Effectiveness of Closed Loop Defect Location and Repair in Caster Mill Rolls

A Paper By

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Table of Contents

1 Introduction

Roll inspection is necessary to ensure that rolls being returned to service in the hot plate mill following reconditioning are free from surface breaking and internal defects that may cause the failure of the roll whilst in service. This paper describes the use of an Automatic Ultrasonic system for the inspection of Caster Rolls, up to 3500mm long and 800mm diameter, and a scheme which uses the data obtained to directly control the renovation process.

The customary practice in mill maintenance workshops was that rolls were ultrasonically inspected manually, a task that would take two men over 20 minutes to test, on the workshop floor, each roll. If cracks were found, it was necessary to assess each crack individually, to determine the crack's maximum depth (up to 85mm) and its position relative to the roll end. This information would be recorded manually and used by the roll shop to make a judgement, depending on the severity of the cracks found, whether to remove the cracks from the roll or just scrap it. If the roll could be reclaimed, working from the information provided by the manual inspection the roll was mounted in a lathe and the machinist would machine it to remove cracks that were detected. Having machined out all the cracks from the roll it is necessary to replace the removed metal by welding process. The typical roll shop practice is illustrated in Figure 1, a process which means loading, truing and unloading the roll in a lathe up to four times.

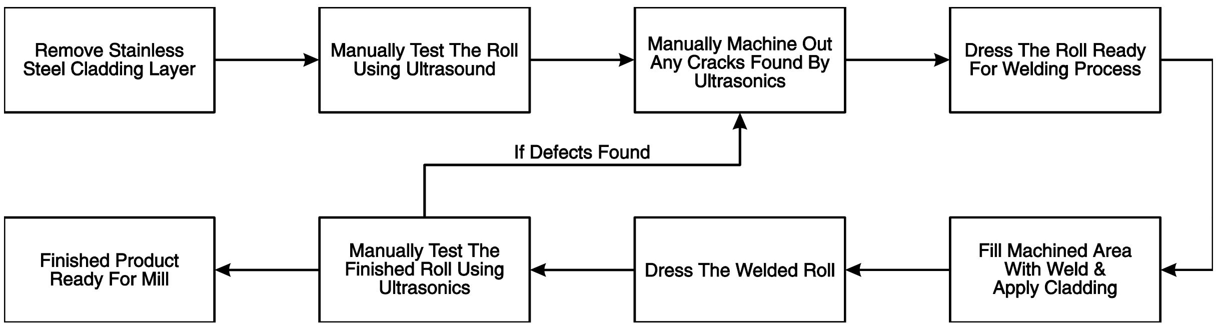


Figure 1 - Typical Roll Shop Practice

Insight NDT has developed an automated ultrasonic inspection system, designed to work in conjunction with a CNC lathe, which would quantify cracks found in the roll, providing position and depth data. The system would also provide a guaranteed 100% coverage inspection of the roll barrel for cracks, and weld slag inclusions since a closely controlled helical scan can be performed with the ultrasonic probes mounted on the tool carriage. On the information obtained from the automatic ultrasonic inspection, a suitable roll machining profile could be calculated, and an appropriate CNC lathe program generated to machine this profile.

An example of a roll shop practice when using an automated ultrasonic inspection system, in conjunction with a CNC lathe is illustrated in figure 2. All processes can be carried out in the same lathe.

