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Design of Adapting Multi-Servo Concept with Optimal Change in Tractor Brakes

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Abstract: ***All of the agricultural tractors are weighed down by heavy cargo loads & ploughing so safety and efficient reliability is utmost important. Now-a-days tractors are conventionally having brakes which are being actuated by Mechanical linkages which is dominantly having several mechanical load distribution losses. This mechanical actuating stuff is going to get replaced by hydraulic actuation which will meet the reduction of increasing losses considerably.This paper introduces a conceptual illustration of adopting multi servo effect in traditional tractor brakes where the servo effect is present under optimal manner in dry tractor brakes. Also application of hydraulic actuation reflects a considerable reduction in pedal effort and travel which is the major mechanical advantage that can be attained. Thus, this article shows a conceptual analysis of increased braking efficiency by two variant packages: 1) Multi-Servo effect and 2) hydraulic actuation.***

Keywords: Hydraulic Actuated Multi Plate-Disc Brake, Multi servo Brake, Tractor Brakes.

I. INTRODUCTION

Traditionally brakes are constructed with the two ends containing primary shoe at one end and secondary shoe at another end (in case of drum brakes). When the brakes are applied, the primary shoe which is actuating in the direction of the drum rotation assists the servo effect whereas the secondary shoe which is in the opposing actuation side will have a conflicting servo effect [1]. This will make the pedal effort to be necessarily less and this is extensively used in common heavy commercial brakes. Here the servo-effect is drawn into the friction surface of the drum brake, by virtue of which the maximum clamping force is attained as much as it can. However the shoe which is behind the primary one will actuate against the surface of the drum rotation will not retard the drum effectively and thus, it does not encourage the effective clamping force.

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Similarly, the tractor brake employs above said principle instead the fact that the primary and secondary shoes (servo components) are replaced by means of actuating discs. However,
adopting the Multi-Servo concept influences the elimination of above said non-Servo face (shoe which possesses high drag force comparatively) and additionally hydraulic actuation which is a new actuation category that facilitates in holding the finest pedal travel and pedal effort.

II. CURRENT BRAKE DESIGN

In our current design of tractor brakes as shown in fig: 1.1, when the brake is applied the effort from the user end through pedal linkages rotates the actuator in opposite direction which in turn lifts the ball and makes it to travel on the ramp that results in the expansion of the actuators in the axial perpendicular direction especially because of the presence of opposite sided ramps as shown in fig: 1.2 in individual actuators [2].

Fig: 11 CURRENT TRACTOR DRY BRAKE

This indulges the actuator to apply a clamping load on the friction disc lining area to stop the vehicle. When our vehicle is moving in forward direction the wheels rotate in anti-clockwise and the actuator which is rotating in the identical direction assist in giving the servo effect [3].

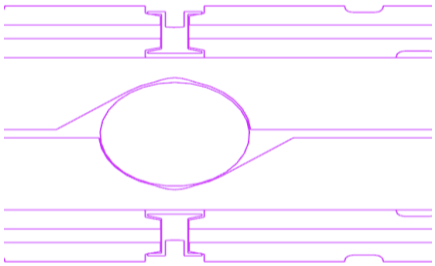

Fig: 1.2 RAMP AND BALL MECHANISM IN CURRENT BRAKE SYSTEM

Whereas the trailing actuating disc which is rotating in the opposite side does not help in boosting the servo effect. Although we have a servo face, the existence of opposite retarding face, results in having a considerable amount of more drag value compared to that of servo assisting side, thus reducing the servo assistance.

III. PROPOSED DESIGN BRAKE

In our modified design, overcoming from that retarding unfavorable effect, we use the "MULTI SERVO" concept where the both above said faces are acting as the servo assisted faces. For this, we are using a concept of rotating both the actuators in the same direction. But in our existing tractor brake design as said above, the actuators are made rotated in opposite direction to each other (i.e) it cannot work if rotate both the actuators in the same direction because of the presence of ramp direction

