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Fabrication and Analysis of Automated Manual Transmission in Two Wheelers

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Abstract - The increasing consumption of petroleum products due to increased number of vehicles has been a matter of great concern for the country for the financial growth as well as environmental pollution abatement. The situation offers us a challenge as well as an opportunity to bring out new technical ideas for both economic and environmental benefits to the country. At present, most of the vehicles on road use manual transmission i.e. the driver has to shift the gear manually by operating the clutch and thereby changing the speed of the vehicle. But this is a very tiresome process especially in heavy traffics and causes great discomfort.

It is proposed to develop an electromechanical system to be incorporated into the manual transmission which is supposed to improve the fuel efficiency. The system has both the options -manual as well as automatic. This system uses micro-controller (Arduino) to make the accurate decision for gear shifting by sensing the torque required. This project aims at developing a test rig to compare the transmission efficiencies and thereby fuel consumption of continuous variable transmission and manual transmission. Utilizing the above results and national statistics, one could estimate the total savings in fuel consumption and thereby opening a new path for pollution control.

Key Words:

1. INTRODUCTION

A transmission is an integral part of any vehicle. The automotive industry started out with a manual gearbox in which the clutch inputs and gear changes were actuated by the driver. This means that the driver has to physically couple and decouple the transmission from the engine drive shaft.

With traditional manual transmissions, the driver can shift the gear, by moving the shifter to the appropriate position. A clutch must be disengaged before the new gear is selected, to disengage the running engine from the transmission, thus stopping all torque transfer whereas the automated gear transmission enables changing gear ratios automatically as the vehicle moves, freeing the driver from having to shift gears manually and to achieve efficient driving. They are also beneficial in terms of fuel economy and while meeting drivability and performance goals, these savings become more significant.

The goal our project is to transmit the gears in bikes without the human interference as and when necessary, especially in heavy traffic and to attain efficient, safe and easy driving in cost effective way. Microcontroller is the heart of the system which handles all the sub devices connected across it.

2. AUTOMATION

Automation is the use of control system to control a process replacing the human operators. It is a step beyond mechanization, where human operators are provided with the physical requirements of work. Automation is now often applied primarily to reduce the human effort thereby to attain desired operation. Another major shift in automation is the increased emphasis on flexibility and convertibility in different process. One safety issue with automation is that it is often viewed as a way to minimize human error in the system, increasing the degree and the levels of automation also increase the error that is accidentally created in automated systems.

3. LITERATURE SURVEY

In the present world of automobiles, gear shifting system is manual and automatic. Gear shifting system is important in automobile to vary the speed. This gear shifting system reduces cost compared to automatic gear shifting system and is flexible or simple then manual gear shift system, and by applying this system on automobile it is easier to

drive. It also reduces the possibility of transmission error of manual gear system.

The automatic transmission in automobiles is a unit which supplies the power from the clutch to the differential. 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 movers only use torque convertor. Besides the traditional automatic transmission, there are also other types such as continuous 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. Nowadays to facilitate and simplify the process of driving the automatic transmission control is connected to vehicles. There are few types of the automatic transmission system that provides high economic, dynamic, and excellent performance and reduces the impact of human factors on the control processes. Due to this the driver is free from having to shift gears manually by using the transmission computer to change the gears. Automatic transmission, automated manual transmission and intelligent gear shift schedules are key systems to improve the benefits and performance of a vehicle. The engineers are continuing to improve the fuel economy, efficiencies, performance of the gear transmission system. The CVTs have been used in decades but the limited torque, reliability have inhibited their growth. Torque convertor acts as simple fluid coupling. These systems consist of planetary gear train. The comparison between automated manual transmission and automatic transmission is also required for showing which is better and suitable transmission for advance technology.