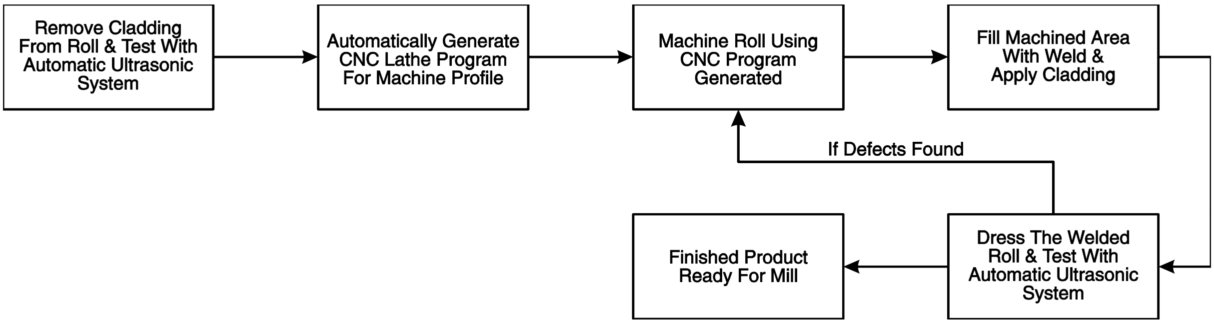
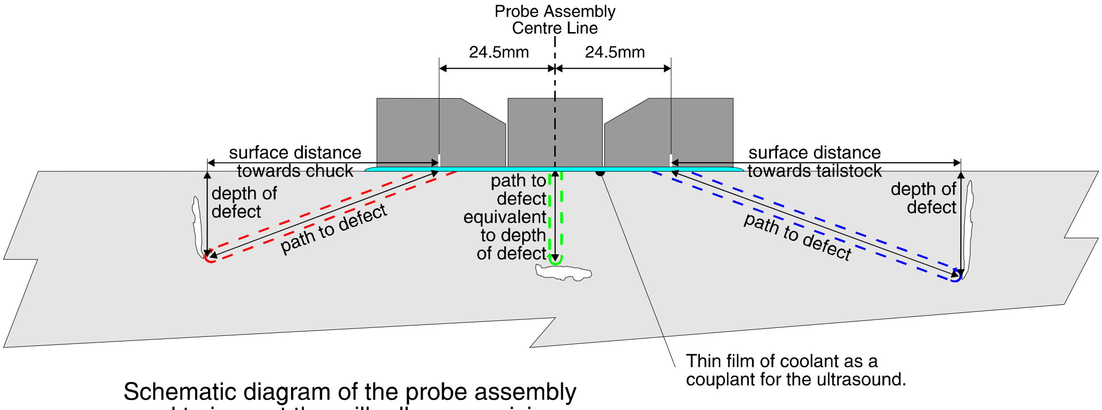


Figure 2 - Roll Shop Practice Using an Automated Ultrasonic Inspection System

The ultrasonic inspection of the roll is carried out in a CNC lathe, after the roll barrel has been skimmed, to remove the working surface which is a stainless steel cladding and to provide a suitable surface for ultrasonic inspection. The ultrasonic probe assembly fits into the CNC lathe tool turret mounted in a standard machine tool post, and uses the lathe cutting fluid as the ultrasonic couplant. The probe assembly uses a gap scanning technique, where he probes' faces are kept at a 0.3mm gap from the surface of the roll; the fluid fills the gap to provide coupling of the ultrasound. Figure 3 is an illustration of the probe assembly.

The CNC lathe operator enters the roll diameter and the barrel length in to the system. This information would be used by the system to generate a CNC program which would position the ultrasonic probe assembly to maintain the 0.3mm gap and automatically select an appropriate roll RPM to ensure that the peripheral speed of the roll would be approximately 600mm/s.



Schematic diagram of the probe assembly used to inspect the mill rolls. comprising of a compression probe in the centre and a shear wave angle probe each side.

Figure 3 - An Illustration of the Probe Assembly

A single pass of the roll whilst rotating is required for the ultrasonic inspection, this achieved using the CNC lathe to provide a 10mm pitch helical scan of the roll barrel, scanning from the chuck end to the tailstock end . The computer section of the system is used to record the defects found by the ultrasonics and calculate the depth and the position of each flaw relative to the reference, which is the tailstock end of the roll barrel.

Figure 4 - The Ultrasonic System Inspecting a Roll

Based on the position and depth of the defects found, the computer will create a machining profile to completely remove the defects from the roll barrel. In the creation of this machining profile, the computer takes into account the requirement that each side of any cut-out should have a 30^0 angle, to facilitate the welding process. If two defects are closer together than 50mm then the land between them is also machined to the depth of the deepest defect. This profile is presented to the machinist in the form of a roll machining graphic. Figure 5, shows the relative position of each machining band each band being a circumferential cut of 6.5mm together with the volume of material to be removed and the deepest depth of defect, is also presented in the form of a roll inspection report.

