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DESIGN AND FABRICATION OF TANDEM DRIVE HUMAN POWER FLYWHEEL MOTOR FOR APPLICATION OF WATER PURIFICATION

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Abstract – *The Main Aim of This Paper Design and Fabrication of Human power flywheel motor (HPFM) is to generate maximum energy with minimum amount of time. The word tandem drive means double pedal in machine. The main component of this machine is flywheel, pedal, chain sprocket, shaft, freewheel, centrifugal pump, gear. The machine is very simple and comfortable, it can be easily operated either male or female. The machine is economically viable and it can be operated skilled and unskilled people. In India most of people suffering from electricity. So overcome above this problem we select HPFM, which operated manually. This machine is used so many applications. In rural and urban areas keeps water is very bad, he can take care of water naturally pure of this motor. The motor has to attached to centrifugal pump, the upper half will keep two tanks with the help of motor will get muddy water from centrifugal pipe.*

Key Words: HPFM, Flywheel, Tandem, centrifugal pump, shaft, gear

1. INTRODUCTION

In today's developing world, New ideas have taken the world to industrialized has taken in all directions relating to production and safety in competitors. The water scarcity in India also extensively affects the agricultural and industrial areas.

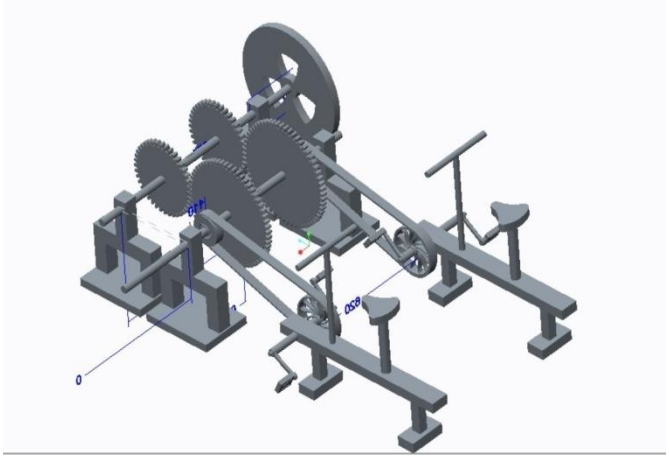

Fig - 1 CAD model of tandem drive human power flywheel motor

India has only 4% of the world's fresh water resources despite a total population. The major portion of the human population does not have a reliable and constant means of getting water for their daily needs. More than 65% of all reservoirs in India reported below normal water levels and 12% are completely dry. With nearly more than 70% of water contaminated. India ranks 120th in a global water quality index, the report is noted. India holds about 4% of global freshwater. In India seven people die every day due to mud water that's why our team is working on purification of water. Authors has worked this motor in different different applications but we are doing something different in HPFM. First of all we are putting two pedal in which we are more power generate at least in time. We also generate more power with minimum time. The component of machine is flywheel, pedal, gear, chain sprocket, shaft, centrifugal pump. In HPFM centrifugal pump will connect to the motor and upper half keep two tanks. The mud water below the centrifugal pump will go up and will fall in the tank. That tank four layer is present that is bottom to top. First layer is cotton balls, cloths or coffee layer, second layer is activated charcoal, third layer is gravel or small stones, forth layer is clean sand. This four layer purify water and turn second tank through pipe. We can use this machine near pond, river, drain. We can make water is naturally pure with this machine.

2. DESIGN AND ANALYSIS

2.1 Design of Flywheel

Fig : Reference by google images

Where, E = flywheel kinetic energy (Joule)

I = moment of inertia (kg m^2)

ω = angular velocity (rad/s)

k = inertial constant- depends on shape of flywheel

m = mass of flywheel (kg)

r = radius (m)

