IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

DESIGN ANALYSIS & PERFORMANCE EVALUATION OF MECHANICAL TORQUE BOOSTER WITH COTTON ROPE

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Abstract - In many mechanical systems it is required to amplify the torque to operate the devices, especially in cases where the control input is in the form of hand wheel that is operated manually to either lift or lower heavy loads as in application of hoists , non-linear broaching, load positioning application, remote metering and counting. In all above systems the control force which is supplied as input is not sufficient to operate the control the mechanism and hence a torque booster is needed.

The proposed mechanical torque booster applies the principle of capstan . Mechanical torque booster uses a capstan is simple mechanical amplifier-rope wound on motor driven drum slips until slack is taken up on the free end . Force needed on free end to lift the load depends on the coefficient of friction and number of turns of rope . The kinetic energy of the drum is transferred via the rope to the output shaft and thus amplified power and torque is obtained at the output shaft.

The project aims at the concept development of the torque booster system , the gear train to obtain the desired motion of the drums spinning in opposite direction is attained through the system design. The components of the system will be designed using theoretical methods and the strength of the components will be validated using analysis. The components of the system will be modelled using Unigraphix Nx-8 and the analysis of the components will be carried out using Ansys workbench 16.0.

The system will be manufactured and testing will be carried out to derive the performance characteristics of the torque booster. Two different materials of rope namely cotton and leather will be tested and the comparative performance evaluation will be presented in the report.

Keywords: Torque booster, Gear train, Kinetic energy , Leather , cotton rope.

INTRODUCTION

In many applications it is required to control a large output load using a relatively low control force. Applications such as load positioning , non-linear broaching , hydraulic winch control etc, can be cited to describe the need of a suitable effort amplification device in the form of mechanical power amplifier..

This mechanical power amplifier has a fast response. Power fromits continuously rotating drums is instantaneously available .When used for position-control applications, pneumatic, hydraulic, and electrical systemsð even those with continuously running power sourcesð require transducers to change signals from one energy form to another. The mechanical power amplifier, on the other hand, permits direct sensing of the controlled motion.

Problem Statement

In many applications it is required to control a large output load using a relatively low control force. Applications such as load positioning , non-linear broaching , hydraulic winch control etc, can be cited to describe the need of a suitable effort amplification device in the form of mechanical power amplifier..

Precise positioning and movement of heavy loads are two basic jobs for this all-mechanical torque booster.

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Four major advantages of this all-mechanical device are:

1. Kinetic energy of the power source is continuously available for rapid response.
2. Motion can be duplicated and power amplified without converting energy forms.
3. Position and rate feedback are inherent design characteristics.
4. Zero slip between input and output eliminates the possibility of cumulative error.

Objectives

1.Design and analysis of components of mechanical torque booster

2.Test and trial on mechanical torque booster with cotton rope to determine the performance characteristic of the drive.

a)Reduction in cycle time of mixing

b) Improvement of viscosity and spread-ability

c) Productivity improvement owing to use of developed system

2. METHODOLOGY

a. Literature survey: During this period detail literature surveyhas been done to learn available power amplificaion systems and their utility also their literatures of different types of lifting systems and its difference between have been observed.

b. Problems in existing systems: The problems regarding the existing lifting system have been found such and thorough proper magnification of torque at desired rate is not attained by the conventional methods.

c. Conceptual Design: Taking problem statement from above and studying the fundamental engineering concepts various concepts regarding modified torque amplification system are prepared and amongst those best and compact torque booster design has been selected for further phases. Testing phase includes testing of the Prototype model under real environment.

d. Modeling in software: Putting the ideas on the modeling Modeling of the components has been done using the Unigraphix software and the analysis of the components has being done using Ansys work bench 16.0.

