DESIGN AND ANALYSIS OF SENSOR BASED GEAR SHIFTING SYSTEM

[1]Akshay A Bhagat, [2]Dr.Prashant Deshmukh
[1]M.E Student, [2]Professor
Department Of Mechanical Engineering,
Datta Meghe College of Engineering, Airoli, India.

Abstract: A recent survey in automobile sector shows that Continuous Variable Transmission (CVT) is in demand as compared to the gear featured bikes. In CVT's meshing of gears are absent which enhances a smooth ride, but the fuel efficiency is less when compared with the gear featured vehicles. The main objective of this research work is to automate the gear transmission in a gear featured bike to ease the driving and further to increase the efficiency of the bike. Aim of this research work is to develop Automatic Transmission System which shifts the gears with respect to the speed of the wheel. In this paper, a focus is given on simplifying the transmission and optimizing the consumption of fuel. Automation of gear transmission can be achieved by Embedded system. Microcontroller ATmega328 is used in the present research work with Keil µ vision software to write the assembly level language in the microcontroller. By implementing this system into a clutch feature bike, automatic transmission of gears has been achieved while driving the motor bike. Since the developed mechanism transmits the gears with respect to the speed of the bike this automated transmission can be controlled by the acceleration. After fabricating, installing and testing it is found that the efficiency of the vehicle has been increased. This is the new innovative model mainly used for the vehicles to control the vehicle and improve its efficiency. This work contributes to design and fabricate a dedicated mechanism for two wheelers by using the electronic devices.

Keywords **– Fuel efficiency, Automation, and Microcontroller**

I. INTRODUCTION

A Motorcycle (also known as a motor bicycle, motorbike, bike, or cycle) is a single-track, two-wheel automobile powered by an engine. Motorcycles vary significantly reckoning on the task that they're designed. In many parts of the world, motorcycles are among the least expensive and most widespread forms of motorized transport. In two wheelers the gear transmission is mostly carried out manually which may end in fatigue while driving in cities or traffic areas. New technologies like Anti Braking System (ABS) system, active steering mechanism etc. has been developed to overcome the difficulties in manual operations in order to increase passenger safety and comfort. Quality, cost and increased demand on performance are the main challenges for today's automotive industry, in an environment where movement, component and every assembly operation must be immediately and automatically recorded, checked and documented for maximum efficiency. One of the automated applications includes Pneumatic Gear Changer. This study describes in detail about understandable way to convert the traditional manually gear shifting mechanism by automatic system using microcontrollers (control unit- relays). [1, 11, 14 and 15]

Automation is the use of control system which controls the process replacing human operations. Automation is 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 interchangeability in numerous methods. The automatic gear change mechanism could be a revolution towards easing the driving operation of the bike and at the same time efficiently controlling the transmission system thereby making certain optimum effectiveness of the engine. Automatic gear change mechanism is implemented commercially in four-wheeler automobiles through hydraulic mechanisms or by incorporating CVT within the automobile. These systems can't be put in a two-wheeler automobile as they're commodious and hulking. Hence a simplified system must to be developed which might solve the aim of automatic gear change and would be versatile and compatible with all two-wheeler vehicles. The following paper describes a system which can be applied easily to a two-wheeler automobile to automate the gear shifting process. The system consumes less space and is flexible enough to be applied to any two-wheeler automobile externally. [6, 8, 9 and 16]

According to a recent survey tremendous growth has been observed in variety of applications related to fuzzy logic that varies from client merchandise like cameras, camcorders, laundry machines, and microwave ovens to industrial process management, medical instrumentation, decision-support systems, and portfolio choice. The fact that most of human reasoning and concept formation is linked to the use of fuzzy rules it makes Fuzzy Logic Toolbox so powerful. It provides a systematic framework for computing with fuzzy rules; the Fuzzy Logic Toolbox amplifies the power of human reasoning. Further amplification results from the utilization of MATLAB and graphical user interfaces areas during which the mathematics Works has unequaled experience. The Fuzzy logic tool case is extremely spectacular. It makes fuzzy logic an efficient tool for the conception and designing of intelligent systems [12, 13 and 17]

II. METHODOLOGY

The topic of the paper is to develop an automatic transmission system which has finite number of gearshifts and transmits the power automatically with respect to speed of the vehicle. Gearshift in automatic transmissions includes a change in power flow path through the transmission. The main Advantage of this automatic transmission includes simplicity of mechanical design and savings in transmission size and weight, which are beneficial in terms of fuel economy and production costs. This enables gain in fuel economy while meeting drivability and performance goals, these savings become more significant. The designed automatic transmission can be applied effectively and efficiently in clutch featured bikes through suitable control techniques. The ultimate goal of the research work is to transmit the gears without human interference and to achieve efficient, easy and safe driving in cost effective way.

