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Design and Analysis of Active Electro-hydraulic Thruster Brake for Application of Lifting Machine

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ABSTRACT

Thruster brake is device to retard the speed of moving machinery and stop it accurately to desire position. The braking force is applied to brake shoe by pre-stressed compression spring. The convectional thruster brake employs either an electro-mechanical thruster or passive hydraulic thruster. The electro-mechanical thruster utilize electro mechanical solenoid to apply braking force, where as hydraulic thruster brake is applied a force via thruster that is operated by hydraulic force. The value of hydraulic force is fixed irrespective of load to under braking force or over braking force leading to slip the load i.e. improve load positioning or over force braking leading to excessive and un-necessary brake wear. Thus there is a need for a new type of hydraulic thruster where in we can change the value of hydraulic force as per requirement i.e. an active hydraulic thruster. For that we have to determine theoretical breaking force, selection of brake material, geometry of brake drum and brake, analysis of thruster brake system, and finally design the Active Electro-hydraulic thruster.

Keywords- Passive hydraulic brake, Electro–mechanical brake, Active electro-mechanical thruster brake.

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I. INTRODUCTION

The active electro - hydraulic thruster will have a construction as shown in Fig. 1, here the motor used is a 12 volt dc motor with voltage based speed control mechanism in built, made suitably to vary the force for three operating conditions. The pump system is proposed to be piston pump type depending upon the force requirements of the system. The braking spring functions merely to bring the hydraulic piston back to original position once the braking load is released. Pressure lug connects the hydraulic thruster to the brake application lever of the brake calliper where as the mounting end is used to mount the hydraulic thruster onto the frame.

In Active electro-hydraulic thruster, the motor transmits the power to the brake drum via shaft and coupling drive, motor is variable speed so that we can have different vehicle speeds, the speed is regulated using electronic speed regulator. The dynamometer pulley is used to determine brake energy consumption and load positioning accuracy

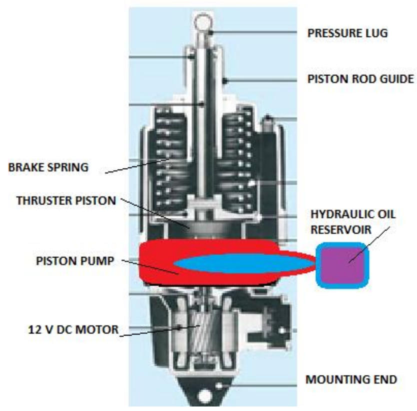

Fig. 1 Active Electro - Hydraulic Thruster.

I. LITERATURE REVIEW

Tatiana A. Minav, Lasse I.E. Laurila, in the paper “Analysis of electro hydraulic lifting system with direct electric drive pump control (2013)”, states that, Energy efficiency has become a major research issue in all fields of engineering. the modelling and testing of an electro-hydraulic lifting and lowering system and a forklift with two lifting zones are carried out and analysed.

Bing Xu, min cheng, huayong yang, meisheng yang, in the paper "Safety brake performance evaluation and optimization of hydraulic lifting system in case of overspeed dropping (2013)" states that, Safety is the most important issue for mobile and industrial machinery, and overspeed dropping of lifting actuators is extremely hazardous to the equipment, environment and operators. to evaluate and improve the safety brake performance of hydraulic lifting systems in this emergent case, a multi objective optimization model was proposed.

Arley G. Lee, Katy, TX (US), in the paper "Electro-Mechanical Thrusters (2009)" states that, A drilling system, including, a drill bit and a thruster to apply a force to the drill bit. The thruster may include: an inner tubular member disposed within and configured to axially move within an outer tubular member.

Peter M. Darley, Jimmy Liang, in the paper "Crane Modernization (1998)" states that, Crane modernization refers to an exercise in which a crane is modified, refurbished or upgraded for the purpose of achieving improved productivity, increase reliability and safety, enhanced maintainability. The scope of modernization could include structural dimensional changes, mechanical system upgrade or electrical or drive control upgrades.

II. DESIGN AND DEVELOPMENT

The development of concept is divided into two steps:

A. *Design of System*
B. *Design of Parts*

Design of system mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man and machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

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

A. Designed Parts
B. Parts to be purchased

A. *Design of system*

In system design we mainly concentrated on the following parameters:

- ✓ System Selection Based on Physical Constraints

While selecting any machine it must be checked whether it is going to be used in a large-scale industry or a small-scale industry. In our case it is to be used by a small-scale industry, so space is a major constrain.

- ✓ Arrangement of Various Components

Keeping into view the space restrictions the components should be laid such that their easy removal or servicing is possible.

- ✓ Components of System

As already stated the system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed & compact.