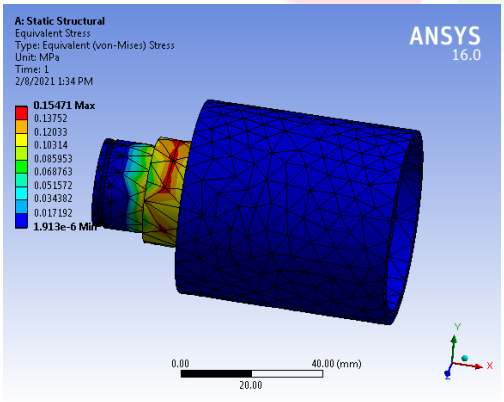
e. Fabrication: This phase includes fabrication of prototype in the workshop from the procured material and preparing the Prototype model from the software model.

f. Assembly & Testing: This include Assembly of all the sub parts, also the arrangement of the motor and its wiring is done, all finishing operations like grinding, trimming, painting is done here. Testing phase includes testing of the Prototype model under real environment.

3. MODEL AND ANALYSIS

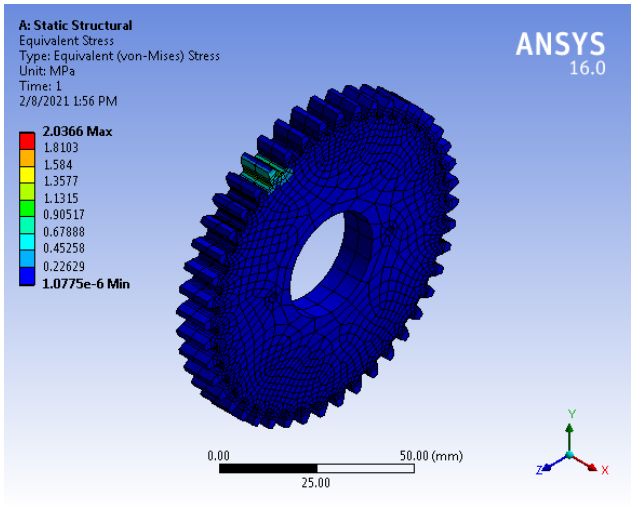
The components of the system were designed using theoretical method and the solid modeling was done using Unigraphix Nx and the Analysis of components is done using Ansys workbench 16.0 . The safety of the components has being attained through the combined theoretical and analytical design.

Design-Analysis-Load Drum



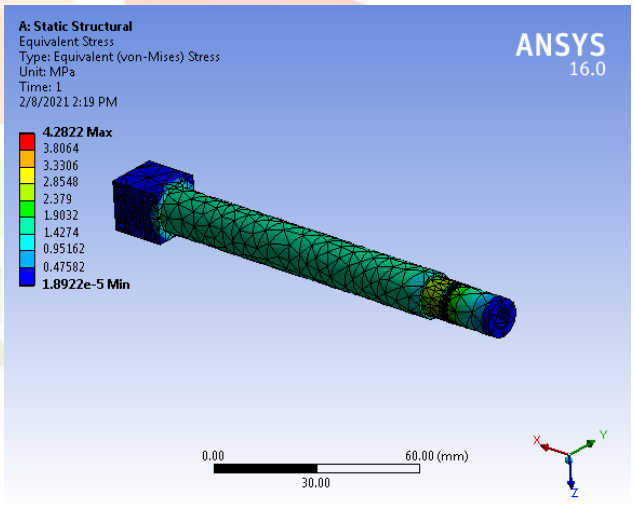
The maximum Von-misses stresses in the part are 0.1571MPa which is far below the allowable stress hence the part is safe

Design-Analysis-Gear.



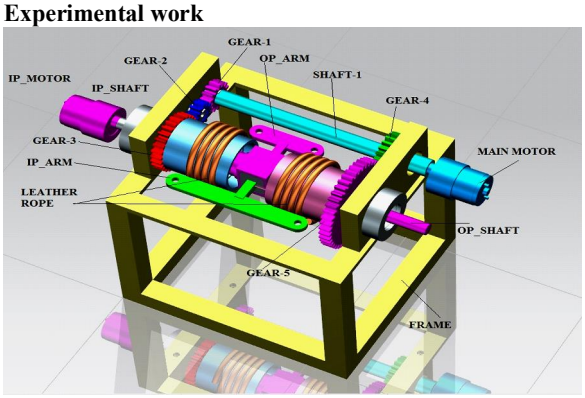
The maximum Von-misses stresses in the part are 2.036 MPa which is far below the allowable value hence the part is safe

Design-Analysis-Input shaft.



