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DESIGN AND ANALYSIS OF OVERLOAD TORQUE LIMITER WITH ELECTROMECHANICAL CLUTCH

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ABSTRACT

Positive clutches are used to transmit power between two coincident shafts. The positive engagement between the clutch elements ensures 100% torque transmission on but occasionally the output shaft may the subjected to a sudden overload which may make the driving motor or engine to stall; which will lead to burnout of the electric motor. In extreme cases this overload will lead to the breakage of drive elements or the clutch itself. Which increases due to damage cost and time of operation in order to avoid the damage of the transmission elements it is necessary that the input and output shafts be disconnected in case of sudden overloads. The isolation of the input driver member i.e. motor from the output member is absolutely necessary to avoid damage and it is possible by called ball clutch or electromechanical clutch. Torque limiters are overloading safety devices with Torque limiters which provide reliable overload protection. When overload or excessive loading occurs the Torque Limiter will reliably and quickly release to prevent system damage. These torque limiters are tamper-proof. Once installed, the torque value cannot be changed. This is an important feature that ensures the integrity of the machine design. Costly and potentially risky calibration procedures are not necessary. The torque value is controlled by the part number that is ordered. That value determines what spring is used during the assembly at the factory.

Keywords: Driving Motor, Electromechanical Clutch, Machine Design.

I. INTRODUCTION

Clutch is a mechanism which enables the rotary motion of one shaft to be transmitted, when desired to a second shaft the axis of which is coincident with that of the first. Positive clutches are used to transmit power between two coincident shafts. The positive engagement between the clutch elements ensures 100% torque transmission on but occasionally the output shaft may the subjected to a sudden overload which may make the driving motor or engine to stall; which will lead to burnout of the electric motor. In extreme cases this overload will lead to the breakage of drive elements or the clutch itself. In order to avoid the damage of the transmission elements it is necessary that the input and output shafts be disconnected in case of sudden overloads. The isolation of the input driver member ie; motor from the output member is absolutely necessary to avoid damage and it is possible by called electromechanical clutch.

Charles W. Yeiser was focuses on the motor selection, torsional design, and analysis process associated with revamping two existing 7000 hp synchronous motor –driven industrial gas compressor trains with 8000 hp synchronous motor drives.**[1].Volker Hiitten** was focuses on the responsible factor for the machinery dynamics of compressors and compressor trains of order related tasks.**[2].Akram Ayoub** was focuses on the he Protection against transient torques during start-ups shut down and overloads.**[3] Nicolae Eftimie** has discussed For a correct, safe and economical clutch working, it is necessity of the component elements of this to be designed and accomplished properly. **[4]M.Hussein** was discussed the engagement of dry friction clutch is a very important process both to ensure small friction wear and good power-train performance. **[5]Andrew Lechner**, Contributing Writer. As a primary or redundant safety device, backlash-free ball-detent torque limiters serve as a mechanical circuit breaker for machine drive protection. **[10]**.

II. METHODOLODGY

1. System design as to number of ball-springs for desired torque capacity.
2. Design and geometrical derivations of the groove profile in input base flange.
3. Design and geometrical derivations of spring plunger profile.
4. Selection and geometrical profile of clutch body ball holder.
5. Selection and design of torque control using plunger and casing arrangement.
6. Selection of electromechanical clutch , solenoid coil for transmission of desired power
7. Selection of timer belt drive for open belt drive
8. Mechanical design : This part includes the design and development of springs , selection of suitable drive motor , strength analysis of various components under the given system of forces
9. The critical components of assembly input pulley, solenoid mount, torque limiter input shaft, input base flange, plunger, cylindrical body, output shaft etc., components will be designed using conventional theories of failure using various formulae, 3-D models of the above parts will be developed using Unigraphix software and meshing –analysis will be done, the result of stress produced will be validated using ANSYS-Workbench 14.5 release.