3.1 AMT SYSTEM DESIGN

The AMT system makes use of three actuators for automation of gear shifting and clutch actuation process. Conventional transmission system with actuator was used for AMT. Two more actuators were used for shift and select actuation. A system control device was developed to improve control, stability, and robustness of system. The result showed a way forward for cost effective solution for AMT. The automated clutch is constituted by a standard dry clutch controlled by an electro- hydraulic servo. The clutch actuator is constituted by disks between the flywheel and the clutch plate, whose surfaces are covered with high-friction materials. The electrohydraulic clutch actuator, which is driven by a three-way spool servo valve applies pressure to control the displacement of the clutch piston, which pushes on the release bearing. The transmitted torque can be thought as stick slip friction, while the maximum transmissible torque (related to static friction) is modulated by the normal force applied to clutch disks. In a clutch actuator model focusing on the hydraulic part and involving the release bearing position as output variable has been developed. The model is refined considering the relation between the force applied to release bearing and the transmitted clutch torque. When no external force is applied, flywheel and clutch disks are pressed together by Belville and pre-load springs and hence engine torque can be transmitted. In order to release the clutch, the hydraulic piston pushes the release bearing The Belville spring, acting as a lever, reduces the normal force applied to the clutch plates, thus separating friction disks. The Belville spring acts both as a spring and a lever with variable coupling ratio. Hence the steady state piston force is related to the force applied to the clutch plate by a nonlinear relation dependent on the clutch piston displacement

3.2 AUTOMATIC GEAR SHIFTING STRATEGY FOR MANUAL TRANS- MISSIONS

An automatic gear shifting strategy for Manual Transmissions is based on two different criteria, namely the engine working conditions and the driver's intention. The gear shifting strategy was designed by taking into consideration the effects of these parameters, with the application of a fuzzy control method. The controller structure is formed in two layers. In the first layer, two fuzzy inference modules are used to determine the necessary outputs. In the second layer a fuzzy inference module makes the decision of shifting by up shift, downshift, or maintain commands. The behavior of the fuzzy controller is examined by making use of ADVISOR software. At different driving conditions the controllers make correct decisions for gear shifting accounting for the

dynamic requirements of the vehicle. The controller based on both the engine state and the driver's intention imitates unnecessary shifting that is present when the intention is overlooked. A microchip is designed in which a required speed in the form of a step function is demanded for the vehicle on level or sloping roads. Both strategies for the vehicle to reach the maximum speed starting from rest allow the gear shift to be made consecutively. Considerable differences are observed between the two strategies in the deceleration phase. The engine-state strategy is less sensitive to downshift, taking even unnecessary upshift decisions. The state intention strategy, however, interprets the drivers intention correctly for decreasing speed and utilizes engine brake torque to reduce the vehicle speed in a shorter time.

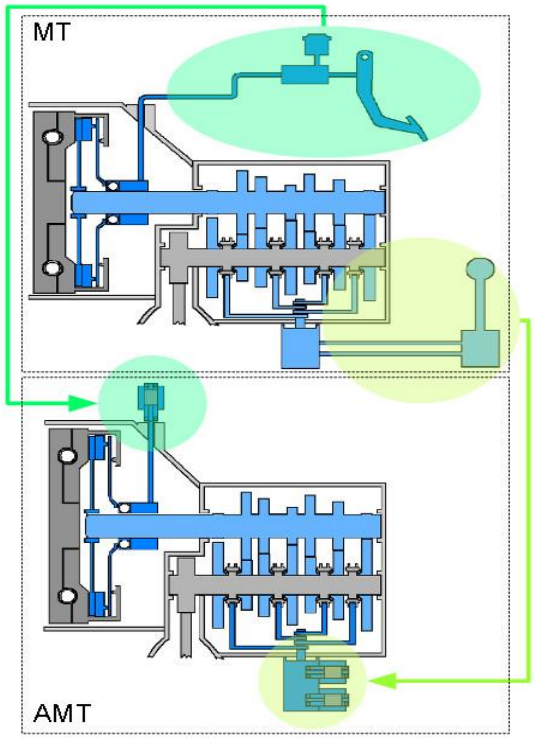


Fig MT to AMT Conversion

A conversion from a MT to an AMT requires:

- replacement of the clutch actuation mechanism with an electrohydraulic / electrical actuator
- replacement of the gear actuation mechanism with an electrohydraulic / electric actuator
- integration of an electronic control module
- integration of input shaft speed sensor, clutch position sensor, gear selection and engagement position sensors, shift lever position sensor, fluid pressure and temperature sensor (in case of an electrohydraulic actuation system)
- engine control software which allows torque control during gearshift

