Review on Micro Air Consumption Engine Vehicle with Energy Multiplier

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Abstract - *Air engines are known for producing clean green power only dis-advantage being that they consume considerable amount of air to produce this power, thereby the power required to produce the compressed air also increases, this fact makes the utilization and implementation of air engines directly to automobile transmission impractical. The aim of this project is to develop a micro air consumption engine with low air consumption up to 3 cc per stroke and will operate such that when this compressed air expands, the energy is released to do work. So this energy in compressed air is utilized to displace a piston which operates a linear to rotary actuator which further drives the energy multiplier flywheel. Thus together by combination of the micro air consumption engine and flywheel we can get the maximum possible mileage from the compressed air. The project work will include design, development and analysis of the air engine, rotary linear actuator, modified energy multiplier flywheel and the vehicle to demonstrate the working of the combined system.*

Key Words: Air Tank, Multiplier Flywheel, Proximity sensor, DCV, Bearing, etc.

1. INTRODUCTION

The ideology is to build an air system that utilizes exceptionally small amount of air (just enough quantity) to displace the vehicle on the road surface. Conventional or standard system mostly consists of bulky air compressors which ultimately renders the system very noisy and oversized. The experiment is to replace the compressor with air tank and a 5/2 DCV regulator which regulates the air flow supply required. The conventional system is heavy, oversized, uneasy to operate, costly and requires heavy maintenance. It comprises of air engine coupled to a flywheel that is driven by the compressed air supplied from the compressor directly. The unregulated supplies of compressed air pose greater threat to the system. The cut off supply from compressor once damaged the vehicle remains stationary and useless until repair.

The experimental setup comprises of many electrical and mechanical components.

Mechanical components like air tank, rack and pinion arrangement, energy multiplier flywheel, clutch housing, bearing housing, cylinder, and various electronic components as proximity sensor, direction control valve, etc. The setup is quite compact in size and supports greater load carrying capacity. It is cost effective than the conventional system. It generates less noise and is eco -friendly to environment. It utilizes the air stored in the tank to drive/working of system. The energy multiplier ie the torque convertor flywheel generates enough energy transfer to displace the vehicle. The linear motion of piston cylinder is transferred to the rack and pinion arrangement which is further transferred to the uni-directional clutch system which converts it from linear to rotary and is further supplied to the flywheel.

The air usage is in quite less amount as compared to the conventional system which eventually makes the system more effective and efficient economically as well as environmentally. The experimental setup was earlier designed component by component in catia software. The parts were brought together on assembly platform and assembled as per the conventional system design. The assembly file was imported in ansys software for analysis of the system. Further various actual machining processes like turning; drilling and milling are to be performed for the manufacturing of the system.

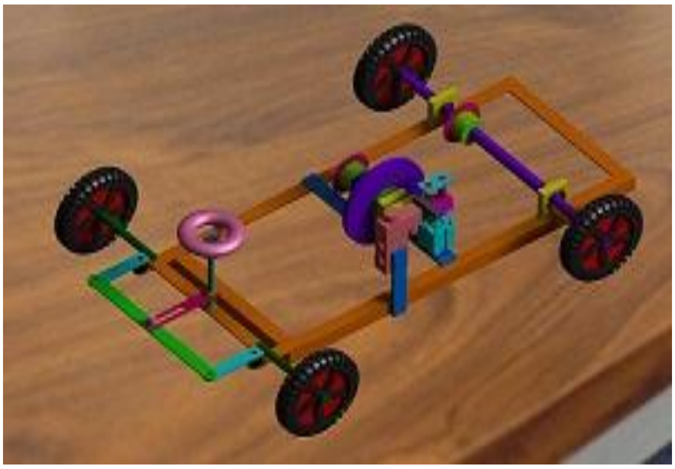

Fig -1: Assembly of system

2. PROJECT CONCEPT

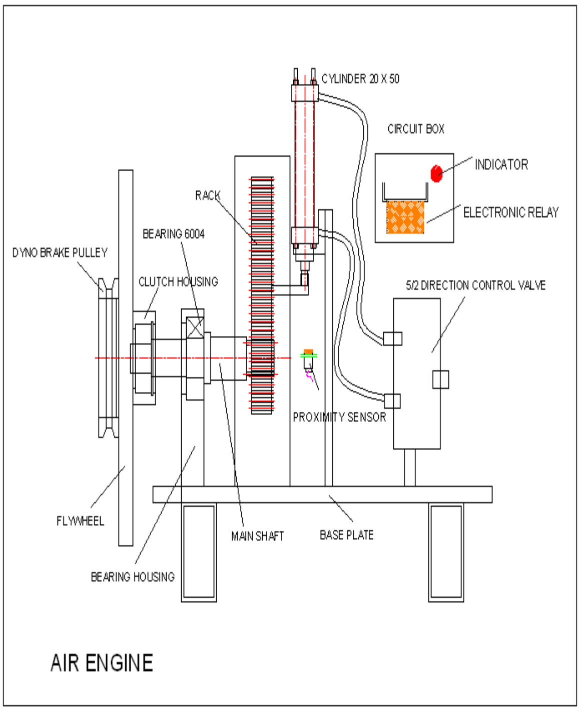

Fig -2: Project Concept

The air engine comprises of the following parts:

2.1 Double Acting Pneumatic cylinder (20 x 15)

Pneumatic cylinder is double acting with 1/8" inlets 20 mm bore and 50mm stroke .It is mounted in inverted condition where in the piston threaded end is connected to a 1 module. The air supply to the cylinder results in to either downward motion or upward motion of the rack.