- ✓ Man Machine Interaction

The friendliness of a machine with the operator that is operating is an important criteria of design.
Following are some of the topics included in this section.

- Design of foot lever
- Energy expenditure in foot & hand operation
- Lighting condition of machine.

- ✓ Chances of Failure

The losses incurred by owner in case of any failure are important criteria of design. Factor safety while doing mechanical design is kept high so that there are less chances of failure.

- ✓ Servicing Facility

The layout of components should be such that easy servicing is possible.

- ✓ Height of Machine from Ground

For ease and comfort of operator the height of machine should be properly decided so that he may not get tired during operation.

- ✓ Weight of Machine

The total weight depends upon the selection of material components as well as the dimension of components.

B. *Design of Parts*

Mechanical design is very important from the view of designer as the project depends on the correct design analysis of the problem.

Many preliminary alternatives are eliminated during this phase. Designer should have adequate knowledge above physical properties of material, loads stresses, deformation, and failure. Theories and wear analysis, He should identify the external and internal forces acting on the machine parts.
Selection of factors of safety to find working or design stress is another important step in design of working dimensions of machine elements. The correction in the theoretical stress values are to be made according in the kind of loads, shape of parts & service requirements.

The parts to be purchased directly are selected from various catalogues & specification so that anybody can purchase the same from the retail shop with the given specifications.

- ➢ Motor Selection

Thus selecting a motor of the following specifications

- 12 V PMDC motor
- Power = 90 watt
- Speed= 0-2880 rpm (variable)

Motor is a 12 V DC motor, Power 90 watt, the speed of motor is varied by means of an electronic speed variator. Motor is a commutated motor i.e. the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator; thereby the speed is also is changes. Motor is foot mounted and is bolted to the motor base plate welded to the base frame of the indexer table.

- Design of Coupling
- Design of Main Shaft
- Selection of Bearing at 'A'
- Selection of Bearing at 'B'