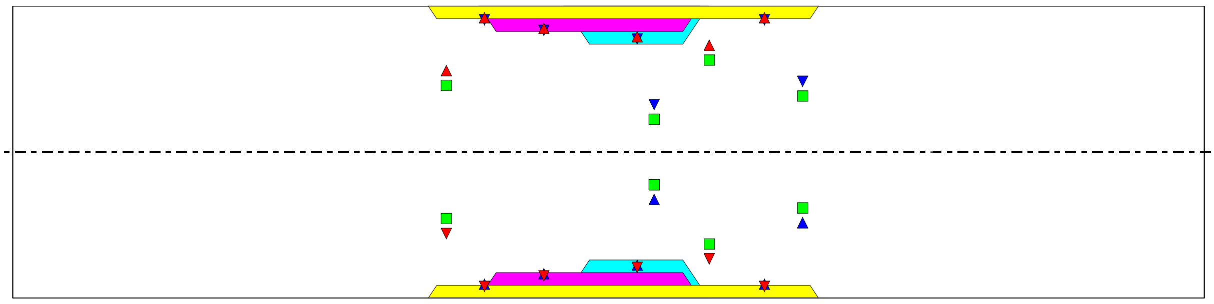


Figure 5 - An Example Roll Machining Profile

The machinist responsible for the roll could then decide if the roll has to be scrapped or reworked. If the decision is to rework the roll, the computer system can be instructed to take the required machining profile and convert it in to a program for the CNC lathe. This lathe program can be downloaded to the lathe's controller, and the program run

Having machined the roll using the CNC program generated by the ultrasonic inspection system, the next step is to weld up the machined area and apply the stainless steel cladding. The welding process is simplified, since the information about the machined roll profile is available from the test data.

The final step in this project, which as yet has not been implemented in practice, is to take the machine profile information from the ultrasonic scan and convert it to a program that a CNC welding machine could run. This would then provide a complete roll remanufacturing system, using a CNC lathe with a CNC welding machine.

The key component in such a system is the automatic ultrasonic inspection that would provide the source information for the machining of the roll based on the cracks found, and later the dimension information for the re-welding of the machined roll.

Once the roll has been welded it is returned to the CNC lathe for finish machining of, both the roll barrel and the bearing shafts. After this stage the roll is rechecked with the ultrasonic system, mainly searching for weld slag inclusion which may have resulted from the welding process.

A typical manual system would involve 1.33 man hours for a skilled ultrasonic operator to manually inspect the roll twice, 3.00 man hours just handling the roll in addition to the time to machine and weld the roll. Whereas the automatic system would take just 0.33 man hours for inspection and require only 2.00 man hours for roll handling, since the roll does not need to be removed from the lathe for testing.

However, the most significant saving of all is in the machining time, in the manual system it takes on average 30 minutes for a highly skilled CNC programmer to write a program for a CNC lathe, this program would have to be dry run before any metal could be cut. These times obviously increase significantly depending on the complexity of the machining required. In the automatic system, the program is generated instantly, by the machinist using the CNC lathe, and can be run as soon as the program has been downloaded into the lathe controller.

Obviously the capital investment required for both the CNC lathe and the automatic ultrasonic system, is relatively high. However, the cost savings to be gained are in reduced manpower to effect the reconditioning of the roll and the improved reliability and confidence which results in longer service life for the roll.

2 Conclusions

Roll inspection has been found to be paramount in today's quality and cost conscious mill operations. The system leads to:

- Improved product quality
- Reduced mill down time
- Improved roll life
- Reduced plant operating costs

In many roll shops, there is still the tendency to ignore the influence of roll quality on the overall operating costs and product quality. The control of roll quality is at worst left to visual inspection or at best the manual ultrasonic inspection of known damaged rolls.

The Automatic Ultrasonic inspection provides an on-line inspection, which becomes the key part of a roll remanufacturing system. The benefits of such a system are clear:

- Guaranteed 100% inspection as part of the roll machining process
- No additional personnel required, the lathe uses the equipment
- Improved product quality by only using defect free rolls
- Reduced overall operating costs.

3 The Next Step

The final step in this project, which as yet has not been implemented, is to take the machine profile information from the ultrasonic scan and convert it to a program that a CNC welding machine could run

This would then provide a complete roll remanufacturing system, using a CNC lathe with a CNC welding machine. The key component in such a system is the automatic ultrasonic inspection that would provide the source information for the machining of the roll based on the cracks found, and later the dimension information for the re-welding of the machined roll.