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Design and Manufacturing of Pneumatic Gear Shifter for Go-Kart

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***Abstract*— Design and fabrication of a semi automatic gear shifting mechanism for a Go Kart a racing car. This gear shifting mechanism had been design to resolve –gear shifting problem, eliminate fully mechanical gear shift ,to have a better control over the steering, to reduce the effort of the driver and to reduce the gear shifting timing which is most important deciding factor in race like scenario where few milliseconds make you a winner or a loser. The idea of pneumatic shifter rose from discussion on alternate methods of the shifting mechanism. Performing the basic analysis, the design was made on the available data and the final design was implemented.**

Keywords—Shifter,Pneumatic,Go-Kart, Automation, Design.

I. INTRODUCTION

Increasing demands on performance, quality and cost are the main challenge for today's automotive industry, in an environment where every movement, component and every assembly operation must be immediately and automatically recorded, checked and documented for maximum efficiency. One of these applications includes the pneumatic gear shifter.

Fig.1 Manual Shifter Assembly

II. COMPONENT SELECTION

It was observed that the Go-kart used by the college team faced problems related to manual gear shifting. Therefore, it was decided that the shifting mechanism be mounted on the same Go-kart to increase its performance. The Go-kart on which the mechanism has been mounted uses:

- Engine: Hero Honda Stunner.
- Gearbox: Integrated 5-speed gearbox.
- Shifting sequence: 1-N-2-3-4-5

A. Cylinders

The pressure used in this pneumatic cylinder should be 2 bar, but due to large openings and leakage of the air from the cylinder the pressure can be increased to 4-5 bar. . As with the categorization pneumatic cylinders can be divided into 2 types-

- Single acting cylinder (SAC)
- Double acting cylinder (DAC)

a) Calculations of cylinders:

For the calculation of force required on gear lever and for clutch, a portable electronic scale was used. It gives a reading of force required in kg. The force exerted by the piston (F) can be simply approximated by the product of the gauge pressure of the gas (P_1) multiplied by the area of the cylinder (A).

P, $=F/A$…. (1)

- For Cylinder 1:

Fig.2 Double acting cylinder for Gear lever

F_1=10kg=98.1 N...(i)

$A_1=\pi/4 *(d^2)$
Where, d=diameter=20mm.

$A_1=3.1415*10^{-5}$ m^2
According to equation 1,

P_1=3.12 bar….(ii)

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- *For Cylinder 2:*

Fig.3 Double acting cylinder for Clutch lever

F_2=6kg =6*9.81 N =58.86 N

$A_2=\pi/4 * (d^2)$
Where, d=diameter=25mm. Therefore,

$A=4.9087*10^{-4}$ m^2

According to equation 1, P_2=1.19 bar.

B. List of components

TABLE I:List of Component

Sr no:	Table		
	Component name	*Quantity*	*specification*
1	Cylinder	2	Cylinder 1:Double acting, Bore= 20mm,stroke= 50mm Cylinder 2: Double acting, Bore= 25mm,stroke= 50mm
2	3/2 direction control valve	4	Solenoid operated ,24V
3	Air canister	1	Max safe pressure =18 bar
4	Pneumatic pipe		O.D =6mm
5	connector	2	t-connector
6	Relay	4	6V
7	Micro-controller	1	Arduino uno-328 operating voltage-5 V
8	Voltage regulator	1	IC 7805
9	Relay connector	1	Operating voltage -5V ,output voltage -12V

III. DETAILED WORKING OF THE MECHANISM

The mechanism consists of the following circuits:

- Electronic circuit
- Pneumatic circuit.

A. Electronic circuit

The electronic circuit consists of the following components:

a) Relay circuit
b) Microcontroller (ARDUINO UNO 328)

a) Relay circuit

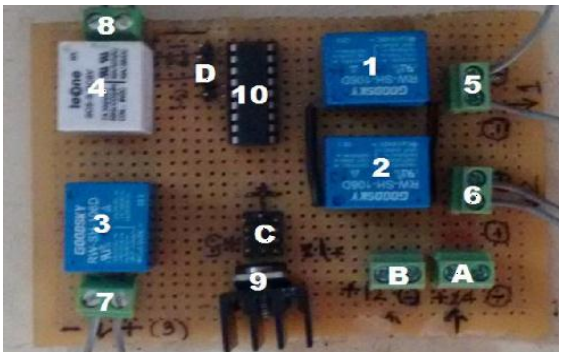

Fig.4 Relay circuit

The above circuit parts are as follows;
1- Relay 1,
2- Relay 2
3-Relay 3
4-Relay 4
5-24 V Supply For Solenoid Valve 1
6-24 V Supply For Solenoid Valve 2
7-24 V Supply For Solenoid Valve 3
8-24 V Supply For Solenoid Valve 4
9-Ic 7805 Voltage Regulator
10- Ic Uln2803 Relay Connector
A- 12 V Supply Input
B- 24v Supply Input
C- Output Terminals For Ic7805
D- Input Logic From Controller