Thickness of the rim= 0.06, width of the rim= 0.08

Density = 7200 kg/m^3

E= *1/2 I* ω^2

$I=mk^2$

m=0.06*0.08*2 π*0.5*7200

m=108.58 kg

K=D/2=1/2=0.5m,

I= 27.14 kgm²

For N=2000 rpm

ω =2πN/60 =2π*2000/60

ω =209.46 rad/sec

$E=0.5*27.14*(209.46)^2$

$E=595363.28$ Joule $E=0.5*27.14*(125.68)^2$

Power=E/60 =9922.72 J/sec

Power= 9922.72

Power=12.9 HP

For N=1200 rpm

ω =2πN/60

ω = 125.68 rad/sec

E=214344.42 Joule

Power= 3572.40 J/sec

Power= 4.64 HP

For N=1500 rpm

ω =157.1 rad/sec

$E= 0.5*27.14*(157.1)^2$

E= 334913.16 Joule

Power= 5581.88 J/sec

Power= 7.25 HP

2.2 Design of Shaft

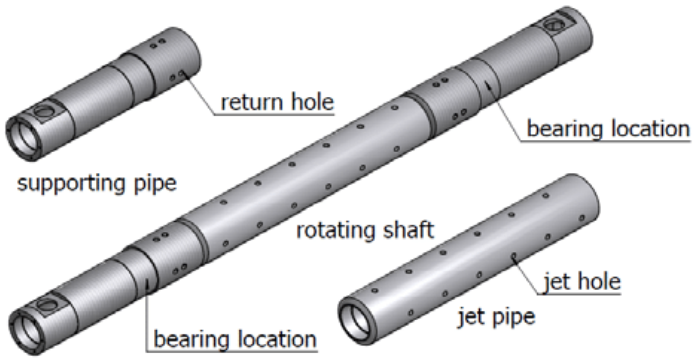

Fig: Reference by google images (https://www.researchgate.net)

For 1200 rpm

Where, N= speed of the shaft in rpm

T= twisting moment in N-mm

J= polar moment of inertia for solid shaft

τ = shear stress

Power= (2*pi*N*T)/60

Power= 3572.40 watt

N= 1200 rpm

T=60×P2π×N

T= 28420 N-mm

T= $\tau \times r/j$

$J= pi/32*d^4$

r= d/2

τ = Sut/FOS = 91.75

d= 14.6 mm

For 1500 rpm

Power= 5581.88 watt

T= 35530 N-mm

d= 15.8mm

For 2000 rpm

Power= 9922.72 watt

T= 47.37 N-mm

d= 17.4 mm

2.3 Design of Gear

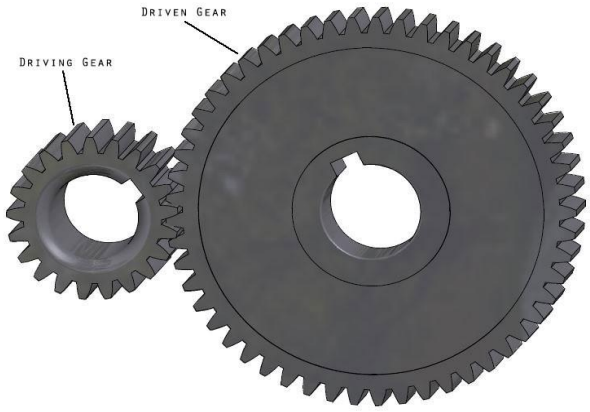

Fig : Reference by google images (http://thereviewstories.com)

For N= 2000 rpm

Power= 9.92272 KW

N = Pinion =2000 rpm

Velocity Ratio = 8

Static Stress = σ_V =120 Mpa

Static Stress = σ_V =100 Mpa

Pinion Teeth = 20

Face width =14m

y= 0.154 -0.192/20

y = 0.1084

Given,

P= 9.92272 KW = 9922.72 watt

N = 2000 rpm

V.R. = TG/TP =8

σop = 120 Mpa = 120 N/mm^2

σog = 100 Mpa = 100 N/mm^2

T_P = 20

b = 14m

m= module in mm

D_P = pitch circle diameter of pinion in mm

Pitch Line Velocity

$V = \pi * D_P * N/60 = \pi * m * T_P * N/60$

$= \pi * m * 20 * 2000/60$

V = 2.0946*m m/s

The service factor (Cs) from table is given by

Tangential tooth load

$W_T = P/V * Cs$

$W_T = 9922.72/2.09466\ m * 1$

$W_T = 4737.1506/m$ N

Velocity Factor

$C_V = 3/3+V = 3/3+2.09466m$

$C_V = 0.5888m$

Tooth from Factor (Pinion)

