HUMAN POWERED FLYWHEEL MOTOR BY USING DOUBLE LEVER INVERSION MECHANISM

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Abstract

The ever increasing energy demand, unemployment in developing countries like India, Increased awareness of people towards the health are some of the driving forces for the development of humanly powered machines. These machines includes manually powered brick making machine, chaff cutter, pedal operated flour mill etc. The one of the component among all these machines is the flywheel motor which is being used to store the human energy and subsequently use it drive the respective process. To have increased efficiencies, flywheel motors have some special arrangements of inputting power. They are, 1) Quick return ratio one, 2) Elliptical chain wheel, and 3) Double lever inversion. Hence in this paper arrangement and testing values of Double lever inversion is presented on flywheel motor.

I.INTRODUCTION

During 1979-99, Modak J.P. developed a human powered brick making machine for the manufacturing of bricks (Modak J.P. J.P. 1982, 1994, 1997, 1998) [**1**]. And since then various processes are energized by the human power such as wood turning, cloth washing, chaff cutter [**2**], potter's wheel, flour mill etc. All these machines are operated by the human power with one common mechanism among them- The Flywheel Motor. The Machine consists of flywheel motor , driven bicycle mechanism with speed increasing gearing , which drives the shaft of process of process unit through clutch and torque amplification unit (Gupta 1977)[**1**]. Since ever increasing fuel crises, energy crises, busy schedules of load shading, unemployment justify the need of human powered machines, the constants efforts are being continuously made to optimize the various parameters of these machines so as to provide the ease for the operator and consequently make efficient use of human energy. In an attempt, this paper presents the exhaustive literature survey on the flywheel motor throwing lights on the experimentation done on flywheel motor with double lever inversion for optimizing its performance.

II.FLYWHEEL MOTOR THE CONCEPT

Any machine, to power it by human energy, the maximum power requirement should be 75Watts. Any machine or process requiring more than 75 Watts and if process is intermittent without affecting and product, can also be operated by human energy (Alexandrove 1981)[**3**]. This is possible with the provision of intermediate energy storing unit which stores the energy of human and supply periodically at required rate to process unit, this is called as "human powered flywheel motor." Modak J.P. and his associates are working on flywheel motor from 1977. A manually driven brick making machine was first of its kind in which manually energized flywheel motor is used for first time [**4**]. Essentially the flywheel motor consists of flywheel, which is being driven by a human through a simple bicycle mechanism and pair of speed increasing gears [**3**]. The schematic of flywheel motor is as shown in fig1.

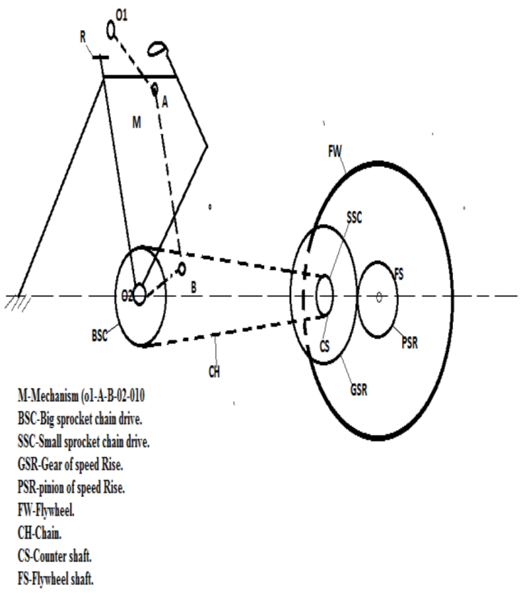

Figure 1. Schematics of flywheel motor.

A rider pedals the mechanism „M" converting the oscillatory motion of thighs into rotational motion of counter shaft „C". This countershaft „C" connected to flywheel shaft „FS" with speed increasing transmission consisting of pair of speed gears [**4**].Driver pumps the energy in flywheel at energy rate convenient to him [**4**]. In this way, the muscular energy of human is converted into kinetic energy of flywheel by this man machine and for its efficient use it is necessary to optimize its parameters[**4**].

III.DESIGN CONSIDERATION IN FLYWHEEL MOTOR.

At the beginning, the flywheel motor was not based on any design data, rather it was built only on the institution of human[**4**]. Later with the numerous experimentation the design data is made available which is discussed below.