The maximum Von-misses stresses in the part are 4.282 MPa which is far below the allowable value hence the part is safe

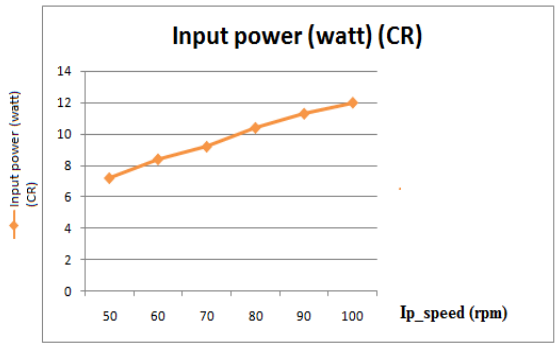
Experimental work



TEST & TRIAL ON POWER AMPLIFIER

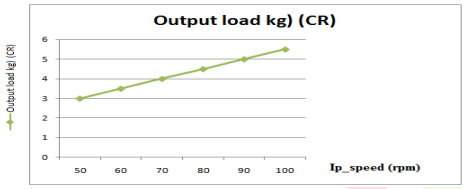
MATERIAL OF BAND : COTTON ROPE

Graph of Input Power Vs Input Speed (Cotton rope)



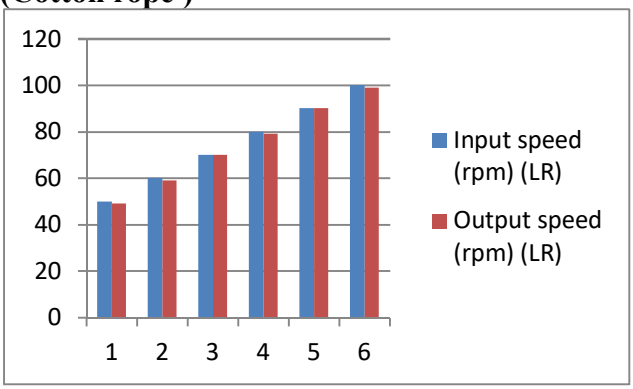
The input power with cotton rope power amplifier is seen to increase with the increase in input speed , as the voltage and current are both increased by the supply side.

Graph of Output load Vs Input Speed (Cottonrope)



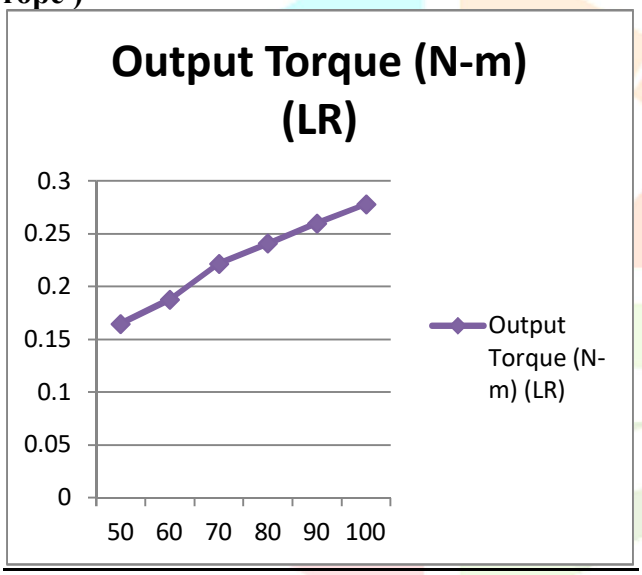
The output load with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed.