Objectives of the Present Work

1. Designing the gear shifting mechanism and modification of the vehicle according to the designed mechanism.
2. To program the microcontroller according to the needs of the mechanism and build the dedicated system with suitable electronic circuit.
3. Calibration of gear shifting mechanism and to check for the improvements in performance and efficiency of the vehicle if any.

Methodology for Objective-1:

In order to reach the goal of making an automatic gear transmission motor bike, different types of systems and components are used. According to this customization and fabrication of the elements, proper placement and fitting of components is carried out. The details regarding various components used and the fabrication methods are explained that gives the knowledge of different components and its working. The design consists of pneumatic cylinders in which two of the cylinders are placed on gear pedal and one at the clutch assembly for shifting of gears. Each part concerned within the gear shifting mechanism was designed with assumed dimensions and later changed with correct measurements. Arrangement of Major components such as gear pedal and pneumatic cylinders are designed in the Solid Works software and assembled

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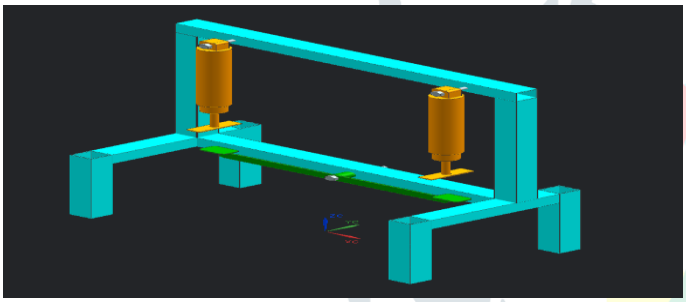

Fig 1: CAD Model of Proposed Design

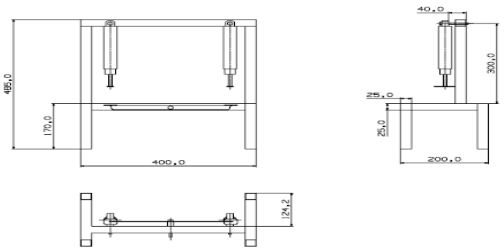

Fig 2: Spefications of The Model

The assembly consists of the following components:

1. Pneumatic cylinder: It is an operative device in which the state input energy of compressed air i.e. pneumatic power is converted in to mechanical output power, by reducing the pressure of the air to that of the atmosphere.
2. A clutch and pedal is used to change gear in vehicles.
3. Flow control valve is used to control the speed of the actuator.
4. Directional control valves are one of the most fundamental parts in hydraulic and pneumatic machinery. They allow fluid flow into different paths from one or more sources
5. Hoses are used in this pneumatic system made up of polyurethane which can withstand pressure up to 10 N/m².

Fig 3: Pneumatic Cylinder [14, 15, 16]

Fig 4: Gear Changing Pedal [1, 14, 16]

Fig 5: Clutch Lever [14, 16]

Fig 6: Flow Control Valve [6] **Fig 7: Direction Control Valve [3, 4, 15]** **Fig 8: Poly Urathane Tubes [1, 14, 16]**

Methodology for Objective-2:

In order to program the microcontroller ATmega328 is used which comes with a pre burned boot loader that allows uploading a new code to it without the use of an external hardware programmer. The communication is carried using the original STK500 protocol (reference, C header files). Electric circuit is built using some of the components like proximity sensor, microcontroller, LCD display unit and relays.

Fig 9: Control Unit [2, 5, 6]

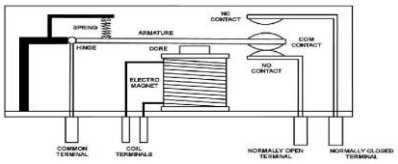

Fig 10: Circuit Diagram of Relay [4, 5, 15]

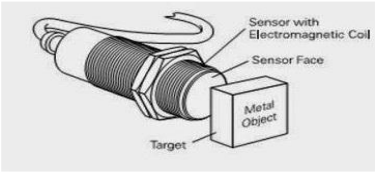

Fig 11: Proximity Sensor [7, 10]

Block Diagram

The block diagram of the proposed solution is shown in Figure 12 and experimental model is shown in Figure 13. In this, both speed sensor and ECU are powered using the power supply. The speed sensor provides the appropriate readings or signals to the ECU; the ECU operates the compressor and sends signals to the valve. The compressor sends pressurized air to the valve; the valve sends the pressurized air from the compressor to the pneumatic cylinder. The pneumatic cylinder then operates both gear pedal and clutch pedal via upward and downward motion of pneumatic cylinder piston.

