Literature Review for Optimization of Kinetic Energy Stored in a Manually Driven Flywheel Motor Using Various Mechanisms

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Abstract: In the recent past days various mechanisms of human powered **flywheel motor such as existing mechanism, elliptical sprocket, circular sprocket, quick return mechanism and double lever inversion mechanism were developed. A manually driven brick-making machine has recently been developed without the benefit of any design data. Generally, a flywheel is used for the purpose of storing energy. The flywheel is used in manually driven machines, mainly as flywheel motor. This paper reports on investigation to be performed by optimizing various mechanisms for maximum kinetic energy gain through human powered flywheel.**

Keywords: **flywheel, mechanisms, experimental model, optimization.**

Literature Survey

J. P. Modak & A. R. Bapat [1] conducted "Formulation of generalized experimental model for manually driven flywheel motor and its optimization" and they came to conclusion that maximum efficiency will obviously be the requirement if the energy demand of the process unit is very high.

J. P. Modak [2] conducted "Bicycle-it's Kinematics and Modifications" and they came to conclusion that elliptical sprocket is to reduce the ineffective time & in double lever inversion, this ineffective time is zero.

J. P. Modak & A.K. Pitale [3] conducted "Human Powered Flywheel Motor - A Review" and they came to conclusion that the effect of multiple operators with alteration in the mechanisms such as double lever inversion quick return ratio=1, and elliptical sprocket can also be analyzed for the human powered flywheel motor.

P. A. Hatwalne & A.K. Pitale [4] conducted "Design of CAD based model for flywheel motor & its optimization" and they came to conclusion that the energy stored is more in case of elliptical chain wheel as compared to the circular chain wheel.

Introduction

With a manually driven brick-making machine developed by Modak (1982) the muscular power of the rider is used to drive the production process. Now a days, this mechanism is very useful in farms and factories for different applications.

A manually driven brick-making machine was developed by Modak in absence of any design data. A schematic representation of the machine is as given in fig. 1. A driver pedals the mechanism 'M', converting oscillatory motion of thighs into rotational motion of the counter shaft 'C'. This is made possible by using various mechanisms such as quick return mechanism, double lever inversion mechanism and elliptical sprocket which improve human energy utilization by 17%, 34%, & 18%. The counter shaft is connected to the fly-wheel shaft 'FS' with a speed increases transmission, consisting of a pair of spur gears 'G'. The driver powers the fly-wheel at a comfortable energy input rate. Thus, this man-machine system converts the human muscular energy into rotational kinetic energy of the flywheel. It was then felt necessary to develop the parameters involved in this pedal driven flywheel motor.

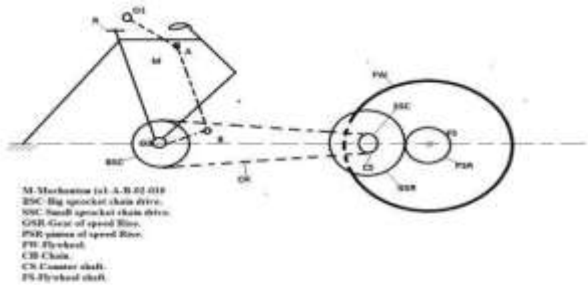

Fig. 1: Schematics of Manually Driven Fly-wheel Motor

1) Quick return ratio-one:

It is modified form of mechanism called as Quick Return Ratio One. In the existing mechanism, the ratio of forward travel to return travel is 0.82. In the Quick Return Ratio One, the ratio is one therefore; the second paddle will be immediately ready when the first one goes down.

In this, the thigh oscillation angle, thigh length and the leg length are kept same. In existing mechanism, the crank length is 18.5 cm and in QRR- one it is 20 cm.

Similarly, in existing mechanism the frame length i.e. crank Centre to rider's hip joint 74 cm and frame inclination to vertical is 20^0. But in QRR-one, the frame length ie. Crank centre to rider's hip joint 67 cm and frame inclination to vertical is 11^0.

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 O2A is 32 cm long and frame O_1O_8 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.