➢ *Working of the circuit:*

- 12 v and 24 V supply is given to the circuit through terminals A and B as shown in the figure, of which,12V supply is used to actuate relays and 24V supply is directly given through terminals 5,6,7,8 to valves 1,2,3,4 respectively.
- 12 V supply is stepped down to 5V through IC 7805, which is a voltage regulator. Microcontroller is powered by this 5V. Extreme left row of C provides 5 V supply, extreme right row provides 12 V supply and the middle row is ground.
- The 12 V supply is given to IC ULN 2803. At module D, controller gives logic 0 or 1 according to which IC 7805 actuates relays by 12V supply, which in turn actuates solenoid valves through 24 V supply.

b) Microcontroller

Fig 5 Microcontroller (Arduino UNO 328)

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The above figure shows microcontroller ARDUINO UNO 328. The connection through module D are as follows:

Pin 9 to relay 1
Pin 10 to relay 2
Pin 8 to relay 3
Pin 6 to relay 4.

Ground of relay circuit and microcontroller is common through ground pin of microcontroller and module C. Thus the electronic circuit is completed.

B. Pneumatic circuit

The pneumatic circuit consists of the following components:

- Double acting cylinders
- 3/2 solenoid operated DCVs

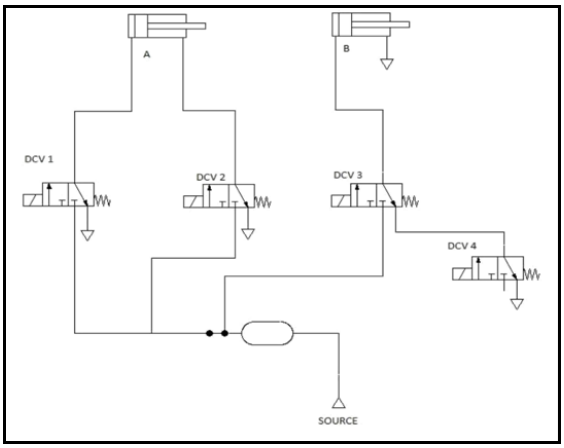

Fig 6 Pneumatic circuit

DCV-1, 2, 3, 4 and Cylinders-A and B

The working of the circuit is as follows:
DCV 3 is actuated through the relay circuit and piston of cylinder B is extended due to which clutch is disengaged. Now DCV 1 gets actuated due to another signal which is delayed by 50 milliseconds after the actuation of the DCV 3. Due to this, Cylinder A gets actuated and due the extension of the piston, which is joined to the gear shifting lever, the gear is shifted.

Similarly, operating other DCV"s, other required gear positions are obtained.

IV. CONSOLIDATED WORKING OF ELECTRONIC AND PNEUMATIC CIRCUIT AND PROGRAMMING

The Consolidated working can be sub divided into three main categories as follows:

- Up shift
- Downshift
- 1st gear

A. Programming

Program to be fed to the microcontroller was done using the programming software.