III. DESIGN AND STATISTICAL ANALYSIS

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy and efficiency. Hence a careful design approach has to be adopted. The total design work has been split up into two parts;

3.1 System Design

System design mainly concerns with various physical constrains, deciding basic working principle, space requirements, arrangements of various components etc.

Following parameters are looked upon in system design.

a) Selection of system based on physical constraints. The mechanical design has direct norms with the system design hence system is designed such that distinctions and dimensions thus obtained in mechanical design can be well fitted in to it.

b) Arrangement of various components made simple to utilize every possible space.

c) Ease of maintenance and servicing achieved by means of simplified layout that enables quick decision assembly of components.

d) Scope of future improvement.

3.2 Mechanical Design

In mechanical design the components are listed down and stored on the basis of their procurement in two categories,

- Design parts
- Parts to be purchased.

For designed parts detailed design is done and dimensions there obtained are compared to next dimensions which are already available in market. This simplifies the assembly as well as the post production and maintenance work. The various tolerances on work are specified .The process charts are prepared and passed to manufacturing stage. The parts to be purchased directly are selected from various catalogues and are specified so as to have case of procurement.

In mechanical designed at the first stage selection of appropriate material for the part to be designed for specific application is done. This selection is based on standard catalogues or data books.

Approach to mechanical design of ‘overload slipping ball clutch, In design the parts we shall adopt the following approach;

a) Selection of appropriate material.

b) Assuming an appropriate dimension as per system design.

c) Design check for failure of component under any possible system of forces.

3.3 Design Of Input Shaft

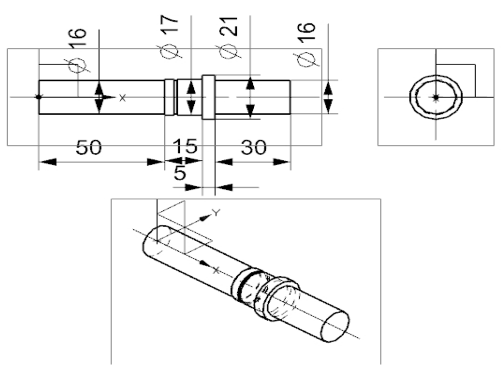

Fig. No. 3.3.1 2-D Drawing Of Input Shaft.

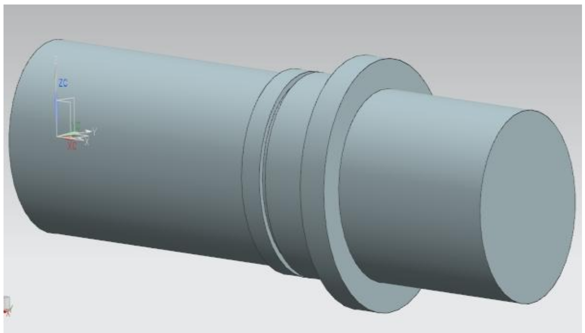

Fig. No. 3.3.2 Design of Input Shaft

3.3.1 Material Selection

Table No. 3.3.1 Material Selection

Designation	Ultimate Tensile Strength(N/mm^2)	Yield Strength (N/mm^2)
EN24	800	680

