Design and Development of Dual Worm Self-Locking Lifter

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Abstract: **In most of the gear drives, when the driving torque is suddenly reduced as a result of power off, torsional vibration, power outage or any mechanical failure at the transmission input side, then gears will be rotating either in the same direction driven by the system inertia, or in the opposite direction driven by the resistant output load due to gravity, spring load, etc. The latter condition is known as back driving. However, there are also solutions in gear transmission that prevent inertial motion or back driving using self-locking gears without any additional devices. The term self-locking as applied to gear systems denotes a drive which gives the input gear the freedom to rotate the output gear in either directions but the output gear locks with input when an outside torque attempts to rotate the output in either direction. Worm gears are one of the few gear systems that can be made self-locking, but at the total of efficiency, they rarely exceed 40% efficiency, when made self-locking. The experiment is carried in the laboratory with sufficient small prototype model.**

Index Terms: **Self Locking; Efficiency; Input shaft; Output shaft.**

1. INTRODUCTION

This innovation in gearing is a combination of two worm screws that gives self-locking characteristics or to operate as fast acting brake when power is shut off. The Mating worm self-locking system is a simple dual worm system that not only provided self-locking with maximum efficiency, but also exhibited a new phenomenon called deceleration locking. The mating worm gear drive is quite simply constructed, two threaded rods, or worm screws are meshed together. Each worm is wound in a different direction and has a different pitch angle. For proper mesh the worm axes are not parallel but slightly skewed. But by selecting proper and different pitch angles, the drive exhibit self-locking or combination of self-locking and deceleration locking as desired. Some of the solutions for these, there is no principle or accuracy in manufacturing these gears but for solution on that the twin worm gear drive is quite simply constructed two thread rod or worm screw meshed together. Each worm is wound in different direction and has different pitch angle for proper mesh the worm axes are not parallel but slightly screwed. By selecting proper and different pitch angle the drive wheel exhibits self-locking or combination of self-locking and deceleration on desired. The term self-locking as applied to gear systems denotes a drive which gives the input gear the freedom to rotate the output gear in either directions but the output gear locks with input when an outside torque attempts to rotate the output in either direction. This characteristic is often shown after by designers who want to be sure that the loads on the output side of the system cannot affect the position of the gears. Worm gears are one of the few gear systems that can be made self-locking, but at the total of efficiency, they rarely exceed 40% efficiency, when made self-locking.

2. PREVIOUS WORK ON SELF-LOCLING DEVICES

Mr. Vikrant D. Sathe et.al they studied about self-Locking lifting device by application of twin worm arrangement. He made a prototype load lifting device for lifting weight up to 10 kg. He conducted test and trial on machine for different loads and find that the use of twin worm gear is helpful for lifting load with less effort. He find that as the lifting load increases the torque required to lift that load will also increases, but the speed will reduced. He found that power required is maximum for increasing load. He also found that in his trial as the load increases to maximum the efficiency is also maximum. [1]

Prof. P.B. Kadam et.al they compared their research with the patent paper of Devid W. Pessen who give the twin worm pair have efficiency of 92%. P. B. Kadam in his research of using two worm gears found the efficiency of 89.30%, which it gives to nearer to theoretical efficiency. They also stated that using of twin worm gear in self-locking gear box reduce the whole gear box lifting mechanism size, which reduces cost and size of the load lifting device. So they said that using of twin worm gears in self-locking gear box is very useful in lifting devices and in industrial application. [2]

Prof. Abhay M. Kalje for his study of compact self-locking lifter with zero slip he constructed all the required part like lifter drum, bearing housing, left hand internal worm gear, right hand external thread shaft for his device. Then he did theoretical design and analysis of parts is discussed. In that with the help of Lewis strength equation he finds the dimension and module for gear and pinion. He also find the stresses and torsional failure for all the parts after getting all the values he stated that all designed parts for compact self-locking lifter is safe from torsional failure. [3]

Mr. Naeem B. Tamboli he designed and studied about dual worm self-locking system for improved transmission efficiency & deceleration locking property. In this he compared the conventional system and mating worm gear. He said that the efficiency of worm gear depends on the coefficient of friction and the lead angle. In order to obtain a worm gear with high efficiency it is recommended to use the lead angle in the range between 15° and 30°. In his study he also concluded that mating worm pair system

also exhibits a self-locking ability as that of conventional worm gear system. Also the efficiency of the mating worm pair system is also greater than that of conventional worm gear system if they use in mesh fashion. If we can modify the warm gear for helix angle, lead angle and other parameters the replacement of conventional system i.e. existing system is possible with proposed system i.e. worm pair with self-locking system also we can achieve maximum efficiency and less frictional losses. [4]

3. METHODOLOGY

The twin worm gear self-locking system input shaft is connected to the drive motor, which provides the input power. The input right hand worm gear drives the output worm gear in the direction such that load connected to the load drum (not shown) on the output shaft is raised, now if the motor power is shut off, the input seizes to rotate, and the load will have a tendency to move down due to gravity, thereby the output shaft tries to rotate in opposite direction, but arrangement of the worm threads is made to satisfy the self-locking condition, hence the output shaft locks with the input shaft and thus the motion of the load in the down ward direction is stopped. Thus the self-locking is effectively attained.