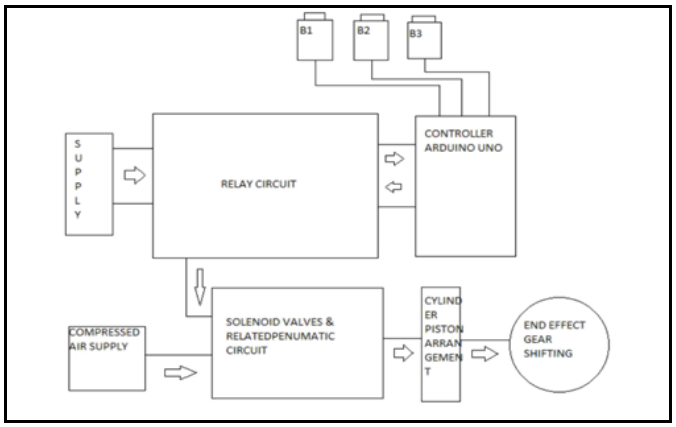

Fig 7 Block Diagram of system

Fig 8 Mounting of the buttons on steering wheel and their position

B. Up shift

- Button 1 is connected between pin 13 and gnd.
- When button 1 is pressed, controller enters into loop 1 (if loop) of the program.
- This gives a 5V signal through pin 8 to relay circuit module D.
- This in turn actuates solenoid DCV through relay 3.
- Due to this, cylinder B (clutch cylinder) disengages the clutch.
- After a delay of 50 milliseconds, incorporated in the program, logic of 5V is given
- through pin 9 to relay 1, thus actuating solenoid DCV 1 of cylinder A.
- Thus, cylinder A shifts gear.

C. Down shift

- Button 2 is connected between pin 12 and gnd.
- When button 2 is pressed, controller enters into loop 2 (if loop) of the program.
- This gives a 5V signal through pin 8 to relay circuit module D.
- This in turn actuates solenoid DCV through relay 3.
- Due to this, cylinder B (clutch cylinder) disengages the clutch.
- After a delay of 50 milliseconds, incorporated in the program, logic of 5V is given through pin 10 to relay 2, thus actuating solenoid DCV 2 of cylinder A.
- *Thus, cylinder A shifts gear.*

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D. First Gear

- Button 3 is connected between pin 11 and gnd.
- When button 3 is pressed, the controller enters into loop 3 (if loop) of the program.
- This gives a 5V signal through pin 8 to relay circuit module D.
- This in turn actuates solenoid DCV through relay 3.
- Due to this, cylinder B (clutch cylinder) disengages the clutch.
- After a delay of 50 milliseconds, incorporated in the program, logic of 5V is given
- through pin 10 to relay 2, thus actuating solenoid DCV 2 of cylinder A.
- Thus the system shifts to 1st gear.
- After this, controller gives 5V logic to module D in order to actuate relay 4.
- Relay 4 actuates solenoid DCV 4 which is connected to the exhaust of solenoid valve 3.
- DCV 4 is normally open type.
- With the help of this loop, program turns relay 4 ON and OFF, which controls the Solenoid
- DCV 4 to give a smooth return stroke for cylinder by restricting the exhaust of cylinder in return stroke.
- This ensures smooth engagement of clutch which is required for the smooth starting of vehicle from static condition.

V. TESTING

Testing was conducted in two stages as follows:

A. Stage 1

- In this stage, the vehicle was put on jack.
- In this, he engine was running on no load condition.
- The mechanism was tested under these conditions initially.

B. Stage 2

- In this stage, the vehicle was dynamically tested on 20m patch.
- Results obtained are tabulated in result table.
- It was observed during this testing, that, the time required for shifting and the manual effort involved was considerably reduced.

Fig 9 Go-kart on which shifter was implemented

Fig 10 Rear side of Go- kart

VI. RESULT

The main objective of the project was to reduce the time required for shifting gears. Manual shifting required 2 to 3 seconds for shifting.
Now, by implementing pneumatic shifting mechanism, time required for shifting I reduced to 0.5 to 0.7 seconds.

TABLE II: Comparison

Sr No.	Table		
	Criteria	Manual shifting	Pneumatic operated shifting
1	Shifting time	2 to 3 seconds	0.5 to 0.7 seconds
2	Precision	Good	Better than manual
3	Control	Relatively less, as the hands get engaged in gear shifting	Relatively more, as button for shifting gears are mounted on the steering itself.
4	Effort	More effort	Less effort
5	Comfort	Less comfort	More comfort

VII. CONCLUSION

With the use of pneumatic shifter in traditional geared go-kart, it makes easy to shift gears.
Not only does it give quick response while shifting but also decreases effort of driver.
Implementing such type of shifter system increases the overall of performance of vehicle in race like scenario. To implement this on the vehicle it would require additional mountings for the, cylinders and canister or an onboard compressor. That would indeed increase the weight, but simultaneously it would improve the performance of the engine as it uses the same supply used for the engine which is charged (battery) by the engine itself.
The system can be considered as a starting point for further development of pneumatically operated gear shifter which can be optimized further, made simpler in design and reliable in operation.

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