On-line inspection system for train wheel dimensions

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Abstract: This paper introduces three types of on-line inspection system for train wheel dimensions developed by the authors in recent years. The first system is an inspection line for semi-manufacturing wheel used for the wheels just after rolling. Then, the second system is used to inspecting the manufactured wheels at the end of the wheel manufacturing flow. Thirdly, a wheel profile measuring system that can be used for wheel monitoring instead of manual measurement with a hand-held gauge in rail maintenance operation has been developed in our lab. Finally, a RRS (Reconfigurable, Reusable and Scalable) design principle for agile manufacturing and measurement/inspection system is discussed in this paper.

1. Introduction

Railway systems are receiving increasing attention by Chinese governmental entities and consumers in the transport field. This is due to the rapidly increasing needs of transport of goods and passengers in China in recent years. Especially, the high-speed-train requires careful consideration of problems related to its manufacture. With regards to safety problems, there are three components of primary importance to guarantee the safety of trains: axles, rails and wheels. The attention must be firstly paid to the train wheel because the complexity in its form and dimensions. Figure.1 shows the geometry of a wheel. More than 20 dimensional and form parameters must be kept within strict tolerances. Therefore, these parameters require to be inspected in their manufacturing process and maintenance process.

Measuring specifications of measured train wheel: outer diameter range: 760~1100 mm; measured parameters: 24 dimensions and form-position deviations, as Figure 1.

Figure 1. Geometry of train wheel

According to the contour of train wheel, a cylindrical coordinate (X, Y, θ) is set up as the main coordinate system (Figure 2). Its longitudinal axis goes through the central axis of the inner bore of the
train wheel. Some 3D measuring units with displacement sensors are fixed upon the coordinate system to measure the geometry parameters of the wheel as shown in Figure 2. Following are two on-line inspection systems for semi-manufactured wheel and fully manufactured wheel respectively.

2. Inspection line for a semi-manufactured wheel
For a semi-manufactured wheel, non-contact measuring sensors have to be used in measurement of rough surfaces of the train wheel. One kind of non-contact pneumatic displacement sensor developed by the authors can be used for measuring the dimensional deviation of the semi-manufactured wheel with accuracy of 0.05mm in a displacement range of 5mm. A picture of the measuring machine used for inspecting semi-manufactured wheel is shown in Figure 3.

3. Inspection line for manufactured wheel
Another kind of non-contact eddy-current-type displacement sensor is used to measure the finished wheel with accuracy of 0.05mm in a range of 10mm. The sensors are mounted on some two-dimension servo-systems (Figure 4) that can be fixed on the framework of the measuring machine [5]. Figure 5 shows the local picture of the measuring machine for inspecting of the manufactured wheel.

4. Wheel profile measurement system
Railway vehicle maintenance schedules call for frequent visual inspection of wheels, often using hand-held gauges. Results can be subjective, as gauges provide little or no advance warning of failures, and collating data across a whole contour of wheel is extremely difficult. AEA Technology Rail (UK) has developed a family of machine vision components, which can be used to automate railway vehicle inspection. TreadVIEWTM is one such system that will automatically measure wheel profiles as a train passes. But in China, no system like this has yet been used in practice.

Recently, we have developed a system for wheel profile measurement in our lab [4,6]. Two linear type laser lights are projected onto the surface of wheel to form a contour of the wheel profile (Figure 6).
6). The profile measurement result is obtained with a computer image processing system as shown in Figure 7.

5. Discussion
As there is complexity in the form and dimensions of a train wheel as well as some other large machine components, the design of an on-line inspection system should be considered according to some special criteria. In our systems mentioned above, a Reconfigureurable, Reusable and Scalable (RRS) design principle for agile manufacturing and measurement/inspection system (AMIS) has been proposed [1,2,3], e.g.:

(1) Accuracy principle
Accuracy principle means that the accuracy of measurement results with AMIS is designed surely within an accuracy range of specification.

(2) Agility principle
Agility of system can result in three domains: hardware, software and design methods.

(3) Traceability principle
Traceability is a characteristic of connecting the measurement results with the national or international metrology standards through a continual chain of comparators.

(4) Function-suitability principle: flexible capacity; scalable frame; limited function.

We have researched and developed several AMIS for machinery manufacturing enterprises. Some of them have been used for a few years. Examples for online measuring and inspection of a train wheel are given above. An inspection line for manufactured wheel has been used for more than 300 thousands of wheels in Ma’An’Shan Steel Company in China since June 2000.

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