3.1 Need of Clutch for Project

Positive clutches are used to transmit power between two coincident shafts. The positive engagement between the clutch elements ensures 100% torque transmission on but occasionally the output shaft may the subjected to a sudden overload which may make the driving motor or engine to stall; which will lead to burnout of the electric motor. In extreme cases this overload will lead to the breakage of drive elements or the clutch itself. In order to avoid the damage of the transmission elements it is necessary that the input and output shafts be disconnected in case of sudden overloads. The isolation of the input driver member i.e.; motor from the output member is absolutely necessary to avoid damage and it is possible by called ball clutch.

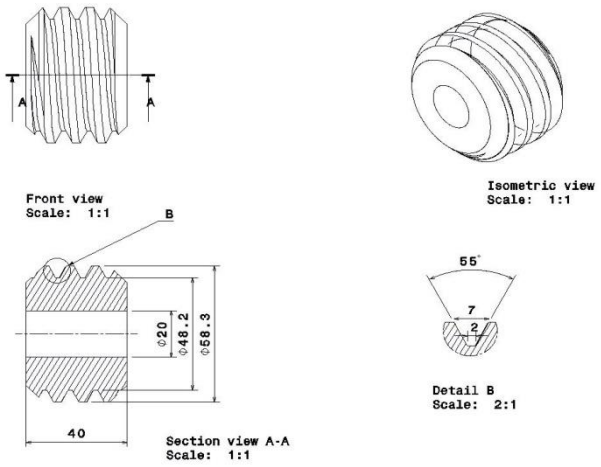
3.2 Working of Clutch

The overload slipping ball clutch is an safety device used in the transmission line to connect the driving and driven elements such that in case of occasional overload the clutch will slip there by disconnecting the input and output member . This protects the transmission elements form any breakage or damage. For a particular loading conditions the clutch is preset to set the cylindrical body for slipping at a different overload, it is simply mounted on output member by means of a key. Casing is adjusted in the appropriate direction, during which the balls will remain pressed against the serrations; thus setting operation is simple, rapid and reliable. The clutch is there connected to the output member or load. When the input shaft is in rotation through the reduction pulley and motor, the base flange is rotated, along with it the balls pressed against Vee - serration also rotate. This motion is transmitted through springs; plunger to the cylindrical body which then rotates the output shaft.

When the load on the output shaft exceeds the preset design overload the resistance of the balls to more in direction of motion of base flange, there by balls start slipping in the Vee - serrations. At one point the balls completely come out of the serrations into open space in base flange thereby disconnecting the base flange and the cylindrical body. Thus the input shaft keeps rotating whereas the output shaft comes to stand still. The overload value at which clutch slips can be designed and preset by moving the casing in either direction of the cylindrical body .To increase the overload value; move casing towards the base flange where as to reduce the overload ; move the casing away from the base flange. The casing can be locked in position by means of the lock nut.