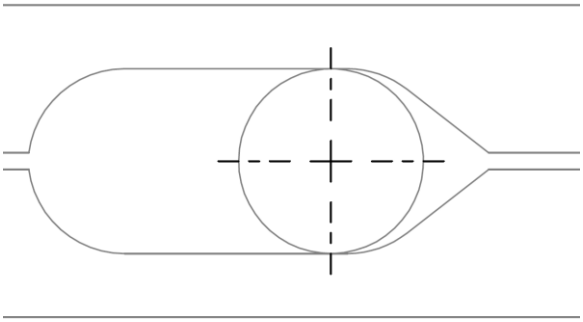

Fig: 1.3 Ram And Ball Mechanism In Proposed Design

Here in our concept, we applied same sided ramp design in a projectile path which follows a pre-defined pitch circle diameter as shown in fig: 1.3 and the main innovative concept we have engaged here is usage of ramp angle paths with opposite hand directions consecutively which concentrates on each individual ball pockets as shown in the figure. Additionally, the ball ramp consist of slot type guide through which the ball have a provision to travel in each direction of application (i.e) forward and reverse direction. Also the construction of our concept includes the presence of the tail lug on both side of each actuators where there is only one tail lug is present in each actuating disc in existing design (as shown in fig: 1.4) This two tail lug on single actuating disc itself facilitates the hydraulic actuating mechanism to move both the actuators in same direction with corresponding gradual increase in angle of rotation [4].

The existing tractor brake design consist of two actuating discs where the reaction force of one disc is transferred to another and vice versa. Whereas in our design it's not feasible. Therefore we engage a separate provision called ball holding plate which acts as a bearing like structure (as shown in fig: 1.5) in between the actuators with suitable clearances provided as per modelling design. Moreover, this ball holding plate is stable and it allows the ball to rotate in its pockets machined as suitable to the ball diameter. And it is clearly said here that the reaction force of both actuating disc is transmitted to the ball holding plate.

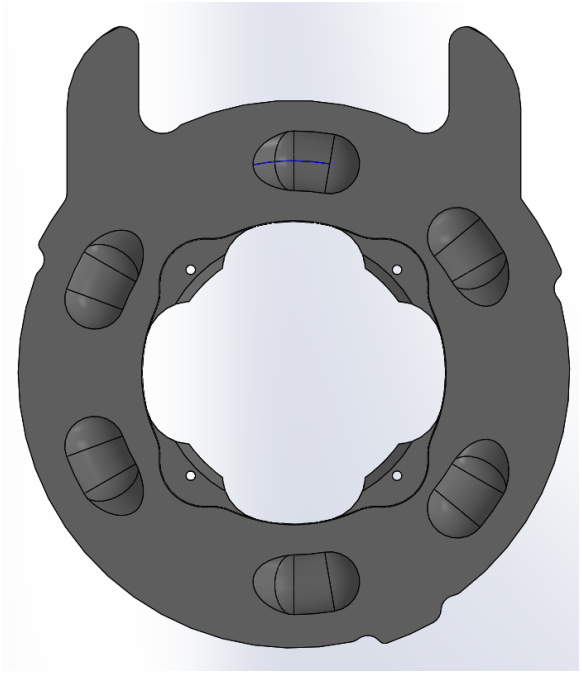

Fig: 1.4 Ramp Slot Arrangement On Actuator For Proposed Design

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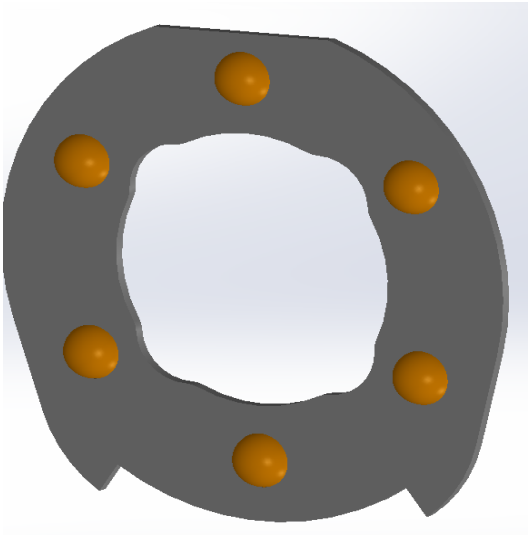