3.3.2 Analysis Of Input Shaft

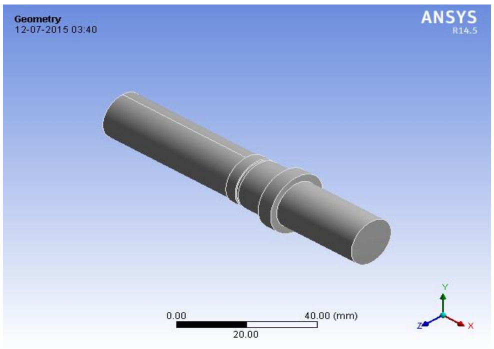

Fig. No. 3.3.3 Geometry of input shaft

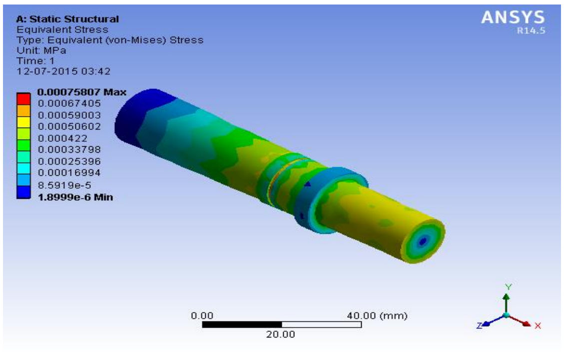

Fig. No. 3.3.4 Static Structural Equivalent Stress

Part Name	Maximum theoretical stress N/mm^2	Von-mises stress N/mm^2	Result
INPUT SHAFT	0.310	0.007	Safe

Table No. 3.3.2 Result Table

3.4 Design of Key

Table 3.4.1 Dimensions Of Key

For Shaft Diameter	Above Upto	17 22
Key cross section	Width Height	6 6

3.5 Design of Cylindrical Body

Table No. 3.5.1 Material Selection

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
EN 24	800	680

3.6 Design of Casing

Table No.3.6.1 Material Selection

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
EN 24	800	680

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3.7 Design Of Ball Plunger

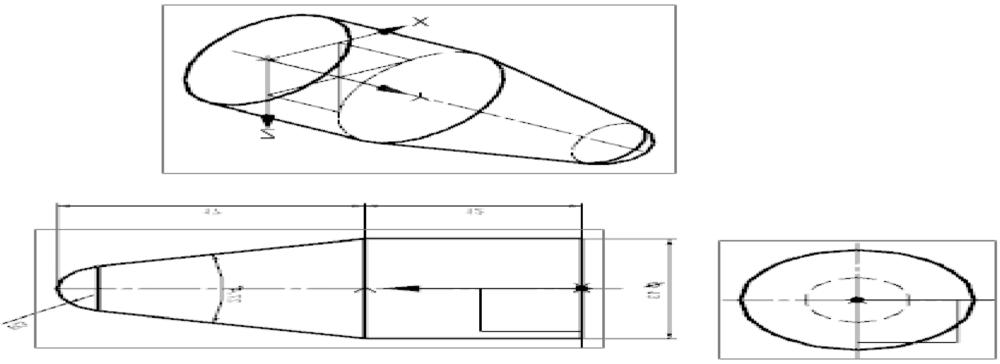
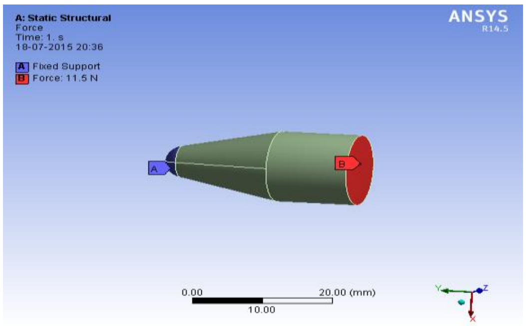


Fig. No. 3.7 1 2-D Drawing Of Ball Plunger

Table No. 3.7.1 Material Selection

Designation	Tensile Strength N/mm^2	Yield Strength N/mm^2
EN24	800	680



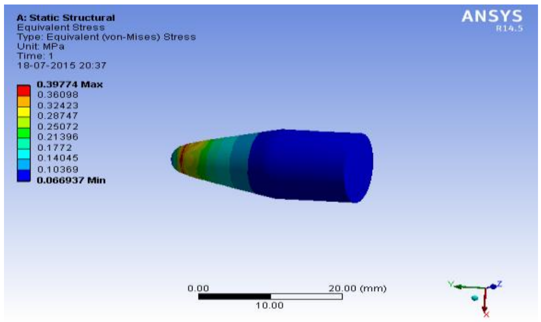


Fig. No. 3.7.2 Static Structural Equivalent Stress Fig. No. 3.7.3 Static Structural Total Deformation