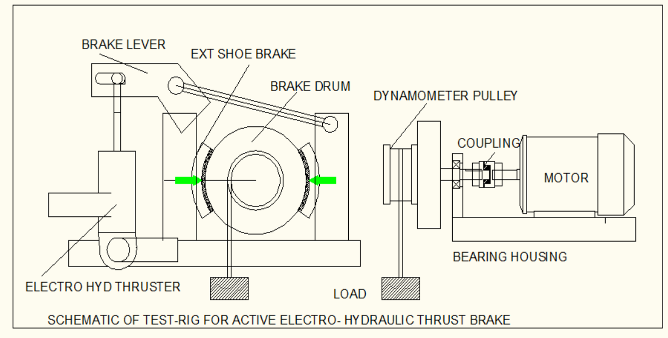

Fig. 2 Design setup of Active Electro-hydraulic Thruster

C. Modelling and Analysis of Components

A. Design of Shaft

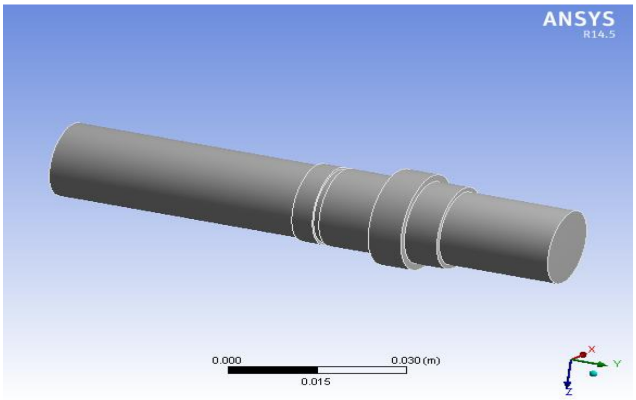

Fig. 3 Modelling of Input and Output Shaft

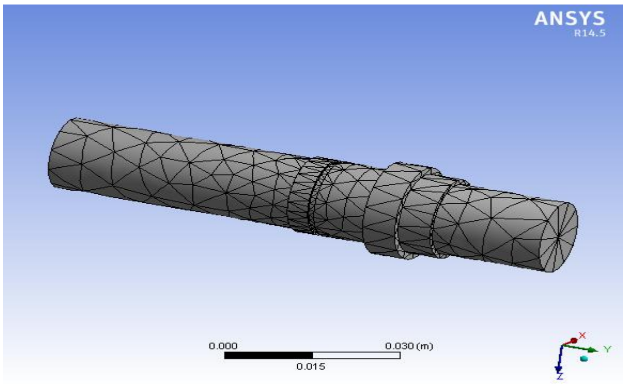

Fig. 4 Meshing of shaft

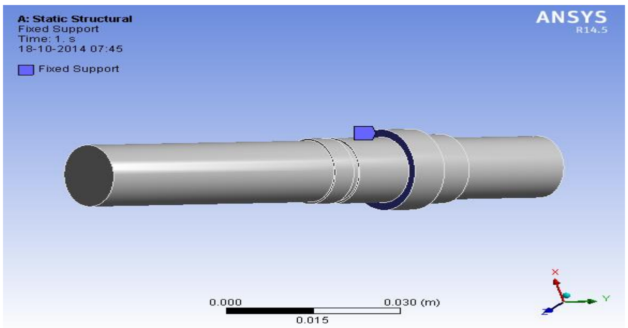

Fig. 5 Boundary Conditions

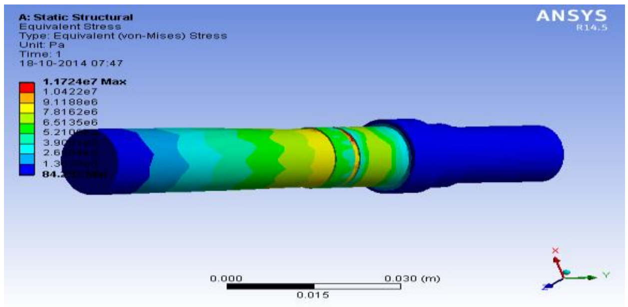

Fig. 6 Results of O/p I/p shaft

B. Design of Input Coupler

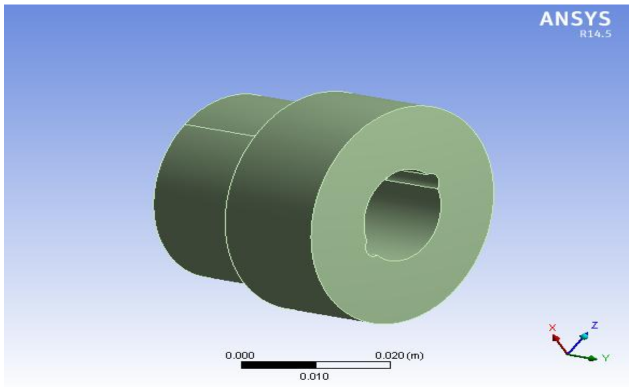

Fig. 7 Modelling of input coupler

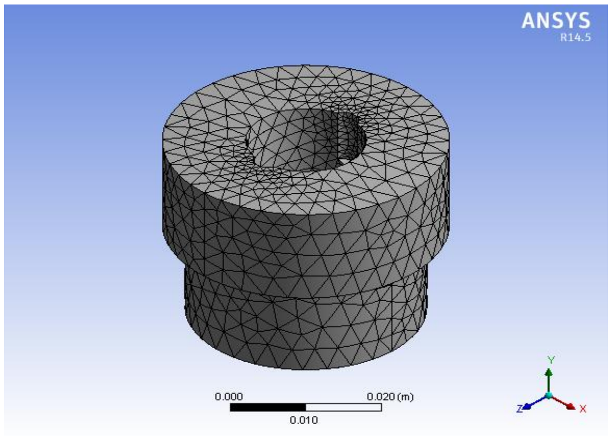

Fig. 8 Meshing of coupler

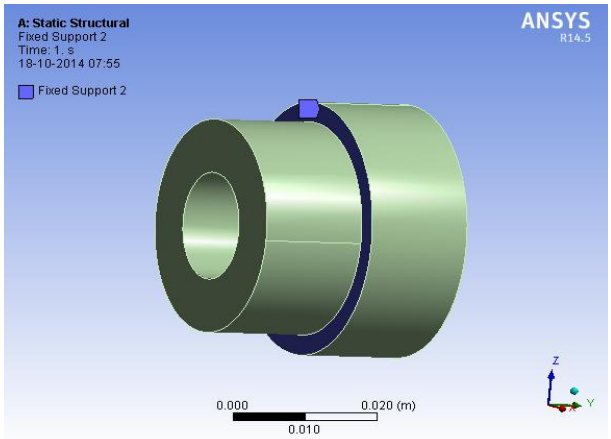

Fig. 9 Boundary Conditions

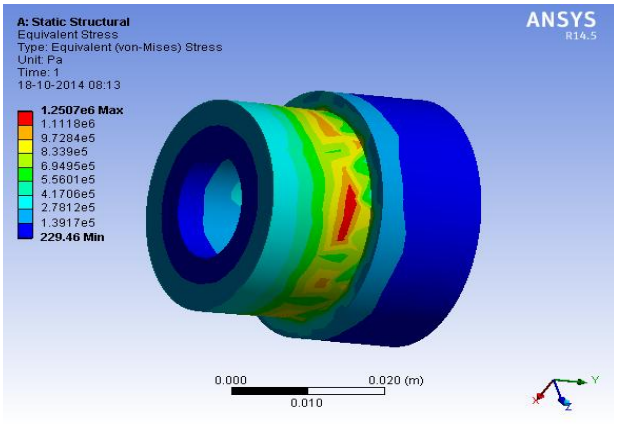

Fig. 10 Results of input coupler

A. Design of Output Coupler

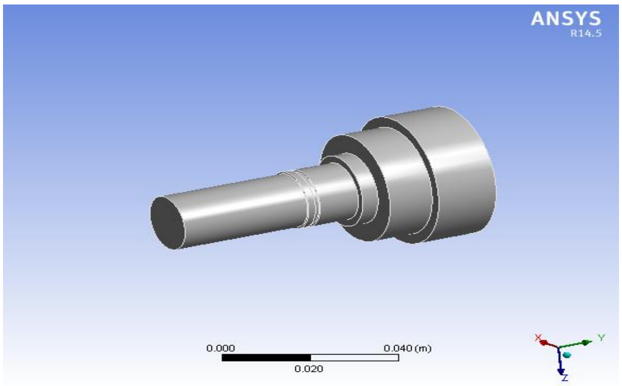

Fig. 11 Modelling of Output Coupler

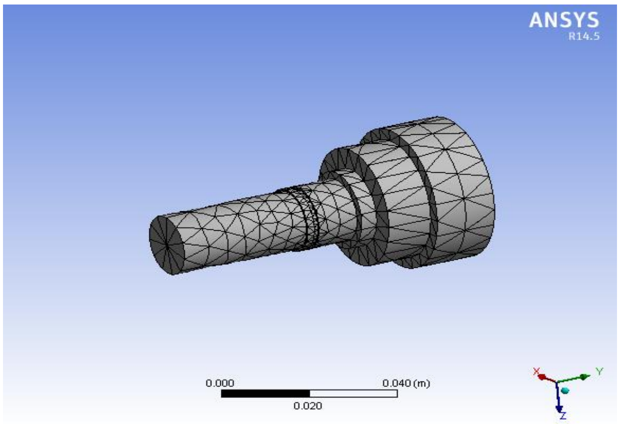

Fig. 12 Meshing of coupler

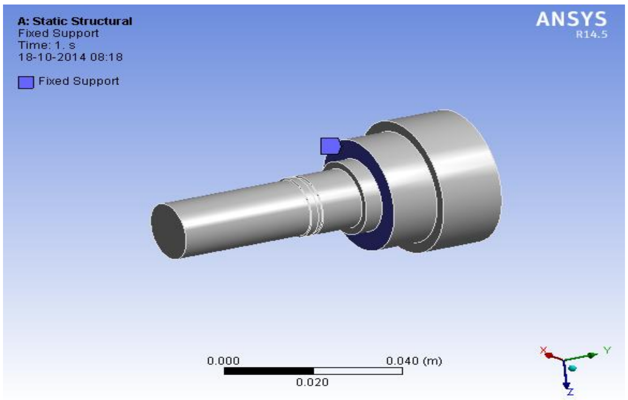