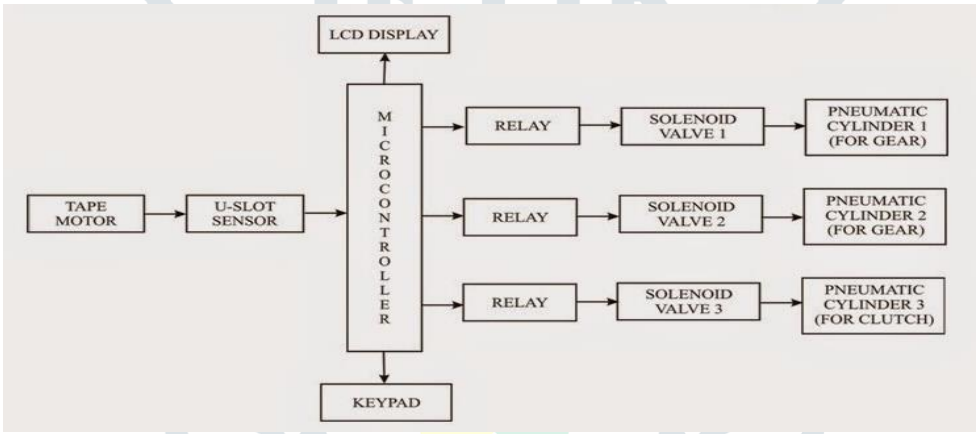

Fig 12: Block Diagram of Automatic Gear Changer

Working Principle

It consists of two pneumatic cylinder arrangements for applying the gear which are arranged on either side of the vehicles pedal rest. The pneumatic cylinder is fixed at the end of the flat pedal rest which has a pivot at the center. These cylinders are controlled by the control unit and operated with the help of electric power supply. One cylinder is used to apply the gear and another for reducing the gears. The gears are applied depending up on the speed of the vehicle. The speed sensors are placed near the wheel which senses the signal and gives the output signal to the control unit. For this purpose a tape motor with a U slot sensor is used such that the speed can be varied through the tape motor. Depending up on the signal the clutch and gears will automatically change with the help of the control unit. When the vehicle speed increases automatically based on the sensor signal the clutch and the gear will change in the vehicles. The arrangement is shown in the below diagram.

Fig 13: Experimental Model of Automatic Gear Changer

Methodology for Objective-3:

The calibration and analysis of automatic gear shifting with respect to rear wheel speed is done by using MATLAB software. The efficiency and performance of the vehicle can be tested manually on existing vehicle by trial and error method.
A Graphical user interface (GUI) tools provided by the Fuzzy Logic Toolbox is used for building the system. It consists of five primary GUI tools for building, editing, and observing fuzzy inference systems in the Fuzzy Logic Toolbox: the Fuzzy Inference System or FIS Editor, Membership Function Editor (MF's), Rule Editor, Rule Viewer, and Surface Viewer.

Defining Gear Shifting Problem

Given a number between 1 and 700 that represents the pulses from the proximity sensor (where 700 is maximum) and another number between 1 to 80 that represents the speed of the vehicle in Kmph, what should the gear be? The starting point is to write down the golden rules of gear shifting, based on years of personal experience from driving and data collected.

1. If input pulse is low then output 1 speed is low and output 2 is 1st gear.
2. It he input pulse is medium then output 1 speed is medium and output 2 is 2nd gear.
3. If input pulse is high then output 1 speed is high and output 2 is 3rd gear.
4. It he input pulse is very high then output 1 speed is very high and output 2 is 4th gear.