2.2 5/2 Way Direction Control Solenoid Valve

Pneumatic 5/2 way direction control valve with 230 volt ac input is provided to supply air to the double acting cylinder. The 5/2 direction control valve operation is controlled using a proximity sensor that is operated to switch the 5/2 way valve on or off.

2.3 Rack and Pinion Arrangement

The rack and pinion arrangement converts the reciprocation motion of the rack into rotary motion of the pinion which is rather oscillatory; this oscillatory motion is further rectified to convert into rotary by using a unidirectional clutch.

2.4 Electrical circuit to control motion of engine:

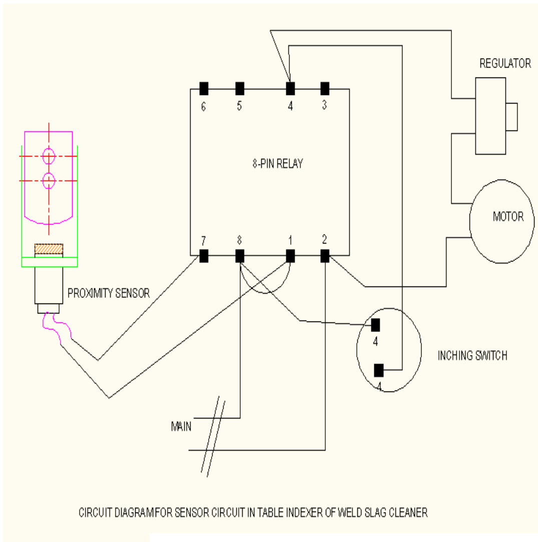

Fig -3: Pneumatic Cylinder

2.5 Electronic Speed Regulator

Motor is an commutator motor i.e., the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator, thereby the speed is also is changes.

2.6 Electronic Relay

The electronic relay is mounted on the sheet metal panel on the base frame. The electronic relay is connected to the proximity sensor and the motor input circuit. The function of the electronic relay is to cut off power supply when the proximity sensor is operated.

2.7 Electronic Proximity sensor

The electronic proximity sensor is mounted on the sheet metal panel on the base frame by means of an Z shaped clamp. The proximity sensor as the name suggests senses the proximity of the indexer buttons which acts as stops, such that when they come in front of the proximity sensor the table the relay is operated to stop the table motion. The proximity sensor is connected to the electronic relay and the power source.

2.8 Inching switch

The inching switch is connected between the electronic relay and the proximity sensor, this switch when operated by-passes the proximity sensor, thereby operating the motor momentarily as long it is kept pressed.

3. CALCULATION

3.1 Design of Piston Rod Material Selection

Table -1: Material Selection

Designation	Tensile Strength N/mm^2	Yield Strength N/mm^2
EN9	600	380

Direct Tensile or Compressive stress due to an axial load

$$fc_{act} = \frac{W}{(\pi/4) \times dc^2}$$

$$= \frac{70}{(\pi/4) \times 5^2}$$

fc_{act} = 3.56 N/mm^2

As $fc_{act} < fc_{all}$; Piston rod is safe in compression

3.2 Design of Rack & Pinion

INPUT DATA:

RACK: 1module, 60 teeth, Pinion 1 module , 15 teeth.

Load = 70 N

Material of pinion and gear is High steel

Tensile strength =800 N/mm^2

S_{ult} Pinion = S_{ult} Rack = 800N/mm^2

Service factor (Cs) = 1.5

dp = 15

$$\text{Now; } T = Pt \times \frac{dp}{2}$$

Pt = 10 N. -------- (A)

A) Lewis Strength equation

WT = S_{bym}

Where ;

$$Y = 0.484 - \frac{2.86}{Z}$$

Y_p = 0.294

S_{yp} = 235.2 N/mm^2

W_T = (S_{yp}) x b x m

= 235.2 x 10m x m

W_T = 2352m^2---------- (B)

Equation (A) & (B)

2352.m^2 = 10

⇒m=0.068 ....APPROX.... 0.1

Selecting standard module =1 mm

No. of teeth on pinion=15

No. of teeth on rack=60

Module = 1mm

3.3 Design of Pinion Shaft.

MATERIAL SELECTION: - Ref :- PSG (1.10 & 1.12) + (1.17)

