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Research on Automatic Identification Method of Train Speed Based on Ground Test Data

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ABSTRACT: In order to ensure the safety and reliability of high-speed railway train operation, a large number of orbit dynamic tests have been carried out and the dynamic response analysis of the test results has been carried out. Among them, the train speed is an important parameter in the dynamic response analysis of high-speed railway, but the speed of the existing train is mainly artificial, inefficient and labor-intensive. Based on the MATLAB program, this paper uses the Fourier transform correlation theory, combined with the model size, according to the original input test data automatically calculate the train speed. The results show that the method of automatic identification of train speed based on ground test data is reliable.
Keywords: dynamic response, fast Fourier, vehicle speed, automatic recognition

I. INTRODUCTION

China began to study high-speed railway technology from the 1990s, after 20 years of efforts, China's railway line passenger and cargo transport density, strength has been located in the world. Literature shows that with the high-speed railway train speed, the wheel between the action force increases. Excessive action force not only exacerbates the fatigue damage of the moving parts, but also increases the random irregularity of the track, endangering the stability of the track structure. Therefore, the speed of high-speed railway train is an important parameter to evaluate the force of wheel-rail interaction.

In the actual power test, the power test to test at different times, test sites, test sites for multiple trips test, so the power test tends to get a lot of test results. In order to get the train running speed of each trip, the traditional method is to manually select the peak directly on the waveform, and calculate the train speed through the time difference between the peak and the size of the vehicle. This method is slow and efficient Low, and labor-intensive, if you need to deal with massive amounts of data this approach seems powerless. In this paper, a calculating method of train speed is established. Using the Fourier transform correlation theory, the mathematic software MATLAB is used to process the data. The original data can be directly calculated to calculate the running speed of the train. effectiveness.

II. HIGH-SPEED RAILWAY GROUND TEST DATA CHARACTERISTICS

Train vibration is mainly affected by thevehicle and the track together. For the vehicle, it is mainly due to wheel abrasions, track joints and geometric irregularities caused by the state. Vertical vibration is mainly caused by the track irregularities; high and low irregularity is the track along the length of the rail in the vertical rugged. It is caused by the elevation deviation of the line construction and overhaul work, the deflection of the bridge, the uneven settlement of the track bed and the roadbed, the unequal gap between the parts of the track, the existence of the dark pit, the hanging board and the vertical elasticity inconsistency of the track of. In the vertical longitudinal plane of the wheel-rail system, there are a variety of vibration sources. The unevenness of the existing track surface, but also the system of the cyclical irregularities, especially in the rail joints, like the low joints, teeth joints, large rail joints, more universal. In addition, under the rail foundation may also exist, such as empty hanging board or track bed compaction and other defects, the formation of uneven dynamic uneven dynamic. Dynamic test of the rail test vertical displacement waveform shown in Figure 1.

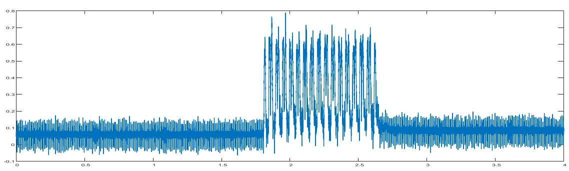

Fig.1 Vertical displacement waveform of rail

Since only the steel wheels are in contact with the rail during the course of the train, the vertical displacement or acceleration measured at the fixed rail joints is a significant fluctuation only for a short period of time when the wheels are in contact with them. And these fluctuations certainly with the train wheelbase, car length and other dimensions are closely related. When the rail and the measuring point is in contact, will have the greatest fluctuations in the acquisition of the time domain signal is shown in the peak. Since a bogie has two pairs of wheelsets, there are two adjacent peaks. This feature is particularly evident in the displacement waveforms, where the acceleration signal needs to be processed accordingly. For the processing of large quantities of data, due to the different measurement environment, resulting in the measured peak data loss, ups and downs suddenly large and small, clutter interference and other circumstances, the error will be different. It is difficult to find a common data processing method to find out all the measured data through the speed. In order to deal with this situation, first of all data in the frequency domain conversion and then filter out the clutter. The measured signal will be affected by the temperature, wind direction, equipment itself, the presence of clutter, resulting in the signal characteristics are very obvious, so here the data fast Fourier transform and then filter processing.

