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Disc brake system and method for braking a vehicle

Abstract

A disc brake system includes a first brake pad having a first type of friction material, a second brake pad having a second type of friction material different from the first type of friction material, and a poshrod arrangement configured to apply force in varying amounts on both the first brake pad and the second brake pad, the poshrod arrangement comprising an actuator movable to different, positions relative to the first brake pad and the second brake pad to vary a percentage of total braking force applied by the first brake pad and the second brake pad. A method for braking a vehicle is also provided.

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Background/Summary

BACKGROUND AND SUMMARY

(1) The present invention relates to a disc brake system and method for braking a vehicle and, more particularly, to such a system and method wherein a brake pad of the system comprises a first brake pad having a first type of friction material and a second brake pad having a second type of friction material different from the first type of friction material.

(2) Over the years, vehicles, particularly commercial vehicles, have been designed to transport heavier loads than they did in the past. Further, with improvements in active and passive safety measures and equipment, average vehicle speed limit has also tended to increase. Such developments have pushed vehicle brake design to the edge of engineering in order to meet the braking requirements at higher speeds and higher loads. Additionally, strict copper content laws have presented enormous challenges to brake designers.

(3) Brake designers are presented with the challenge to provide optimal or at least acceptable friction under a range of operating temperature and wheel velocities while also minimizing brake wear and meeting legal requirements. It is difficult to provide brake pads that work well under all operating conditions.

(4) It is therefore desirable to provide a disc brake system and method for braking a vehicle that can work well under a range of operating conditions without excessively compromising brake life.

(5) In accordance with an aspect of the present invention, a disc brake system comprises a first brake pad having a first type of friction material, a second brake pad having a second type of friction material different from the first type of friction material, and a pushrod arrangement configured to apply force in varying amounts on both the first brake pad and the second brake pad, the pushrod arrangement comprising an actuator movable to different positions relative to the first brake pad and the second brake pad to vary a percentage of total braking force applied by the first brake pad and the second brake pad.

(6) In accordance with another aspect of the present invention, a method is provided for braking a vehicle having a disc brake system, the disc brake system comprising a first brake pad having a first type of friction material, a second brake pad having a second type of friction material different from the first type of friction material, and a pushrod arrangement configured to apply force in varying amounts on both the first brake pad and the second brake pad. The method comprises moving an actuator of the pushrod arrangement to different positions relative to the first brake pad and the second brake pad to vary a percentage of total braking force applied by the first brake pad and the second brake pad.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The features and advantages of the present invention are well understood by reading the following detailed description in conjunction with the drawings in which like numerals indicate similar elements and in which:

(2) FIGS. **1**A-IC show a disc brake system according to a first aspect of the present invention showing an actuator of a pushrod arrangement in different positions; and

(3) FIG. **2** shows a disc brake system according to a second aspect of the present invention including multiple pushrod arrangements.

DETAILED DESCRIPTION

(4) FIGS. **1**A-**1**C show a disc brake system **21** for a vehicle **23** (shown schematically in phantom in FIG. **1**A). The disc brake system **21** comprises a first brake pad **25** having a first type of friction material and a second brake pad **27** having a second type of friction material different from the first type of friction material. For example, the first brake pad **25** may have a different performance curve (friction utilized) than the second brake pad **27**, where the performance curve depends on

various factors such as fade point, slip (relative velocity), temperature, compressibility, etc. The first brake pad **25** might, for example, perform well at low temperatures while the second brake pad **27** might perform well at high temperatures. Similarly, the first brake pad **25** might perform better at low velocity than high velocity, and the second brake pad **27** might perform better at high velocity than low velocity.

(5) The first brake pad **25** and the second brake pad **27** brake the vehicle by being forced against a rotor **29** connected to a wheel of the vehicle. The disc brake system **21** further comprises a pushrod arrangement **31** configured to apply force in varying amounts on both the first brake pad **25** and the second brake pad **27**. The pushrod arrangement **31** comprises an actuator **33** movable to different positions relative to the first brake pad **25** and the second brake pad **27** to vary a percentage of total braking force applied by the first brake pad and the second brake pad. The actuator **33** will ordinarily be in the form of a pneumatic piston and cylinder arrangement (piston of actuator shown only) connected via pneumatic lines (not shown) in a conventional manner to a source of pressurized air (not shown), with a valve (not shown) that is opened and closed by operation of a brake pedal (not shown). The actuator **33** will ordinarily but not necessarily be movable relative to the first brake pad **25** and the second brake pad **27** in a direction that is perpendicular to a direction in which the actuator applies force to the first brake pad and the second brake pad.