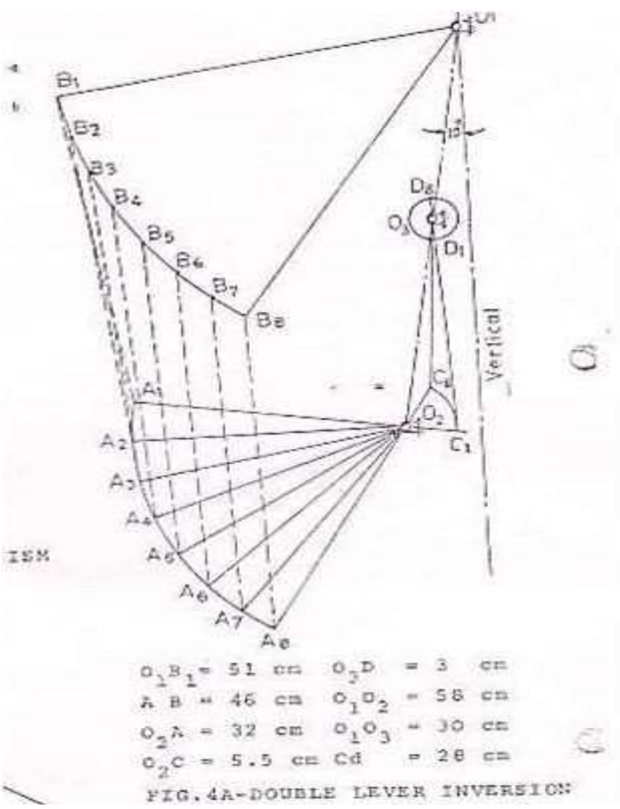

Fig. 3: Modified Mechanisms (Double Lever Inversion)

3) Elliptical Sprocket

In modified mechanism, an elliptical sprocket is at the crank and circular sprocket at the wheel. The main objective of using elliptical sprocket to such a drive can be that the chain

Table 1: Test envelope, Test points and Test sequence becomes alternately loose and tight.

An elliptical sprocket, chosen, the chain becomes loose by 0.8 cm only from its tight condition and sag of only 3 cm is produced by its weight in the span of 49.5 cm. Here an elliptical sprocket of major diameter 24 cm and minor diameter is 12 cm. chosen so as to keep the chain length same.

Assuming that the chain speed is constant, the elliptical sprocket will rotate at a higher speed when the transmission angle is poor and will rotate slow when the transmission angle is good. Thus, giving more time to the mechanism for receiving power input.

Discussion

As this is human-machine system it is rather difficult and unreliable to adopt a totally theoretical approach, so instead an experimental approach. The design of the experimentation required has already been explained by Modak and Bapat (1987) and Bapat and Modak (1989, 1990).

Established the dimensional equation for the process is as follows:

$$WT = f\,[(I/RT2), (ME), (G)]$$

Where,

W = angular velocity of flywheel in rad/sec. reached after time internal T secs.

K = constant of equation (to be decided after performing the tests).

f = stands for function

T = peddling time, in second.

I = moment of inertia of flywheel in Kg.m2

R = energy input by rider in Kgf.m

ME = effectiveness of mechanism.

And G = speed increasing gear ratio.

To found that, the Test envelope, the Test points and the Test sequence for every independent P term or parameter which have been worked out based on this equation. It is not possible to estimate Test envelope for (I/RT2) because it is not possible to adjust R for the given rider. Hence Test envelope for parameter I only is considered.

Sr. No.	Mechanism	Existing	Expected
1	Double lever inversion mechanism	38%	48%
2	Elliptical sprocket	17%	27%
3	Quick return ratio-one	18%	28%

All the above mechanisms should be compared for the work they can supply to the rear wheel for same force applied. The values of torque developed for a unit force in one downward stroke of thigh by various mechanisms. Comparing the areas under these mechanisms, one finds the advantages of various mechanisms compared to existing mechanism as below:

Sr. No.	Terms	Test envelope	Test sequence
1	'I' moment of inertia of flywheel in Kg.m2	0.255 to 3.48 (for I)	0.255, 1.867, 3.48, 1.061, 2.673
2	'ME' effectiveness of mechanism	1 to 1.18	1, 1.17, 1.18
3	'G' gear ratio	1.14 to 4.0	1.14, 1.5, 4.0, 2.0, 1.3

Table 2: Advantage of various mechanisms in terms of kinetic energy gain

For this generalized experimental model the pedal-driven flywheel motor with various mechanisms was developed. The model uses the quick return mechanism with different ratios and as well as the double lever inversion mechanism. The use of these mechanism is maximize kinetic energy gain. In the present work, the various mechanisms (quick return mechanism and double lever inversion mechanism) will be compared for maximum kinetic energy gain. The earlier works with multiple riders shows that the kinetic energy stored in flywheel increases with increase in weight of operator up to certain weight of operator and then it falls down slightly. The present work will be studied any two mechanisms in the respect of storage of maximum kinetic energy gain.

Conclusion

Various applications are developed such as existing mechanism, elliptical sprocket, circular sprocket, quick return mechanism and double lever inversion mechanism etc. The flywheel motor is finding the importance in the rural side of developing countries like India. And hence it is necessary to optimize its performance parameters. In an attempt lots of experimental and numerical models are developed which are already discussed. The effect of multiple operators with alteration in the mechanisms such as double lever inversion, quick return ratio=1, and elliptical sprocket can also be analysed as future work for the human powered flywheel motor. The use of this mechanism is maximize kinetic energy gain. In the present work, the various mechanisms will be compared for highest kinetic energy gain.

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