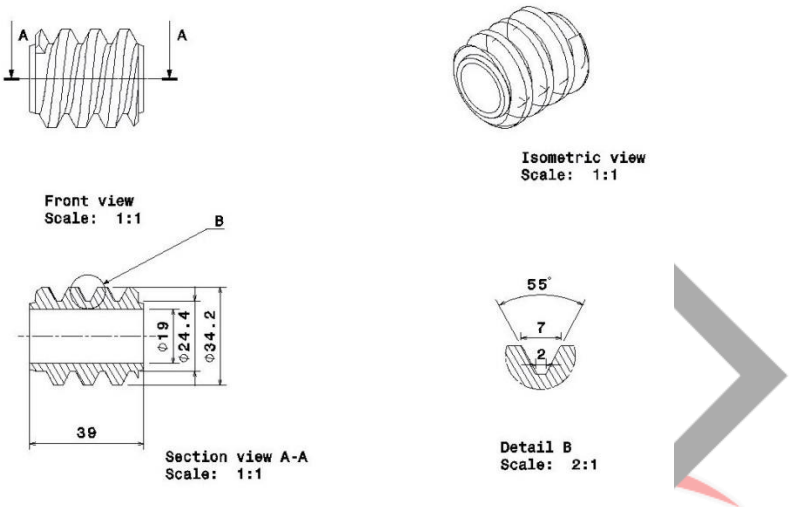
4. DESIGN OF PARTS

a) Input Worm



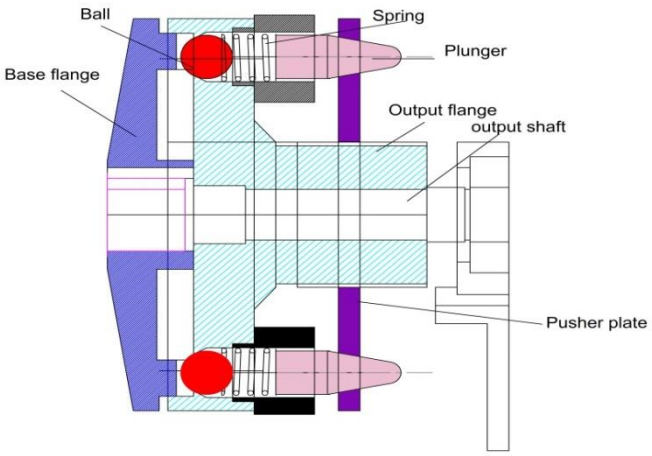
Fig

b) Output Worm



Fig

c) Clutch



Fig

5. RESULTS AND DISCUSSION

AIM: -To conduct trial

a) TORQUE Vs SPEED CHARACTERISTICS

b) POWER Vs SPEED CHARACTERISTICS

In order to conduct trial, a dyno brake pulley cord, weight pan are provided on the output shaft.
INPUT DATA:-
Drive Motor
12 V dc 92 rpm OUTPUT
Power = 10watt
Diameter (Effective) of Dyno brake drum = 100 mm.
PROCEDURE:-

1) Start motor

2) Let mechanism run & stabilize at certain speed (say 45 rpm)

3) Place the pulley cord on dyno brake pulley and add 0.5 KG weight into, the pan, note down the output speed for this load by means of tachometer.

4) Add another 0.5 Kg wt & take reading.

