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Design, Development, Analysis And Testing Of Compact Self-Locking Lifting Device By Application Of Twin Worm Arrangement.

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Abstract : **Gears are mostly used in many material handling devices. A compact lifting device to be operated using 12 Volt DC power system to be button operated with easy loading and unloading has been discussed so that operator can single handed load or unload the work-piece onto the machine. Twin worm drive is used for serving the purpose. The concept of self-locking has been used.**
Threaded rod or "worm" and an internal threaded ring gear are meshed together. By selecting proper, and different, pitch angles, the drive will exhibit either self-locking, or a combination of self-locking and deceleration locking characteristics, as desired and drive efficiency can range up to 90%.

Index Terms **- worm, efficiency, self-locking, input shaft, output shaft, PMDC motor**

I INTRODUCTION

In machine tool applications like centre lathes, milling machine, CNC turning lathes, Vertical machining centers, vertical turret lathes, etc. it is often required to lift heavy work-pieces using conventional winches or chain blocks which may require assistance from two or more workers for loading the work-piece on the machine which is rather contradictory to the one man-multi machine concept. Hence there is a need of compact lifting device which will be operated by the machine operator himself without any others assistance. Problem in hand is to develop a compact lifting device to be operated using 12 Volt DC power , system to be button operated with easy loading and unloading facility so that operator can single handed load or unload the work-piece onto the machine. . 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. Worm gears are one of the few gear systems that can be made selflocking. But at the expense of efficiency it hardly exceeds 40%, when made self-locking.

II PROBLEM DEFINITION

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 characteristics is often sought out 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 expense of efficiency, they seldom exceed 45% efficiency, when made self- locking.

But if worm gear drives when used for lifting applications with self-locking as the primary objective for safety considerations the drives are extremely inefficient. Hence there is a need of special purpose drive that will provide better transmission efficiency in self- locking condition so as to reduce power consumed by the device ...i.e. lowering the running cost of device.

III PROPOSED SOLUTION

Proposed system will be designed by developing twin worm system in form of external threaded worm and internal threaded ring with view to develop a compact winch system to be operated using 12 Volt DC PMDC motor for loading lifting application up to 100 kg. But by selecting proper, and different, pitch angles, the drive will exhibit either self-locking, or a combination of self-locking and deceleration locking characteristics, as desired and drive efficiency can range up to 90%.

IV LITERATURE REVIEW

1. Padmanabhan.S.,Chandrasekaran.M., Srinivasa Raman.V [1]., 'Design Optimization Of worm gear drive', The paper focuses on the gear optimization . Gears are used in almost all mechanical devices and its main aim is to provide gear

reduction. At the same time it has to provide maximum power with minimum weight. Gears are machine elements used to transmit rotary motion between two shafts, normally with a constant ratio

2. Syed Ibrahim Dilawer, Md. Abdul Raheem Junaidi, Dr.S.Nawazish Mehdi [2] 'Design, Load Analysis and Optimization of Compound Epicyclic Gear Trains,'The paper focuses on the Gears in the Epicyclic gear trains which is one of the most critical components in the mechanical power transmission system in which failure of one gear will affect the whole transmission system, thus it is very necessary to determine the causes of failure and an attempt to reduce them. This research deals with the Optimization of the gear design leading to the reduction in the load failure of the gears.

3. Feng Li, Shenzhen (CN), jing Ning Ta,Hong Kong (CN)[3] 'United States Patent' The present invention provides a self-locking worm gear drive which has a simple and efficient structure. In the invention, to achieve self-locking of the gear train, the design of the worm and worm wheel has to be modified from ideal or optimal from an efficiency view point.

4. Faydor L. Litvin, Alessandro Nava, Qi Fan, and Alfonso Fuentes[4] ' New Geometry of Worm Face Gear Drives With Conical and Cylindrical Worms: Generation, Simulation of Meshing, and Stress Analysis' New geometry of face worm gear drives and cylindrical worms is proposed. The generation of the face worm-gear is based on application of a tilted head cutter. A predesigned parabolic function of transmission errors for reduction of noise and vibration is provided. The stress analysis of the gear drive is performed using a three-dimensional finite element analysis.