A. MODIFICATION IN EXISTING BICYCLE MECHANISM.

Modak J.P (1985) has established the relationship between the useful torques developed at the crank as function of crank position during its revolution [**5**]. Modak J.P. also observed that out of 360° rotation of pedal crank, only from 30°-115° of crank position from top dead center is useful. The rest of the period of crank position i.e. 0°-30° and 115°-162° is not effectively used and from 162°-360° is completely idle. Even when both the cranks are considered the useful driving angle is found to be 154°.[**5**]. Consequently for maximum utilization of operators energy Modak J.P. suggested three modified mechanisms namely Quick return ratio one, Double lever inversion and Elliptical sprocket[**5**].Based on his mathematical modeling he concluded improvement of 17%,38%, and 18% in human energy utilization for Quick return ratio one, Double lever inversion and Elliptical sprocket respectively. This performance of various bicycle drives then was experimentally verified by Modak J.P, Chandurkar K.C. et ,al (1987) and found almost matching with theoretical values[**6**].

B. FLYWHEEL SPEED AND MOMENT OF INERTIA

Modak J.P(1987) during the experimentation has ob-served the maximum thigh oscillation for the average person of 165 cm stature from age group 20-22 years is 40. [**7**]. With the available chain drive for existing 22" bicycle frame the flywheel speed of 240 rpm was fair enough from point of total speed rise from pedals to flywheel shaft [**7**]. Further with calculation Modak J.P.(1987) has deter-mined the size of flywheel with the objective to store the maximum energy irrespective of speed fluctuations(180-240 rpm)[**7**]. The Flywheel rim diameter is found to 82 cm which gives the weight of flywheel as 150Kg and 266 Kg for 240 rpm and 180 rpm respectively. Hence Modak J.P.(1987) suggested the flywheel with 150 Kg @240 rpm[**7**]. Further Modak J.P.(1987) has also found that driving tor-que of pedal is unaffected by increasing flywheel moment of inertia and stores same energy for same frequency of thigh oscillation [**7**].

C. GEAR RATIO

Modak J.P. (1987) suggested the value of gear ratio as 4:1 so as to reduce the effect of jerk induced at process unit shaft as result of energy or momentum exchange during the clutch engagement. If lower value of gear ratio is to be used then flywheel speed should be maintained higher than 240 rpm [**7**].

IV.DOUBLE LEVER INVERSION

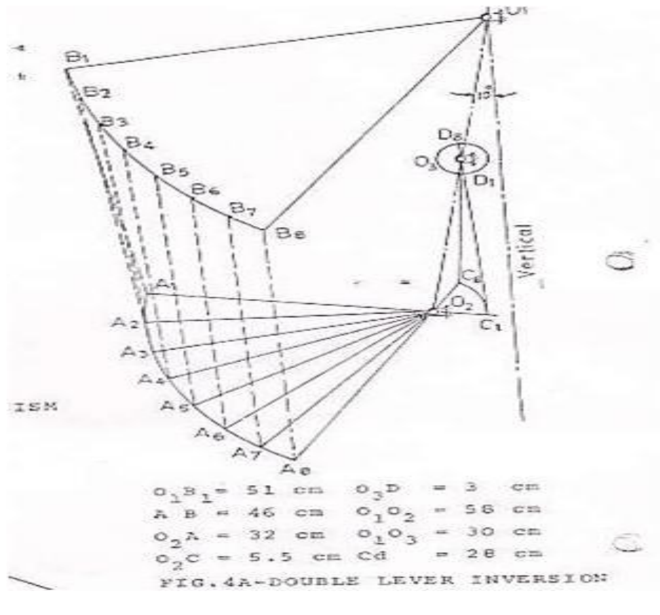

Figure 2. Double lever inversion

From figure, O_2A is a crank which does not rotate completely but oscillates. Therefore, O_2A is chosen to give sufficient angular displacement and good transmission angle. The lever centre or crank centre O_2 was located on the perpendicular bisector of A_1A_8 so as to give an oscillation angle $A_1O_2A_8$ of 70^0.

In double lever mechanism, lever O_2A is 32 cm long and frame O_1O_2 is 58cm at an angle 10^0 to vertical. Another four bar chain O_2CDO_3 is provided in series. This auxiliary four bar chain is a crank lever inversion with crank O_3D rotating and lever O_2C oscillating along with O_2A. In addition to timing the lever, oscillates in positions O_2A_1 to O_2A_8 the auxiliary mechanism serves an additional purpose, when lever for one leg is moving down, it moves the lever of another leg upward. The crank O_3D for both the levers is kept 180^0 out of phase. The auxiliary mechanism is designed for a quick return ratio less than one to ensure that the two levers of different height do not come to dead centre position at the same time.