$Y_P = 0.154 – 0.912/20$

$Y_P = 0.1084$

Tooth from Factor (Gear)

$Y_G = 0.154 – 0.912/ T_G$

$= 0.154 - 0.912/8*20$

$Y_G = 0.1483$

$\sigma op * Y_P = 120 * 0.1084$

= 13.008

$\sigma og * Y_G = 100 * 0.1483$

= 14.83

$\sigma op * Y_P < \sigma og * Y_G$

Pinion is weaker

Using Lewis equation to the pinion

$W_T = \sigma wp * b * \pi * m * Y_P$

$= (\sigma op * C_V) * \pi * m * Y_P$

$4737.1506/m = 120\ (3/3+2.09466\ m)*14m * \pi*m*0.1084$

$3+2.09466m = 0.04512\ m^3$

Solving this equation by hit and trial method

m= 7.44 mm

m= 8 mm

Face width

b= 14 m = 14*8 mm

b = 112 mm

Pitch Circle Diameter of pinion

$D_P = m* T_P$

= 8*20

D_P = 160 mm

Pitch Circle diameter of gear

$D_G = m* T_G = 8*160$

D_G = 1280 mm

N = 1200 rpm

V = 1.2568*m m/s

W_T = 2842.45/m N

Velocity factor,

$C_V = 0.7047m$

$Y_P = 0.1084$

$Y_G = 0.1483$

Using Levis equation,

m = 2.65 mm

m = 2 mm

Face width (b) = 28 mm

Pitch circle diameter for pinion

D_P = 40 mm

Pitch circle diameter for gear

D_G = 320 mm

N = 1500 rpm

V= 1.571*m m/s

W_T = 3553.07/m N

Velocity Factor,

$C_V = 0.6563m$

$Y_P = 0.1084$

$Y_G = 0.1483$

3+1.571 m = 0.4831 m^3

m = 3.076 mm

m = 4 mm

Face width (b) = 56 mm

Pitch circle diameter for pinion

D_P = 80 mm

Pitch circle diameter for gear

D_G = 640 mm

2.4 Design of Chain

Module = 8 mm

$T_P = 20$

$T_G = 160$

$D_P = 160$ mm

Pitch of the chain,

$D_P = P \text{ cosec } (180/20)$

$160 = P \text{ cosec } (180/20)$

P = 25.02mm

Therefore, the minimum centre distance between the smaller and larger sprockets should be 30 to 50 times the pitch.

Therefore,

Centre distance between the sprockets = 30 P = 30 × 25.02 = 750.6 =~ 751 mm

In order to accommodate initial slag in the chain.

The value of centre distance is reduced by 215 mm.

X = 751 – 3 = 748 mm

Therefore,

Number of chain links,

$K = T1 + T2 / 2 + 2x / P + [T2 – T1 / 2\pi]2 \times T / x$

$= 20 + 160 / 2 + 2 \times 748 / 25.02 + [160 – 20 / 2\pi]2 \times 25.02 / 748$

K = 166.30

K = 167 mm

Link of chain,

L = P × K

= 25.02 × 167

= 4178.34 mm

L = 4.178 m

Pitch line velocity of small sprocket,

V1 = π dp N / 60 = π × 160 ×2000 / 60

V1 = 16.755

Find the value of torque

T_{mean} = total area/ 2π

= (1/2 * b*h) + (½ *b*h)

= (1/2 *6*10.4) + (½ *6*1.7)/ 2π

= 5.77*20

T_{mean} = 115 N-m

Sr.no/Ang	d	F	θ	Fcosθ	r	T
1	0°	240N	0	0	0	0
2	30°	240N	60	240cos60°	0.18	21.6N-M
3	60°	240N	30	240cos30°	0.18	37.41N-M
4	90°	240N	90	0	0.18	43.2N-M
5	120°	240N	30	240cos30°	0.18	207.84N-M
6	150°	240N	60	240cos60°	0.18	21.6N-M
7	180°	240N	90	0	0.18	0
8	210°	240N	120	240cos120°	0.18	-21.6N-M
9	240°	240N	150	240cos150°	0.18	-37.41N-M
10	270°	240N	270	0	0.18	-43.2N-M
11	300°	240N	150	240cos300°	0.18	-37.41N-M
12	330°	240N	240	240cos330°	0.18	-21.6N-M