III. STUDY ON THE PROCESSING METHOD OF GROUND TEST DATA

3.1 Fast Fourier Transform

In the actual signal will have many clutter, the original signal of the peak is not easy to get, for this need to filter the data collected to get the data we need. Document 4 shows that the processing of test data need to be Fourier transform, the so-called Fourier transform has the following integral definition:

$$F(\Omega) = \mathrm{F}[f(t)] = \int_{-\infty}^{\infty} f(t)e^{-j\Omega t}dt \quad (3\text{-}1)$$

$$f(t) = \mathrm{F}^{-1}[F(\Omega)] = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\Omega)e^{j\Omega t}d\Omega \quad (3\text{-}2)$$

Usually called (3-1) is the Fourier transform formula, (3-2) is the inverse Fourier transform formula. Where Ω is the angular frequency, it has the following relationship with the actual frequency: $\Omega = 2\pi f$, so the Fourier transform can also be written as:

$$F(f) = \mathrm{F}[f(t)] = \int_{-\infty}^{\infty} f(t)e^{-j2\pi ft}dt \quad (3\text{-}3) \qquad f(t) = \mathrm{F}^{-1}[F(f)] = \int_{-\infty}^{\infty} F(f)e^{j2\pi t}df \quad (3\text{-}4)$$

$F(\Omega)$ Usually a complex function, can be written as:

$$F(\Omega) = \left|F(\Omega)\right|e^{j\varphi(\Omega)} \quad (3\text{-}5)$$

$\left|F(\Omega)\right|$ is the amplitude function of $F(\Omega)$, which represents the relative size of the spectral density at each frequency in the signal; $\varphi(\Omega)$ is the phase function of $F(\Omega)$, which represents the phase relationship of the frequency components in the signal. In engineering technology, $\left|F(\Omega)\right|$ is usually called the amplitude spectrum, $\varphi(\Omega)$ is the phase spectrum, they are continuous function of frequency Ω.

The signal can be Fourier-transformed by the formula (3-1) or (3-3). However, (3-6) represents only a sufficient condition for the Fourier transform of the signal function and is not a necessary condition. After the introduction of the generalized function, some do not meet the (3-6) signal function can also be Fourier transform. Filtering contrast before and after the following chart:

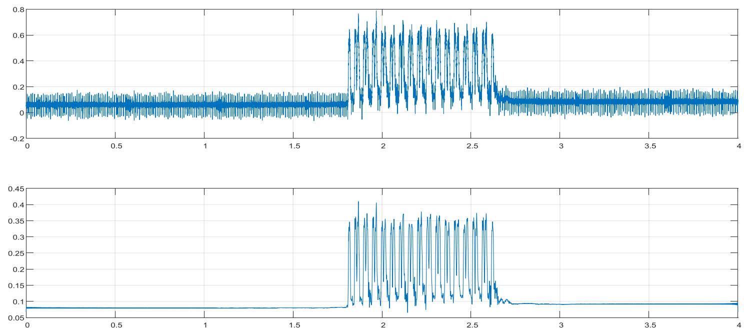

Figure 2 before and after filtering comparison

It can be seen that the peak value after filtering is more obvious than before, facilitating subsequent processing.

3.2 Peak screening

Since only the steel wheels are in contact with the rail during the course of the train, the vertical displacement or acceleration measured at the fixed rail joints will only fluctuate significantly during the time when the wheels are in contact with them. And these fluctuations certainly with the train wheelbase, car length and other dimensions are closely related. When the rail and the measuring point is in contact, in the acquisition of time-domain signal is shown in the peak.

The above is the ideal state, the actual situation of the peak is not so obvious, the need for screening. In the processed signal, use MATLAB to find all the peaks of the undulating apparent segment, which has many invalid data points due to random errors. Using two principles to filter. One peak is greater than a certain threshold will be hired; we need to get the peak is the car through a range of maximum value, due to other causes of random wave peak is less than the maximum value, set a critical Value can effectively filter these error points. Second, the abscissa of the two adjacent wave crests must be greater than a certain set range, the train may run more than in the wheel rail contact generated peak value, in other places due to track rail wear and other reasons may also have a peak, Setting the range of the adjacent peak difference can effectively avoid the input of the peak value.