5) Tabulate the readings in the observation table

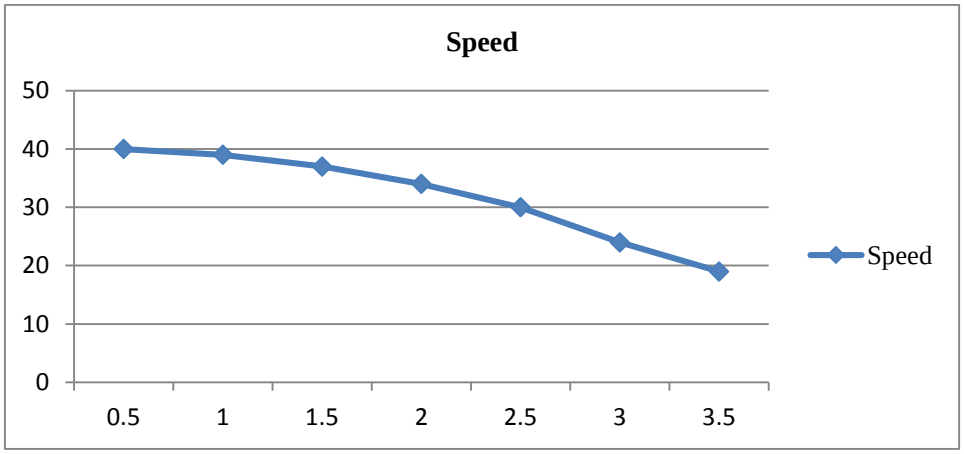
6) Plot Torque Vs speed characteristic

7) Power Vs speed characteristic

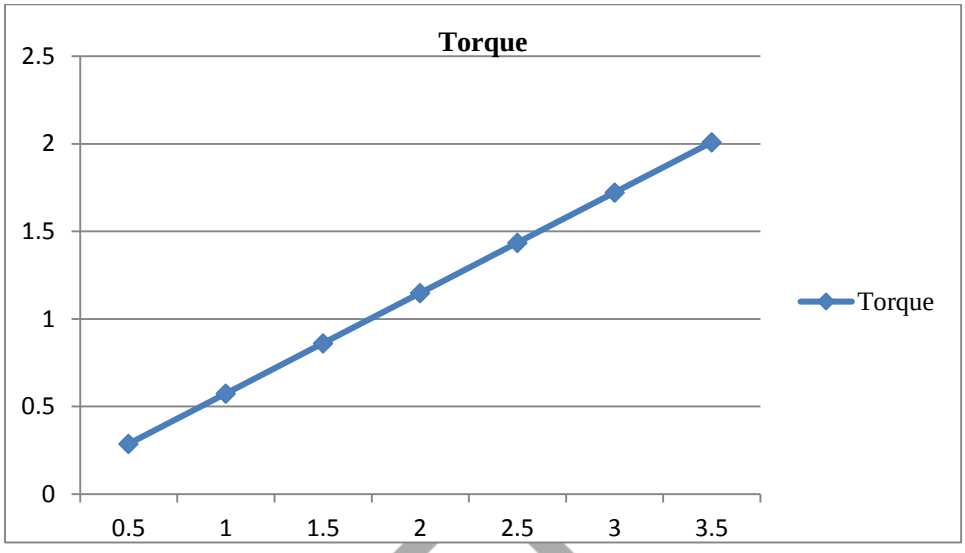
Table 1. Experimental Values

SR NO	LOAD (gms)	SPEED (rpm)	TORQUE (N.M)	POWER (watt)	Efficiency
1	0.5	40	0.286943	1.2021	24.042
2	1	39	0.573885	2.344091	46.88181
3	1.5	37	0.860828	3.335823	66.71647
4	2	34	1.14777	4.087132	81.74265
5	2.5	30	1.434713	4.507868	90.15736
6	3	24	1.721655	4.327552	86.55104
7	3.5	19	2.008598	3.996976	79.93952

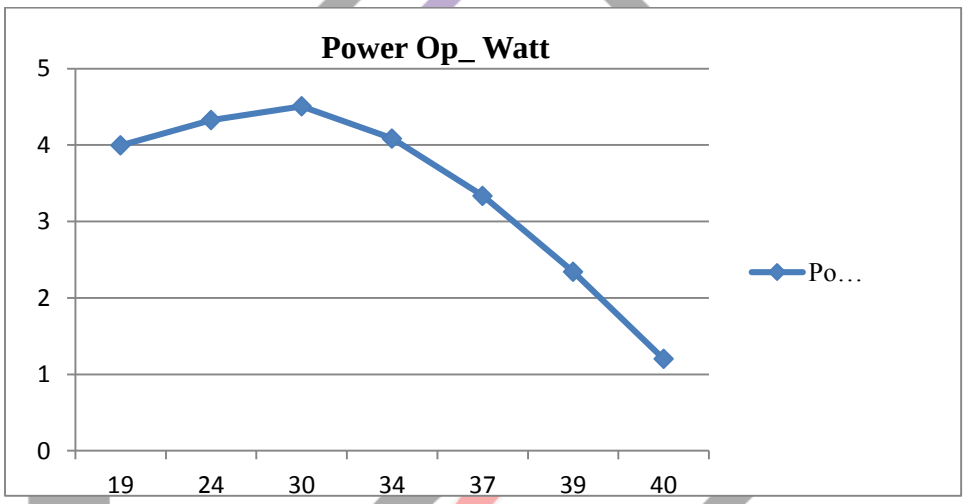
Graph 6.1 Speed vs Load



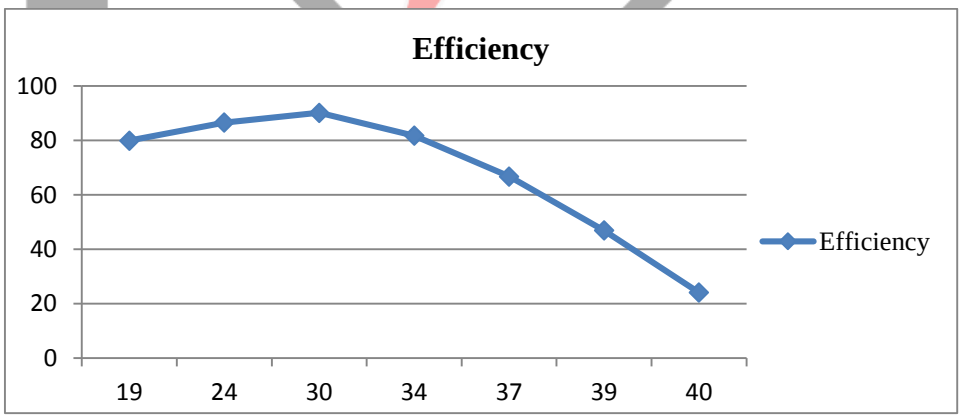
Graph 6.2 Torque vs Load



Graph 6.3 Power Op_ Watt vs Speed RPM



Graph 6.4 Efficiency vs Speed RPM



Maximum efficiency is attained at a speed of 30 rpm

8. CONCLUSION AND FUTURE SCOPE

8.1 Conclusion

A simple, compact, high efficiency, low cost device will be developed, so also a new technology of 3-D printing will be learnt through the project. The project will provide the industry with a new device to solve backlash problems in many machines in many applications. Maximum efficiency is attained at a speed of 30 rpm.

8.2 Future Scope

Worms can be made of high grade steel to increase load carrying capacity. Limit switches can be used for position control. Higher power motor with epi-cyclic gear box will multiply the lifting capacity. For heavy loads lubrication casing can be used.

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