Table-1: Padelling force at 30° each (Thesis: Design of Human Powered Vehicle by Ashwin Kubde and Guided by G. D. Mehta. as a reference)

3. Literature Review

Harsh Dubey, M.P Singh, J.P Modak, Rahul Makade (2020) Preferable Gear ratio, Angular velocity, Diameter of flywheel and other parameters to get maximum output in minimum driving force on HPFM New material with high strength, lower weight will be to achieve and less vibration in HPFM.

Pawan Chandak, Arti Lende, J.P Modak

(2017) Designing of HPFM by empirical approach. By empirical formula of parameters present in HPFM. We can also design HPFM by considering only the empirical formula of various parameters required in designing the HPFM. In this experiment we have seen that the HPFM machine is modified as it works on artificial neural network (ANN). It is based on a collections of connected unit. This is the unique method of selecting optimal ANN network as results we found that the reliability of the derived ANN model is about 97%.

S.N.Waghmare, Dr. C.N.Sakhale, (2015) The paper presents to formulate an experimental data based SPSS model for stirrup making operation by using Human Powered flywheel motor. The SPSS is study and SPSS model formed for three dependent response variable similarly find the value of R, R square, Adjusted R square and standard error of the number of bends estimate for processing time. Statistical package for the social science (SPSS) was introduced in this experiment to generate the correct values of the output parameters corresponding to the input parameters. This process unit improves the number of bends for the stirrup making. This process unit is a establishment for the making stirrup energized by human powered flywheel motor.

D. Mohammed Rafi, Mr. B. Raja kumar, G. S. R. Nagamalleswar A Rao (2016)

Gear box of multi purpose milling machine (SPM).This experiment of HPFM proposed that we can use the human power to perform the milling as well as drilling operation in a single machine with good results. Here the design software creo 3.0 was used for the gear alignment for requirements of different torque. In this operation variable torque plays an important role as the low torque is good for milling and high torque is good for drilling. For the shifting of the drilling and milling operation, shaft has been introduced to change the torque. Torque is analyzed by finite element analysis by using ANSYS work bench 15.0

V. D. Ghuge, J. P. Modak (2013) Develope a Constant Output Speed Transmission For Human Powered Flywheel Motor (HPFM) with Variable Input Speed-a Novel Gearbox Human Powered Flywheel Motor, Pedal Powered Bicycle system, Constant Output Speed Obtian 3 to 9 horse power.

M.S. Giripunje (2016) Literature Review Paper on Human Powered Food Grain Crusher machine Process Unit, Pedal Design, etc parameters of HPFM. For a longer period we can operate the food grain crusher without fatigue. If we replace hand operated pedal food grain crusher. A complete unit consist of this mechanism, which includes transmission and an appropriate clutch of the system which could be any process. The capacity of such a system is in the range of 2.5 to 8. 5 hp. The economic

viability and functional feasibility of this system has also confirmed. Environmental pollution compelled humans to think of renewable energy resources.

Sahil Sharma, Mudit Sharma, Naveen Kumar (2018) Pedal Powered Water Filtration System. In this paper to concentrate on the design of a pedal powered water purifier which can be used in rural areas for the filtration of water at small scale. At different rpm experimental investigation can be carried which can be helpful in determining the adequate flow rate required and therefore, the amount of power required. It can suitable for drinking the man power can be harnessed to purify water.

Ketan Tekale, Yashodip Chawre, Akshay Kapre, Shailesh Kumar, Praveen Mali (2017) Design and Development of Groundnut Oil Extracting Machine by the HPFM Concept. In this research paper we learn the process of oil extraction by using human powered flywheel motor. Oil extraction is a agriculture process of recovering oil from oil bearing agricultural product through manual, mechanical, or chemical extraction. We learned from this paper the concept and objectives of ground nut oil extraction, working principle of this project and design and calculations of various components of that projects like chain drive, flywheel, shaft, shaft bearing etc. Proper Modeling and fabrication of various components is very important for generating appropriate energy to extract oil.

