Research on Automatic Processing of Worn Tread Test Data

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Abstract. Wheel tread wear monitoring is of great significance to ensure the safety of train operation. In view of the large amount of data in daily test of tread and the error easily occurred in manual analysis and processing, a solution of automatic processing of tread wear test tool based on MATLAB is proposed. The automatic tool first loads the test data of WPA + wheel profile measuring instrument, eliminates the data with large error, gives the index of wheel wear and generates a report; then according to the generated report, it gives the analysis data of wheel wear, and draws the comparison diagram between the measured tread profile and the standard one, and finally gives the wear analysis conclusion. At last, some test data are used to verify the effectiveness of the program.

Keywords: Tread wear, Train safety, Automation, Report

1. Introduction
The monitoring of tread wear is one of the important contents of the daily maintenance of railways. It is necessary to process test data and generate test reports. A report needs to be obtained by the railway department as soon as possible once the tread test is completed, in order to evaluate the rail vehicle performance in time and ensure the safety of the train running on the track. Due to the large amount of measurement data very day, the work of processing data and generating test reports is boring and repetitive, and manual processing is easy to make mistake due to fatigue. Therefore, it is necessary to develop a tool to process data and generate reports of tread wear test automatically.

For the technology of process automation, many scholars in China and abroad had conducted lots of work on it. MATLAB is a common and powerful tool which can realize the convenient interaction with other application software, such as Word, C++, and so on[1]. Aiming at the problem of large amount of test data with the same format in daily work, the data can be processed and analyzed through the open source tools such as MATLAB, Origin C, and JXL[2-6]. Hui Yijing[7] used the technology of VSTO to develop a system that automatically processes data and generates reports; Qu Liang[8] applied the data processing for radar image to obtain oil pollution information and automatically generate oil spill monitoring reports. These works mean that the technology of automatically data processing and report generation is not only quite mature but also the trend in the future. However, there is no similar tool to automatically process and analysis the wheel tread wear data of rail vehicles currently. The huge data processed by the daily railway maintenance work is cumbersome and high error rate in manual. Develop a set of professional programs which can quickly process test data of wheel wear and automatically generate the reports of worn tread. That tools can reduce the labor of worker, improve the work efficiency,
and then provide the technical support for the safe operation of rail vehicles.

An automation program is developed for the above purpose based on MATLAB software. It is used for human-computer interaction through the GUI (graphical user interface) tool in the developed program. End users can quickly process data and automatically generate test reports just clicking several buttons. The generated reports would draw the comparison tread profiles of wheelsets according to the measured one and standard one, and analyze the worn tread features, then summarize the conclusions.

2. Automation technology and principle
This work develops a tool for automatic processing of tread wear test data based on MATLAB. It can realize the quickly processing of rail vehicle worn tread data and generate the analysis reports using COM, ActiveX and GUI technology.

2.1 COM interface
COM component is a new software technology and its value can be obtained through the interface. It is available for developing engineers to develop the individual component with specific functions, or combine them according to their actual needs[9].

2.2 ActiveX interface
ActiveX interface is developed based on COM components[10]. It is available for MATLAB to control common components such as Excel worksheets and Word documents through the ActiveX automation. ActiveX is a complete set of technical specifications, which is independent in the software for programming. It is useful for developers to use some programming software, including MATLAB and Python, but not limited to these.

2.3 MATLAB/GUI
It is interactive with computers and other devices through GUI for users [11]. The handles.tag input of the user is acquired by MATLAB/GUI through the static text, editable text, pop-up menus, buttons, etc., and then used in the analysis and calculation of the automatic processing. This work optimizes the performance of automation tools, makes the operation more humanized and reduces the burden of users.

3. Automatically data processing and generating report
Wheel tread wear, especially in high-speed EMU, is one of the important indicators affecting the safety of train operation. The daily work of train maintenance would pay more attention on the accurate and evaluation efficient of tread wear test. Since a large number of the worn tread profile form different trains are collected in every day, it is a hard work to get the flange wear, tread wear and other index by comparing the worn one and standard one. Meanwhile, using the CAD software to draw a comparison chart are also necessary for the future analysis and exploration in the report. Such large amount of test data, analysis and processing in manual is error-prone and low-efficiency (It would take 2 days to use the manual method to analyze and process the tread data of train with 8 carriages). Therefore, the development of an automatic processing tool for tread wear has the huge value in engineering.

