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Study on Electronic Gear Shifting Mechanism

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***Abstract*— F-1 cars require some sort of transmission system, and electronically controlled transmission provides a better and efficient means of transmission rather than comparing it with the manual system. This paper entails the concepts and methodologies, required to devise a transmission system in F-1 racing car at student level for a FSAE event. Formula SAE team, MECHSONIC Racing had a manual gear shifting system which leads to driver fatigue and loss of control while driving the vehicle. In order to upgrade the earlier design different methods to enhance the driving and gear shifting process are investigated. This paper formulates the theories and evaluations done in the design and fabrication process of electronic gear shifter.**

Keywords: Gear/Paddle shifter, assembly, electronic, pneumatic, solenoid, transmission, gear ratio, FSAE.

I. INTRODUCTION

Electronic gear shifters are more suitable for F-1 cars as it provide an ease of control for gear shifting, by keeping both hands of the driver on steering wheel and gears can be shifted by means of paddle shifters (2 electrical switches) for upshifts and downshifts. To design this entire system work on different sections was done and a complete reliable gear shifting system is developed for the 2015 MECHSONIC Racing SAE race car.

Formula SAE® [4] is a student design competition organized by SAE International. Competition challenges engineering students from across the world at a single platform to develop an open cockpit, Formula-style racecar. The competition has its own set of rules wherein students has to build the prototype racecar which is evaluated for its designing prospects as a production item. Students compete against each other and showcase their engineering skills by developing fastest, lightest, most affordable, reliable and effective racing vehicle. Competition gives a chance to teams, to be creative in their designs and to enhance their proficiencies in all aspects: research, design, fabrication, testing, marketing and team management.

Figure 1: MECHSONIC RACING Team's 2015 Vehicle.

II. LITERATURE REVIEW

Many designs of electronic Gear Shifter are implemented. Our study includes the consideration of earlier methods as well as the design requirements of the 2015 MECHSONIC Racing SAE race car. This paper includes the study of the earlier models, the alternates available and modeling done in the design phase of the gear shifter, for the vehicle. Various theories and different parameters of the transmission system are investigated, before coming to the final model. The

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finalized model is considered on the factors of availability, cost, reliability, ease of designing and its functioning.

III. PROBLEM STATEMENT AND ANALYSIS

Formula SAE team, MECHSONIC Racing currently employs Honda CBR 600 RR engine in the car which has a 6 speed sequential transmission engagement which constitute that gears can only be shifted sequentially. Team's earlier design comprises of a manual gear shifting mechanism. This design pose some problems while shifting gears, as it reduces maneuverability, manual shifting leads to driver fatigue, as in a race, a driver has to shift gears for about 500-550 times. In order to completely eradicate these issues, there is a need to adopt some form of electronic gear shifting system.

Figure 2: Manual hand Shifting Gear lever.

Different models of electronic gear shifting system can be formulated, but it depends on the type of transmission to be developed. Two types of electronic transmission systems which can be incorporate in the vehicle:

A. Semi-Automatic Transmission

This type of transmission includes flappy-paddle or paddle shifters in their design so as to shift gears, without the need of pressing clutch pedal. System involve an electronically controlled system which shift gears whenever the signal is given from paddle shifter, and it automatically presses the clutch and make actuations, thus making gear shifts. This arrangement generally consists of microcontrollers [11], pneumatics and solenoids in their arrangements.

B. Automatic Transmission

This type of transmission includes automatic or self-shifting mechanism, which allows the change of gear ratios or transmissions automatically as the vehicle moves. This system makes the driver free from any kind of manual actuation and handling.

Considering the requirements and resources availability, we finalize the semi-automatic transmission system with manual clutching. The system so chosen is inexpensive and provides an ease in implementation of design.

To accomplish and fabricate this design various methodologies can be accepted. Different types of systems which can be devised in the vehicle are:

A. Electronic Solenoid

This method of actuation provides a most susceptible means of gear shifts as it is actuated by means of a solenoid coil, which on getting energize moves the plunger linearly in outward and inward direction.