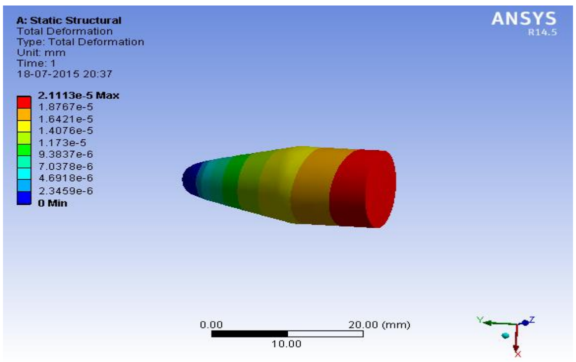


Fig. No. 3.7.4 Static Structural Total Deformation

3.8 Result Analysis of Plunger

Table No. 3.7.2 Result

Part Name	Maximum theoretical stress N/mm^2	Von-mises stress N/mm^2	Max deformation Mm	Result
Input Shaft	0.08	0.3975	2.11e-5	Safe

3.9 Design Of Ball Cage Carrier

Table No. 3.8.1 Material Selection

Designation	Ultimate Tensile Strength N/mm^2	Yield Strength N/mm^2
EN24	800	680

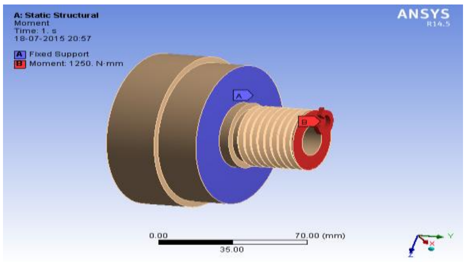


Fig. No. 3.8.1 Static Structural Moment Of Cage Carrier

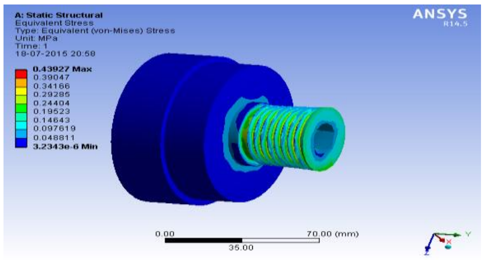


Fig. No.3.8.2 Static Structural Equivalent Stress Of Cage Carrier

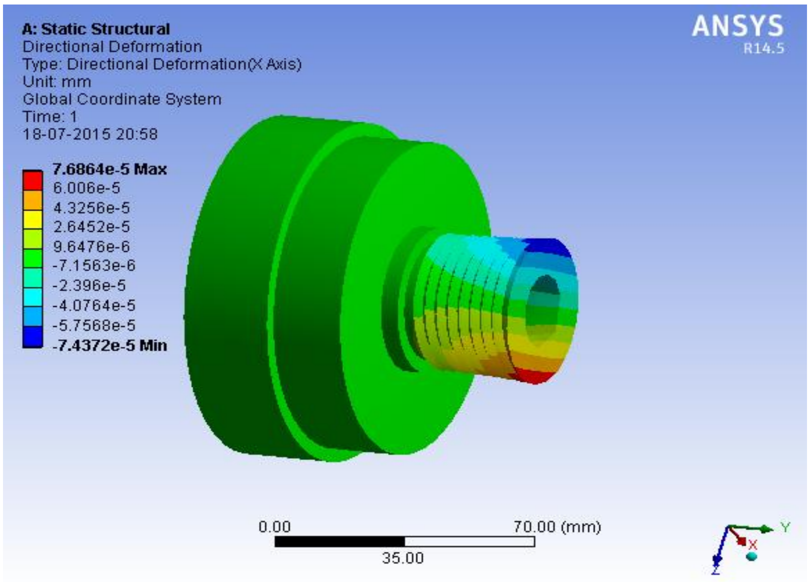


Fig. No.3.8.3 Static Structural Direction Deformation Of Cage Carrier

3.10 Design of Splines

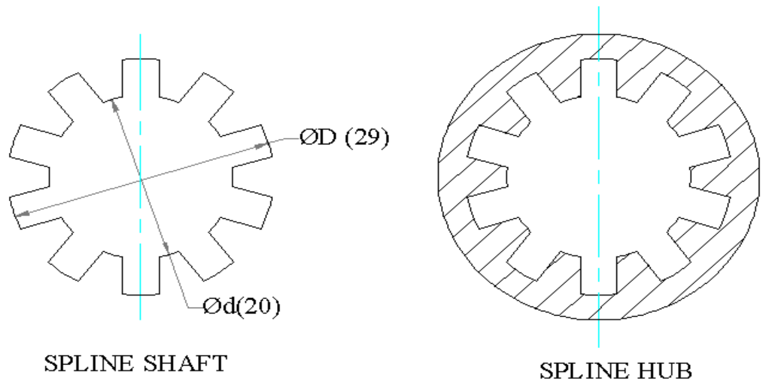


Fig. No. 3.9.1 2-D Design Of Spline

Sult = 800 N/ mm^2, Sylt = 680N/mm^2

$\Rightarrow$ fs_{all} = 108 N/mm^2

D = Major diameter of splines = 29, d = Minor diameter of splines = 20

L =Length of hub = 30, n= No. of splines =10

3.11 Design of Output Spline Shaft

Table No. 3.10.1 Material Selection

Designation	Ultimate Tensile Strength N/mm^2	Yield Strength N/mm^2
EN24	800	680

IV. RESULT AND DISCUSSION

4.1 System Trial

To conduct trials on Torque Vs Speed Characteristics, Power Vs Speed Characteristics & Efficiency Vs load characteristics

