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Review

Analysis of separation test for automatic brake adjuster based on linear radon transformation

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ABSTRACT

The linear Radon transformation is applied to extract inflection points for online test system under the noise conditions. The linear Radon transformation has a strong ability of anti-noise and anti-interference by fitting the online test curve in several parts, which makes it easy to handle consecutive inflection points. We applied the linear Radon transformation to the separation test system to solve the separating clearance of automatic brake adjuster. The experimental results show that the feature point extraction error of the gradient maximum optimal method is approximately equal to ± 0.100, while the feature point extraction error of linear Radon transformation method can reach to ± 0.010, which has a lower error than the former one. In addition, the linear Radon transformation is robust.

Contents

1. Introduction

The automatic brake adjuster of vehicles is widely used in heavy trucks; it is one of the important components in the braking system to ensure the vehicle is working safely and is reliable. The automatic brake adjuster can recover and offset the braking clearance when the brake pad is worn out. For this reason, the automatic brake adjuster can guarantee the brake system against failure such as the insufficient braking force braking sideslip, etc.

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The performance of one-way clutch of automatic brake adjuster can directly judge whether the function of self-regulation is available or not. Since the separating clearance of the automatic brake adjuster can reflect the performance of one-way clutch, whether the function of self-regulation is available or not can be estimated by testing the separating clearance. The test results, in turn, are the important data for product inspectors to evaluate the performance of the automatic brake adjuster.

Extracting the separating clearance from the test curve is significant and difficult for the online test system of an automatic brake adjuster. Ideally, the force/displacement test curve consists of three sections of line with different slope (not including $y=0$). Due to the influence of interference signal, in fact, the test results are usually shown as three sections of curve with low frequency noise rather than straight lines separated clearly by separating points. Theoretically, the traditional method to extract the inflection points of online test curve that is commonly used in industry areas is the gradient maximum optimal method by solving its maximum gradient. But this method is usually affected by the smoothness of the curve and it is hard to handle consecutive inflection points; it can increase the feature point extraction error of the online test curve with noise [1–6]. The linear Radon transformation has a strong ability of anti-noise and anti-interference by fitting the online test curves to the lines with three different slopes [7–11]. After that we can get the separating clearance by calculate the distance between the two inflection points.

2. Working principle of automatic brake adjuster

The control arm of automatic brake adjuster is fixed on the axle. The motion arm is installed on the braking cylinder to transfer braking force. The worm gear is connected to the S-shaped cam through a gear shaft, forming a closed-loop system. In this closed-loop system, the automatic brake adjuster can transfer braking force to S-shaped cam and recognize the increased braking clearance. Thanks to the complex mechanical structure of automatic brake adjuster, once the brake pad happens to worn in the braking process, the automatic brake adjuster can offset the brake clearance to the standard level automatically when braking release [12–14]. Fig. 1 shows the structure of the automatic brake adjuster.

An appropriate separating clearance is the key reference to the improvement of the structure of an automatic brake adjuster, because it directly determines whether the function of self-regulation is available or not. One-way clutch, consisting of Parts 1–3 in Fig. 1, is the one main component to achieve self-regulating function. Separating clearance is the motion distance from one side of the worm to the shaft sleeve of the body. It reflects the bevel gear's meshing situation of one-way clutch. When the separating clearance goes smaller, the one-way clutch and the worm gear will be slip, and it will lead to the function failure with the self-regulating value decrease. On the contrary, it would increase the manual adjust torque when the separating clearance goes larger, which goes against the actual operation.

3. Calculation of separating clearance by linear radon transformation

We can get the image projection of $f(x,y)$ on path direction of line L by solving the binary function $f(x,y)$ with linear Radon transformation. Such an algorithm can extract inflection points of piecewise function.

Let us assume line L as $y=px+\tau$; like Fig. 2 shows, the linear Radon transformation for $f(x,y)$ along the path L can be defined as below[15–17]:

$$R_f(\tau,p)=R[f(x,y)]=\int_L f(x,y)d_s=\int_{-\infty}^{+\infty} f(x,px+\tau)\sqrt{1+p^2}d_x \tag{1}$$

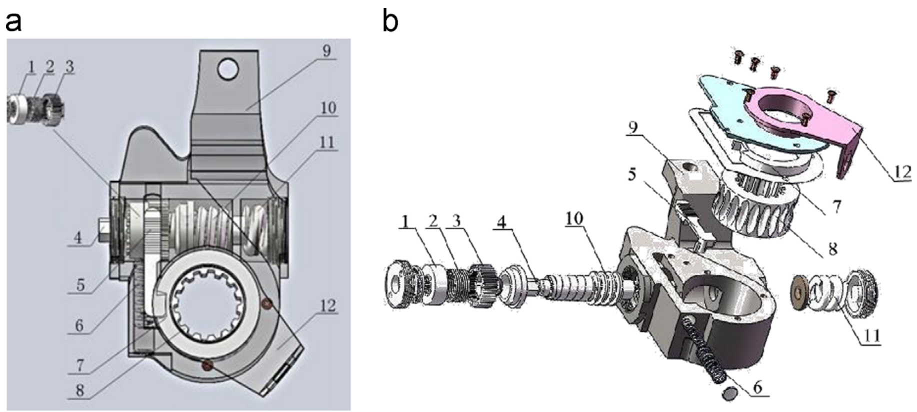

Fig. 1. The structure of automatic brake adjuster: (1) The clutch thrust ring, (2) rectangle spring, (3) the pinion, (4) the worm party head, (5) the gear rack, (6) the combined spring, (7) the control ring with a gap, (8) the worm gear, (9) the motion arm, (10) the worm, (11) the compression spring, and (12) the control arm. (a) Perspective view and (b) Explosive view.