4. HARDWARE DESCRIPTION

4.1 SENSORS USED IN THE AMT SYSTEM

In relation to driving safety, wheel speed sensors are of particular importance and are used in various applications in various vehicle systems. In driver assistance systems such as ABS, TCS, ESP or ACC, motor control units use these sensors to determine the wheel speed. Due to this variety of applications, wheel speed sensors make a direct contribution to driving dynamics, driving safety, driving comfort and reduced fuel consumption and emissions.

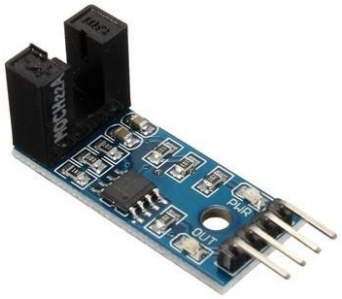


Figure : Wheel speed sensor

4.2 HALL EFFECT SENSOR (FOR THROTTLE POSITION)

A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall Effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications.

In its simplest form, the sensor operates as an analog transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced.

4.3 ARDUINO

The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog input/output (I/O) pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an Integrated Development Environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.

4.4 RELAY SWITCH (2 CHANNEL RELAY)

Relays are devices which allow low power circuits to switch a relatively high current and voltage ON/OFF. For a relay to operate a suitable pull-in and holding current should be passed through its coil. Generally, relay coils are designed to operate from a particular voltage at 5Vor 12V.

The NPN transistor BC547 is used to control the relay. The transistor is driven into saturation (turned ON) when logic1 is written on the port pin thus turning ON the relay. The relay is turned OFF by writing logic 0 on the port pin.

Figure : 2 Channel 5V relay switch

4.5 VOLTAGE REGULATOR 7805

Voltage sources in a circuit may have fluctuations resulting in not giving fixed volt- age outputs. Voltage regulator IC maintains the output voltage at a constant value. 7805, a voltage regulator integrated circuit (IC) is a member of 78xx series of fixed linear voltage regulator ICs used to maintain such fluctuations. The xx in 78xx indicates the fixed output voltage it provides. IC 7805 provides +5 volts regulated power supply with provisions to add heat sink as well.

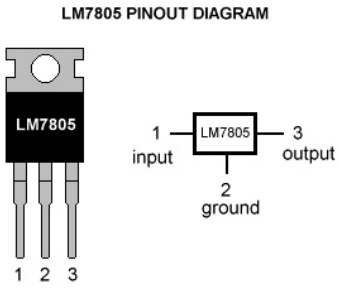


Figure : Voltage regulator (7805)

4.6 DRIVE SWITCH

A drive switch is an ON/OFF switch which is used to switch between manual trans- mission mode and automatic transmission mode. When the switch is in ON position, the transmission changes to automatic mode freeing the driver from gear shifting process. The automatic transmission mode works based on the embedded system. The use of this drive switch would be very useful when one encounters with high traffic areas where manual transmission is very difficult to achieve. Once the switch reaches the OFF position, one could get back into complete manual transmission mode.