(6) The illustrated embodiment of the pushrod arrangement **31** comprises a bias bar **35** along which the actuator **33** is movable relative to the first brake pad **25** and the second brake pad **27**. The pushrod arrangement **31** further comprises a first pushrod **37** connected at a first end **39** of the first pushrod to the bias bar **35** and a second end **41** of the first pushrod disposed proximate the first brake pad **25**, and a second pushrod **43** connected at a first end **45** of the second pushrod to the bias bar and a second end **47** of the second pushrod disposed proximate the second brake pad **27**. The pushrod arrangement **31** ordinarily also comprises a beam **49**, which may be in the form of, e.g., a rigid plate or rod, having a first surface **51** to which the second end **41** of the first pushrod **37** and the second end **47** of the second pushrod **43** are attached and an opposite second **53** surface to which the first brake pad **25** and the second brake pad **27** are attached.

(7) As illustrated, the bias bar **35** is in the form of a threaded rod that mates with internal threads on the first pushrod **37** and the second pushrod **43** and that is rotated by a drive **55**, such as an electric motor. Starting from a central position as shown in FIG. **1**A in which a force F applied by the actuator **33** is evenly distributed with one half of the force (F/2) to the first pushrod **37** and one half of the force to the second pushrod **43**, rotation of the bias bar **35** in one direction will cause the actuator **33** to move toward the first pushrod and away from the second pushrod as seen in FIG. **1**B so that a larger portion F′ of a force F applied by the actuator is distributed to the first pushrod than the portion F″ distributed to the second pushrod. Rotation of the bias bar **35** in an opposite direction will cause the actuator **33** to move away from the first pushrod **37** and toward the second pushrod **43** as seen in FIG. **1**C so that a larger portion F′ of a force F applied by the actuator is distributed to the second pushrod than the portion F″ distributed to the first pushrod. Ordinarily at least some component of the force F applied by the actuator **33** is distributed to each of the first pushrod **37** and the second pushrod **43**, however, if desired, the pushrod arrangement **31** can be constructed to permit all or substantially all of the force applied by the actuator to be applied to one or the other of the first pushrod or the second pushrod, such as by causing the direction of force applied by the actuator to be aligned with the longitudinal axis of the one of the first pushrod or the second pushrod.

(8) The disc brake system **21** can comprise a controller **57** configured to adjust a position of the actuator **33** to alter braking characteristics of the disc brake system at least in response to braking demand, such as by controlling operation of the drive. For example, when there is low braking demand, it may be desirable to position the actuator **33** relative to one of the first brake pad **25** and the second brake pad **27** so that the temperature of the rotor **29** and the one of the brake pads is optimized instead of optimizing brake performance. When there is high brake demand, by contrast,

it may be desirable to position the actuator **33** relative to one of the first brake pad **25** and the second brake pad **27** so that brake performance is optimized.

(9) The disc brake system **21** can further comprise one or more sensors **59** that can sense factors that can affect braking, and send one or more signals to the controller **57** to control the drive and position the actuator **33** in response to the signals. For example, a sensor **59** can sense brake pad and/or rotor temperatures and/or environmental temperature and send a signal to the controller **57** which, in turn, can be configured to control the drive **55** to adjust a position of the actuator **33** to alter braking characteristics of the disc brake system in response to the temperature signals. Another sensor **59** may sense velocity of the vehicle **23** of which the disc brake system **21** is a part and send a signal to the controller **57** which can be configured to control the drive **55** to adjust a position of the actuator **33** to alter braking characteristics of the disc brake system at least in response to the velocity of the vehicle, such as to optimize brake performance at high velocity and to optimize characteristics affecting brake life at low velocity. A sensor **59** can sense brake pressure in the brake system's pneumatic lines (not shown), although pressure applied by the actuator **33** may also or alternatively be sensed, which may reflect braking demand, and send a signal to the controller **57** which can be configured to adjust the position of the actuator to alter braking characteristics of the disc brake system at least in response to the signal, such as to optimize brake performance at high pressure/high brake demand and optimize other characteristics such as brake longevity at low pressure/low brake demand. It is presently contemplated that the most important inputs from sensors to the controller **57** to determine where to position the actuator **33** along the bias bar **35** will be, in order, brake pressure, brake temperature, and sliding velocity of the brake pads **25** and **27** relative to the rotor **29**, which is directly related to vehicle velocity. It is further presently contemplated that the controller **57** will ordinarily position the actuator **33** along the bias bar **35** in response to such sensed inputs to optimize brake wear and braking force.

