DESIGN AND ANALYSIS OF HIGH EFFICENCY SELF LOCKING LIFTER

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Abstract— When an external load applies a dynamic or static torque to the output worm gear shaft, and this torque does not result in any rotation of the input worm, the reducer is considered self-locking. Depending on several design and load characteristics, worm gear speed reducers may be selected which either self-lock or back-drive and in some limited cases can do both depending on external loads and operational conditions. When an external load applies a dynamic or static torque to the output worm gear shaft, and this torque does not result in any rotation of the input worm, the reducer is considered self-locking. Depending on several design and load characteristics, worm gear speed reducers may be selected which either self-lock or back-drive and in some limited cases can do both depending on external loads and operational conditions. For that purpose, we need to analyse at which load the self-locking occurs.

***Key Words*:**Self-locking, Worm Gear, Lifting.

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1 INTRODUCTION

Lifting devices are used in industry to lift loads, in small machines even though the lifting capacity required is low, self-locking is very necessary.

What is Self-locking?

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 both directions but the output gear locks with input when an outside torque attempts to rotate the output in either direction. This is desired in lifting machines meaning that if motor is lifting a load and it suddenly stops (due to power failure / breakage) load will stop moving and it will not come down due to gravity, thus complete safety is ensured.

2. PROBLEM DEFINITION

2.1 Problem Statement

The efficiency of worm gear box depends upon coefficient of friction and lead angle , but lead angle must be between 1^0 to 3^0 to get self-locking , so efficiency of worm gear box is very low. The Ratchet and pawl mechanism is not reliable or safe and it also takes a lot of space. Hence a compact system with high efficiency is needed for lifting devices.

2.2 Solution

The twin worm gear drive is simple, two threaded rods, or worm screws (Input worm is Right hand & Output worm is Left hand and have a different pitch angle) are meshed together for proper mesh the worm axes are not parallel but inclined to each other, the drive shows self-locking or combination of self-locking and deceleration locking as required.

Thus the drive solves problem by

- High efficiency of transmission
- Compact system -requires less space
- Quick –Self-locking
- Added feature of Deceleration locking to prevent overloading

2.3 Project Objectives

- Design of twin worm system for design load to achieve self-locking condition.
- Application of 3-D printing technology for fast and low cost manufacturing of input and output worm.
- Test and trial to determine Torque-Speed-Power-efficiency of system.

3. LITERATURE SURVEY

a. **Jian Chen et al (2014)** discusses about the feature of involute gear. According to the design principle of involute gear cutter, the index able gear insert with three cutting edges is designed. The milling FEM of index able gear insert is built in Deform 3D software, the FEA milling is analysed with different relief angle and the best relief angle is 6°. Considering cutting force and processing efficiency, the optimal cutting speed is 186.83mm/min and cutting depth is 2.5mm, which the relief angle of index able gear insert is 6° [1].

b. **R. Thirumurugan and G. Muthuveerappan (2011)** calculated maximum contact and fillet stress for normal and high contact ratio gear. The research is based on load contact ratio implementing finite element method and performed for single point load model and multipoint contact model. The effect of various gear parameters such as pressure angle, teeth number, gear ratio, tooth size and addendum on the load sharing ratio and corresponding stress was investigated. Calculation of maximum fillet and contact stress in the case of normal contact ratio gear and high contact ratio gear using the load sharing ratio was performed [2].

c. **G. Marunic (2012)** explains the deformation in the middle web of thin rimmed involute spur gear in mesh with solid spur gear is expressed in the form of displacement as non-dimensional form is analysed. It is concluded that the comparison of maximum rim and web displacements shows that rim deforms considerably more than the web. This result additionally spurred to the necessity of approach that fully respects the actual gear structure and the contribution of every part that the gear teeth are supported [3].

d. **Carlos H. Wink and Nandkishor S. Mantri (2012)** explained about the gear design optimization. The predicted tooth contact temperature using LDP and the temperature estimated from micro hardness and material tempering curve is obtained for an existing gear set which is tested at high speed and without

e. lubrication. The gear design is then optimized using both the RMC and LDP programs. The main reason for the reduction in contact temperature of the optimized design is due to the slip-to-roll ratio reduction, which is proportional to the reduction in temperature. The low contact temperature of the optimized design can significantly contribute to prevent tooth surface damage under no-lubricant operating conditions; this will be confirmed through dynamometer endurance testing [4].

f. **Prakash, D Patel and J.M.Patel (2012)** studied the influence of a variety of operating conditions on the power losses and efficiency of an automotive manual transmission through experimental investigation. The experimental methodology is developed to measure power losses of a manual transmission under both loaded and unloaded conditions while all operating parameters are controlled tightly. A set of fixtures and instruments are designed and implemented for a five-speed manual transmission system of a frontwheel-drive passenger vehicle. Experimental parametric studies were performed to quantify the influence of operating conditions including load, oil [5].

