Nondestructive Testing of Mill Rolls

Yaver SAMEDOV, DEMAS, Moscow, Russia

Abstract. To obtain data on the depth distribution of flaws in backup rolls, we have analyzed the results of manual ultrasonic testing of over 300 rolls at rolling mills. On the base of the statistical analysis were obtained the main reasons of destruction of working and backup rolls. Our results show the importance and necessarity of inspection the entire volume of rolls, including roll necks.

The application of automated ultrasonic and eddy-current testing is a feasible way for decreasing the rate of emergency breakdowns of mill rolls.

"RollScope"-type multichannel devices developed for the automated nondestructive testing of mill rolls. The inspection results are displayed as 3D-type scanning defectograms.

Introduction

The available data and foreign experience shows that surface and subsurface flaws, cracks in particular, constitute are one of the main reasons of the rolls breakup. According to statistics, 95% of roll breakups is a result of surface and subsurface flaws, and only 5% of breakups are due to internal flaws [1, 2].

The decrease of mill rolls destruction which cause a material losses will allow to aggrandize the effectiveness of mill products. In this present main attention devotes to sheet rolling mills. It cause by importance of rolling sheet securing and its dependence from mill rolls quality.

In these latter days a quality questions becomes more and more important and causes an increasing interest to automatic machines for mill rolls control. The alternative to automatic control can be human monitoring which have some disadvantages: low assurance, small efficiency, asperities in control results figuration. The supplementary advantage of automatic control is decreasing role of human factor during the control and elaboration process.

1. Distribution of flaws in supporting rolls

To obtain data of the depth distribution of flaws in supporting rolls, we have analyzed the results of ultrasonic testing of over 300 rolls at rolling mills 1700 and 2800 in 1999–2004 years.

Figure 1 describes defects allocation by relative depth in mill rolls. The magnitude of depth was obtained as relative by division on defective mill diameter. Figure 2 describes histogram of defects allocation by their equivalent values during backup roll control.

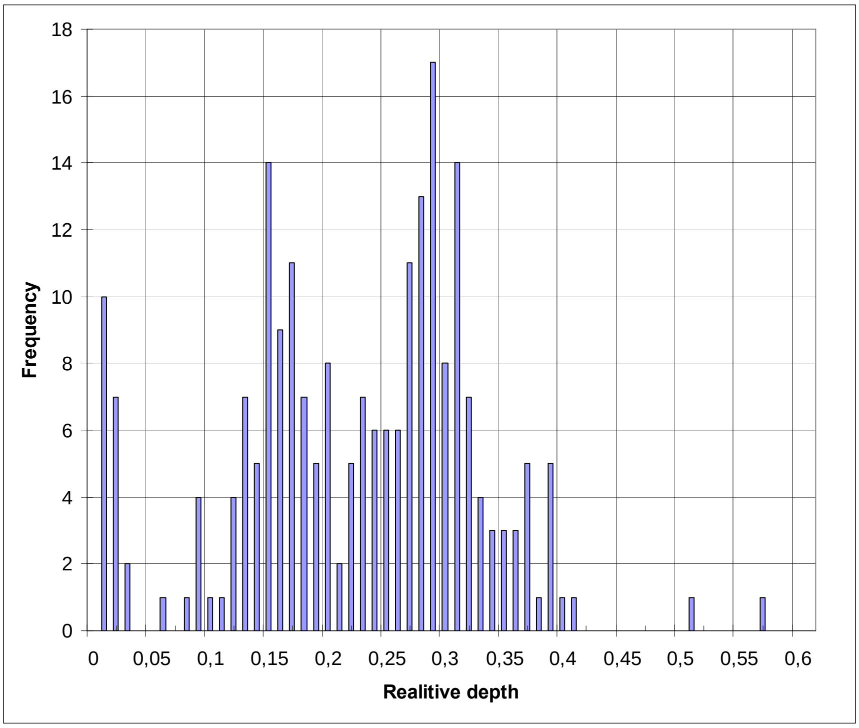

Figure 1. Distribution of flaws in backup roll mill.