The FIS Editor

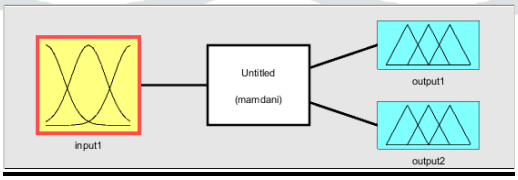

Fig 14: The FIS Editor

To start this system from scratch, type
>>Fuzzy
At the MATLAB prompt dialogue box the generic untitled FIS Editor opens, which contains one input, labeled **input1**, and one output, labeled **output1.** For this project work a one-input and two output system program is constructed

The Membership Function Editor

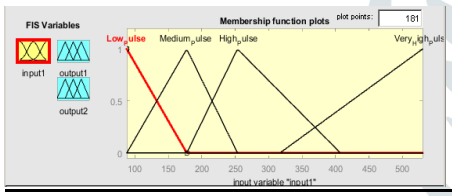

Fig 15-a: Input Variable Function

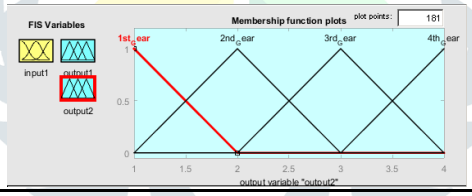

Fig 15-b: Output 2 Variable Function

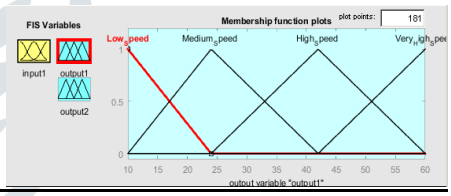

Fig 15-c: Output 1 Variable Function

The Membership Function Editor is the tool that displays and edits all of the membership functions associated with all of the input and output variables for the complete fuzzy inference system. The membership functions for the **output variable**, **gear position, speed** and **for input variable, pulses** are to be created. To create the output variable membership functions, Variable Palette on the left is used, selecting the output variable, **output 1**. The inputs ranged from 1 to 700, but the output scale is going to be gear position between 0 and 4.and speed from 1 to 80.

The Rule Editor

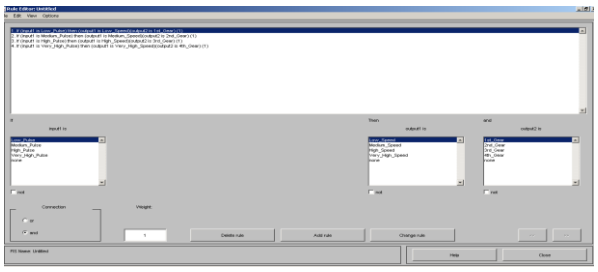

Fig 16: The Rule Editor

To insert the first rule in the Rule Editor, select the following:

1. Low pulse under the variable input
2. Low speed under the variable output 1
3. 1st gear under the output variable , output 2

The resulting rule is:

- if (input is low pulse) then (output 1 is low speed) (output 2 is 1st gear)(1)

The numbers in the parentheses represent weights that can be applied to each rule if desired. The weights can be specified by typing in a desired number between zero and one under the **Weight:** setting. The weights are assumed to be unity (1) if not specified. Following a similar procedure to insert the second third and fourth rule to get:

- if (input is low pulse) then (output 1 is low speed) (output 2 is 1st gear)(1)
- if (input is medium pulse) then (output 1 is medium speed) (output 2 is 2nd gear)(1)
- if (input is high pulse) then (output 1 is high speed) (output 2 is3rd gear)(1)
- if (input is very high pulse) then (output 1 is very high speed) (output 2 is 4th gear)(1)

The Rule Viewer

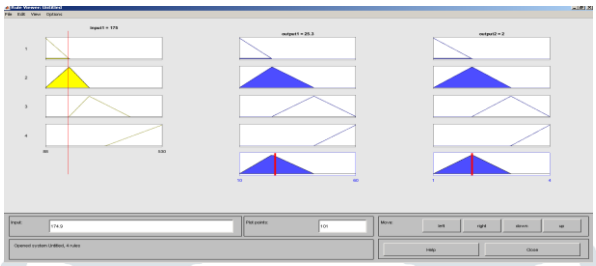

Fig 17: The Rule Viewer

The Rule Viewer displays a map of the whole fuzzy inference process. It's based on the fuzzy inference diagram described in the previous section. A single figure window with 10 small plots is nested in it. The three small plots at the top of the figure represent the antecedent and consequent of the first rule. Each rule is a row of plots, and each column is a variable. The first two columns (the six yellow plots) show the membership functions referenced by the antecedent, or the if-part of each rule. The third column(the three blue plots) shows the membership functions referenced by the consequent, or the then-part of each rule.by clicking once on a rule number, the corresponding rule will be displayed at the bottom of the figure. The fourth plot in the third column represents the aggregate weighted decision for the given inference system. This decision depends on the input values for the system

