Design & Analysis of Active Electro-Hydraulic Thruster for Emergency Brake Assist

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Abstract— Thruster brake is device to retard the speed of moving machinery & stop it accurately to desire position. Electro mechanical thruster utilize electro mechanical solenoid to apply braking force, whereas 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 under braking force or over force leading to excessive & unnecessary brake wear. Thus there is need for a new type of hydraulic thruster where in we can change the value of hydraulic force as per requirement that is an active hydraulic thruster. Objective of project is determination of braking force required for emergency braking at three operating speed condition & selection of the braking system arrangement that is disk brake & caliper arrangement suitable for derived condition.Design development and analysis of electro hydraulic thruster mechanism with three step operation modes.3D cad modeling using unigraphix and analysis for strength of critical component of thruster using anasys. Development of emergency brake assist system test rig to test elecro-hydraulic thruster to determine braking distance determination for individual stages. Iterative methods will be used to predict safe braking distance at various vehicle speeds for different settings of EBA thruster mechanism.

Key words: Design, Finite Element Analysis, Thruster Body, Ansys, Experimental Setup, Emergency Brake Assist

I. Introduction

There are many different variations and control algorithms for ABS systems. We will discuss how one of the simpler systems works. The controller monitors the speed sensors at all times. It is looking for decelerations in the wheel that are out of the ordinary. Right before a wheel locks up, it will experience a rapid deceleration. If left unchecked, the wheel would stop much more quickly than any car could. It might take a car five seconds to stop from 60 mph (96.6 kph) under ideal conditions, but a wheel that locks up could stop spinning in less than a second.

The ABS controller knows that such a rapid deceleration is impossible, so it reduces the pressure to that brake until it sees an acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the tire can actually significantly change speed. The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up. This gives the system maximum braking power.

When the ABS system is in operation you will feel a pulsing in the brake pedal; this comes from the rapid opening and closing of the valves. Some ABS systems can cycle up to 15 times per second. When the brake is applied within the ABS limit the speed sensor is active , gear pump is started and the hydraulic oil is pumped onto the brake calliper and brake is applied this will try to retard the axle suddenly..this is sensed by the speed sensor, it will cut off supply to the gear pump hence, brake will be off, due to momentum of vehicle axle will again gain speed, sensor will be off now again pump will start and apply the brake….thus the braking will keep on turning 'ON' &'OFF' is quick succession…which is expected from the ABS to prevent locking of the brake.

In case of emergency when the driver forces the pedal beyond predetermined limit the EBA-sensor (proximity sensor) will detect the condition and actuate the electro-hydraulic thruster which will operate at high speed to develop brake force in multiples of the human effort and apply the brake to bring the vehicle to stop.(1) From literature review it was found that very little work was done on Braking system.(2) The main objective of present work is to perform Design development and analysis of electro hydraulic thruster for the EBA mechanism. (3) Present work consists of Determination of braking force and braking torque for abs & eba system using theoretical calculations and determination of system of forces to design both systems in accordance of vehicle speed and vehicle mass.(4) Design development and analysis of various parts of the ABS and EBA system of forces, by theoretical method and validation of results by using ANSYS16.0 (5) Testing of the ABS & EBA system to determine following results (i). Braking distance at various speed for stand alone ABS system. (ii).Braking distance at various speed for stand alone EBA system. (iii).Braking distance at various speed for combination of ABS & EBA system. (iv).Brake efficiency in all three condition for various speed condition. (v).Vehicle safety improvement by application of EBA.

II. Problem Statement

Many accidents caused by ignoring right-of-way, driving on the wrong side of the road, inappropriate speed, insufficient distance from other vehicles and so on might have been prevented had the vehicles been able to brake faster, Studies have shown that many drivers do not apply the brakes sufficiently in emergency situations due to lack of experience. That means that the greatest possible braking effect is not attained because the drivers did not press the brake pedal hard enough. Therefore, the brake assist system was developed to support the driver in critical braking situations.

