IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MICRO AIR CONSUMPTION ENGINE VEHICLE WITH NOVAL ENERGY MULTIPLIER FLYWHEEL

[1]Mr.Rutvik.S.Chaskar, [2]Mr.Ranajit.M.Jadhav, [3]Mr.Mandar.H.Joshi, [4]Mr.Sagar.S.Naik, [5]Prof.C.S. Khemkar

[1234]Student, [5]Professor

Department of Mechanical Engineering

ISB&M College of Engineering, Pune, India

Abstract— The air driven engine is an eco-friendly engine which operates with compressed air. An air driven engine is a pneumatic actuator that creates useful work by expanding compressed air. There is no mixing of fuel with air as there is no combustion, an air driven engine makes use of compressed air technology for its operation. The compressed air technology is quite simple, conventionally rotary air engine are used but they require high operating pressure and high air consumption hence they find limited applications. The aim of project is to develop a micro air consumption engine with low air consumption up to 3cc 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 novel flywheel we can get the maximum possible mileage from the compressed air. The project wok 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—Energy multiplier flywheel, compressed air engine, micro air consumption engine

Introduction

The idea is to build an air system that uses an exceptionally small amount of air (just the right amount) to move the vehicle across the road surface. The conventional or standard system consists mainly of bulky air compressors which ultimately make the system very noisy and oversized. The experiment focuses primarily on the compressor and a 5/2DCV regulator that regulates the required airflow delivery. The traditional system is heavy, oversized, difficult to operate, expensive and high maintenance. It consists of a pneumatic motor coupled to a flywheel driven by compressed air supplied directly by the compressor. Unregulated compressed air supply poses a greater risk to the system. Compressor supply interrupted after damage vehicle remains stationary and unusable until repair is made. The experimental setup consists of many electrical and mechanical component. Mechanical components such as compressor,rack and pinion assembly, power multiplier flywheel, clutch housing, bearing housing, cylinder and various electronic components such as proximity sensor, directional control valve, etc. The configuration is quite compact and supports higher load capacity. It is cheaper than the traditional system. It generates less noise and protects the environment. It uses compressed air to power/operate the system. The performance multiplier, i.e., the torque converter flywheel, creates sufficient power transfer to move the vehicle. The linear motion of the piston cylinder is transmitted to the rack and pinion assembly, which is then transmitted to the overrunning clutch system, which converts from linear to rotary and feeds the flywheel.

PROBLEM DEFINITION

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. We accepted the challenge of increasing the output of air engine by applying the concept of living energy flywheel in the transmission system.

SOLUTION:- The solution to the above problem is to run the automobile transmission as a hybrid one where in electrical power will be used in conjunction to the compressed air to propel the vehicle. The concept is to run the vehicle using battery power to overcome initial inertia of vehicle and then switch to compressed air engine. The modified micro air consumption engine with novel power optimization flywheel uses a 20mm diameter cylinder with 15mm stroke thus air consumption per stroke is as low as 4.7 cc hence the engine produces maximum power with minimal air consumption, the novel flywheel converts the intermittent power strokes from the air engine in continuous rotary output to be delivered to the vehicle transaxle. The details of the air engine are as below. The main objective of this project is to prove the concept of living energy flywheel applied in compressed air engine to increase output by keeping the input same.

PROJECT CONCEPT:-

Fig.1 Prototype

STANDARD COMPONENT AND SPECIFICATION:-

Solenoid Valve

To feed air to the double acting cylinder, a pneumatic 5/2 way direction control valve with 230 volt ac input is provided. The operation of the 5/2 direction control valve is controlled by a proximity sensor that is used to turn the 5/2 way valve on and off.

Pneumatic Cylinder

Double action pneumatic cylinder with 1/8" inlets, 20 mm bore, and 50mm stroke. It is installed inverted, with the piston threaded end linked to a 1 module. The air supply to the cylinder causes the rack to move either downward or upward.

Rack And Pinion Arrangement

The reciprocating movement of piston is converted into rotary motion of pinion with the help of rack and pinion arrangement. This motion is then further transferred to main shaft which is connected to pinion.

Sun and Planetary Gear Arrangement

The sun and planetary gear arrangement is the part of our living energy mechanism concept. 3 planet gears are assembled around a sun gear. The planet gears have weights on them on their outer periphery covering 1/3 portion of outer periphery .When the Sun gear rotates planet gears they also rotate correspondingly and these weights on the planet gears tend to go in and out.