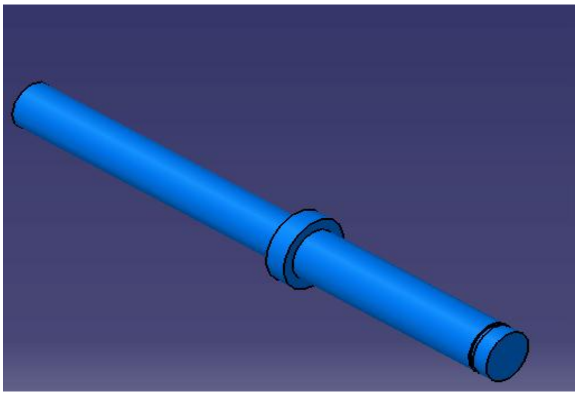

Fig -4: Shaft

Since the loads on most shafts in connected machinery are not constant, it is necessary to make proper allowance for the harmful effects of load fluctuations

According to ASME code permissible values of shear stress may be calculated form various relations.

DESIGNATION	ULTIMATE TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
EN 24	800	680

fs_{max} = 0.18 f_{ult}

= 0.18 x 800

= 144 N/mm^2

OR

fs_{max} = 0.3 $_{fyt}$

=0.3 x 680

=204 N/mm^2

Considering minimum of the above values

fs_{max} = 144 N/mm^2

Shaft is provided with key way; this will reduce its strength. Hence reducing above value of allowable stress by 25%

fs_{max} = 108 N/mm^2

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation

The torque applied is due to the linear motion (push force) applied by the piston rod on to PINION,

T = Pt x R = 70 x (15/2) =525 N-mm

Assuming 25% overload.

T design = 1.25 x T

= 1.25 x 525

= 656 N.mm.

CHECK FOR TORSIONAL SHEAR FAILURE OF SHAFT.

Assuming minimum section diameter on input shaft = 12 mm (mounting diameter for pinion

d = 12 mm

Td = Π/16 x fs_{act} x d^3

$$fs_{act} = 16 \times \frac{Td}{\Pi \times d^3}$$

$$= \frac{16 \times 0.656 \times 10^3}{\Pi \times (12)^3}$$

fs_{act} = 1.93 N/mm^2

As $fs_{act} < fs_{all}$

I/P shaft is safe under torsional load

3.4 Selection of Baring 6004ZZ

Shaft bearing will be subjected to purely medium radial loads; hence we shall use ball bearings for our application.

IsI No	Bearing of basic design No (SKF)	d	D1	D	D_2	B	Basic capacity	
20AC04	6004	20	23	42	36	12	4500	7350

P = X F_r + Y F_a

For our application F_a =0

P = X F_r

As; F_r < e $\Rightarrow$ X =1

P = F_r

Max radial load = F_r =70 N.

P= 70 N

Calculation dynamic load capacity of bearing

$$L = \left(\frac{C}{P}\right)^{1/p}$$, where p= 3 for ball bearings

When P for ball

or Machine used for 8 hr of service per day;

L_H = 12000- 20000hr

But ; $$L = \frac{60\ n\ L_H}{10^6}$$

L = 720 m_{rev}

Now; $$720 = \frac{(C)^3}{72}$$

C= 645 N.

As the required dynamic capacity of bearing is less than the rated dynamic capacity of bearing.

3.5 Selection of Pneumatic Cylinder

Standard cylinder (14167)
DNU-20-50-PPV-A.

Fig -5: Pneumatic Cylinder

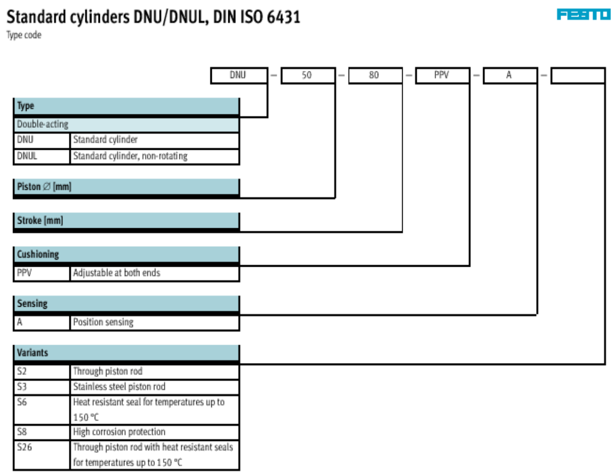

Fig -6: Standard Of Cylinder

4. ADVANTAGES:

1. Low air consumption.
2. High mileage
3. Low cost
4. Highly efficient flywheel
5. Low maintenance cost
6. Reduced vehicle weight and compact system

5. APPLICATIONS:

1. Commercial Cars
2. In plant transport vehicles.
3. Recreational vehicles
4. Hybrid cars.

6. REFERENCES

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