Research Paper on Design and Analysis of Twin Motor Planetary Gear Drive for Dual Speed and Safety Optimization in Hoist Application

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Abstract

Material handling plays vital role in any industry. The hoist crane is one of the demonstrated material handling devices. A hoist is a device used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. In normal operating conditions with rated load and under test conditions with test loads up to 125 percent of rated load, despite this fact many operators and owners of hoists and cranes fear the possible catastrophic damage that can occur if the driving motor of a unit should fail for any reason. This may lead to Loss of life, Damage of goods or property, loss of Production time due to down time of hoist. Hence there is a need of a safety system in advent of failure of the motor that will avoid above damages. One solution to this problem is to feed the power of two motors of equal rating into a planetary gear drive. This system is proposed with view to offer a dual advantage to the existing single motor system, Safety in case one of the motor fails. Dual speed drives so that same device can cater to more than one application.
Keywords: Hoist, Rated load, catastrophic, production time, planetary gear

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I. Introduction

Manufacturing industries an important part of the Indian economy. In every manufacturing industry material handling plays vital role. A hoist crane is a device used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually operated, electrically or pneumatically driven and may use chain, fiber or wire rope as its lifting medium. These project concepts identify problems in conventional hoist and improve them in terms of two motor planetary gear drive attachment.

One motor drives the ring gear, which has internal teeth. The second motor drives the sun gear directly. Both the ring gear and sun gear rotate in the same direction. If both gears rotate at the same speed, the planetary cage, which is coupled to the output, will also revolve at the same speed (and in the same direction). It is as if the entire inner works of the planetary were fused together. There would be no relative motion. Then, if one motor fails, the cage will revolve at half its original speed and the other motor can still lift with undiminished capacity. The same principle holds true when the ring gear rotates.

II. Literature review

A number of research papers and patents have been published in recent years on hoist and planetary gear drive. A brief Review of some selected references on this topic is presented here.

V. Moise et al [1] has given an outline of the kinematics analysis of planetary cylindrical gears is usually accomplished 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, this paper presents a simple and intuitive method, easy to apply to the study of planetary cylindrical gears.

Kaustubh V. Wankhade et al [4] have carried out work on Material handling task (of handling molten metal) in casting industries is very difficult and risky one. At present this task carried out manually for small-scale castings and with the help of ladle attached to the overhead crane hook for medium and large-scale castings. Now a day this operation required at least two workers in both cases, and aim of this research paper is to minimize labour requirement for handling and pouring molten metal and with less risk. This paper reviews the design, modeling and computer simulation as a tool for aiding trolley used by various researchers earlier. The results of computer simulations and results obtained by real experimentation compared to get detailed idea about the design ideas. Design and analysis carried out with various CAD software like CREO `

Tomasz Haniszewski et al [5] had discover that, the test object is one-girder overhead travelling crane with a hoisting capacity of 5 [t]. The beam is a typical welded box structure. Immutability of the geometric cross-section of the girder is being provided by located inside the welded membranes and stringers made from rolled channels. In addition to the girder, construction also includes two buffer beams and additional elements such as platform, hoisting winch of hoist drive.

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III. CONCLUDING REMARK

From several studies this paper reported that because of catastrophic damage may occur in hoist crane because of failure of motor due to some uncertain reason. This may lead to loss production time due to down time of hoist, dangerous to worker life, economic loss etc.

On the above research two motor hoist with planetary gear drive as a variable solution to achieve safe and quality material handling in any industry.

IV. THEORETICAL AND FE ANALYSIS

– Design of the Motor Coupler Shaft from Motor to the Planet Gear Box Sun Gear:

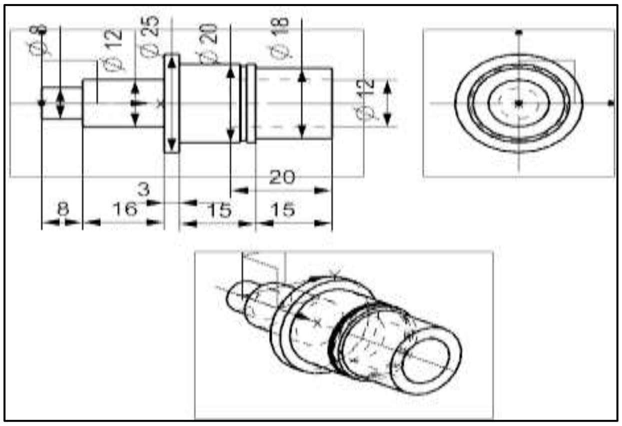

Fig. 1:

$$Fs_{max} = \text{Ultimate tensile stress /F. S.} = 800/2$$
$$= 400 \text{ N/mm}^2$$

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation.
Assuming 100 % efficiency of transmission

$$T_{design} = 0.3 \text{ N-m.}$$

Check for torsion shear failure of shaft:

Torque is applied at the driven gear mounting point on the shaft which 8 mm in diameter that engages with the planet gear box sun gear.

$$T_d = \frac{\pi x f s_{act} x d}{4}$$

$$fs_{act} = \frac{16xT_d}{\Pi x d^3}$$

$$fs_{act} = \frac{16x0.3x10^3}{\Pi x 8^3}$$

$$fs_{act} = 2.9 \text{ N/mm}^2$$

$$\text{As} \quad fs_{act} < fs_{all}$$

Hence, coupler shaft is safe under torsion load.