3.1 Automatic tool development
This tool for automatically processing worn tread data is developed based on MATLAB and it uses the tool interface designed by MATLAB/GUI, including the vehicle type, train number, user name, writer, initial test carriage, final test carriage and other information, as shown in Figure 1. The program work flow chart is shown in Figure 2. This tool can not only process tread wear test data but also generate analysis reports automatically and quickly. At the same time, the end user's computer on site may not be enough highly configured to run the whole MATLAB software, the developed tool is compiled into an independent executable program (*.exe) to install and apply with more convenience.
3.2 **Automatic report generation**

When the tool is running, the user needs to input relevant information and click the "please select file" button to select the corresponding origin test data of the tread profile. The tool obtains the attribute value of handles.tag in the background, automatically fills in the form according to the car number and wheel number, and generates the test report of tread wear. Meanwhile, the tool would name the report in the format of "test date + test vehicle number ", which is available to distinguish the report of each wear test and make it easy to find.

It is necessary to automatically generate the test report of wheel tread wear based on the raw wear test files. The test report is mainly composed of tread parameter definitions, test records, tread curve, conclusions, etc. Insert the processed datasheet of test tread into the report as the test record table, and the number of carriage corresponds to the number of rows in the table. The automation tool would calculate the number of rows of generating cells according to the number of single wheel tread tests and the number of carriages. Some command are used to automatically generate cells with the corresponding number of rows, and the number of compartments are filled in the cells from small to large according to the tested carriages arranged in order. In addition, the row height and column width of the table need to be adjusted properly to ensure that the text and entered data are just inside the cell.
Drawing a curve graph based on the tested tread profile are used for analyzing and processing with the standard one. The manual method is to import the TXT text data into excel, draw graphics through the AutoCAD software, and then cut the pictures and insert them into the test report. However, the problems are as follows: (1) It is not possible to compare the measured wheel-set tread outline with the standard one on the same drawing; (2) It is easy to confuse the outline drawing with the wheel number and make wrong evaluation on the safety of the train; (3) It takes too long to process such a large amount of data, and the work of generating test reports is boring, monotonous and repetitive for staff.

The automatic tool developed based on MATLAB can not only automatically draw the profile of the tread, but also select the corresponding standard one according to the user's needs. By comparing the measured data with the standard profile, the wear parameters are obtained, the tread wear trend of the train is analyzed, and the wear law is summarized, which can provide data support for the formulation of wheel reprofiling regulations.

3.3 Program compilation
Considering the dependence of automation tools on the MATLAB, the original *.m file is transformed into an executable *.exe program by the MATLAB compiler, which can run without MATLAB software. The *.exe file can be run to automatically process and generate test reports even if the MATLAB environment is not installed in the user's computer.

4. Program verification
In order to verify the functionality, applicability, and reliability of the developed automated tools, the tread data from different train, different carriages, and different number of measurements per wheel were used for test verification.

After analyzing and processing the test data of EMU using the WPA+ tread profile measurement instrument, the data and report are shown in Fig. 3 and Fig. 4. The verification result confirms that the function of the tool to automatically process data and generate test reports of worn tread has been fully realized, and the total running time of the data analysis and report generation of a train with 8 carriages is within 2 minutes, which greatly improves the work efficiency and reduces the work time compared with the previous manual methods.

Wheel wear measurement report of **** EMU

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Fig.3 Wheel wear test report

| Wheel number | Flange height | Flange thickness | Flange taper | Tread wear | Tread Concavity |
|--------------|---------------|------------------|--------------|-----------|-----------------|
| 01-1R        | 28.4          | 30.6             | 8.99         | 0.4       | 0.049           |
| 01-1L        | 28.42         | 30.56            | 8.97         | 0.42      | 0.0466          |

Fig.4 Wheel wear test report
In order to verify the independence of the automatic tools, running the automation tool on a computer without MATLAB installed. The results show that the data reports and wheel tread wear test reports can still be quickly generated by the developed automated tools.

In addition, different types of standard wheel tread shapes (LM, LMA, LMB, etc.) can be selected according to the needs of users to compare with the actual measured tread through the tool. It can be also used for the tread wear evaluation of Mainline railway, subway, tram, and other rail vehicles.

5. Conclusion
In this paper, MATLAB is used to develop a tool which is human-computer interactive for automatic analysis and report generation of rail vehicle tread test data.

(1) This tool can not only automatically analyze and process wheel tread abrasion, but also quickly generate reports, which can solve the problems of high labor intensity and error-proneness in manual processing in daily maintenance of rail vehicles. Furthermore, it can be applied to rail vehicles such as freight wagon, subways and trams.

(2) In addition, it is converted into an independent *.exe program which can run without the environment of MATLAB, and it is convenient for installation and use at the test field. Therefore, the work have high practical value in engineering.

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