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

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ABSTRACT

Thruster brake is a device to retard the speed of moving machinery and to stop it accurately to the desired position. The braking force is applied to the brake shoe by a pre-stressed compression spring. The shoes press on the rotating brake drum retarding its speed and finally stopping it. The releasing of the brake and compressing of the spring is done by the Thruster. When the thruster motor is energized, the thrust provided by the thruster lifts up the crank lever which moves the arms and the shoe brakes away from the brake drum, and releasing the braking force. The spring is compressed and braking energy is stored for the next cycle. Development of theoretical graphical model of system of forces, derivation and resolution of system forces by drawing free body diagram of worm drive, determination of forces and utilizing system of forces to determine the worm and internal threaded ring dimensions of drive. 3-D modeling of setup will be done using Unigraphix Nx-8.0 and CAE of critical component and meshing using Ansys Workbench 14.5. The experimental validation part of the lifting force developed by the twin worm system be validated using Test-rig developed and performance characteristics of torque, Power and efficiency Vs Speed will be plotted.

Keywords— Electro-Hydraulic Thruster, Brakes, Lifting Machine, FEM

I. INTRODUCTION

Brakes are a critical mechanism on the crane as it is directly in the line of forces of the load. Brake failure often leads to catastrophic consequences. Hence, it is appropriate to discuss this subject at some length. Modern cranes use disc brakes on all functions because of the greater efficiency and emergency stopping power of disc brakes. The rotational speed and energy absorption of disc brakes is higher than that of drum brakes. Also lower lining wear rates and auto adjustment of disc brakes means less maintenance and greater safety.

Electro-Hydraulic thruster brakes actuation gives much smoother brake operation without the mechanical shocks and electric voltages transient on spring return place great stress on the electrical components of DC Solenoid actuator system. This results in high maintenance costs and poorer reliability in comparison with an electro-hydraulic thruster actuator system. Total brake system changes from DC Solenoid drum brakes to electro-hydraulic thruster disc brake are viable and can be justified on the grounds of greater safety and economy of operation. The thruster shoe brake has a pair of cast iron shoes which are lined up with friction pads. The shoes are hinged on the main arm and the side arm of the brake, each of them having a hinge pin fitted in the base. They are connected to each other on top by a tie rod, which is hinge in the main arm and locked to the swivel block in the side arm, by a lock nut. A crank lever is hinged on the main arm, and the other end is fixed to the top clevis of the thruster by a hinge pin. A
brake spring is fixed on the main arm and is pre-locked by a lock nut on the lever. The pre tension in this spring decides the braking torque. The thruster is fitted on the base by a hinge pin. When the thruster is not energized, the brake shoes are pressed on the brake drum fitted on the drive motor shaft and hold it under the effect of braking force provided by the spring. In such a condition, the brake is applied and the drum cannot rotate. When the thruster motor is energized, the thrust provided by the thruster lifts up the crank lever which moves the arms and the shoe brakes away from the brake drum, and releasing the braking force. The spring is compressed and braking energy is stored for the next cycle.

II. METHODOLOGY

The solution to the problem is an active electrohydraulic thruster than will apply the load as per set limit dependent upon the braking load. The electro hydraulic thruster will be operated using a positive displacement piston pump operated using a variable speed 12 Volt DC motor. Thus by varying the speed of motor we can vary the amount of fluid entering the piston chamber and thereby the hydraulic force generated by the piston rod. The piston rod will be coupled to the brake lever of the external shoe brake mechanism and thereby he required braking force will be applied to the brake drum.

III. SCOPE

Design and Analysis of an active electrohydraulic thruster brake for application in lifting machinery like hoist and winches.

ANALYSIS OF THRUSTER CYLINDER BODY

Geometry

Figure 3.1 Test rig for active electro hydraulic thrust brake.

Here 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, and the speed is regulated using electronic speed regulator. The dynamometer pulley is used to determine brake energy consumption and load positioning accuracy.

Figure: 1.1 Hydraulic Thruster Brake

IV. ANALYSIS

Design of hydraulic thruster cylinder body

Material selection.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Ultimate Tensile strength N/mm²</th>
<th>Yield strength N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>380</td>
<td>270</td>
</tr>
</tbody>
</table>

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The active electro-hydraulic thruster will have a construction as shown above, 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 caliper whereas the mounting end is used to mount the hydraulic thruster onto the frame.

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Maximum theoretical stress N/mm²</th>
<th>Von-Mises stress N/mm²</th>
<th>Maximum deformation mm</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thruster cylinder body</td>
<td>1.4</td>
<td>1.6</td>
<td>$1.36 \times 10^{-13}$</td>
<td>Safe</td>
</tr>
<tr>
<td>Piston</td>
<td>0.92</td>
<td>2.9</td>
<td>$4.63 \times 10^{-13}$</td>
<td>Safe</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

1. Maximum stress by theoretical method and Von-Mises stress are well below the allowable limit, hence the Thruster cylinder body is safe
2. Thruster cylinder body shows negligible deformation under the action of system of forces.
3. Maximum stress by theoretical method and Von-Mises stress are well below the allowable limit, hence the piston is safe
4. Piston shows negligible deformation under the action of system of forces.

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