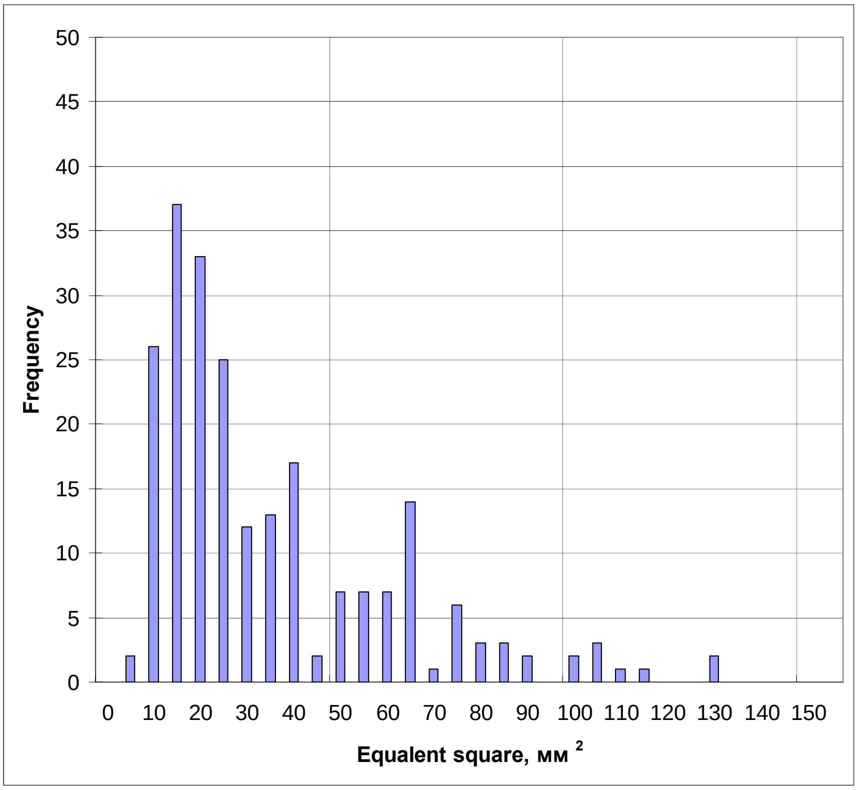

Figure 2. Distribution of flaws in backup roll by sizes.

We were perform research when possible one and two-sheet cast irons rolls ultrasonic control on 0,6 MHz 1 MHz, 2 MHz and 5 MHz frequency. In consequence of experimentation cycle we found what ultrasonic control of all types of backup rolls possible on 1 MHz frequency inclusively. In such case obtains clear backwall in all rolls kinds. In relation to cast irons types it's possible to pursue control on a higher frequency. For example, it was fixed a backwall echo in 5 MHz frequency. Therethrough we can suggest to use 1 MHz frequency for all roll types control. Eddy-current testing allows surface flaws (such as spalling cracks, deteriorating cracks, bruises, and burns from a grinding wheel) to be detected in a reasonable time; this makes possible to prevent the chipping and deterioration of rolls.

Internal flaws in rolls are detected more efficiently by means of ultrasonic testing. Statistics over many years shows that manual ultrasonic testing does not ensure the detection of all intolerable flaws. Moreover, the productivity of the process is small, and documenting of the testing results is a time-consuming procedure.

The application of automated ultrasonic and eddy-current testing is a feasible way for decreasing the rate of emergency breakdowns of mill rolls.

1.1. Development stand.

We were developing a stand for methodical and hardware-based measure elaboration for automated machine (Fig. 3). The mill roll was imitated by thickwalled aluminum tube. Converters line speed movement from 0 to 2000 mm/sec was obtained by gearing variation rotation. The lengthwise displacement speed of the scanning system changes from 0 to 2000 mm/sec.

For picking-up coordinates were used total actuating devices. Its was settled to use and created a wireless LAN to obtain information from coordinates actuating devices. One of the advantages of this method in using ISM band (2.4 GHz) and small power of emission which lower another electronic equipment disturbances. It was obtained a high translation speed – till 1 Mb/sec. On this stand was made a big experimental work which allows determining the best conditions for ultrasonic and eddy current control.

Figure 3.

2. Results

The author in cooperation with such companies like "DEMAS" and "TSNIITMASH" (Russia) has developed the type automated devices for nondestructive testing mill rolls – RollScope.

The device is designed as a dustproof and moisture proof monoblock unit, which is arranged on a free area of the frame (plate) of a roll-grinding machine, with a detachable scanning mechanism installed on a sliding carriage with the acoustic unit. There is also a design variety that ensures easy mounting of the device on a wall, as well as easy dismounting.

The one-channel device RollScope-EC is intended for the automatic monitoring of the working and supporting mill rolls. It is designed as a tool for a grinder. The operating procedure is sufficiently simple for a grinder and does not require the knowledge and comtransducerency expected from an expert on non-destructive testing. The device employs an eddy-current probe. The wide-span eddy-current probe detects surface flaws and subsurface flaws located down to 5 mm deep. Both structural changes (burns) and cracks can be detected. The device ensures a high scanning rate (up to 2 m/s). A working roll and supporting roll can be tested in 5 and 10 minutes, respectively.

The two and more -channel device RollScope -5 offers the largest functionality. It has been designed for the comprehensive testing of rolls and can be used for inspecting thick-walled pipes, cylindrical items, etc., which are 300–2000 mm in diameter.

