To execute the functioning and biasing of force acting on two master cylinder using single brake pedal a mechanical system, i.e., balance bar is used which is designed to divide the force applied by the driver on the brake pedal to the master cylinders. Moreover in master cylinder pushrod’s movement is critical for proper functioning of master cylinder. So to achieve linear motion correct position and orientation of brake pedal and pushrod mounting is required. After motion analysis and practical examination it is shown how to decide the mounting’s of pushrod.

**Keywords:** Balance bar, Disc brakes, Master cylinder, Pushrod

**INTRODUCTION**

In vehicle when braking force is applied weight is transferred to the frontwheels, so to lock all the wheels higher braking force is required on front wheels then the rear wheels, also in case of cornering weight is transferred from inner to outer wheels which again results in different braking force. In hydraulic braking system the braking force is applied by means of hydraulic cylinder, i.e., master cylinder. As different braking force is required at front and rear wheels so biasing of input force to the two master cylinders is needed. Which can be done with the help of mechanical balance bar. This adjusts the force acting on the pushrod by changing the distance between pushrod mounting and pedal.

The force applied on the piston by pushrod, i.e., force is transmitted by pushrod. The motion of pushrod is critical for complete function of master cylinder. To transfer the applied force with minimum loss, the pushrod should move in a straight line and must goes maximum inside the cylinder.

**BALANCE BAR DESIGN**

**Balance Bar**

A balance bar (also called a bias bar) on dual master cylinder systems, divides the force from the brake pedal to the two master cylinders.
cylinders. It is called a “balance bar” because that is exactly what it does. The torque on one side of the bar must balance the torque on the other side of the bar. Remember that a force applied over a distance causes torque. Therefore, the master cylinder closer to the pivot point on the bar has a shorter lever arm and will receive a higher braking force. Balancing bars take force from one side and give it to the other.

**Design**

- It consists of a solid rod which is mounted using bearings on its both the ends. The bearings are attached to the frame of vehicle.
- A slot of dimension 300*15*15 mm of cut out in the solid rod.
- A sleeve is put on solid rod with a clearance of 2 mm between the two. The pedal is welded to the sleeve.
- Two holes of diameter 15 mm are drilled in the sleeve and a M15 nut is welded over the two holes. The holes are made so that M15 bolt can be screwed to the nut welded on the hole up to the bottom surface of slot and a check nut is also put on screw to prevent it from unscrewing due to vibrations.
- In this way the sleeve gets fixed onto the solid rod as bolt get stuck in the slot cut in the solid rod. Hence, there is no relative motion between sleeve (on which pedal is welded) and the solid rod.
- Two strips are welded on the solid bar with a hole in them. The clamps of master cylinder pushrods are attached to the strips through nut and bolt. The master cylinders are fixed on the frame of the car.
- As a result, when the pedal is pressed, the solid rod rotates along with pedal movement. The strips welded on the solid bar move along an arc and since, the master cylinders are fixed, the pushrods are pressed due to the movement of the strips.
- If the sleeve is in the centre of the slot, then, equal force is applied on both the pushrods and hence, equal braking pressure is created in both master cylinders.
- However, in order to bias the force being applied on both pushrods, the bolts of sleeve are loosened and the sleeve is moved towards the master cylinder on which more force is needed, and the bolts is tightened again. As a result, the pedal force is unequally distributed and hence, unequal braking pressure is created in the master cylinders.

**Advantage**

- In design, when the pushrod is fully pressed into the master cylinder, the pushrod is
parallel to it. As a result, maximum braking force is applied and no vertical component of force acts on the pushrod, due to which it has maximum service life.

- This setup needs less space because the master cylinders are situated above the pedal and not in line with pedal (which requires more space).
- Easy to design, manufacture and installation.
- The bearing provides a twisting moment which helps in reversal of pedal once pedal input force is removed. As a result, no need for return spring.

**MOUNTING ANALYSIS OF PUSHROD MOUNT**

As pedal follows a circular profile about the point of pivot, such that the pushrod mounting fixed on balance bar also follows a circular arc, so the circular motion of mounting strip is transformed into linear motion of pushrod. The path followed by the pushrod depends on the mounting position of strip. These mount strip can be attached as:

**Case 1:** When mounting strip is mounted at 0 degree angle with vertical. As force is applied on the pedal the bearing will rotate in anticlockwise sense, so as the mounting strip following the circular arc, this will move pushrod in the forward direction but the force is not exactly in horizontal sense but inclined downward.

The resultant downward force which will be act in horizontal direction will be less and also the component along the downward direction will tend to move the pushrod in downward direction and not exactly horizontal. This may damage the master cylinder.

![Figure 2: CAD Model of Balance Bar](image)

![Figure 3: Case 1 - Pushrod and Strip Vertically Mounted](image)
Case 2: When the mounting strip of pushrod is mounted as shown in Figure as the force applied on the pedal shaft on which strip is attached rotates in anticlockwise sense and hence the mounting strip will also move on a circular arc (shown by red dotted arc). The mounting strip is attached in same angle as the angle of travel of pedal so that force transmitted via pushrod doesn’t goes in downward inclination.

Case 3: To obtain the completely horizontally transmitted force in pushrod. The pushrod should be attached to the mounting strip making some angle (as shown in Figure), such that when mounting moves in circular arc the force completely transmitted to pushrod.

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