Fig. 13 Boundary Condition

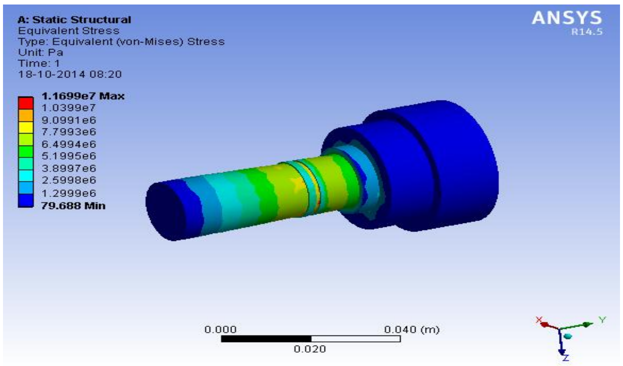

Fig. 14 Results of output coupler

III. Results And Discussions

Table 1 Theoretical and FEM Results

Part Name	Allowable shear stress N/mm^2	Theoretical maximum stress N/mm^2	Equivalent Von-mises stress N/mm^2
Input/ Output Shaft	198	2.648	0.11
Coupler	108	71.61	1.25

IV. Conclusions

Conclusion of the Active Electro-hydraulic thrusters brake by determine

A. Maximum stress by theoretical method and von-mises stress are well below the allowable limit, hence the input/output shaft is safe.

B. Maximum stress by theoretical method and von-mises stress are well below the allowable limit, hence the coupler is safe.

C. Effect of thruster motor speed on braking energy consumption and thereby recommendations of the three thruster speeds for variety of applications.

D. Stresses are below the allowable stress limit, so system is safe.

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