5. FABRICATION OF AUTOMATIC MANUAL TRANSMISSION

TVS VICTOR GL

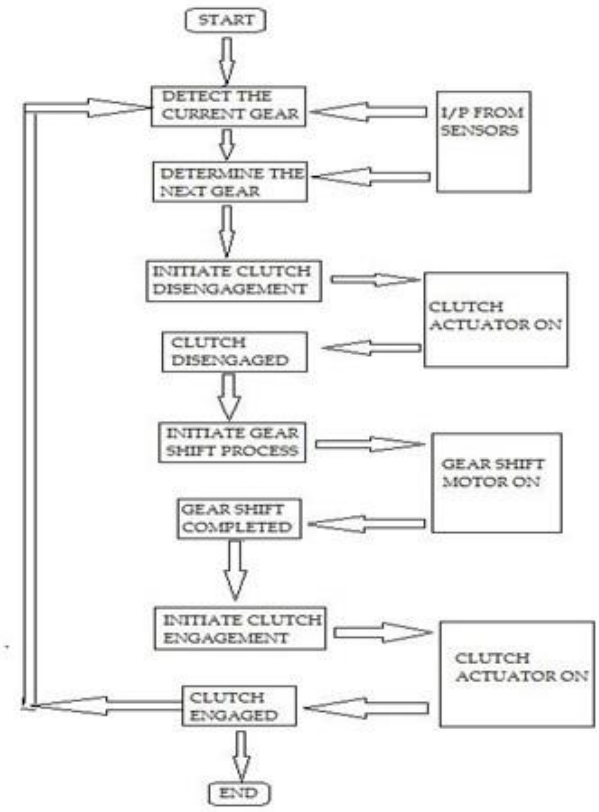
Engine displacement : 109 cc

Maximum power : 8.2 ps at 7250 rpm (8.085HP)

Maximum torque : 8.1 Nm at 5500 rpm

Bore and stroke : 51*53.5 mm

Figure 4.1: TVS Victor GL Engine



Flow chart of the program

LOAD TEST FOR EFFICIENCY COMPARISON

- To develop a test rig for the comparison of the transmission efficiencies of continuous variable transmission, manual transmission and automatic manual transmission.
- To find the most fuel efficient transmission.
- Performance analysis to study the effect of brake power on total fuel consumption, specific fuel consumption, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency.

6. RESULTS AND DISCUSSIONS

6.1 COMPARISON OF TOTAL FUEL CONSUMPTION

The figure compares the total fuel consumption of CVT, MT and AMT at varying percentage loads. The TFC curves of three of the transmissions show a non-uniform trend. In case of CVT, the consumption of fuel increases with load reaching its maximum at about 80% load. But there is a sudden dip in the curve at 35% load.

It is observed that for both AMT and MT, the maximum amount of fuel is consumed at the start of loading followed by a sudden fall in the total fuel consumption which may be due to the high starting torque. But on comparison with MT, the fuel consumption has slightly reduced in AMT approximately by more than 1%.

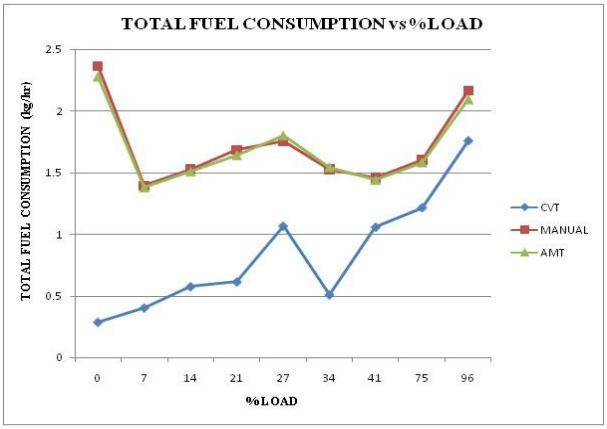


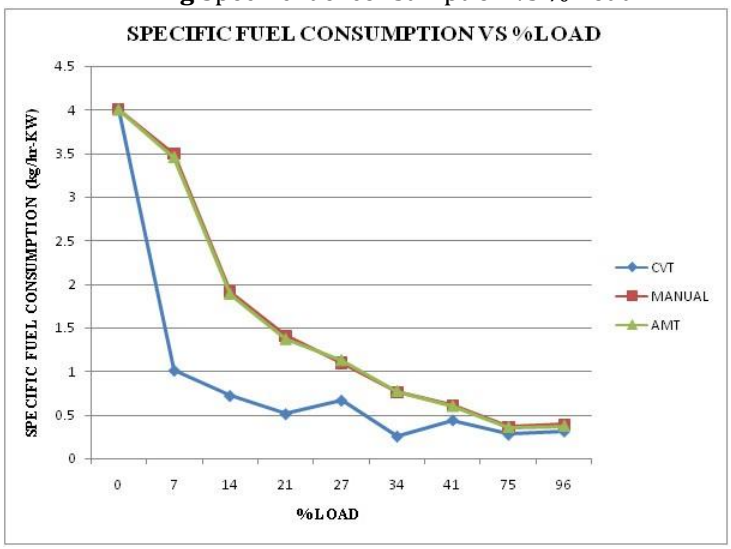
Fig Total fuel consumption vs % Load

6.2 COMPARISON OF SPECIFIC FUEL CONSUMPTION

The figure compares the Specific Fuel Consumption (SFC) of CVT, MT and AMT at varying percentage loads. The value of specific fuel consumption obtained for AMT is lesser than that of MT.