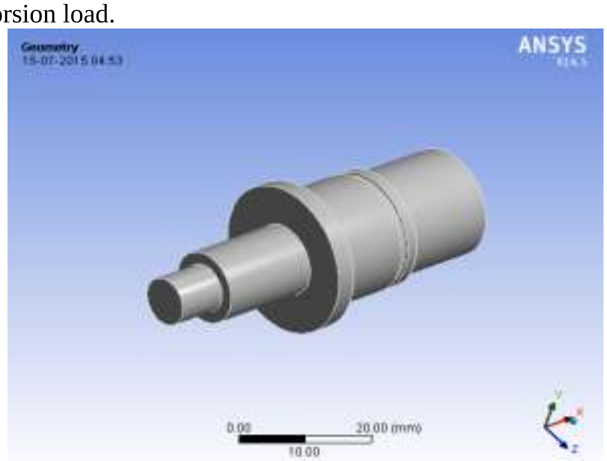

Fig. 2:

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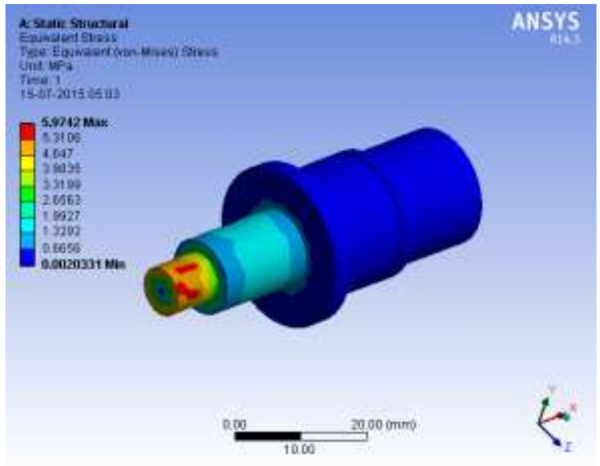

Fig. 3:

Part Name	*Maximum theoretical stress N/mm²*	*Von-mises stress N/mm²*	*Maximum deformation mm*	*Result*
COUPLER SHAFT	*2.9*	*5.9*	*0.0014*	*safe*

1) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the coupler shaft is safe.
2) Coupler shaft shows negligible deformation under the action of system of forces

A. Design of Load Drum:

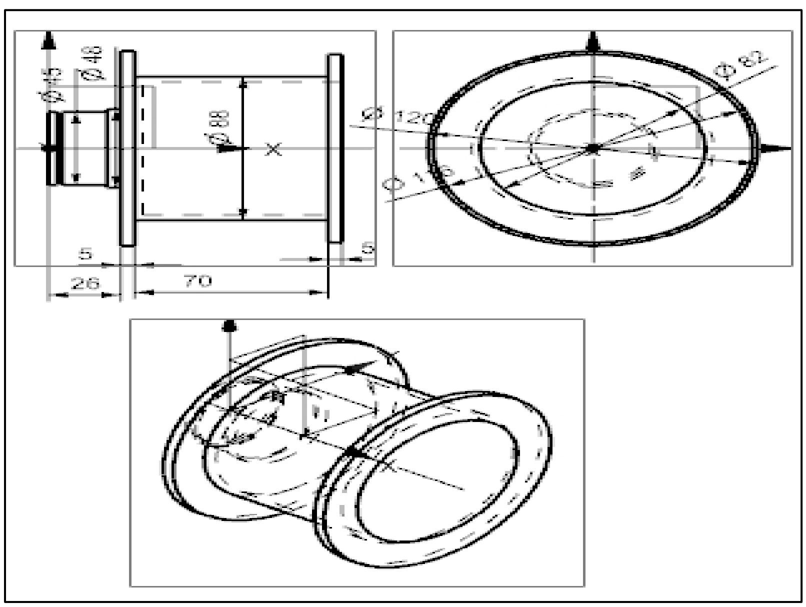

Fig. 4:

$$fs_{max} = \text{Ultimate tensile stress /F. S.} = 600/2 = 300 \text{ N/mm}^2$$

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation.
Assuming 100 % efficiency of transmission

$$T_{design} = 0.43 \text{ N-m}$$

$$T_d = \frac{\pi}{16} \times fs_{act} \times \frac{(D^4 - d^4)}{D}$$

$$fs_{act} = \frac{16 \times T_d \times D}{\pi \times (\quad |4 - d^4)}$$

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$$fs_{act} = \frac{16 \times 0.43 \times 10^3 \times 88}{\pi \times (88^4 - 84^4)}$$

$$fs_{act} = 0.013 \ N/mm^2$$

$$As \quad fs_{act} < fs_{all}$$

Hence, load drum is safe under torsion load.