B. Pneumatic Assembly

Pneumatic assembly [10], consist of solenoid valves which are actuated according to the algorithm implemented in the electronic system(microcontroller) and this actuation allows the air to move from metallic tank to pneumatic cylinder. This makes the piston of the pneumatic cylinder move up and down. Piston is attached with the gear lever which in turns rotates the spindle [2],

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thus upshift and downshift of the piston forces the lever to shift the gear. This method provides an appreciable torque to rotate the spindle of the gearbox.

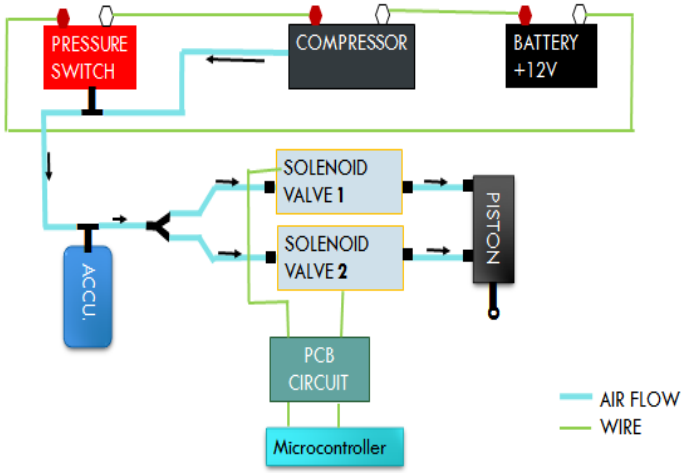

Figure 3: Block diagram representation of Pneumatic System.

C. *Electric Motor*

This arrangement of electronic gear shifter consists of an electric motor which rotates the spindle up-to a desirable rotation so that it can lead to a gear shift. The rotation of the motor can be controlled by designing an electronic system using a microcontroller and actuations are done by providing 2 electrical switches to the driver at steering wheel.

Pneumatic assembly is selected to design the gear shifting system for 2015 MECHSONIC Racing SAE race car. The low cost system setup, reliability in performance and ease of availability of tools makes its implementation feasible.

IV. CONCEPTUALIZATION AND WORKING METHODOLOGIES

To design and fabricate the selected various parameters are scrutinized i.e. amount of forces required to shift the gears, sizing and selection of the appropriate components, transmission box of the engine and the design of electronic system.

By considering these parameters the overall design is formulated into 2 categories:

A. *Pneumatic Systems*

The modeling of the pneumatic system involves the conceptualization and evaluation of different parameters:

Pneumatic cylinder: The spindle attached with the gear lever needs a rotatory motion, so there's a need to actuate the gear lever linearly (back and forth). A double acting pneumatic cylinder provides the necessary bidirectional movement to the gear lever. The sizing of the pneumatic cylinder is considered on 2 factors:

Maximum force required to complete a shift: Necessary force required for the gear shifts is evaluated by performing iterations. Several values are considered and graphs are drawn at constant air pressures and final value of force is attained. On the basis of desired force, bore diameter of the pneumatic cylinder is proposed.

Travelling Length of the actuator: The linear motion of the actuator is converted into the rotatory action of the spindle of the gear box. Thus, length of the actuator is considered on the factor of angle of rotation traversed by the gear lever while making a shift.