Sfc = TFC/pb Kg/hr-Kw

Fig Specific fuel consumption vs % Load



At no load condition, Pb = 0. Hence the SFC curve starts from infinity. With the increase in load, the SFC value initially tends to increase up to 15% load (approx.). With further increase in load, the SFC value tends to decrease for AMT and MT but this decrease is non-uniform in case of CVT as the plot indicated above moves in a zigzag manner. At approximately 80% load, the SFC value of AMT and MT approaches to that of the CVT. Thus, it can be concluded that CVT is more fuel efficient than AMT which follows next and is lesser for MT. The approximate percentage de- crease in SFC of AMT compared to MT is 1.02%.Better SFC in CVT over MT and AMT may be due to difference in their engine displacement, year of make etc

6.3 COMPARISON OF BRAKE THERMAL EFFICIENCY

Brake thermal efficiency is the ratio of energy in brake power to the input fuel energy in appropriate units. The variation of brake thermal efficiencies of the engines with CVT, AMT and MT are compared in figure . From the test results it was observed that with the increase in percentage load the brake thermal efficiency increases. The brake thermal efficiency increases gradually with load for both AMT and MT. While comparing the brake thermal efficiencies of AMT and MT, it is evident from the graph that AMT is much more efficient than MT approximately by 1.22%. But in case of CVT, the increase in efficiency with load is found to show a non-uniform trend initially increasing and then decreasing and again goes on increasing.

The maximum brake thermal efficiency is obtained at about 35% load in CVT but in case of AMT and MT it is attained at about 80% load. At the same time, it is observed that the brake thermal efficiency of CVT is always greater for varying loads followed by AMT and then MT.

Better thermal efficiency in CVT over MT and AMT may be due to difference in their engine displacement, year of make etc

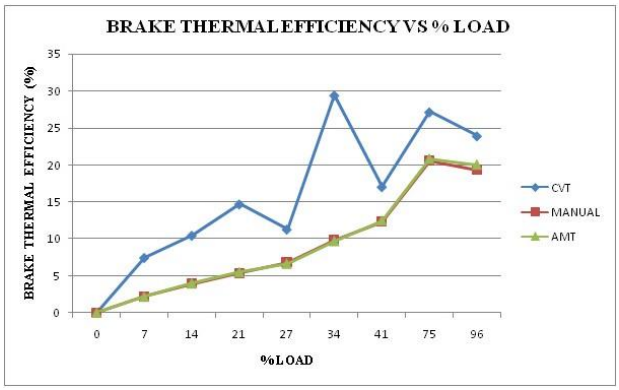


Fig Brake thermal efficiency vs % Load

CONCLUSIONS

AMT is an idea under incubation for the past few years. It has been used in many four wheelers, but not in two wheelers due to the bulk size of its components. If AMT is needed to be brought in two wheelers it is only possible through a fully electronic control system consisting of actuators, sensors and relay circuits. And in our system, we are just proud to say that we have achieved it to a great extent. We are successful in controlling the clutch and gear and its shifting accordingly.

Moreover, using the load test for transmission efficiency comparison, AMT is found to be much more efficient than the MT in two wheelers at varying loads. It has several advantages as it allows infinite number of gear ratios, better response to changing conditions and facilitates smoother ride. But AMT is more costly than MT.

The present technologies are focused in developing fuel efficient vehicles and this is an important part of our work. With AMT, we can achieve fast transmission between gears and speed

change. This reduces the wastage of fuel during slowing down of the vehicle, to change gear. Thus, fast shifting of gears add on to increasing the mileage of the vehicle, compared to the others.

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