Design Analysis and Performance Evaluation of Dual Motor Hoist Mechanism

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DESIGN ANALYSIS and PERFORMANCE EVALUATION of DUAL MOTOR HOIST MECHANISM

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Abstract

Hoist is very important material handling equipment in industry because of safety, fast speed, reliability etc. Many operators and owners of hoists and cranes fear the possible catastrophic damage that can occur if the driving motor of a unit fails for any reason. This may result in a loss of life, as well as damage to products or property. Important production time is also lost due to hoist downtime. As a result, in the event that the motor fails, a safety mechanism is needed to prevent the above-mentioned damages. One alternative is to use a planetary gear drive to combine the power of two motors of equal rating. Prototype of dual motor hoist mechanism is developed with optimal load lifting capacity, optimal factor of safety. 3-D modeling of set-up is done using Unigraphix Nx-8.0 and CAE of critical component and meshing done using ANSYS Work-bench 14.5. Comparing the theoretical and analytical result we concluded that the mechanism is safe and spur gear configuration is used for regular lifting applications and the planetary system is used for back up.

Keywords: Hoist Mechanism; FEA of Dual Motor Hoist Mechanism; Performance Evaluation.

I. INTRODUCTION

A hoist is a device that lifts or lowers a load using a rope or chain wrapped around a drum or lift-wheel. It can be operated manually, electrically, or pneumatically, and it can lift with cord, fibre, or wire rope.

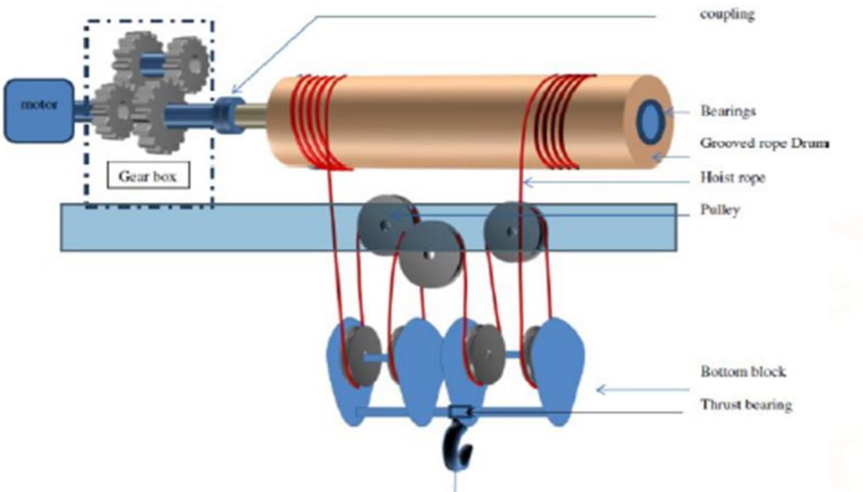

Fig.1 Hoist Mechanism *[2]*

The load is attached to the hoist by means of a lifting hook. The basic hoist has two important characteristics to define it: Lifting medium and power type. The lifting medium is either wire rope, wrapped around a drum, or load-chain, raised by a pulley with a special profile to engage the chain. The power can be provided by different means. Common means are hydraulics, electrical and air driven motors. Both the wire rope hoist and chain hoist have been in common use since the 1800s, however mass production of an electric hoist did not start until the early 1900s and was first adapted by Germany. A hoist can be built as one integral-package unit, designed for cost-effective purchasing and moderate use, or it can be built as a built-up custom unit, designed for durability and performance. Nowadays many hoists are package hoists, built as one unit in a single housing, generally designed for ten-year life, but the life calculation is based on an industry standard when calculating actual life [1], [2].

In the field of planetary gear design, comprehensive research has already been completed. Many researchers have published studies on single-stage planetary gears. Single stage differential planetary gear arrangements can achieve high reduction ratios, but they are only suitable for low torque applications such as robotics and aerospace positioning systems. V. Moise et al (2007): presents the kinematics analysis of planetary cylindrical gears by using Willis's method. This method is difficult to follow in the case of complex mechanisms. By analogy with the relative coordinate's method, from the linkages, author presents a simple and intuitive method, easy to apply to the study of planetary cylindrical gears. Author presents an instantaneous axis method to the study of planetary cylindrical gears. Also determine the reduction ratio of two stage gear box is discussed. Gaballa M Abdalla (2014, U.K.): reported the effect of varying degrees of installation misalignment of planetary gearbox is investigated based on vibration measurements using spectrum analysis and modulation signal bispectrum (MSB) analysis. It has shown that the misalignment can be diagnosed in the low frequency range in which the adverse effect due to co-occurrence of amplitude modulation and frequency modulation (AM-FM) effect is low compared with the components around meshing frequencies. Reshma Kharche (2016, India): investigated that wire rope hoists are simpler to use than hydraulic hoists, because there is no air in system to worry about, no checking of fluid level, no leakage, filtration or contamination problems. On the basis of total deformation, equivalent stress, shear stress, maximum shear stress, maximum principle stress, optimized mass, analysis had done using two materials. These materials are Alloy Steel and Cast Iron. From the comparison of analysis results of two materials, Alloy Steel proved better at working condition with optimized weight. Just a few researchers had written about their research into the design of a dual motor hoist mechanism. As a result, create a model of a planetary gear drive with twin motors for maximum load lifting power and a high factor of safety [1]-[6].

