Accordingly, one aspect of such an alternative technology involves a brake system for a passenger transportation system. The brake system includes a brake lining and a brake surface, wherein a gap exists between the brake lining and the brake surface when the brake system is in an open position. The brake system includes also an optical monitoring system and a processor. The optical monitoring system has a light source arranged to emit light towards at least one of the gap and the brake lining, and a light detector arranged in a light path of the light emitted by the light source. The light source and the light detector are arranged on opposite sides of the gap and the light path extends through the gap, wherein the brake lining blocks the light path in a closed position of the brake system. The light detector generates an electrical signal as a function of impinging light. The processor is coupled to the optical monitoring system to receive the electrical signal and to generate a predetermined indication if the signal indicates a value that is equal to or greater than a predetermined threshold value Vmax.

Another aspect of the alternative technology involves a method of monitoring a brake system of a passenger transportation system. The brake system includes a brake lining, and a brake surface, wherein a gap exists between the brake lining and the brake surface when the brake system is in an open position. According to that method, a light source of an optical monitoring system is activated to emit light towards at least one of the gap and the brake lining. An electrical signal is generated by a light detector arranged in a light path of the light emitted by the light source and belonging to the optical monitoring system, wherein the electrical signal is generated as a function of impinging light. The light source and the light detector are arranged on opposite sides of the gap and the light path extends through the gap, wherein the brake lining blocks the light path in a closed position of the brake system. A predetermined indication is generated by a processor if the electrical signal indicates a value that is equal to or greater than a predetermined threshold value Vmax.

The technology provides an optoelectronic monitoring method that avoids moving parts. Once installed and adjusted the optical monitoring system can be used for various monitoring procedures, for example, for continuous monitoring or monitoring according to a predetermined schedule or event. The processing of signals can be performed locally within the brake system or within a controller of the passenger transportation system. These aspects allow flexibility regarding how to implement the brake monitoring without having a service technician to inspect the brake system on-site.

The technology not only provides for flexibility, but also for a high degree of safety. In one embodiment, operation of the passenger transportation system may be stopped in response to the processor generating the indication. As described herein, such an indication may indicate a worn brake lining. In another embodiment, a service request message may be generated in response to generating the indication. It is contemplated that a service request message may be generated in response to stopping of the passenger transportation system.

The technology allows also flexibility regarding the optical monitoring system, for example, to adapt to specific space limitations. That is, the monitoring system may use direct light. In one embodiment, light passes through the gap to impinge (directly) on the light detector, wherein the light source and the light detector are located on opposite sides of the gap.

In yet another embodiment, the brake lining has an edge region at a front (wear) side of the brake lining that acts upon the brake surface, wherein the source and the light detector are arranged in proximity of the edge region. The light source emits light towards the edge region that reflects the light towards the light detector. The light detector generates the electrical signal as a function of the reflected light. As the brake lining wears with use, the area of the reflective surface on the edge region of the lining will reduce, which will in turn reduce the reflected light from the edge surface. This embodiment is an alternative to passing light through the gap which in certain passenger transportation systems might be impractical. Yet, this embodiment provides for the advantages of the optoelectronic monitoring.

In certain embodiments, the edge region includes one of a polished surface and a surface with applied reflective material. The surface of the edge region may be configured to have a gradient reflective surface.

Light used in a brake application may be subject to interferences and inaccuracies caused by ambient light, dust or particles in the path between the light source and the light detector. To minimize these effects, various modulation techniques may be used. In one embodiment, the processor generates a drive signal having a predetermined frequency to drive the light source to emit light that is modulated according to the predetermined frequency. The processor further operates the light detector to detect light according to the predetermined frequency.

The technology described herein may not only be used for monitoring the wear of brake linings, but may further be used to provide input signals to the brake controller. In one embodiment, the electrical signal is determined when the brake system is in a fully closed position. That electrical signal is then used to control supply of electrical power to a drive.

