Aerospace
Conventional Power Generation
Manufacturing
Maritime
Nuclear Power Generation
Oil and Gas
Rail and Transport

VEQTER

Residual Stress Experts

VEQTER is an engineering company providing excellence in the measurement, analysis and management of residual stresses. We are world leaders in our field and offer expertise on any aspect related to residual stresses in engineering components and structures.

Case Study: Steel Roll - large measurement depth

During the manufacture of steel rolls for the Rolling Mill industry the rolls are passed through a hardening process. The hardening process is carried out to improve the wear resistance of the outer surface of the rolls and extend their working life. Also, as a beneficial consequence of the hardening process, compressive (i.e. crack arresting) residual stresses are introduced within the outer layers of the roll material. However, due to the equilibrating nature of residual stresses, tensile residual stresses are also introduced deeper within the rolls. Therefore the life extending effects of the hardening process are counteracted by the life diminishing effects of the tensile residual stresses. In order to improve the compromise between hardening and tensile residual stress generation a roll manufacturer supplied a steel roll for the measurement of residual stresses using the Deep-Hole Drilling technique.

The deep-hole drilling technique was deemed uniquely applicable for this measurement requirement due to the very large measurement depths, the hardness of the component material and the portability of the deep-hole drilling equipment to enable further on-site measurements on full-scale components.

To find out how VEQTER can help you, please contact us on +44 (0) 117 992 7970 or using experts@veqter.co.uk

VEQTER
Residual Stress Experts

Component design:

The steel roll consisted of a cylinder of overall length 780mm with a step in diameter from 380mm to 433mm at a distance of 300mm from the small end. Figure 1 shows the design of the roll for clarification. The steel roll, described as a mini mock-up, was forged from a solid martensitic steel billet and weighed 830kg. Therefore the term “mini” is used here very loosely (the real rolls supplied to the Rolling Mill industry vary in size from 80 – 460 tonnes)! The residual stresses were generated within the roll during a final differential hardening process.

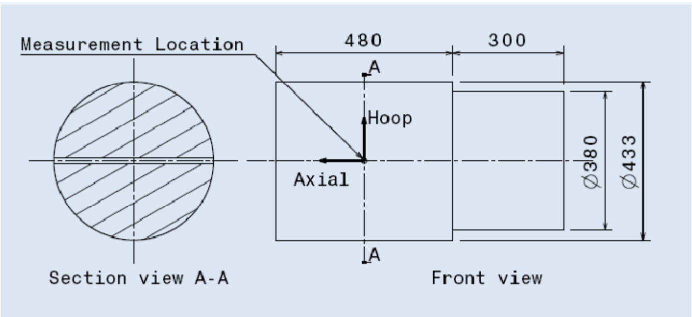

Fig. 1: Sketch of the steel roll mini mock-up and DHD measurement location (All dimensions in mm)

Measurement location:

The location of the deep-hole drilling measurement was along a radial line through the centre of the larger diameter step (i.e. 433mm OD) and at mid-length along the step, as show in Figures 1&2. Due to the axi-symmetric design of the roll the entrance of the reference hole around the circumference was chosen arbitrarily.

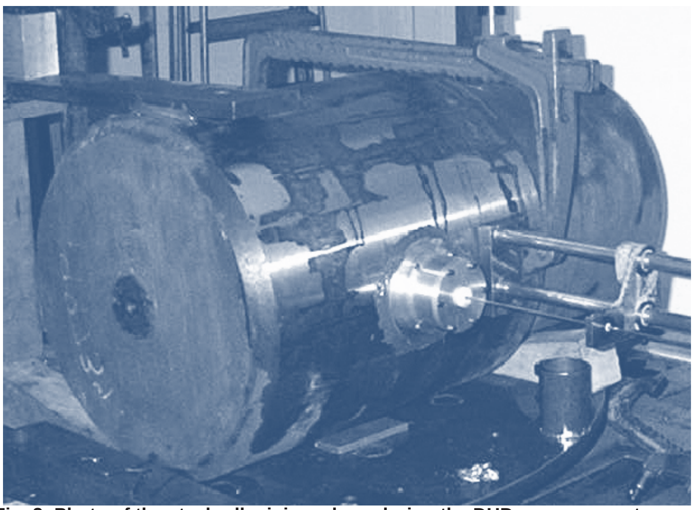

Fig. 2: Photo of the steel roll mini mock-up during the DHD measurement process

Results:

The residual stresses measured in the steel roll are presented in Figure 3. Hoop stress refers to the stresses in the circumferential direction of the roll and axial stress refers to the stresses along the main axis of the roll, as shown in Figure 1. The residual stresses are shown as functions of depth through the roll from the outer surface.

As expected, the hoop and axial residual stresses were found to be compressive in the outer layers and tensile deeper within the bulk. The hoop and axial residual stresses were approximately equi-biaxial and compressive for the first 30mm depth. Once tensile, the hoop and axial residual stresses separated, with a maximum tensile axial residual stress of 135MPa at a distance of approximately 85mm from the surface of the roll.

The in-plane shear stresses across the diameter of the roll were found to be approximately zero, indicating that the hoop and axial stresses were the principal stresses.
It can also be seen that the residual stress distributions were found to be symmetrical about the centre-line of the roll. This was as expected from the axi-symmetric component shape and the measurement line chosen.

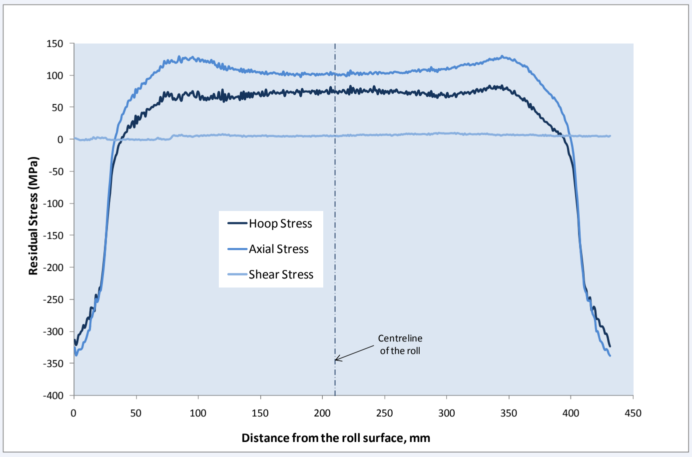

Fig. 3: Residual stress distributions measured in the steel roll mini mock-up