5. JalchinBons Popper,Kiryat Motzkin,Isrnel[5], 'United States Patent Office' The present invention relates in its broader aspects to cooperating wedges, and includes mating worms. The invention in one aspect includes self-locking in one way motion gears in which the function of the driving and the driven gear is not interchangeable. The purpose of this invention is to provide self-locking gears which has higher efficiency. It also provides self-locking without large reduction ratios.

6. Alex Kapelevich and Elias Taye[6], 'Application for self-locking gears' In most gear drives, when 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, et c. The latter condition is known as back driving. During inertial motion or back driving, the driven output shaft (load) becomes the driving one and the driving input shaft (load) becomes the driven one.

7. Wikto w. Panjuchin, Wladimir[7], 'United States Patent' A self-locking dual worm with parallel axes and linear contact for the worm with involute herringbone gears is characterized by the fact that the cross-section for curvature radii and the longitudinal section for the curvature radii of the worm profile are always determined at the contact. One special feature of such gears is the very large tooth inclination angle which makes it possible to use the production method used for helical toothed gears, spinning machines or worms to cut these gears.

8. R.D. Ankush, P.D.Darade [8], 'Design and Analysis of worm pair used in self-locking system with Development of manual clutch' The paper presents the fact that in most material handling equipments, gear drives are used. In these systems when the driving torque is suddenly decreased due to power cut off or any other mechanical failure at the input shaft of the system then the 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.

9. Prof. P. B. Kadam, Prof M. R. Todkar [9],' Improvement in the Design and Manufacturing Of Twin Worm Self-locking techniques and Applications' Has presented the mating worm self-locking system which is a simple dual worm system that not only provided self-locking with maximum efficiency but also exhibited a new phenomenon called deceleration locking. In this system both the worms are wound in different directions and has a different pitch angle. For proper mesh the worm axes are not parallel but slightly skewed.

V. OBJECTIVES

- Design of mathematical model of twin worm system with internal threaded ring system for optimal load lifting capacity
- Optimal factor of safety and optimal efficiency for reduced power consumption.
- Derivation of optimal power for the PMDC motor.
- Selection of PMDC motor for application so as to make device compact.
- Development of theoretical graphical model of system of forces, derivation and resolution of system forces by drawing free body diagram of worm drive, determination of forces and utilizing system of forces to determine the worm and internal threaded ring dimensions of drive.

VI. DESIGN METHODOLOGY

- To make a detail study of the existing system and its drawbacks.
- Studying all the available research related to the self-locking lifting device.
- Designing the mathematical model of the worm and the ring gear system.
- Derivation and resolution of system forces by drawing free body diagram of linkage, determination of forces and utilizing system of forces to determine the linkage dimensions of following parts:

(i) Right hand worm

(ii) Left hand threaded ring gear

(iii) Lifter drum

(iv) Lifter drum shaft

(v) Motor mounting bracket system

(vi) Ring gear cage

- Mechanical design of above components using theoretical theories of failure after selection of appropriate materials.
- 3-D modelling of set-up using Unigraphix Nx-8.0
- CAE of critical component and meshing using ANSYS ----i.e. **the preprocessing part**.
- Mechanical design **validation** using ANSYS …. critical components of the system will be designed and validated.
- Validation of strength calculations of critical components using ANSYS..... i.e. **the post processing** part for all the parts mentioned above.
- Layout and Design of setup:

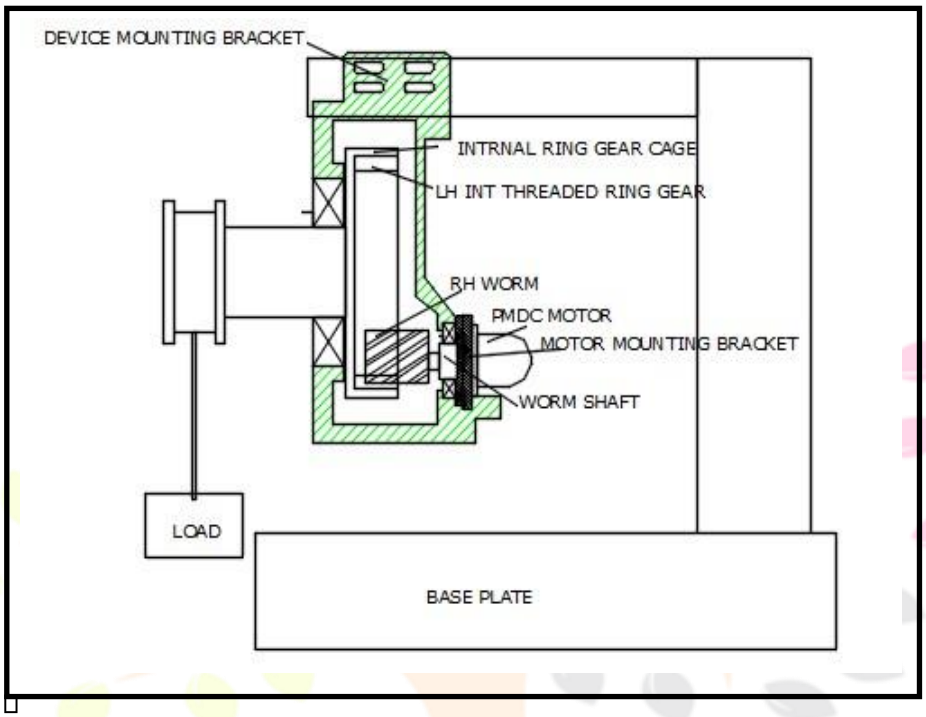

fig 1.Layout of the setup

- Creation of Prototype: The selected mechanism and machine will be designed using following machines :

➢ Centre lathe

➢ Milling machine

➢ Jig Boring machine

➢ Electrical Arc Welding

➢ RPM metres

VII. EXPERIMENTAL VALIDATION

The experimental validation part of the lifting force developed by the twin worm system be validated using test-rig developed . Following characteristics will be plotted.

a)Torque Vs Speed.

b)Power Vs speed.

c) Power consumption of motor under rated load.

d) Efficiency of system Vs speed.

VIII. RESULT AND DISCUSSION

The maximum stress by theoretical method and the von-mises stress of the right hand worm are found to be below the allowable limit , and hence it is safe .The right hand worm shows negligible deformation under the action of system of forces. The maximum stress by theoretical method and the von-mises stress of the internal threaded ring gear are also below the allowable limit , and hence it is also safe. It also shows negligible deformation under the action of system of forces.

Table 1. Maximum stress by theoretical method and von- mises stress

Sr.NO	Part Name	Maximum theoretical stress in N/mm^2	Von-mises stress in N/mm^2	Deformation	Result
1	Ring cage	0.196	0.708	$1.2x10^{-4}$	Safe
2	System bracket	2.45	0.8537	$4.25x10^{-5}$	Safe
3	Input worm shaft	2.42	6.266	$1.56x10^{-3}$	Safe
4	RH worm	7.46	14.738	$2x10^{-3}$	Safe
5	Load drum	0.023	1.9726	$3.8x10^{-4}$	Safe
6	Ring gear	0.00539	0.04856	$2.83x10^{-6}$	Safe

IX CONCLUSION

The analysis of all the components of Compact lifter are carried out considering theoretical theories of failure and are found to be within allowable limit. Validation of strength of all the components are carried out using ANSYS and all the components are found to be within the allowable limit and hence safe.

X FURTHER MODIFICATIONS

RH worm shaft is mounted on a separate bracket, instead it can be made integral with the system bracket for proper support and better performance. The entire casing can be made closed to provide better lubrication and improve life of worm**.**

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