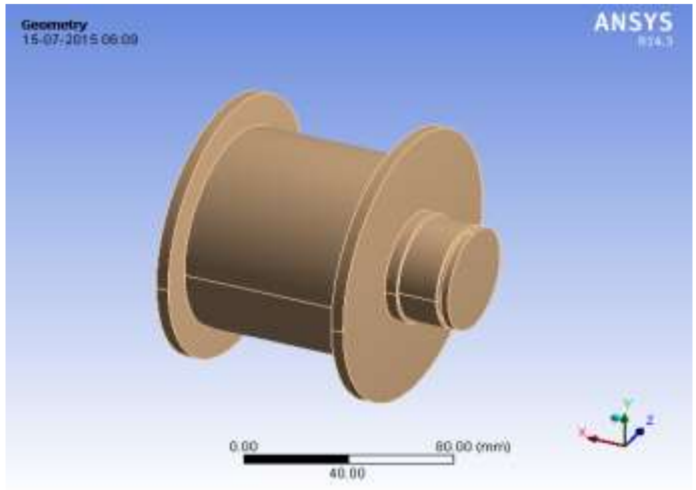

Fig. 5:

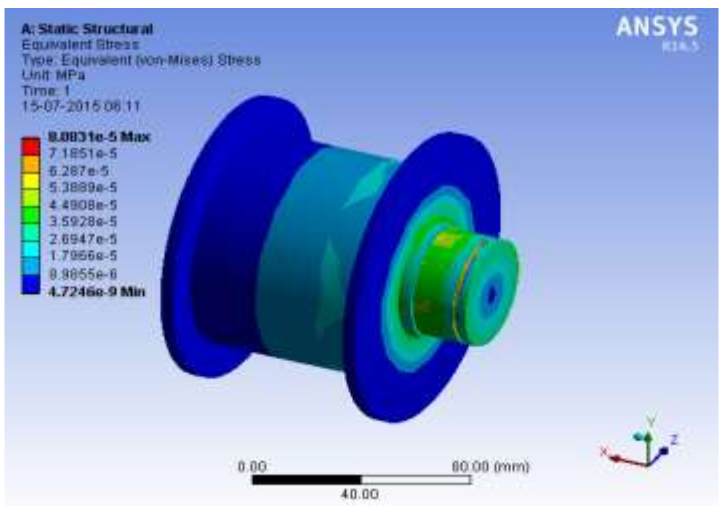

Fig. 6:

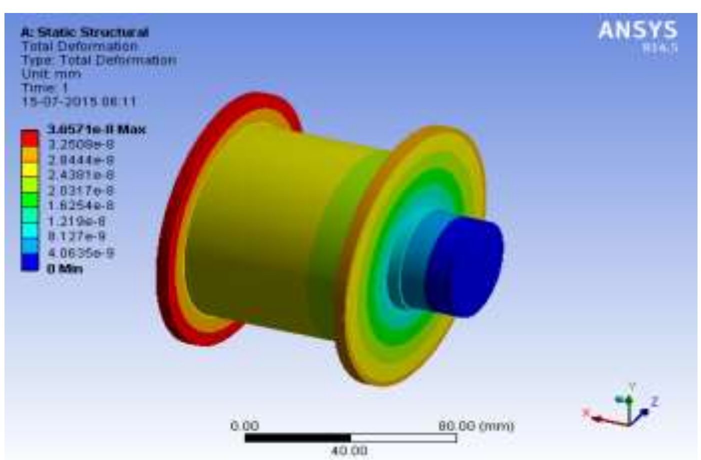

Fig. 7:

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Part Name	*Maximum theoretical stress N/mm^2*	*Von-mises stress N/mm^2*	*Maximum deformation mm*	*Result*
LOAD DRUM	*0.0136*	*0.00008*	*3.85 E-8*	*Safe*

1) Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the load drum is safe.
2) Load drum shows negligible deformation under the action of system of forces

B. Result discussion:

1) Comparative graphs:

Comparative graph of power Vs speed shows that the planetary gear box configuration gives slightly less power output than the spur gear configuration this may be used to the fact that certain amount of power is lost in friction in the planetary gear box.

Comparative graph of power Vs speed shows that spur gear configuration gives slightly higher efficiency than the planetary gear configuration hence it is recommended that the spur gear configuration be used for regular lifting applications and the planetary system be used for back up

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