Mapping of Residual Stress in Ship Hull Structure

S.Y. Kenno[1], S. Das[1], R. B. Rogge[2], and M. Gharghouri[2]

[1] University of Windsor, Windsor, Windsor, ON, Canada
[2] NRC Canadian Neutron Beam Centre, Chalk River Laboratories, Chalk River, ON, Canada

Residual stresses from the welding process can result in early failure of a ship hull. A full understanding of the residual stress distribution in these welded plates was the aim of this study. This study was completed in three phases. The first two phases of data collection were summarized in the NRC CNBC Annual Report [1]. Selected results of the third and final phase of the study will be presented here. Six specimens were tested during the first two phases and another six specimens were tested in the third phase of the data collection. The test matrix for Phase III is shown below in Table 1.

Specimen 7 was constructed to compare the spacing of the stiffeners to Specimen 2, 3 and 5 from Phase I and II, respectively. Specimen 2 had only one stiffener and therefore assumed as infinite spacing. Specimen 3, 5, and 7 had two stiffeners spaced at 250 mm, 400 mm, and 325 mm, respectively. The object was to determine how the spacing between the first and the second stiffener affects the residual strains across the plate. Figure 1 shows the longitudinal strains from all four of these specimens at the depth closest to the welded surface of the plate. The 250 mm spacing and the 400 mm spacing have the highest tensile peak at the second welded stiffener approximately 2000 microstrain. The 325 mm spacing and the infinite spacing have a tensile peak closer to 1750 microstrain. At the first welded stiffener, the highest tensile strain was 2100 microstrain for the 250 mm spacing and around 1700 microstrain for the rest of the specimens. These results indicate that a spacing of 325 mm is the most favourable since this spacing resulted in the same maximum tensile strains at both stiffeners. Further testing and the residual stress values must be determined before this assumption can be confirmed.

Specimen 8 had the only differing thickness for the parent plate from all three phases. All of the specimens had a parent plate thickness of 9.5 mm where Specimen 8 had a thickness of 16 mm so it could be determined what the effect the thickness of the plate has on the residual stress distribution through the thickness. Specimen 9 is a series of tests on four plates with a weld bead on plate and no stiffeners. These four specimens were designed to determine what effect an inconsistency in the welding process has on the residual stress distribution. The welding process was halted and resumed in the centre of the plate for zero to 60 seconds as shown in Table 1. The results from Specimen 8 and the Specimen 9 series of tests have yet to be analyzed.

To complement the information found using the neutron diffraction method, the X-Ray diffraction method will be utilized on a select number of these specimens and a finite element model will be designed to complete a parametric study on the variables investigated in these three phases.

Table 1. Phase III test matrix.

Specimen	Base Plate (L x W x D)	Weld Details
7	400 mm x 600 mm x 9.5 mm	Two 400 mm long stiffeners spaced 325 mm apart attached with fillet welds
8	250 mm x 250 mm x 16 mm	One 250 mm long stiffener in the centre attached with fillet weld
9a	200 mm x 200 mm x 9.5 mm	Bead on plate, continuous across plate
9b	200 mm x 200 mm x 9.5 mm	Bead on plate, stop in welding process in centre of plate for 10 seconds before restart
9c	200 mm x 200 mm x 9.5 mm	Bead on plate, stop in welding process in centre of plate for 30 seconds before restart
9d	200 mm x 200 mm x 9.5 mm	Bead on plate, stop in welding process in centre of plate for 60 seconds before restart

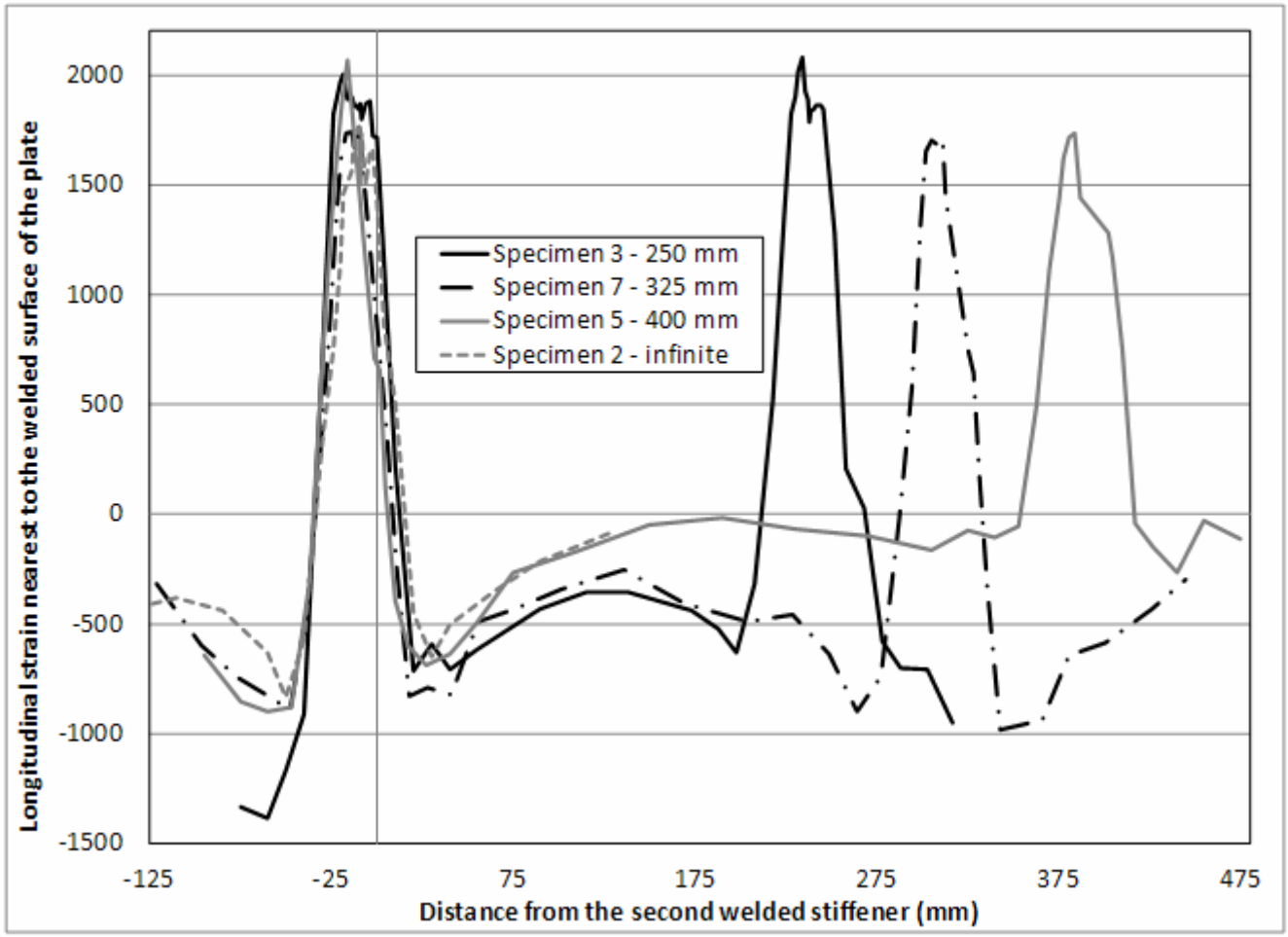

Fig. 1 Two stiffener specimens - spacing comparison

References

[1] Kenno, S.Y., Das, S., Kennedy, J.B., Rogge, R., and Gharghouri, M., *Mapping of Residual Stress in Ship Hull Structure*, NRC Canadian Neutron Beam Centre Annual Report, 2008, 57-59.