4. CONSTRUCTION

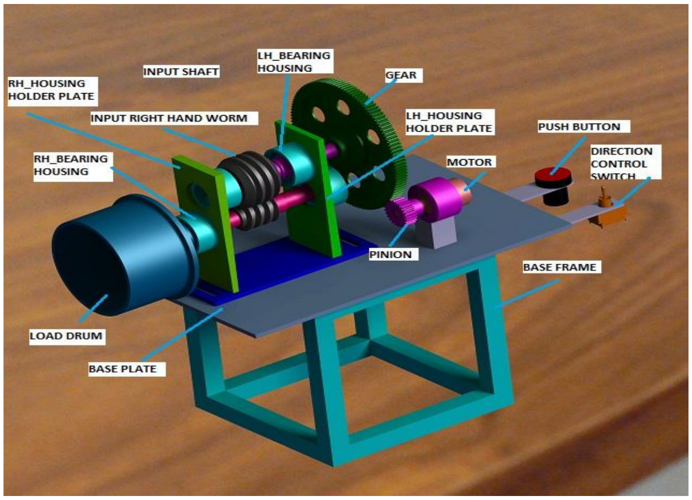

Fig. 4.1Construction of Self- Locking Lifter

The Twin worm system comprises of following parts:

1.Right hand worm gear:

The right hand worm gear is the input gear of the system;it has worm threads of 10 modules which are machined with right hand of operation with helix angle of 2 degrees. The manufacturing process used is 3-D printing method.

2.Left hand worm gear:

The left hand worm gear is the output gear of the system;it has worm threads of 10 modules which are machined with left hand of operation with helix angle of 5 degrees. The manufacturing process used is 3-D printing method.

3. Input shaft:

Input shaft is made of high grade alloy steel EN24, it is held in ball bearings at both ends, at one end a spur gear is mounted to receive power from the motor through a pinion.

4. Output shaft:

Output shaft is made of high grade alloy steel EN24, it is held in ball bearings at both ends, at one end carries the load drum to lift or lower the load

5. Bearings:

Four ball bearings are used in the project. Single row deep groove ball bearing 6004zz is used at each end of shaft. Bearings are held in the bearing housings which are fitted on to the bearing housing holders.

6. LH/RH bearing housings:

These are round members of the system that support the above two shafts in ball bearings, the bearings on the output shaft are appropriately locked, they are mounted on housing plates.

7. Housing mounting plates

Housing mounting plates are vertical members that hold the bearing housings, they are machined at angle of 2.5 degrees to provide proper angle of inclination between the input and output shat so that the desired self-locking characteristic is achieved.

8.Baseplate

The base plate is the base member that houses the entire assembly of system. The housings are bolted to the base plate.

9. Load drum

The load drum is fastened to the output shaft of the system. The rope is wound on the drum with its one end fixed to the drum whereas the other free end carries the load.

10. Motor

The drive motor is 12 VDC motor coupled to a planetary gear box.

Specifications of motor are as follows:

Power 5 watt, Speed = 60 rpm TORQUE = 0.833 N-m

11.BaseFrame:

Base frame comprises of the base plate and base frame structure both made from mild steel. Square pipe of (20x20) mm cross-section and 1.6 mm thickness is used for frame structure.

12. Direction Control Switch:

2-pole 2-way (DP /DT) switch is used to control the direction of motor to rotate motor clockwise or anti-clockwise which will be used to lift or lower the load.

13. Push button

It is used for point to point control i.e.; it is push-to 'On' switch

5. WORKING

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.

6.. ADVANTAGES

a) Twin worm system offers 90 % efficiency
b) Lower power consumption
c) Compact in size
d) Low weight
e) Low production cost
f) Deceleration locking possible.
g) Very low maintenance cost
h) No lubrication required for light loads

7. APPLICATIONS

- Mechanical Cranes
- Hoists and lifts
- Machine tool feed drives
- Propulsion lifts
- Power winches

8. DISCUSSION

Analysis of components is done and the stresses developed in them is well within the limits.Maximum Efficiency is achieved at 30 rpm which is 90.157 %.

9. CONCLUSION

In this project we had successfully designed and analyzed the high efficiency self-locking lifter. A simple, compact, high efficiency , low cost device will be developed,

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