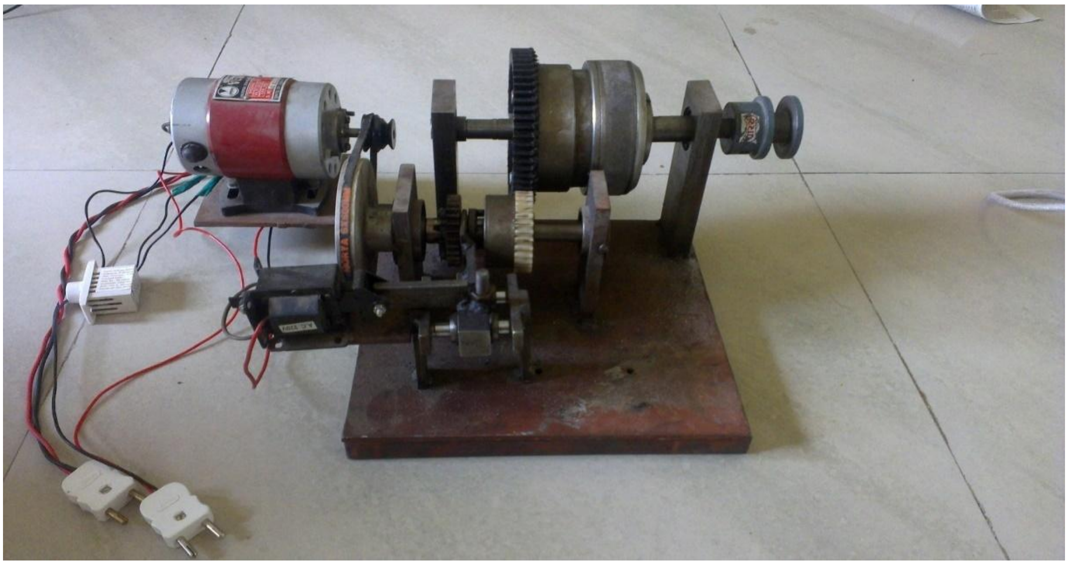


Fig. No.4.1.1 Set Up Of Overload Toque Limiter with Electromechanical Clutch

Observation Table

Table No.4.1.1 Observation Table

LOAD	SPEED	TORQUE	POWER	EFFICIENCY
50	990	0.012263	**1.27145**	23.11727
100	974	0.024525	**2.501802**	45.48731
150	965	0.036788	**3.718027**	67.60049
200	948	0.04905	4.870037	88.54613

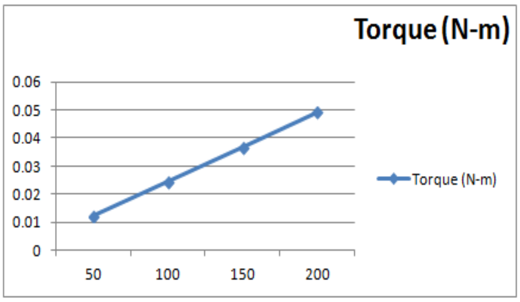


Fig. No. 4.1.2 Torque Vs Load

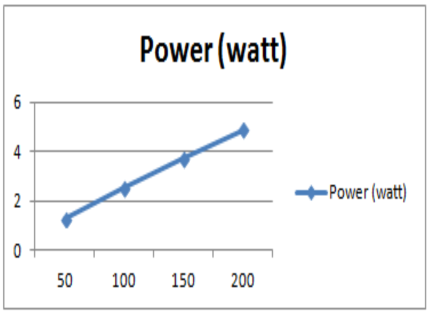


Fig. No. 4.1.3 Power Vs Load

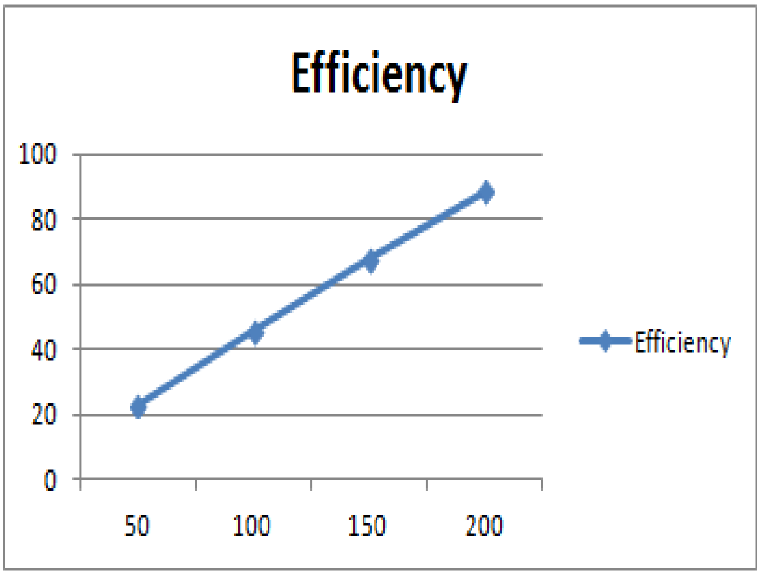


Fig. no. 4.1.4 Efficiency Vs Load

Fig. No. 4.1.2 graph shows relation between torque & load. In this case as load increases torque also increases proportionally, Fig. No. 4.1.3 graph shows relation between power to load, power also increases with load increases. Fig. No. 4.1.4 graph shows relation between efficiency & load, efficiency is more when speed is decreases at that time load also increases.

V. CONCLUSION

Overload slipping ball clutch prevents the breakage of the couplings and other drive members, which are subjected to overload. Also prevents the burnout or damage to the electric drive motor due to sudden over load. Overload slipping ball clutch is capable of transmitting a wide range of torque which can be precisely preset on the drive itself.

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