Flywheel

To even out the fluctuations in power and thereby make a smooth transmission of output power flywheel is installed in our assembly. Planet gears are mounted on the flywheel.

DESIGN CALCULATIONS

DESIGN FOR PISTON ROD

INPUT DATA

1. Theoretical force at 6 bar when advancing of piston = 754 N
2. Piston rod threading end = M10 x 1.25 pitch Ref: - (PSG – 1.12)

Material selection:

Table. 1 Material Properties for Piston Rod

Designation	Tensile Strength N/mm^2	Yield Strength N/mm^2
EN24	800	680

Direct Tensile or Compressive stress due to an axial load: -

$fc_{act} = W/A$

$fc_{act} = \frac{754}{\pi/4 \text{x} 8.75^2}$

$fc_{act} = 12.53\ N/mm^2$

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

Shear stress in threaded end due to axial load :-

$fs_{act} = W/\pi ndct$

t = width thread at root = p/2

t= 0.625 mm

n = No of threads in contact = AM/ pitch = 30/1.25 = 24

$= \frac{754}{\pi \text{x} 24 \text{x} 8.75 \text{x} 0.625}$

$fs_{act} = 1.82\ N/mm^2$

As $fs_{act} < fs_{all}$ the screw threads are safe in shear.

Stresses due to buckling of piston rod:-

According to Rankine's formula, crippling load is given by,

$$W_{cr} = f_c A/\{l + a\left(\frac{l_e}{k}\right)^2\}$$

Where; Wcr = Crippling load on screw (N)

A = Area of c/s at root (mm^2)

A= constant

Le= Equivalent unsupported length of screw (mm) decided by end conditions.

K= Radius of gyration = dc/4 (mm)

Fc= Yield stress in compression (N/mm^2)

le = 0.707L;as one end of screw are considered to be fixed and other free

(Ref.PSG Design Data Pg. No. 6.8)

Here transverse of the piston is 40 mm, total length of piston rod = (Zj + AM)

=80 +30 =110

For effective length,we have…

le = 0.707 x 110 = 77mm

Now, substituting all values in formula…

$$W_{cr} = 400\text{x}(\frac{\pi}{4}\text{x } 8.75^2)/\{1 + (\frac{1}{7500})\left(\frac{77}{8.75/4}\right)^2\}$$

$$W_{cr} = 66.03 \text{ x } 10^3 N = 66.03 kN$$

As, The critical load causing buckling (66.03 kN) is high as compared to actual compressive load of 3.016 kN .So, the piston rod is safe in buckling .

DESIGN OF RACK & PINION

INPUT DATA:

Rack: 1 module, Pinion: 1 module, 22 teeth.

Load = 754 N

Material of pinion and gear is High steel EN24

Tensile strength =800 N/mm^2

Sult pinion = Sult rack = 800 N/mm^2

Service factor (Cs) = 1

dp = 12

Now

$T = P_t \text{ x } \mathrm{d_p}/2$

Pt = 754 N. -------- (A)

A) Lewis Strength equation

$W_T = Sbym$

Where;

$y = 0.484 - 2.86/Z$

$y = 0.484 - 2.86/22$

$y = 0.354$

$S_{yp} = 283.2$

$W_T = (S_{yp})\text{x } b \text{ x m}$

$W_T = 283.2 \text{ x } 10 \text{ m}^2$

$W_T = 2832 \text{ m}^2$ ---------- (B)

Equation (A) & (B)

$2832m^2 = 754$

m=0.515

Selecting standard module =1mm

GEAR DATA

No. of teeth on pinion=1

No. of teeth on rack=30

Module = 1 mm

DESIGN OF MAIN SHAFT.

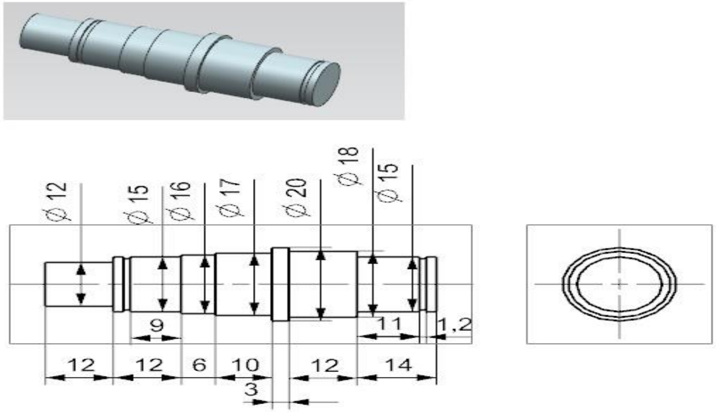

Fig. 2 Main Shaft

Material selection: -Ref:- PSG (1.10 & 1.12) + (1.17)

Table 2 Material Properties for Main Shaft

Designation	Ultimate Tensile Strength N/mm^2	Yield Strength N/mm^2
EN 24	800	680

ASME code for design of 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 relation.