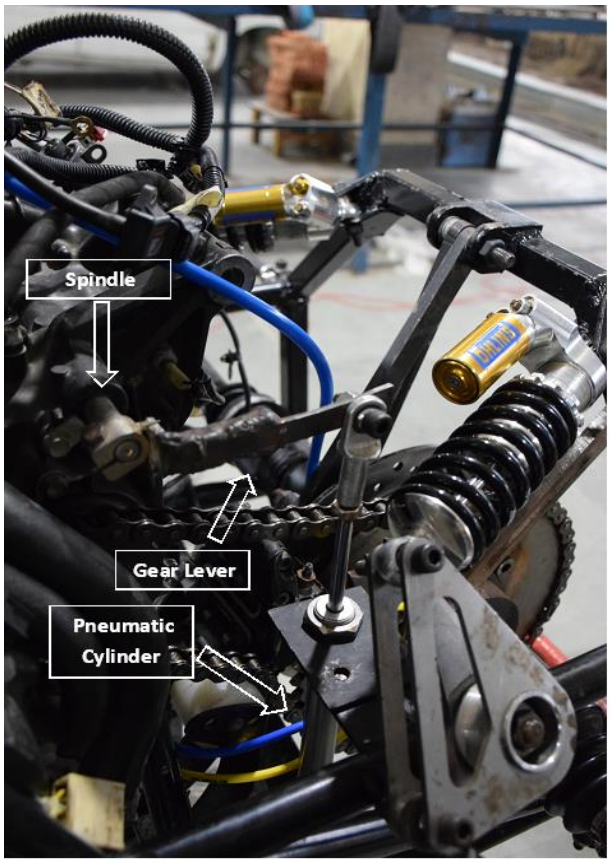

Figure 4: Pneumatic Cylinder installed.

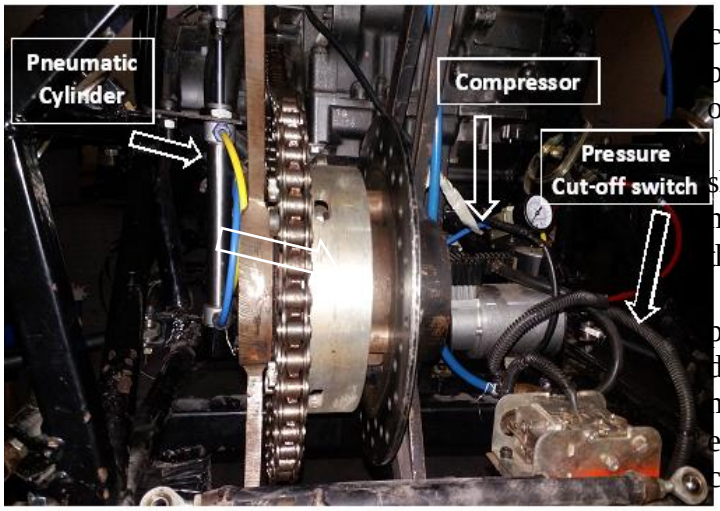

Figure 5: Installed Pneumatic Assembly.

B. *Electronics Design*

Electronic design requires the analysis on the programming logic, circuit designing, PCB installation and suitable electronic components selection so as to get the desired unerring executions.

Logic Design of the Microcontroller:

Microcontroller is required to receive the signal from the paddle shifters and in-turn actuates the solenoid valve. The logic of actuation is formulated in the microcontroller and this logic depends on the arrangement of the gears in the transmission box. Honda CBR 600 RR has a gear arrangement of 1-N-2-3-4-5-6 i.e. neutral comes in between 1st and 2nd gear.

Gear Indication: 7-segment display is used for the gear indication and its circuitry is designed on the PCB. CBR 600 RR doesn't have a gear position sensor in its transmission box so in order to achieve the value of exact gear, ratio of speed and engine rpm is computed. In this way by scrutinizing gear ratio [1], value of gear is displayed on 7-segment display.

V. CONCLUSION

Several designs are available in the market, the convenient design and the suitable component will be selected for the vehicle by considering the factor of cost and reliability in executions.

Theoretical analysis for the electronic gear shifting mechanism accomplished, fabrication and manufacturing of selected design is incorporated in the vehicle on the basis of this study.

In the Future's design, a graphical display providing engine rpm will be integrated at the dashboard, this enhances the driver's suitability by making gear shifts in the defined rpm range. By eliminating manual clutching, transmission system can be made as entirely semi-automatic.

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