II. FINITE ELEMENT ANALYSIS of DUAL MOTOR HOIST MECHANISM

Uni-graphics is used to build a CAD model of the hoist mechanism and Finite Element Analysis of dual motor hoist mechanism is done using ANSYS Work-bench 14.5. Every continuous object has an infinite number of degrees of freedom, so solving the problem in this format is impossible. With the aid of discretization, or meshing, the finite element method reduces an object's degrees of freedom from infinite to finite. Meshing is done with a tetrahedral element. The value is approximated using this method. The parameter of interest in the continuum is approximated using this approach. i.e. discretization is the method of separating a modelled body into an identical set of smaller bodies or units known as finite elements that are interconnected at popular points, edges, and surfaces. Rather than solving the problem for the entire body in one process, the equations for each finite element are now developed and combined to obtain the solution for the entire system. The structure problem can be solved by determining the displacement at each node and the stress within each element of the structure that is subjected to applied loads. Important parameter such as displacement, stresses and deformation is studied in this paper. Analytical calculations and numerical calculations are discussed in result section.

III. PERFORMANCE EVALUATION

The performance of developed mechanism is carried out and discusses in following section. Firstly start the motor then run mechanism and stabilize at certain speed (say 190 rpm). Place the pulley cord on load drum and add 0.2 KG weight into the pan, note down the output speed for this load by means of tachometer. Tachometer is used for measuring the speed of load lifting and lowering. Add another 0.2 KG cut and take reading. Tabulate the readings in the performance table.

Table 1 Performance of Dual Motor Hoist Mechanism

Sr. No.	Load (grams)	Speed of Motor 1(rpm)	Speed of Motor 2(rpm)	Power of Motor 1(watt)	Power of Motor 2(watt)	Efficiency of Motor 1	Efficiency of Motor 2
1	0.2	182	190	1.64	1.73	27.42	53.08
2	0.4	158	180	2.85	3.22	47.62	49.22
3	0.6	143	166	3.87	4.42	64.65	45.07
4	0.8	130	141	4.70	5.03	78.36	38.43
5	1	102	109	4.61	4.84	76.85	29.58