III. BRAKING SYSTEM DESIGNED

A. Emergency Brake Assist System with Electro Hydraulic Thuster

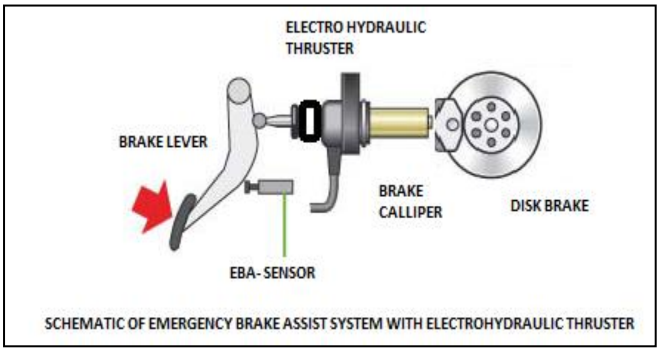


Fig. 1.1: Design of braking system

The system comprises of the brake lever which when operated at first operate the conventional solenoid braking of ABS type ie. the brake will cycle between 'ON' & 'OFF' condition to prevent the skidding of the vehicle, preventing accidental locking of braking owing to excessive heating as a result of continuous contact of disk brake and caliper shoes. But In case of emergency when the driver forces the pedal beyond predetermined limit the EBA-sensor (proximity sensor) will detect the condition and actuate the electro-hydraulic thruster which will operate at high speed to develop brake force in multiples of the human effort and apply the brake to bring the vehicle to stop.

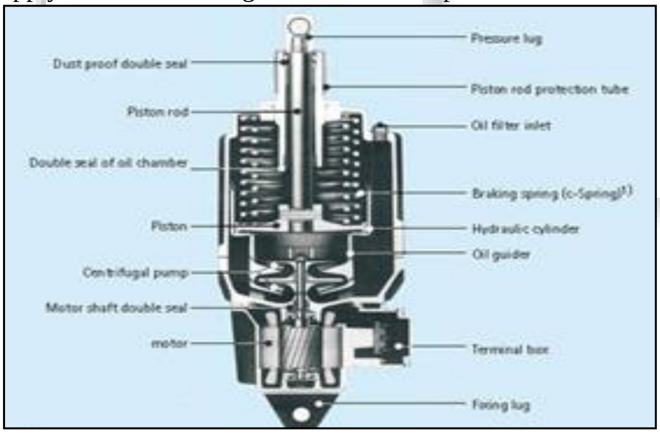


Fig. 1.2: Electro-Hydraulic thruster

The 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 carry ot the test of the system under three operating conditions. The pump system is proposed to be centrifugal pump type or piston type depending upon the reaction time and force requirements of the system. The braking spring functions merely to bring the hydraulic piston back to original position once the foot from the pedal is removed. Pressure lug connects the hydraulic thruster to the brake application lever of the brake caliper where as the facing lug s used to mount the hydraulic thruster onto the frame.

IV. NUMERICAL EVALUATION

Hoope's stress due to exhaust gas pressure:

Maximum pressure induced in system due to steam= 3 bar

$$fc_h = \frac{P\,xd}{2t} \qquad fc_h = \frac{2 \times 28}{2 \times 6}$$

Fcact = 4.66 N/mm2

As $fc_h < fc_{all}$; damper body is safe.

V. ANALYSIS OF THRUSTER BODY

Equivalent stresses are extracted from static structural analysis by using Ansys mechanical module. Load cases are considered for the analyses are mentioned as I, II & V. Material properties for thruster body are Young's modulus 600 N/mm2, Yield strength 480 N/mm2. Fig.1.3 shows the result obtained because of tensile loading at thruster body equivalent stress observed in model is 7.2877 MPa .

Hence from fig.1.4 Maximum theoretical stress 4.66 N/mm2, Von-mises stress 7.8 N/mm2, Maximum deformation 0.004mm. Maximum stress by theoretical method & von-mises stress are well below the allowable limit, hence the thruster body is safe.