Vivek Padole, Laxminarayan M. Patorkar (2017) This paper aim is to threshing, separating and cleaning rice paddies. To reduced the diligence. To develop a really low cost machine which can be used by farmer to convert their semi-finished (CORN) into finished product (Corn). Save electricity. Reduce human effort.

The thresher can help to substantially reduce the human labour involved in threshing at an reasonable cost and also reduces the time used for threshing operation on small farms.

Vijaykumar S. Shende, Girish D Mehta, Jayant P. Modak, Pravin V. Jadhav, Vishal Kaushik, Krunal Mudafale, Akshay A. Pachpor (2019) The main aim of this paper is for an alternative energy source. Apart from this costly energies. The human power is an alternative source of the energy.Therefore, the use of human power has great scope particularly in rural and remote areas.

Y.M. Sonkhaskar, Swapnil S. Asati, Abhinav M. Purohit (2015) This research paper reports the various process units energized by Human Powered Flywheel Motor (HPFM).In the world of fossil fuels, human power was neglected but hazardous environmental pollution caused by fossil fuels again brought the human power in the main stream of renewable power resources.

Working principle of the pedal operated water purification motor

Our Machine does the work of purifying water. In todays scenario, the water which comes in villages and cities from natural sources and that water is not in good condition as it has particulate matter, impurities, etc which is harmful for the life of human beings and animals. For easing this problem, we are making pedal operated water purifier machine.

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When you pedal machine chain sprocket is rotate. In this chain sprocket driven and driver gear is present. This chain sprocket is connected to shaft. In this shaft gear pinion arrangement is present. This gear pinion arrangement is connected to another shaft and flywheel mounted on it. When pedaling machine then rotating a gear pinion arrangement through chain. This rotating gear pinion arrangement connected to another rotating shaft and flywheel mount on it. This rotating flywheel rotational energy stored on it. This rotational energy converted into electrical energy. This energy use water supply downward to upper half through pipe. This pipe is connected one tank of upper half. The mud water below the centrifugal pump will go up and will fall in the tank. That tank four layer is present that is bottom to top. First layer is cotton balls, cloths or coffee layer, second layer is activated charcoal, third layer is gravel or small stones, forth layer is clean sand. This four layer purify water and turn second tank through pipe. We can use this machine near pond, river, drain. We can make water is naturally pure with this machine.

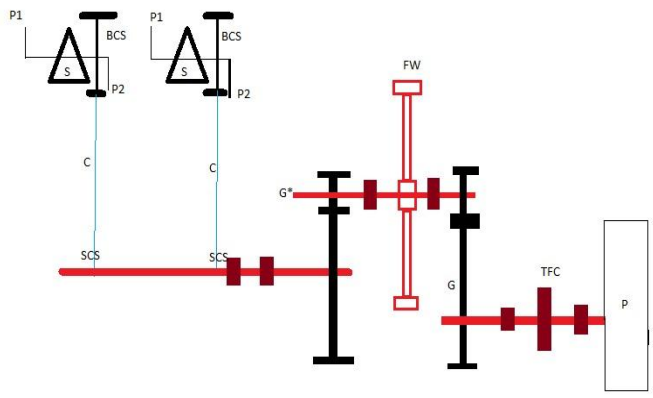

Fig - Reference by A review on the advancement of human powered flywheel motor (HPFM) in India and its application for rural empowerment

Table -2: Table format of values related HPFM

	For 2000 rpm	For 1500 rpm	For 1200rpm
Power (hp)	12.9 hp	7.25 hp	4.64 hp
Shaft diameter (mm)	17.4 mm	15.8 mm	14.6 mm
Module of gear	8	4	2
Diameter of gear and pinion (mm)	Dg = 1280 Dp = 160	Dg = 640 Dp = 80	Dg = 320 Dp = 40

4. CONCLUSIONS

1. The HPFM is study and design model is formed for different variables or values similarly find the value of power, shaft diameter, module of gear, diameter of gear and pinion.

2. By using HPFM model find out values of machine parts for different different rpm that is 1200 rpm, 1500 rpm and 2000 rpm.

3. The maximum power output for 2000 rpm is 12.9 hp.

4. Module of gear is 8 for 2000 rpm is

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