(10) Sensors **59** can be provided to provide signals to the controller **57** relating to a variety of different factors, such as braking demand, pneumatic pressure in a piston and cylinder portion of the pushrod arrangement, brake pad and disc temperature, brake pad wear level, wheel load, velocity of a vehicle of which the disc brake system is a part, and a total force applied by the actuator. The controller **57**, in turn, can be configured to control the drive **55** to adjust a position of the actuator **33** to alter braking characteristics of the disc brake system **21** in response to one or two or more of those factors, i.e. braking demand, pneumatic pressure in a piston and cylinder portion of the pushrod arrangement, brake pad and disc temperature, brake pad wear level, wheel load, velocity of a vehicle of which the disc brake system is a part, and a total force applied by the actuator. The controller **57** may further be configured to adjust a position of the actuator **33** to alter braking characteristics of the disc brake system **21** to optimize at least one of braking performance, brake wear, brake stress, and brake component thermal loading.

(11) As seen in FIG. **1**A, the disc brake system **21** may further include a third brake pad **25′** and a fourth brake pad **27′** on the opposite side of the rotor **29** from the first brake pad **25** and the second brake pad **27** as might be particularly useful in a floating caliper form of brake. Ordinarily, but not necessarily, the third brake pad **25′** will be of the same type as the first brake pad **25** and the fourth brake pad **27′** will be of the same type as the second brake pad **27**. For example, the third brake pad **25′** may have the first type of friction material that is also on the first brake pad **25** and be disposed opposite the first brake pad and the fourth brake pad **27′** may have the second type of friction material that is also on the second brake pad **27** and be disposed opposite the second brake pad.

(12) As seen in FIG. **2**, a disc brake system **121** can comprise the features of the disc brake system **21** shown in FIGS. **1**A-IC, such as a first brake pad **125** and a second brake pad **127**, and a rotor **129**. The description of the structure and functioning of the features of the disc brake system **121** that are the same as or analogous to the features of the disc brake system **21** is substantially the same for purposes of discussion here, and is not repeated for the sake of brevity.

(13) In addition to the surface **129***a* against which the first brake pad **125** and the second brake pad

127 are urged by the first pushrod arrangement **131**, the rotor **129** has a second surface **129***b* against which at least one additional brake pad is adapted to be urged. The at least one additional brake pad comprises a third brake pad **161** and a fourth brake pad **163**.
(14) Ordinarily, but not necessarily, the third brake pad **161** will be of the same type as the first brake pad **125** and the fourth brake pad **163** will be of the same type as the second brake pad **127**. For example, the third brake pad **161** may have the first type of friction material that is also on the first brake pad **125** and be disposed opposite the first brake pad and the fourth brake pad **163** may have the second type of friction material that is also on the second brake pad **127** and be disposed opposite the second brake pad.
(15) An illustrative second pushrod arrangement **165** can be configured to apply force on both the third brake pad **161** and the fourth brake pad **163** in substantially the same manner that the first pushrod **131** applies force. In the illustrated embodiment, the drive **167** for the second pushrod arrangement **165** will move the second actuator **169** of the second pushrod arrangement along a bias bar **171** to parallel the movement of the actuator **133** for the first pushrod arrangement **131**. The drive **167** can be controlled by a controller **157** in substantially the same way that the drive **155** is controlled by the controller. The second pushrod arrangement **165** may be particularly useful in brake systems that use a fixed caliper.
(16) In the present application, the use of terms such as “including” is open-ended and is intended to have the same meaning as terms such as “comprising” and not preclude the presence of other structure, material, or acts. Similarly, though the use of terms such as “can” or “may” is intended to be open-ended and to reflect that structure, material, or acts are not necessary, the failure to use such terms is not intended to reflect that structure, material, or acts are essential. To the extent that structure, material, or acts are presently considered to be essential, they are identified as such.
(17) While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