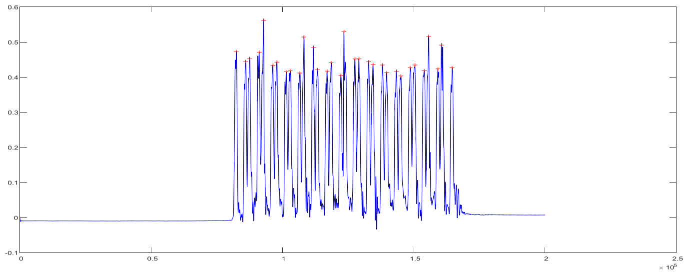

Fig.3 The original data of rail displacement

The figure is the scene of the rail displacement data acquisition, blue mark for the peak. It is clear that a peak near the peak is accompanied by another high or low another peak, it is clear that this is a pair of bogies on wheels results. This is consistent with the structure of the train. The two pairs of wheelsets in one compartment are spaced apart and the adjacent wheelsets of adjacent cars are significantly smaller than this distance, resulting in the above-mentioned gap in Fig.

3.3 Train speed calculation

The collected data can be combined with the vehicle size to obtain the corresponding speed. For the acceleration signals with obvious peaks, we neglect the adjacent wheelsets of the same bogie, mainly to find the peak signal between the different bogies to reduce the accuracy of the data requirements. Known bogie center distance of 17500 mm, two adjacent compartment between the bogie center distance of 7500mm.

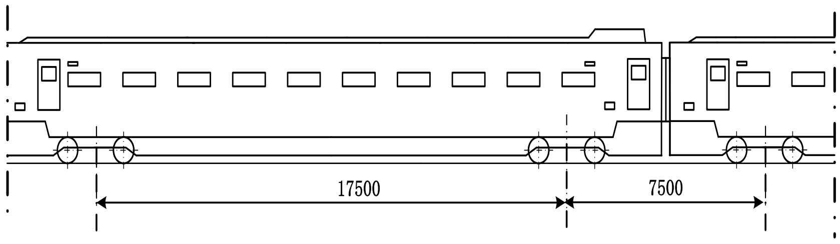

Fig.4 Steel wheel position diagram of train bogie

You can get the size chart shown in Figure 4, can be seen in contact with the steel wheel rail time point is a specific size value of the decision. Followed by the law is s1 = 17500, s2 = 7500; and then turn down. Of course, different car sizes different body size will have different parameters are calculated. Therefore, we find these peaks corresponding to the value of the abscissa to find the corresponding difference, combined with the sampling frequency fs, can get the train through the distance of these time. As a result of the passage of time is shorter, the train speed is faster, traveling as a uniform speed, you can get the train speed. And finally get n0 group speed value, obtained by the average traveling speed of the train.

From the initial data to draw the original image, after filtering, using MATLAB to find the image peak, the end is to find the abscissa corresponding to the peak (the time axis). After processing the peak time difference of each node, from these 31 points can be obtained at least 31 speed values. To make the results more accurate, remove the two largest values and the smallest two values, the rest of the speed of the node map:

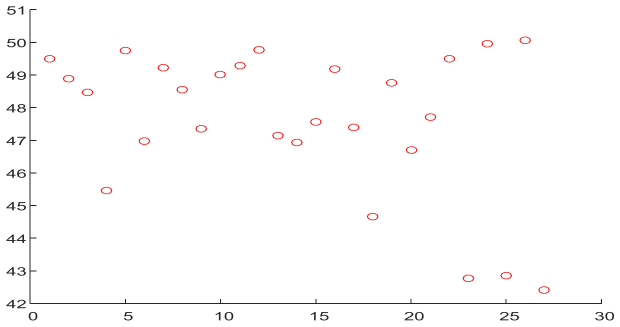

Fig.5 Node diagram of train peak speed processing

Reference 5 shows that the sum of squares of the differences between the arithmetic mean and the number is the smallest, where the arithmetic mean is used as the final result. Get the final relative gap between the 27 speed values, obtained the average value is the final train average speed.

And finally get the train running speed of 171km/h. Combined with the collection point in the Shanghai-Hangzhou high-speed rail line Jiaxing section of high-speed rail line limit speed of 200km/h, the speed value in the normal permitted range.

IV. APPLICATION OF GROUND TEST DATA PROCESSING METHOD

This result can be applied to many fields of rail transit field measurement. When a section of the track needs to be troubleshooted, the speed of the vehicle is one of the important parameters. To query time. Extended to real life, as long as the fixed distance of the installation of sensors, you can get in the sections of the various types of vehicles traveling real-time speed. In the road speed also provides a different from the radar speed and optical speed of the new method.

V. CONCLUSION

When the train through the test line, as a result of rail contact with the wheel sensor response, so the sensor signal generated by the train through the various parameters are closely related. The speed of the train can be calculated accurately by using the algorithm in this paper. The speed of the train can be used as an important index to evaluate the running quality and safety of the train without borrowing extra tools, which greatly simplifies the experimental steps.

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