FIG: 1.5 BALL HOLDING PLATE

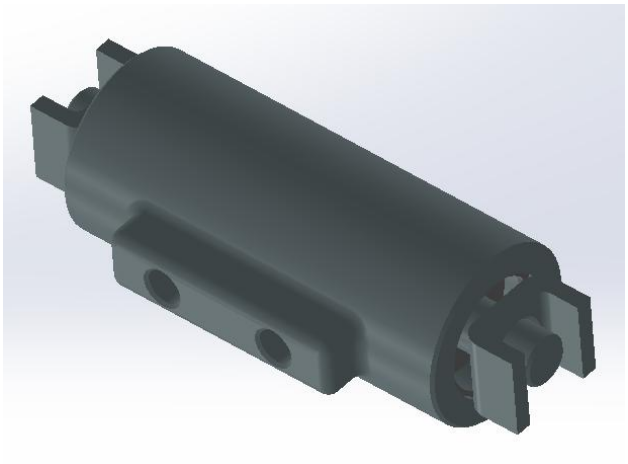

FIG: 1.6 DOUBLE ACTING SLAVE CYLINDER

The application of 3/2 directional solenoid valve plays a major role in function in-between the slave cylinder and master cylinder. This solenoid valve can be actuated pneumatically, hydraulically, mechanically and manually where we use hydraulic method of actuation. Normally it has two states open states in two directions respectively and has three ports (i.e) inlet port, outlet ports, When the valve is not in energized condition, the fluid flows in one side of the double acting slave cylinder and actuates that slave cylinder in that particular direction. And when the solenoid valve is in energized condition, the exhaust port connected to another side of the double acting slave cylinder actuates it in that particular direction. Moreover, we use the compensated central valve master cylinder especially here in tractor brakes because it has a major role playing in compensation of pressure difference between the both left hand and right hand brakes. This master cylinder have a compensation port which develops the fluid to flow from low pressure area to high pressure area thereby compensating the pressure and making the pedal travel in equal manner for both hands of brakes [5,7].

FIG: 1.7 3/2 SOLENOID VALVE

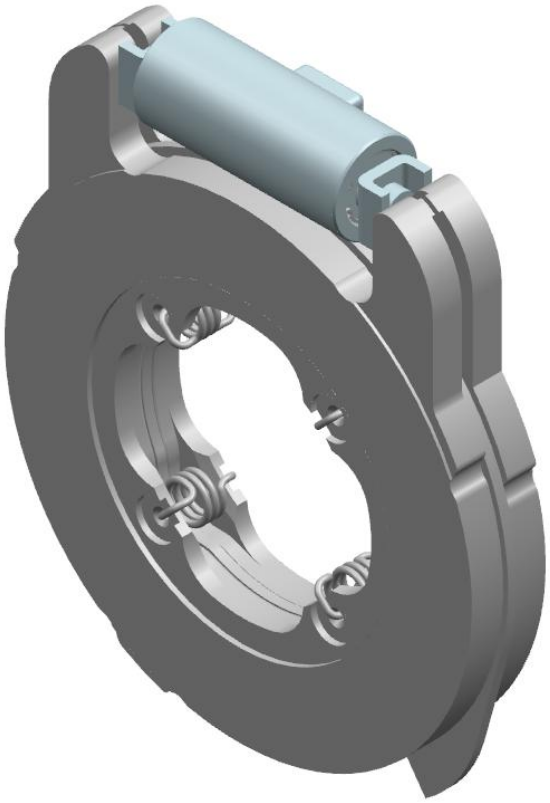

FIG:1.8 PROPOSED DESIGN BRAKE

This is due to the fact that while using the tractors for field applications, user have to lock one wheel which is referred commonly as spin turn applications to rotate or turn the tractor according to the user need. There appears the uneven wear in friction discs creating a uneven pedal travel as well as uneven pressure variation between both hands of the brakes [6,8]. This is eliminated by the above said CCV master cylinders and gradual operation of L.H and R.H brakes can be attained. And all together assembled (as shown in fig: 1.6) When the pedal is operated, this mechanical force creates a push over the master cylinder piston which in turn creates a hydraulic pressure over the solenoid valve followed by the double acting slave cylinder. And, the sensor senses the direction of