The Surface Viewer

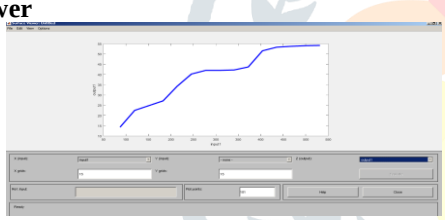

Fig 18-a: Output response 1

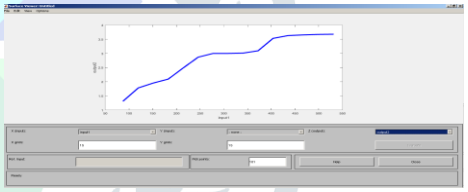

Fig 18-b: Output response 2

Upon opening the Surface Viewer, it is presented with a two-dimensional curve that represents the mapping from pulses to gear position and pulses to speed. Since this is a one-input two-output case, we can see the entire mapping in two plots.

III. RESULTS AND DISSCUSSION

It is important to check the performance of the vehicle after implementing the new technology, which can shift the gears without human interference as discussed in the present work. The gear shifting according to the calculations of designed system has been observed while riding the bike. The gears are changed with respect to the wheel speed. As soon as the designed system was brought to first gear manually, from neutral, proximity sensor senses the speed of the wheel. Once the system is accelerated, the sensor transfers the higher input pulses to the microcontroller. The pulses per 8 seconds were counted which decided the position of the gear. At higher speed, relay 1 was actuated which resulted in the up shift of the gear automatically. It was possible to reach the top gear position (4th) with further acceleration. The vibrations produced during the gear change were negligible. By maintaining constant speed of the bike, it could maintain a constant gear ratio which proved to be major factor for fuel efficient ride. As the speed of the system was reduced uniformly, the gear shifted down with a delay time. There is a delay time in between each gear position to smoothen the gear down mechanism. Once the acceleration was brought down to zero, the designed system was successful in bringing the gear position to the first gear.

The complete electrical circuit was given the power supply from the bike's battery. The microcontroller was programmed according to desired gear changing technology by trial and error method. The pulse range programmed for each gear position was sufficient to obtain constant gear ratios.

Some observations while driving according to the calculations of designed mechanism are listed below.

- Automatic up shift of gear was observed without any interference other than accelerating.
- A Delay time was observed between each gear positions.
- The ride was smooth during traffic condition since the gear shifting was dependent upon the wheel speed.
- The fuel efficiency of the bike was improved by 4km i.e. the total fuel efficiency was 58km while driving by calculations.

After observing and by analysis in two different modes of the bike, it could be seen that the main objective was succeeded i.e. (Optimizing the fuel consumption).The complete 'C' program in the microcontroller, fabrication and analysis by MATLAB/Simulink software resulted in better performance of the bike. The field test results of up shifting are listed in the Table 1 below.

Field Test Results

Table 1: Up Shifting Conditions

Sr.No	Initial Gear	Pulses (Pulses/sec)	K = Speed (km/h)	Gear From	Changing To
1	First	88	10	First	Second
2	Second	212	24	Second	Third
3	Third	317	42	Third	Forth
4	Fourth	530	60	No Change	

The values of speed are derived from the following formula where K (speed in km/hr) is directly proportional to r (revolution per minute) and d (wheel diameter).

K= d* r * 0.01885

Where, K = kilometer per hour (Km/hr)

d = wheel diameter (cm)

r = revolution per minute (rpm)

IV. CONCLUSION

After designing, fabricating and testing the desired gear shifting system it can be concluded that there is reduction in the fuel consumption. This gear shifting technology will improvise the clutch featured bike into automatic transmission vehicle. The complete gear changing mechanism has been controlled by acceleration of the bike. The vehicle can also be used in manual mode by switching off the power supply to the electrical components. A switch can be provided for this optional mode.

The programmed embedded 'C' codes, in the microcontroller, are optimized which will be the key source for changing gears in city limits as well as highways. Maintaining a proper pulse range and constant speed of the vehicle resulted in better fuel efficiency. The Fuel efficiency has been improved by 2km to 4km. The forces exerted by the cylinders are optimum to move the pedals. Mechanism is realizable and workable. After implementing these calculated optimized values in the system it is concluded that no human operation is necessary, other than accelerating, to ride the motor bike. The result from MATLAB software justifies the gear shifting process.

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