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Design of Gear Shifting Assembly using Paddle Shifters and Electric Solenoid for FSAE Vehicles

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Abstract - *The traditional manual transmission system, which features an H-pattern or sequential configuration is very difficult to the driver while he or she is driving in certain conditions on the track like cornering. In FSAE Events with many turns driver has to make frequent turns for the best performance. So, when a shift is needed, driver would have to make it with one hand because the other hand will be engaged to shift the gear otherwise, he or she has to wait until the turn gets completed and loose time because of bad engine RPM which decreases the overall performance. To overcome this issue Paddle shifters are introduced behind the steering wheel which will actuate the solenoid to shift the gear and help the driver to keep both the hand on the steering wheel while switching gears.*

***Key Words*: FSAE, Paddle shifter, Transmission, Time, Performance**

1.INTRODUCTION

In today's era the competition in the automobile industry is growing rapidly and the customer's demand for new features, safety and performance has also increased.

In FSAE event like Autocross, Skid pad, Endurance time is main concern. When the driver removes his hand from steering wheel to shift the gear, he loses the control over the car which affects the overall performance of the car. So, to overcome this problem we have developed an electronic solenoid shifting assembly in which the driver can change the gears with the help of shifter attached to the steering wheel without removing the hand from steering wheel.

Our FSAE competition car uses 390cc 6 speed single cylinder four stroke engine. The paper elaborates about the designing and manufacturing of paddle, solenoid, actuating lever etc This assembly is electrically operated to shift the gears. The actuator is connected to gear lever for shifting gears. The solenoid used in this assembly provides the necessary force to shift the gears. The paddle attached to the steering wheel helps control the actuation of gears. In comparison with traditional gear shifting system and paddle shifter, there's no doubt that it would be quicker to shift up or down gears with the paddle shifters. The paddle shifter assembly requires less space than traditional gear shifting assembly in driver's cockpit. The effort required by the driver to shift the gear with the help of paddle shifter is less than that of normal gear lever. So, the driver can focus on events with less stress which increases overall performance, more control over the car in events.

Solenoid used in this assembly is linear bi-directional solenoid which helps to upshift as well as down shift. The two springs located in the solenoid helps the plungers to get back to its own position after the shift are actuated. The solenoid is located near the engine and a wired connection is provided from the battery to the switches which actuates the solenoid

1.1 Problem Statement

The FSAE vehicle needed a better shift system since they are using traditional manual system. This traditional shifting is very slow and difficult to use in situation like cornering and breaking as the driver has to remove his hands from the steering wheel, hold the clutch and push/pull the lever and perform a shift this results in-

1. More time taken to shift the gear
2. Decrease in control over the vehicle while cornering

1.2 Proposed Solution

To overcome the above drawbacks Electronic Paddle Shifters are proposed. The driver would be able to shift the gear without removing hand from the steering wheel. The amount of energy required to actuate the shift is also reduced

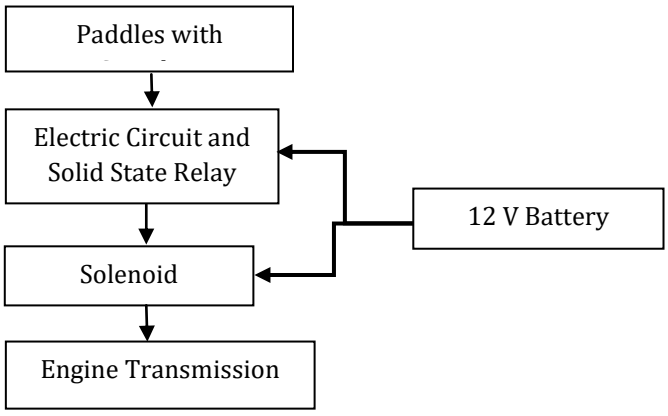

Chart -1: Flow Chart of entire system.

2. DESIGN

The electronic solenoid work on the principle of electromagnetism, where it converts the electrical energy provided to it into mechanical energy, this converted mechanical energy is transferred to the shift mechanism of the engine which will help to move the lever and shift will be produced, based on the type of solenoid, it works as a bidirectional solenoid i.e., actuating on both sides this mechanism is used to shift the gear upshift and downshift.