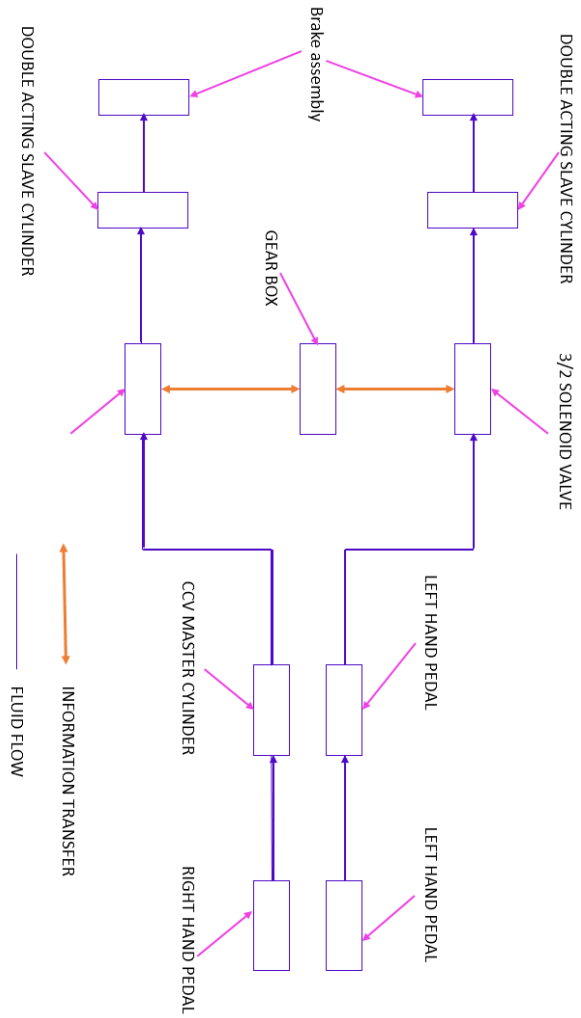

FIG: 1.9 LINE DIAGRAM ACTUATION

the vehicle and operates the solenoid valve correspondingly, so that it actuates the actuator in anticlockwise or clockwise direction for forward and reverse direction of the vehicle respectively

In additional to that we tried the design of V-shaped ramp angle (as shown in fig: 1.9) at first, but it had some negative adverse effects on operating the brakes between forward and reverse direction.

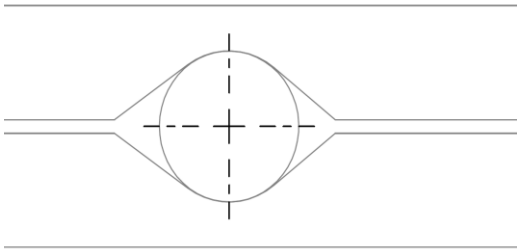

Fig: 1.10 V-Shaped Ram Mechanism

. That is, say when the vehicle changes its operation between forward to reverse direction, the ball in between the ramp pockets have to rotate in opposite projectile direction where it creates some noise issues as well as abnormal movement on change of balls from one side to another which creates a wear too on the ball surface. Therefore, we created a design of a slot type pocket in-between two side of ramps which creates a smooth movement of balls from one side to another between forward to reverse applications and vice versa.

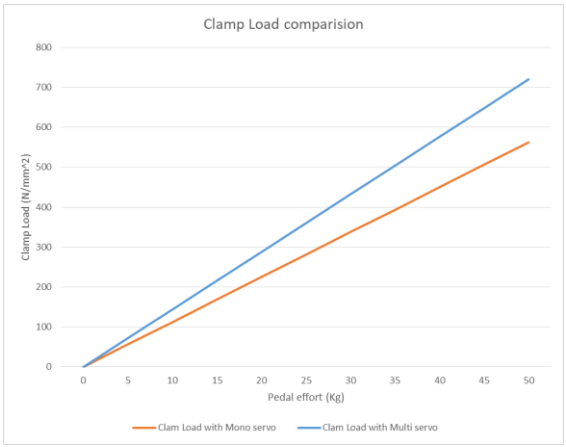

Fig: 4.11 Clamp Load Comparison Graph

We conducted a graphical comparison study which the plotting of clamp load vs. pedal effort gives a considerable result to come pinto a concluded positive way comparison. Also here the clamp load plays a major role in determining the pedal effort where it is advantageous at user end. It is nothing but the clamp load in existing brakes are achieved in prior pedal travel with respect to the lower pedal effort.

IV. CONCLUSION

From above outcome of the results, it is clear that the application of multi servo effect and modified hydraulic actuation principle reduce the pedal travel and pedal effort for the required brake torque by virtue of it amplifies the overall braking force. The usage of hydraulic actuation accommodate the lag in braking between the each hands of brake which is the key advantage of this design.

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