Claims

1. A disc brake system, comprising: a first brake pad having a first type of friction material; a second brake pad having a second type of friction material different from the first type of friction material; and a pushrod arrangement configured to apply force in varying amounts on both the first brake pad and the second brake pad, the pushrod arrangement comprising an actuator movable to different positions relative to the first brake pad and the second brake pad to vary a percentage of total braking force applied by the first brake pad and the second brake pad.
2. The disc brake system as set forth in claim 1, wherein the pushrod arrangement comprises a bias bar along which the actuator is movable relative to the first brake pad and the second brake pad.
3. The disc brake system as set forth in claim 2, wherein the pushrod arrangement comprises a first pushrod connected at a first end of the first pushrod to the bias bar and a second end of the first pushrod disposed proximate the first brake pad, and a second pushrod connected at a first end of the second pushrod to the bias bar and a second end of the second pushrod disposed proximate the second brake pad.
4. The disc brake system as set forth in claim 3, wherein the pushrod arrangement comprises a beam having a first surface to which the second end of the first pushrod and the second end of the second pushrod are attached and an opposite second surface to which the first brake pad and the second brake pad are attached.
5. The disc brake system as set forth in claim 1, further comprising a controller configured to adjust a position of the actuator to alter braking characteristics of the disc brake system at least in response to braking demand.
6. The disc brake system as set forth in claim 1, further comprising a controller configured to adjust

a position of the actuator to alter braking characteristics of the disc brake system at least in response to temperature.
7. The disc brake system as set forth in claim 1, further comprising a controller configured to adjust a position of the actuator to alter braking characteristics of the disc brake system at least in response to velocity of a vehicle of which the disc brake system is a part.
8. The disc brake system as set forth in claim 1, further comprising a controller configured to adjust a position of the actuator to alter braking characteristics of the disc brake system at least in response to a total force applied by the actuator.
9. The disc brake system as set forth in claim 1, further comprising a controller configured to adjust a position of the actuator to alter braking characteristics of the disc brake system at least in response to two or more of braking demand, pneumatic pressure in a piston and cylinder portion of the pushrod arrangement, brake pad and disc temperature, brake pad wear level, wheel load, velocity of a vehicle of which the disc brake system is a part, and a total force applied by the actuator.
10. The disc brake system as set forth in claim 9, wherein the controller is further configured to adjust a position of the actuator to alter braking characteristics of the disc brake system to optimize at least one of braking performance, brake wear, brake stress, and brake component thermal loading.
11. The disc brake system a set forth in claim 1, further comprising a controller configured to adjust a position of the actuator to alter braking characteristics of the disc brake system to optimize at least one of braking performance, brake wear, brake stress, and brake component thermal loading.
12. The disc brake system as set forth in claim 1, comprising a rotor having a first surface against which the first brake pad and the second brake pad are adapted to be urged by the pushrod arrangement.
13. The disc brake system as set forth in claim 1, comprising a rotor having a second surface against which at least one additional brake pad is adapted to be urged.
14. The disc brake system as set forth in claim 13, wherein the at least one additional brake pad comprises a third brake pad and a fourth brake pad.
15. The disk brake system as set forth in claim 14, comprising a second pushrod arrangement configured to apply force on both the third brake pad and the fourth brake pad.
16. The disc brake system as set forth in claim 14, wherein the third brake pad has the first type of friction material and is disposed opposite the first brake pad and the fourth brake pad has the second type of friction material and is disposed opposite the second brake pad.
17. The disk brake system as set forth in claim 16, comprising a second pushrod arrangement configured to apply force in varying amounts on both the third brake pad and the fourth brake pad, the second pushrod arrangement comprising a second actuator movable to different positions relative to the third brake pad and the fourth brake pod.
18. A method for braking a vehicle having a disc brake system, the disc brake system comprising a first brake pad having a first type of friction material, a second brake pad having a second type of friction material different from the first type of friction material, and a pushrod arrangement configured to apply force in varying amounts on both the first brake pad and the second brake pad, comprising: moving an actuator of the pushrod arrangement to different positions relative to the first brake pad and the second brake pad to vary a percentage of total braking force applied by the first brake pad and the second brake pad.