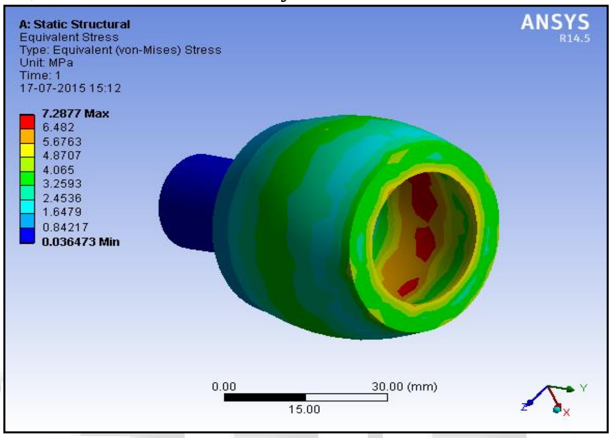


Fig. 1.3: Design Equivalent Stress Load Case 1

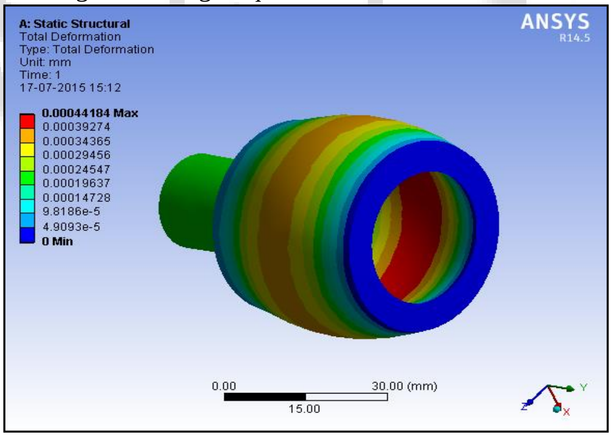
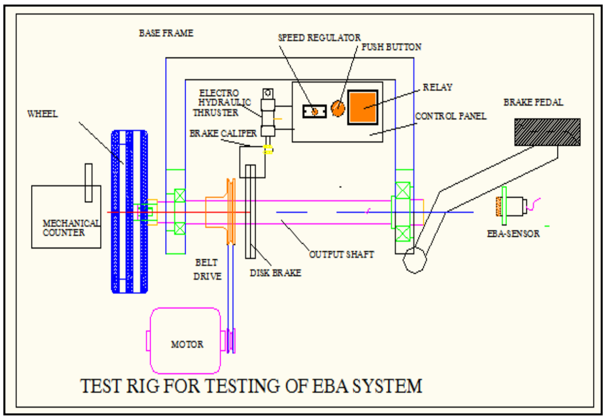


Fig. 1.4: Total deformation condition

VI. EXPERIMENTAL SET UP



The testing rig is to be setup for experimental setup, Here the motor transmits the power to the shaft via open v-belt drive , motor is variable speed so that we can have different vehicle speeds, the speed is regulated using electronic speed regulator. The mechanical counter is used to count the number of rotations of the wheel after EBA is applied thus the distance of braking is determined.

when the brake pedal is pressed harder just as in case of emergency the second limit switch is pressed which will operate the EBA mechanism , the 2 kg solenoid operated the thruster , which will multiply the force three times and thus a force of 6 kg will be applied to the brake caliper lever which will instantaneously stop the vehicle.

VII. Result & Discussion

The main achievement from this study is to Design & Analysis Of electro hydraulic thruster for EBA mechanism. Hence from all above discussion it can be concluded couple of points listed below:

1) Output speed drops with increase in load
2) There is considerable retardation with increase in brake load indicating good effectiveness of brake.
3) Percenatage slip increases with increase in load
4) There is slight increase in slip indicating slight drop in performance of brake but negligible as compared to other friction brakes.
5) Brake power absorbed remains almost constant with change in load
6) The brake performs consistently over load range …with slight drop in power with increased load though very negligible.

VIII. Conclusion

In case of emergency the EBA system applies a force of 3 times more than conventional system thereby applying instantaneous braking reducing the braking distance and thereby the probability of accident.

Results summary explains all about the comparison between Antilock braking system & Emergency brake assist. Table 1 and 2 shows the comparison between ABS and EBA System.

Observation table for ABS:

Sr no	LOAD	SPEED actual	Speed theoretical	TORQUE	Brake power absorbed	% Slip
01	0.5	826	830	0.367875	31.82477	0.481927711
02	1	406	416	0.73575	31.28537	2.403846154
03	1.5	265	275	1.103625	30.63038	3.636363636
04	2	198	207	1.4715	30.51479	4.347826087
05	2.5	159	167	1.839375	30.63038	4.790419162

Observation table for EBA:

Sr no	LOAD	SPEED actual	Speed Theo.	TORQUE	Brake power absorbed	% Slip	BRAKE DISTANCE	VIB-VELOCITY	VIB -ACC-N
1	0.5	560	564	0.55	32.257	0.70	4.46	0.405159	1.00412
2	1	278	281	1.11	32.3	1.06	3.35	0.747716	1.849342
3	1.5	186	189	1.56	30.57	1.58	3.35	1.044453	4.279816
4	2	135	139	2.23	31.527	2.87	4.46	1.306193	3.048947
5	2.5	115	119	2.78	33.48	3.36	4.469	1.540327	3.735268

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