= 0.18 x 800 = 144 N/mm^2

OR

fs $_{max}$ = $0.3fy_t$ =0.3 x 680 =204 N/mm

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 value of shear stress that can be induced in the shaft material for safe operation.

T = Force x radius = 754 x 11 = 8294 N-m

Check for torsional shear failure of shaft.

Minimum section diameter on flywheel shaft = 12 mm & d = 16 mm

$$T_d = \frac{\pi}{16 \text{ x } fs_{act} \text{ x } \mathrm{d}^3}$$

$$fs_{act} = 16 \text{ x} \frac{\mathrm{T_d}}{\pi \text{ x } \mathrm{d}^3}$$

$$fs_{act} = 16 \text{ x} \frac{8294}{\pi \text{ x } 12^3}$$

$$fs_{act} = 24.45\ N/mm^2$$

As fs $_{act}$ < fs $_{all}$ Flywheel shaft is safe under torsional load.

DESIGN (SELECTION OF MAIN SHAFT BALL BRG 6002)

In selection of ball bearing the main governing factor is the system design of the drive i.e.; the size of the ball bearing is of major importance; hence we shall first select an appropriate ball bearing first select an appropriate ball bearing first taking into consideration convenience of mounting the planetary pins and then we shall check for the actual life of ball bearing .

Ball bearing selection.

Series 60

ISI NO	Brg Basic Design No (SKF)	d	D1	D	D2	B	Basic capacity	
							C kgf	Co Kgf
15B C02	6002	15	18	32	26	9	5850	2850

Table 3 Specification Table for Bearing

$P = XF_r + YF_a$

Where;

P=Equivalent dynamic load, (N)

X=Radial load constant

F_r= Radial load(H)

Y = Axial load contact

F_a = Axial load (N)

In our case;

Radial load F_r= 754 N

P= 754/2 = 377 N

L= (C/p) ^{p}

Considering 4000 working hours and speed = 400 rpm

$$L = \frac{60nlh}{10^6} = 96\ m\ rev$$

$$96 = \left(\frac{C}{377}\right)^3$$

$C = 1726\ N$

As required dynamic of bearing is less than the rated dynamic capacity of bearing; Bearing 6002 is safe.

DESIGN OF FLYWHEEL BASE :

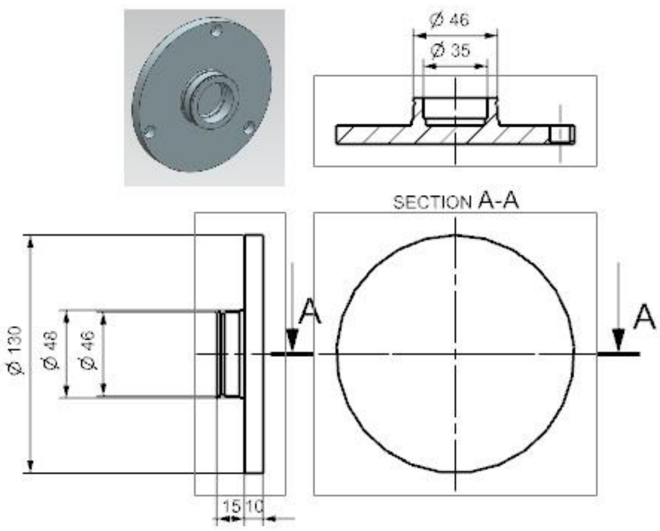

Fig. 3 Design of Flywheel

Material selection: -

Designation	Ultimate tensile strength N/mm^2	Yeild strength N/mm^2
ABS Polymer	80	62

Table 4 Material Strength Properties for Flywheel

As per ASME code Fsmax = UTS /2 = 80/2 = 40 Mpa fs_{max} = 40 N/mm^2. This is the allowable valve of shear stress that can be induced in the bucket material for safe operation.