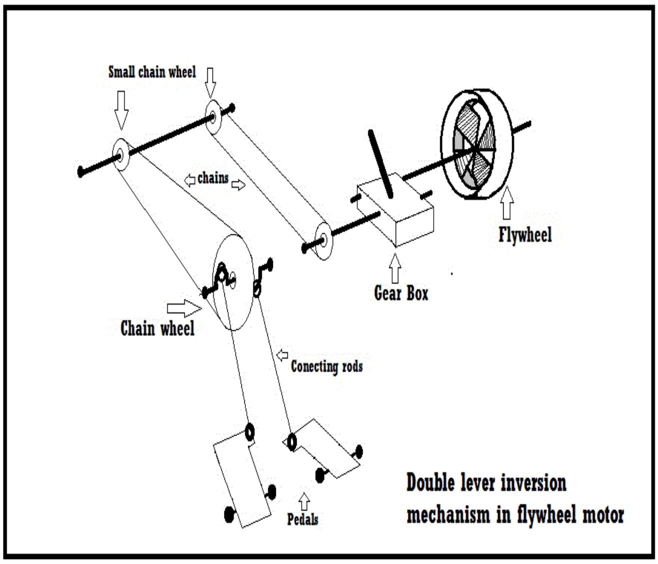

Figure 3. The schematic diagram of practical model of double lever inversion in flywheel motor.

Figure 4. Practical model of double lever inversion in flywheel motor

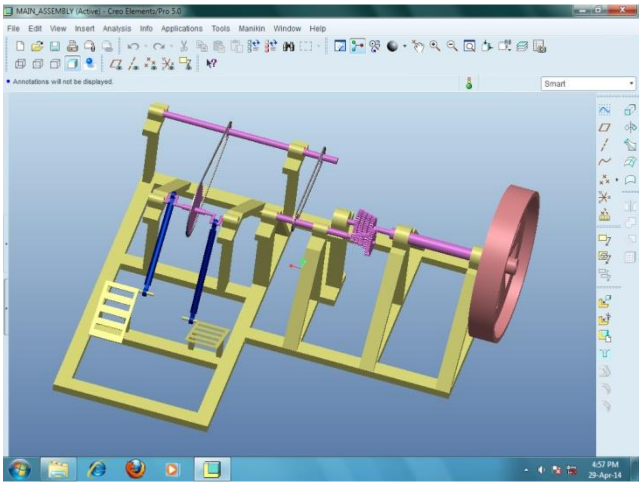

Figure 5. CAD modeling of fabricated human powered flywheel motor with double lever inversion by using PRO-E

V. THE READINGS OF KINETIC ENERGY DEVELOPED IN TESTS OF ACTUAL SETUP.

When the model of human powered flywheel motor with double lever inversion was fabricated in our lab, we took readings of kinetic energy for 15 and 30 seconds, with 2^{nd} , 3^{rd}, and top gear. First we did this for weight wise for eight weight groups between 40-80 kg. Then we did this for age wise for eight age groups between 20-60.

1) WEIGHT WISE:

Sr no.	**Weight of the person in Kg.**	**Cycling time (seconds)**	**KINETIC ENERGY**		
			2^{nd} gear	**3^{rd} gear**	**Top gear**
1	40-45	15	11.54	14.54	12.55
		30	16.50	21.92	23.51
2	45-50	15	8.41	16.84	22.52
		30	7.47	17.52	28.58
3	50-55	15	8.18	17.69	22.52
		30	8.06	8.17	23.71
4	55-60	15	5.38	12.41	19.67
		30	6.07	14.07	25.98
5	60-65	15	3.96	9.03	18.22
		30	5.58	14.70	26.83
6	65-70	15	8.78	17.52	29.25
		30	12.85	41.73	33.66
7	70-75	15	4.38	7.47	14.37
		30	5.58	13.00	19.48
8	75-80	15	5.28	10.45	16.50
		30	6.49	19.48	34.51

Table 1 .weight wise kinetic energy gain.

2) AGE WISE

Sr no.	Age of the person in year.	Cycling time (seconds)	KINETIC ENERGY		
			2^{nd} gear	3^{rd} gear	Top gear
1	20-25	15	8.78	17.52	29.25
		30	12.85	21.74	33.66
2	25-30	15	8.18	18.40	22.91
		30	8.54	15.34	24.12
3	30-35	15	6.50	29.92	32.95
		30	6.81	24.73	34.15
4	35-40	15	7.15	25.56	39.42
		30	7.47	22.91	56.57
5	40-45	15	3.79	4.21	13.00
		30	4.47	14.37	16.84
6	45-50	15	2.81	4.38	13.91
		30	3.18	10.45	17.00
7	50-55	15	2.34	3.96	13.00
		30	3.03	13.00	17.34
8	55-60	15	4.47	13.91	21.15
		30	4.73	15.34	25.56

Table 2 .Age wise kinetic energy gain.

CONCLUSION.

Due to ever increasing energy crises the use of human energized machines are increasing day by day. The number of advantages are associated with this such as unavailability of power specially in rural side of India, less skilled operators, unemployment, bicycle exercising etc . Hence human power machines seem to have great future ahead. In this paper the HPFM with double lever inversion mechanism is proposed. As well as the readings of kinetic energy developed for limited period, weight wise and age wise, are tabulated.

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