In another embodiment, the brake system can be set to indicate a partially open position. In that position, the electrical signal can be determined and used to coordinate buildup of motor torque.

The skilled person will appreciate that the technology is not limited to a particular type of brake system. The technology can in particular be used in a drum brake, where the brake surface is a lateral

Claims

1. A brake system (15) for a passenger transportation system (1), comprising:

a brake lining (20, 21);

a brake surface (22a, 22b), wherein a gap (39) exists between the brake lining (20, 21) and the brake surface (22a, 22b) when the brake system (15) is in an open position;

an optical monitoring system (40) having a light source (41) arranged to emit light towards at least one of the gap (39) and the brake lining (20, 21), and having a light detector (42) arranged in a light path of the light emitted by the light source (41), the light detector (42) generating an electrical signal as a function of impinging light, wherein the light source (41) and the light detector (42) are arranged on opposite sides of the gap (39) and the light path extends through the gap (39), wherein the brake lining (20, 21) blocks the light path in a closed position of the brake system (15); and

a processor (43) coupled to the optical monitoring system (40) to receive the electrical signal and to generate a predetermined indication if the signal indicates a value that is equal to or greater than a predetermined threshold value (Vmax).

2. The system of Claim 1, wherein the brake lining has an edge region (55) at a front side of the brake lining (20, 21) that acts upon the brake surface (22a, 22b), wherein the source (41) and the light detector (42) are arranged in proximity of the edge region (55), wherein the light source (41) emits light towards the edge region (55) that reflects the light towards the light detector (42), and wherein the light detector (42) generates the electrical signal as a function of the reflected light.

3. The system of Claim 2, wherein the edge region (55) includes one of a polished surface and a surface with applied reflective material.

4. The system of Claim 2 or 3, wherein the surface of the edge region (55) a gradient reflective surface.

5. The system of any preceding claim, wherein the processor (43) generates a drive signal having a predetermined frequency to drive the light source (41) to emit light that is modulated according to the predetermined frequency, and wherein the processor (43) operates the light detector (42) to detect light according to the predetermined frequency.

6. The system of any preceding claim, wherein the brake surface (22a, 22b) is one of a lateral surface of a cylinder-shaped brake disk (22), and a cap surface of the cylinder-shaped brake disk (22).

7. A method of monitoring a brake system (15) of a passenger transportation system (1), wherein the brake system (15) includes a brake lining (20, 21), and a brake surface (22a, 22b), wherein a gap (39) exists between the brake lining (20, 21) and the brake surface (22a, 22b) when the brake system (15) is in an open position, comprising:

activating a light source (41) of an optical monitoring system (40) to emit light towards at least one of the gap (39) and the brake lining (20, 21);

generating by a light detector (42) arranged in a light path of the light emitted by the light source (41) and belonging to the optical monitoring system (40) an electrical signal as a function of impinging light, wherein the light source (41) and the light detector (42) are arranged on opposite sides of the gap (39) and the light path extends through the gap (39), wherein the brake lining (20, 21) blocks the light path in a closed position of the brake system (15); and

generating by a processor (43) a predetermined indication if the electrical signal indicates a value that is equal to or greater than a predetermined threshold value (Vmax).

8. The method of Claim 7, further comprising generating by the processor (43) a drive signal having a predetermined frequency to drive the light source (41) to emit light that is modulated according to the predetermined frequency, and operating the light detector (42) to detect light according to the predetermined frequency.

9. The method of one of Claims 7 or 8, further comprising stopping operation of the passenger transportation system (1) in response to generating the indication.

10. The method of one of Claims 7 - 9, further comprising generating a service request message in response to generating the indication.

11. The method of one of Claims 7 – 10, further comprising determining the electrical signal when the brake system (15) is in a fully closed position, and using the electrical signal to control supply of electrical power to a drive (9).

12. The method of Claim 11, further comprising setting the brake system (15) to a partially open position, determining the electrical signal at the partially open position and using the electrical signal to coordinate buildup of motor torque.