The design of the solenoid depends on the electromagnetic field generated at the output. This electromagnetic field is generated by using a long loop of the wire wrapped around a metallic core (plunger), and it produces a magnetic field to generate the linear motion of the plunger when an electric current is passed through the wire coil.

For this purpose, the force required by the shifting lever to shift the gear on upshift and downshift is measured by using a spring balance by attaching one end of the balance to the lever and other end to the manual shifting handle. The recorded force required to shift is given below in the table.

Fig -1: Force measurement using spring balance.

From-To	Shift Up (Kg)	From-To	Shift Down (Kg)
1-2	7	6-5	5.5
2-3	6	5-4	6
3-4	6.5	4-3	6
4-5	7	3-2	6.5
5-6	5	2-1	6

Table -1: Force Identification using spring balance

Therefore, the force required to shift the gear is to be produced by the electromagnetic field in the solenoid for efficient shifting.

This electromagnetic field is related to the input current, the no of turns of coil and the iron core inside the solenoid, The bigger the input current and the no of the coil turns bigger the electromagnetic force.

2.1 Design Calculations

To find magnetic field.

Force developed by electromagnet $F = \frac{B^2 \times A}{2\mu}$

Where, B = magnetic field in Terlor

μ = permeability of space $(4\times\pi\times10^{-7})$

A= Area of Pole in Meter = $\pi/4 * (D1 - D0)$

Number of turns of copper wire

Magnetic field equation $B = \frac{\mu\times N\times I}{L}$

B = magnetic field in Terlor

N = number of turns of copper wire

I = Current supplied in amp (12 amp =measured at current input of solenoid)

L = Length of plunger

μ = permeability of space $(4 \times\pi \times10^{-7})$

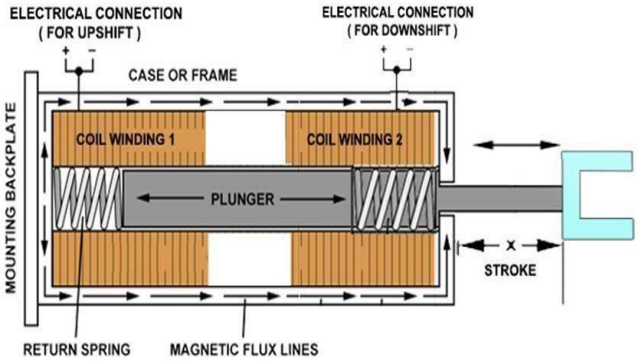

Fig -2: Cross Section of Solenoid.

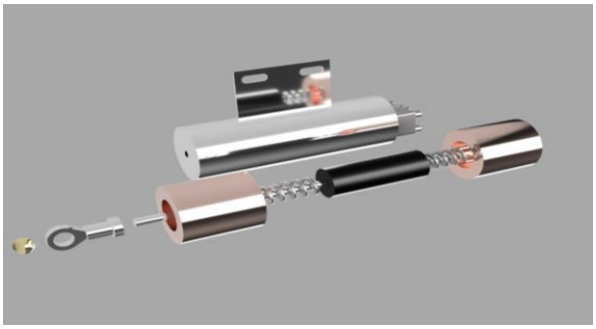

Fig -3 Exploded view of solenoid assembly.

2.2 Design of Paddles

The driver while the race has to follow a racing line to minimize the race time, in order to achieve this the driver has to concentrate on the steering effort and the control of the car, there are several braking points, turn in points and clipping points which the driver should be in control.

Here the shifting of the solenoid is made easy by giving the control of shift on the backside of the steering wheel itself, so there will be no additional effort made by the driver to remove his hand every time while shifting, that also results in reduced control over the car and affect the overall race time.

By proto typing method the actual position of the pedals is fixed on the steering wheel, The actuating pedals are manufactured by using Aluminum 6061 on VMC Machine. And the pedal mounts are manufactured by using the 3D Printing technology by using ABS as the material

This whole paddle shift on steering wheel is connected through an electric circuit which helps in actuating the solenoid for the shift.

