peykan. Conclusion: Results of this research show that Long-term use of clutch pedal in all tested cars, would cause significant discomfort after the work shift. Therefore, it's suggested to replace cars of taxi lines with automatic transmission types in long-term, and to replace Peykan and Roa cars which have the highest discomfort, with other models, in short-term.

Shiv Pratap Singh Yadav et al. [24] The purpose of this paper is to review the design and analyses the single plate clutch; this is achieved by using the commercially available modelling software CATIA V5. A program is coded in C language in order to accommodate the input parameters, and correspondingly get a resultant clutch design. Here, one of the problems which are commonly risen while designing clutches was addressed as a case study, and those parameters were taken into account while input to the program. The input data is also used to design the single plate clutch on CATIA-V5, of required material and required analysis was carried out.

Shivendra Kumar Dubey et al. [25] The clutch is an important part in the transmission system of automobiles. It transmits power from the engine to gear box at various speeds. The function of the clutch is to temporarily disconnect the engine from the gear box unit. When the gear has to be changed from the first to the second, it should be done after disconnecting the engine from the gear box. If this is not done, the gear teeth might break. The clutch is thus helpful when starting, shifting gears and idling. The electromagnetic clutch is very important in vehicles and machinery to transmit the power from driving member to driven member by using clutch linkage. Already the electromagnetic clutch exists, but that clutch has number of problems like wear problem, slipping problem and complicated linkages. The difference Between the electromagnetic clutch and regular clutch is the way they control the movement of pressure plate. In normal clutch spring used to engage the clutch whereas in EM clutch an electromagnetic field is used for engagement. The electromagnetic clutch comes in various form including

magnetic particle clutch and multi disc clutch. But the most widely used form is a single face friction clutch.

Sunny Narayan et al. [26] This paper presents the stresses and deformations of the assembly of the automotive single plate clutch depending on the applied materials. Structural analysis of the clutch was performed by using the finite element method for a repressive vehicle example - Toyota KUN 25. First, the input data for the numerical analysis was calculated. Numerical analysis was performed in the ANSYS software package. As a result, the values of stresses and deformations that occur on the clutch during the vehicle exploitation are obtained.

Suraj S Raut et al. [27] The various developments in the automobile field are going on increasing; hence we have also tried to modify the transmission system of light weight vehicles such as motorbikes for simplicity in driving the vehicle in an efficient way. The disclosure herein is concerned with an automatic transmission gearbox with centrifugal clutches which operates automatically as engine speed (RPM) goes on increasing. In this work we have designed and manufactured the automatic gearbox model which consists of gear assembly with three different gear ratios and centrifugal clutches of various spring tensions, which driven by electric motor. This gearbox overcomes disadvantages of Continuous variable Transmission (CVT) system by replacing belt and pulleys with centrifugal clutches and gear assembly, which is more compact and avoids loss of power when operating at high speed. Also, it is light in weight, efficient, reliable, less time consuming and economical of manufacturing.

U. M. Saravanan et al. [28] A clutch is a device used to make and break contact from the transmission. When it engages, then power is transferred from engine to gear box and when it disengages, power flow is stop, hence it is called free running of engine. There is an innovation done in automobile industry, called electromagnetic clutch, which is recently used by Renault Car Company, which uses the basic principle of electrical energy as well as magnetic forces. This project reveals the manufacturing of electromagnetic clutch. In place of Engine, shaft is directly attached to variance (variable motor) and clutch disc as well as pressure plate is used, in between them friction material called "Asbestos" used to grip between the pressure plate and clutch plate. This project shows, experimental analysis of Electromagnetic clutch, and at last at which speed clutch engage as well as disengage is measured and when clutch disengage, at that time speed of flywheel is also measured.

Yuanjiang Cheng et al. [29] It is known that the shift processes of the four types of clutch-to-clutch shifts can theoretically be divided into two phases which are torque phase and inertia phase, but the execution orders are different. Two virtual clutch controllers are designed with the same eight states which include all control processes for these shifts. An equivalent method is proposed so that AT can be controlled just like DCT by adopting the torque ratios of oncoming clutch and off going clutch of each gear. The powertrain system model and the shift controller are established on MATLAB/Simulink platform. The clutch-to-clutch shift processes have been studied based on the virtual clutch controller by software-in-the-loop simulations. Some typical problems in the clutch-to-clutch shift control are

discussed and several control methods are compared to solve these problems.

Zongxuan Sun et al. [30] Automotive transmission is a key element in the powertrain that connects the power source to the wheels of a vehicle. To improve fuel economy, reduce emission and enhance driving performance, many new technologies have been introduced in the transmission area in recent years. This paper first reviews different types of automotive transmissions and explains their unique control characteristics. We then address the challenges facing automotive transmission control from three aspects: calibration, shift scheduling, and sensing, actuation and electronics. Along the way, research opportunities to further improve system performance are discussed.

III. CONCLUSIONS

Review of the above literature clearly shows that clutches are an important component of any automobile. In order to reduce the losses incurred, associated with the failure of clutches, a lot of research work has been done and most of the research indicates that there is a lot of scope for the betterment of clutches.

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