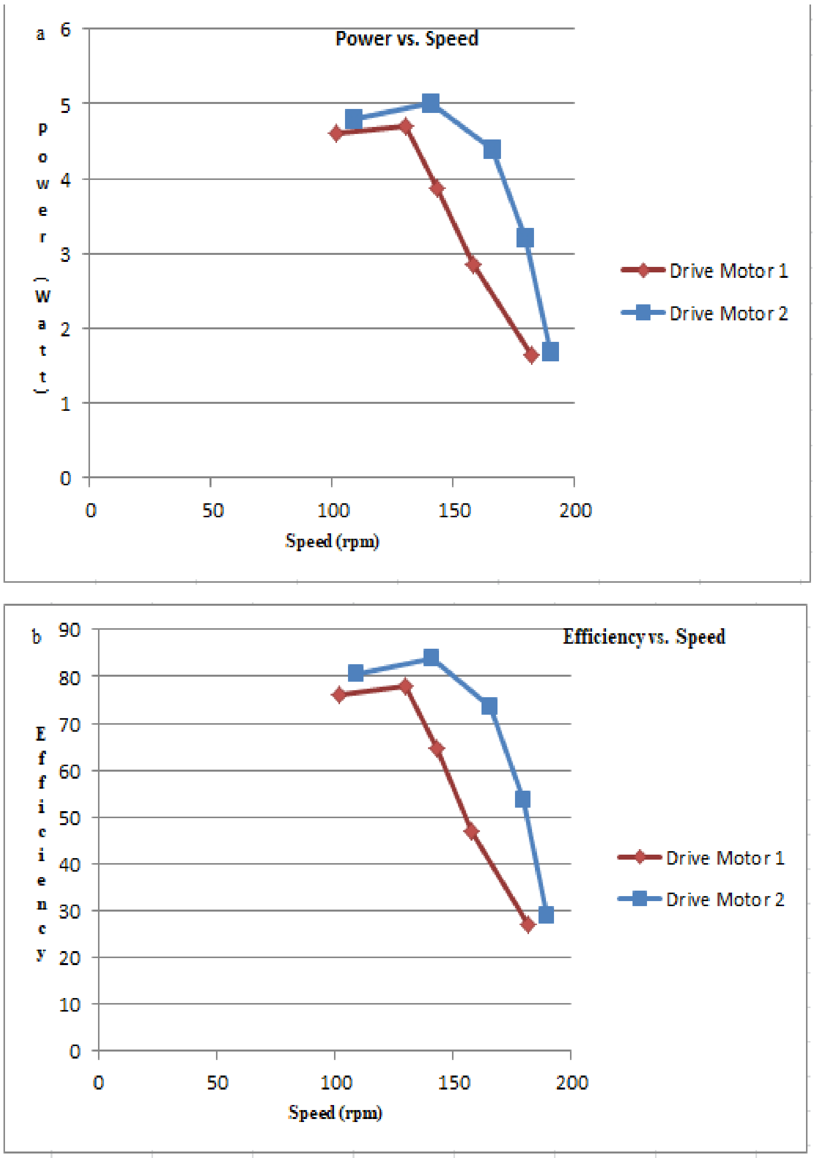

Fig.2 a) Comparative Graph of Power vs. Speed, b) Comparative Graph of Efficiency vs. Speed

Comparative graph of power vs. speed shows that the planetary gear box configuration (Drive Motor 1) gives slightly less power output than the spur gear configuration (Drive Motor 2) this may be going to the fact that certain amount of power is lost in friction in the planetary gear box. Comparative graph of Efficiency vs. Speed shows that spur gear configuration (Drive Motor 2) gives slightly higher efficiency than the planetary gear configuration (Drive Motor 1), hence it is concluded that the spur gear configuration be used for regular lifting applications and the planetary system be used for back up.

IV. RESULT and DISCUSSION

The drive motor -1 provides the lowest speed in the dual speed mode, allowing the maximum load to be lifted while the translation speed is kept to a minimum. The maximum speed in the dual speed mode is achieved by using the drive motor-2, which lifts the least amount of weight while maintaining the highest translation speed.

Table 2: Theoretical Data for Drive Motor

Drive Motor	Maximum Output Speed(rpm)	Maximum load lifted(kg)	Translation speed of load (mm/min)
Drive Motor 1	198	1.039	54.7
Drive Motor 2	210	0.97	58

Maximum shear stress calculated by theoretical method and Von-misses stress calculated by Finite Element Analysis is well below the allowable limit; hence the mechanism is safe. Mechanism shows negligible deformation under the action of system of forces.

Table 3: Analysis of Dual Motor Hoist Mechanism

Part Name	Allowable Shear Stress N/mm^2	Maximum Shear Stress N/mm^2	Von–mises Stress N/mm^2	Maximum Deformation	Result
Coupler Shaft	400	3.73	7.467	0.0018	Safe
Internal Gear Ring	33	0.044	0.065	2.2E- 6	Safe
Bull Gear Output Shaft	400	1.234	3.2392	0.00051	Safe
Load Drum	300	0.0513	0.26067	6.92E- 5	Safe
Load Drum Bracket	600	0.053	0.001995	4.365E- 6	Safe

V. CONCLUSION

The minimum speed in the dual speed mode is 198 rpm with translation of load is 54.7 m/min. The maximum speed in the dual speed mode is 210 rpm with the translation of load is 58m/min. Graphs Shows that operate the hoist in planetary gear configuration of motor 1 in the range of 110 to 140 rpm for maximum power and maximum efficiency and operate the hoist in planetary gear configuration of motor 2 in the range of 110 to 155 rpm for maximum power and maximum efficiency. The device exhibits load lifting ability in vertical upward direction with instantaneous self-locking. The device exhibits load lowering ability in vertical upward direction with instantaneous self-locking. There is marginal deceleration of the load drum with increase in load. Device exhibits increase in power output with increase in load with marginal drop in load speed maximum power output being 4.4 watt. Device exhibits increase in transmission efficiency with increase in load with marginal drop in load speed maximum efficiency being 84%. Maximum power consumption of the input motor a 6 kg load is 5 watt.

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