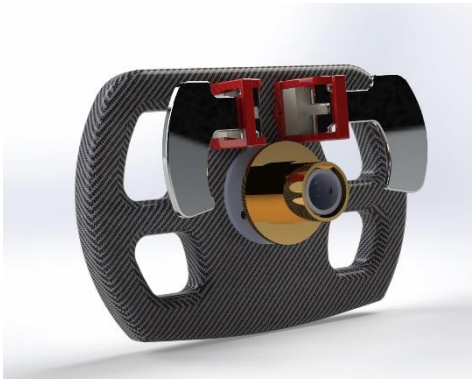

Fig -4: CAD Model of Paddles Assembly.

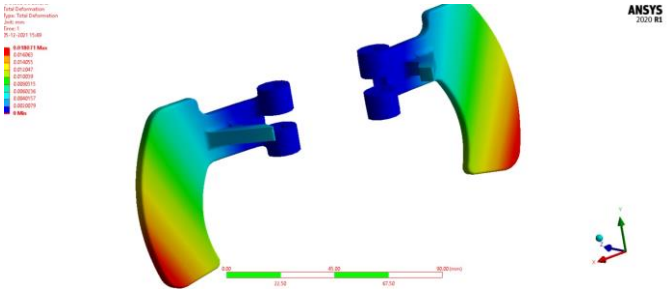

Fig -5: Analysis of Paddles.

Fig -6: Manufactured Assembly of Steering wheel with paddles.

3. ELECTRIC CIRCUIT AND CONNECTIONS

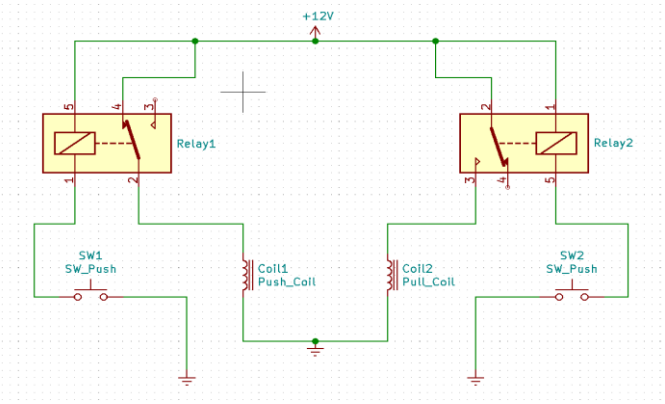

Fig -7: Electric Circuit.

DPDT (Double Pole Double Throw) type of relay is used for the application for controlling two separate circuits controlled through a single actuation.

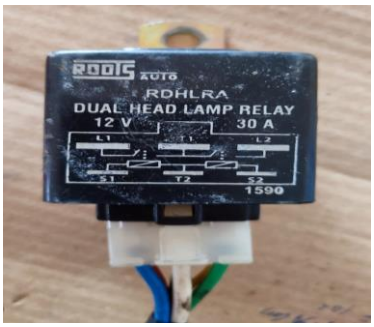

Fig -8: Relay

4. MANUFACTURING PROCESSES

Sr no	Component	Materials used	Manufacturing Processes
1	Steering Wheel	Carbon Fiber	Resin Infusion Vacuum Bagging
2	Paddles	Aluminum 6061	Milling
3	Solenoid Body	Stainless Steel	Turning and grinding
4	Shifting Lever	MS and Aluminum 6061	Milling and CNC Lathe

Table -2: Manufacturing Processes.

5. ASSEMBLY OF SOLENOID

The solenoid is mounted on the chassis by use of fasteners on a welded mount and connected to the Shifter lever using fasteners.

Fig -9: Shifter Lever assembly on Engine.

Fig -10: Solenoid Assembly on Engine.

6. CONCLUSION

This project helped us a lot in understanding the applications of thermotical knowledge, including the manufacturing processes involved during the project. This assembly helps in reducing the time for any event and focusing on the overall control of the car, braking and steering during tough cornering.

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