To increase the probability of detecting differently oriented flaws, the device uses four ultrasonic transducers with different input angles. The direct combined transducers and transmitter-receiver transducers are intended for detecting bulk flaws and planar flaws oriented parallel to the generatrix. The sonication depth of the direct transducer equals half the body diameter. Angle transducers with input angles from 40 to 80 ° are intended for detecting bulk and vertically-oriented flaws at depths down to the axial line of the roll body.

The multichannel flaw detector features a system of temporary sensitivity adjustments and is equipped with a color display; it has a convenient and easy-to-use user interface.

The same scanning range is used to test roll necks and bodies. This makes it possible to detect flaws in roll bodies when testing roll necks. Presumably, this might have resulted in false echo signals; however, experiments on rolls showed that no false echo signals were observed. The subsequent experience of work with the devices confirmed the correctness of this approach.

The software of the device ensures the fast processing and real-time saving of the data. If required, it is possible to turn any channel on or off. Roll necks and bodies are inspected separately. During an inspection, the outline of a roll is output to the display together with an image of the acoustic unit moving in real time.

The computer system acquires data from the ultrasonic transducers and from the position sensors. The positioning system consists of absolute rotation encoder and cross-movement encoder. In case of a machine failure or unexpected shutdown, it is not necessary to start the testing anew, the testing starts from the position where the machine stopped last time.

After testing, the results were analyzed in a separate computer for database backup. To increase the testing productivity, the testing data are automatically transferred via a wireless local network to a computer where a 3D model of the roll is plotted.

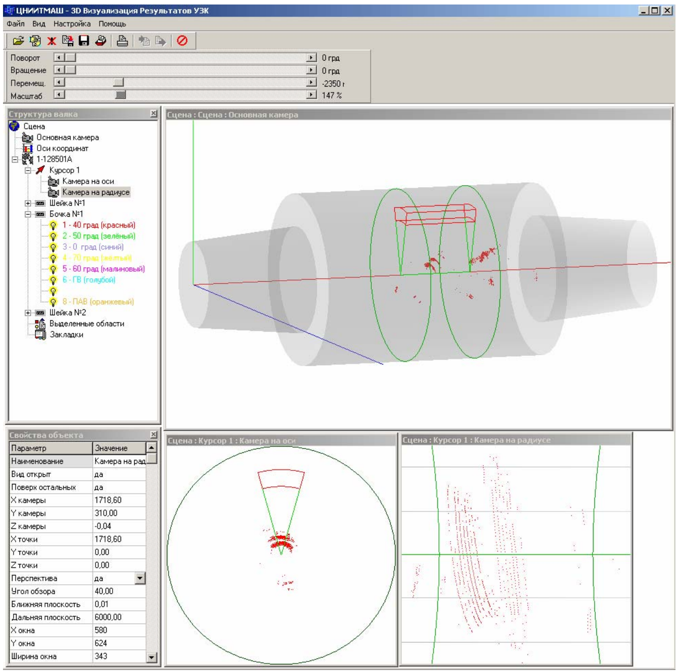

Figure 4. 3-D visualization program

Based on the data obtained, the software operating under "Windows" plots a 3D model of the roll. The visualization program makes it possible to rotate the 3D model in three dimensions. It is also possible to obtain any cross section in a radial plane. For exemplification see picture (Fig. 4). An NDT inspector can measure and select zones with flaws and determine their areas. All selected cross sections and views of harmful flaws are stored as tabs together with the testing data files. After studying the results of testing at different sensitivity levels, an NDT inspector prepares a decision. All testing results are stored on the hard disk of the computer and can be recorded on a CD or on other media.

3. Conclusions.

Inner backup rolls defects were detected through nondestructive control results. It has been created an automatic machine for mill rolls nondestructive control. The main its advantages are in using wireless technology and defective zones 3-D images construction. The five-channel device is used by "Severstal" company (Russia) at the present time. Its buying facility charge recovered in one year.

References.

[1] Flaw Detection Equipment and Methods of Testing Rolls of Hot and Cold Mills. Doklad firmy “LISMAR” na nauchno-prakticheskom seminare “Prokatnye valki i usloviya ikh ekspluatatsii—vazhneishii faktor povysheniya kachestva listovogo prokata” (Presentation of LISMAR Company at the Scientific and Practical Seminar “Mill Rolls and their Operation Conditions as a Factor of Major Importance in Improving the Quality of Sheet Products), Lipersk, 2001.

[2] Materialy seminara “Povysshenie effektivnosti prokatnogo proizvodstva”. Doklad firmy “Sheffield Forgemasters Rolls” (Works of Seminar “Increasing the Efficiency in Rolling Industry”. Presentation of Sheffield Forgemasters Rolls), St. Petersburg, 2002.

[3] Sakurai, K. and Inoue, S., Kantoc Auto-Roll Checking System, The 13th International Forgemaster Meeting , Pusan, Korea, October 12–13, 1997, pp. 319–329.