$T_d = 8294\ N - mm$

$$fs_{act} = \frac{16 \text{ x } \mathrm{T_d}}{\pi \text{ x } (\mathrm{D}^4 - d^4)/D}$$

Outside diameter of flywheel boss = 46 mm

Inside diameter of flywheel boss = 35 mm

$$fs_{act} = \frac{16 \text{ x } 8294 \text{ x } 46}{\pi \text{ x } (46^4 - d35^4)}$$

$fs_{act} = 0.65\ N/mm^2$ As $fs_{act} < fs_{all}$ Flywheel base is safe under torsional load.

DESIGN OF SPUR GEAR PAIR

Input data:

Sun and Planet gear, 1.5 module and 38 teeth.

Load = 754 N

Material of pinion and gear is High steel EN24

Tensile strength =800 N/mm^2

Sult pinion = Sult rack = 800 N/mm^2

Service factor (Cs) = 1

dp = 12

$$T = P_t \text{ x} \frac{\mathrm{d_p}}{2}$$

$P_t = 754\ N$ -------- (A)

A) Lewis Strength equation

$W_T = Sbym$

Where;

$y = 0.484 - 2.86/Z$

$$y = 0.484 - \frac{2.86}{38} = 0.484$$

$y = 0.484$

$S_{yp} = 326.98$

$W_T = (S_{yp}) \text{x } b \text{ x m}$

$W_T = 326.98 \text{ x } 10 \text{ m}^2$

$W_T = 3269.8 \text{ m}^2$ ---------- (B)

Equation (A) & (B)

3296.8m^2 = 754

m=0.478

Selecting standard module =1.5mm

Gear data

No. of teeth on Sun and Plane gear = 38

Module = 1 .5mm.

ADVANTAGES:

- Environmental Friendliness
- Energy Efficiency and Conversion
- Simple Energy Conversion
- Reduced Fire Hazard
- Non-Toxic and Non-Flammable
- Cost and Maintenance

LIMITATIONS:

- Energy Density and Range
- Power and Performance
- Limited Applications
- Reduced Torque

APPLICATIONS:

- Urban Mobility
- Hybrid Vehicles
- Recreational Vehicles
- Sports and Competitions
- Pneumatic Actuators

REFERANCES

1. A comprehensive review on compressed air powered engine; Devang Marvania, Sudhakar Subudhi (Renewable and Sustainable Energy Reviews, Volume 70, April 2017, Pages 1119-1130.)

2. A review of compressed-air hybrid technology in vehicle system; F. Wasbari, R.A. Bakar, L.M. Gan, M.M. Tahir, A.A. Yusof (Renewable and Sustainable Energy Reviews Volume 67, January 2017, Pages 935-953.)

3. A review of compressed air energy systems in vehicle transport; Yidong Fang, Yiji Lu, Anthony Paul Roskilly, Xiaoli Yu (Energy Strategy Reviews Volume 33, January 2021.)

4. Experimental Analysis of a Compressed Air Engine; Qihui Yu, Maolin Cai (Journal of Flow Control, Measurement & Visualization,Volume 3, 2015, Page no.144-153)

5. Experimental Investigation on the Performance of a Compressed-Air Driven Piston Engine; Chih-Yung Huang, Cheng-Kang Hu, Chih-Jie Yu and Cheng-Kuo Sung (Energies, Volume 6, 2013, Page no.1731-1745)

6. Performance of a Compressed Air Engine; N. Pavan Kumar1, N. V. S. Shankar2, V. S. S.N. Prasad Reddy (International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 6 Issue V, May 2018, Page no.2456-2466)

7. Virtual prototype modeling and performance analysis of the air-powered engine ; Xu Qiyue, Shi Yan, Yu Qihui and Cai Maolin (Mechanical Engineering Science, Volume 228(14) ,2014, Page no.2642-2651)

8. Compressed Air Vehicles Drive-Cycle Analysis of Vehicle Performance, Environmental Impacts, and Economic Costs ; Andrew Popson, Felix Kreutzer, and Lee Schipper (Transportation Research Record: Journal of the Transportation Research Board, Volume 2191 ,2014, Page no.67-74)

9. Energy and exergy analysis of compressed air engine systems ; Xuehui Zhang,Xing Wang,Wen Li,Yangli Zhu,Zhitao Zuo,Haisheng Chen (Volume 7 ,November 2021, Page no.2316-2323)