Bar chart of Output speed Vs Input Speed (Cotton rope)



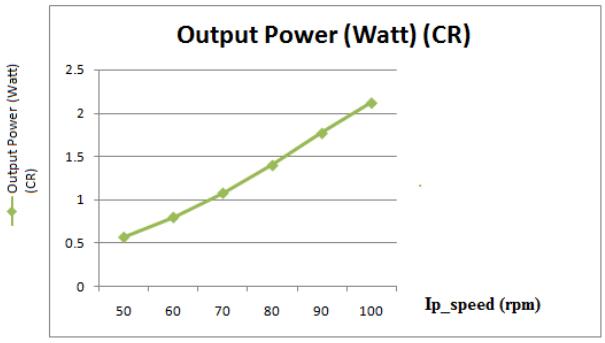
The input and output speeds with cotton rope power amplifier are seen to be same with negligible difference on account that the input and output shafts are connected via the cotton rope through the input and output arms

Graph of Output torque Vs Input Speed (Cotton rope)



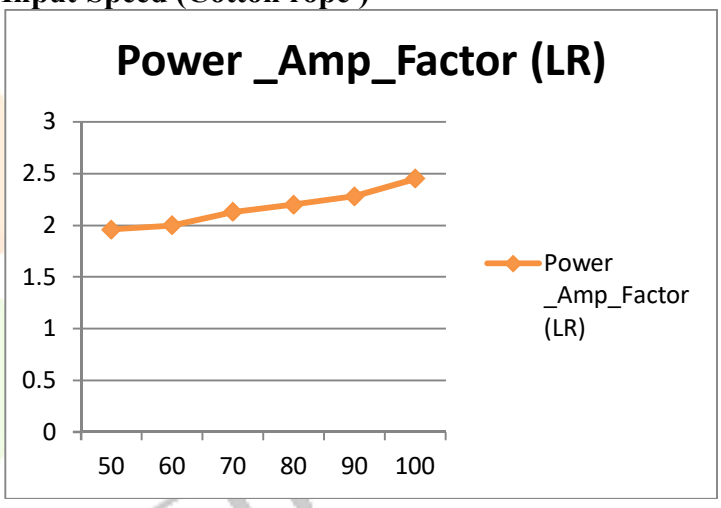
The output torque with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum torque of 0.206 N-m is observed at speed of 100 rpm

Graph of Output Power Vs Input Speed (Cotton rope)



The output power with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum torque of 2.12 watt is observed at speed of 100 rpm

Graph of Power amplification factor Vs Input Speed (Cotton rope)



The power amplification factor with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum PAF of 1.8 watt is observed at speed of 100 rpm and minimum PAF of 1.32 is observed at 50 rpm

Result and Discussion :

1. The components of the mechanical torque booster were designed by theoretical as well as analytical method and were found to be safe.
2. The input power with cotton rope power amplifier is seen to increase with the increase in input speed , as the voltage and current are both increased by the supply side
3. The output load with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed
4. The input and output speeds with cotton rope power amplifier are seen to be same with negligible difference on account that the input

and output shafts are connected via the cotton rope through the input and output arms

5. The output torque with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum torque of 0.206 N-m is observed at speed of 100 rpm
6. The output power with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum torque of 2.12 watt is observed at speed of 100 rpm
7. The power amplification factor with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum PAF of 1.8 watt is observed at speed of 100 rpm and minimum PAF of 1.32 is observed at 50 rpm

Conclusion

The proposed mechanical torque booster applies the principle of capstan . Mechanical torque booster uses a capstan is simple mechanical amplifier-rope wound on motor driven drum slips until slack is taken up on the free end . Force needed on free end to lift the load depends on the coefficient of friction and number of turns of rope . The kinetic energy of the drum is transferred via the rope to the output shaft and thus amplified power and torque is obtained at the output shaft.The project concept development of the torque booster system , the gear train to obtain the desired motion of the drums spinning in opposite direction is attained through the system design. The components of the system have being designed using theoretical methods and the strength of the components have being validated using analysis. The components of the system have being modelled using Unigraphix Nx-8 and the analysis of the components has being carried out using Ansys workbench 16.0.The system has been manufactured and testing has been carried out to derive the performance characteristics of the torque booster. Two different materials of rope namely cotton and leather will be tested and the comparative performance evaluation will be presented in the report. The output power with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum torque of 2.12 watt is observed at speed of 100 rpmThe power amplification factor with cotton rope power amplifier is seen to increase with the increase in input speed , as the power handling capacity of amplifier is seen to increase with the increase in input speed and maximum PAF of 1.8 watt is observed at speed of 100 rpm and minimum PAF of 1.32 is observed at 50 rpm.

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