

Kwiryn Wojsyk, Maksym Grzywiński, Iwona Pokorska

DEFORMATIONS AND STRAIGHTENING OF WELDING STRUCTURES

The purpose of this paper is to analyze distortion in welding. The literature on welding stresses and deformation of welded structures is broad and the reader is referred to [1-27].

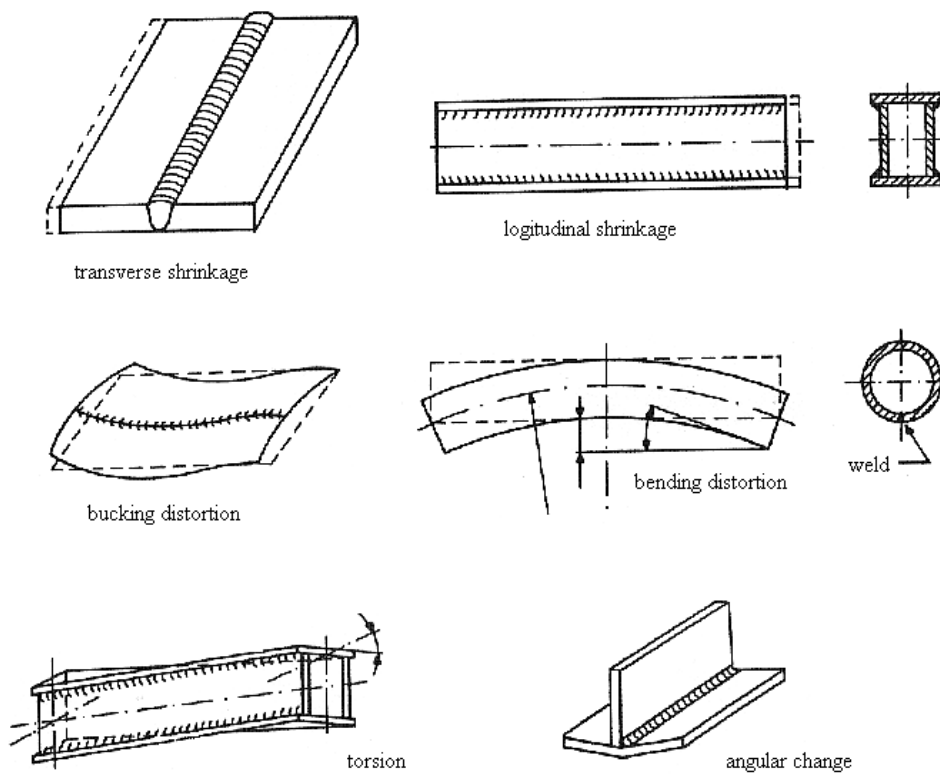


Fig. 1. Types of weld distortion

In the course of heating and cooling processes during welding thermal strains occur in the weld metal and base metal near the weld. The stresses resulting from thermomechanical loadings cause bending, buckling and rotation. These displacements are called distortion in weldments. In welding process three fundamental changes of the shape of welded structure are observed. These transverse shrinkage perpendicular to the weld line, longitudinal shrinkage parallel to the weld line and angular distortion (rotation around the weld line). These changes of welded structure are shown in Figure 1.

A typical structural component in ships, aerospace vehicles, and other structures is shown in Figure 2. It is a panel structure where a flat plate with longitudinal and transverse stiffness fillet is welded to the bottom. In the fabrication of panel structure distortion problem is caused by angular changes along the fillet welds.

The deflection of the panel changes in two directions as shown in Figure 2 when longitudinal and transverse stiffeners are fillet-welded.

The typical distortion in two types of simple fillet-welded structures is shown in Figure 3. In both cases, the plates are narrow in one direction and the distortion can be considered as two-dimensional.

If a fillet-joint is free from external constraint then the structure bends at each joint and forms a polygon. If the stiffeners are welded to a rigid beam the angular changes at the fillet welds will cause a wavy, or arc-form distortion of the bottom plate.

The above figures illustrates only the character of welding deformations. The amount of deformations should be calculated for each case of welding process and structure separately, because there not exist any simple formula for determination of welding deformations. The straightening of welding structures is based on heating of elements. The typical methods of straightening are presented in Figures 4-6.

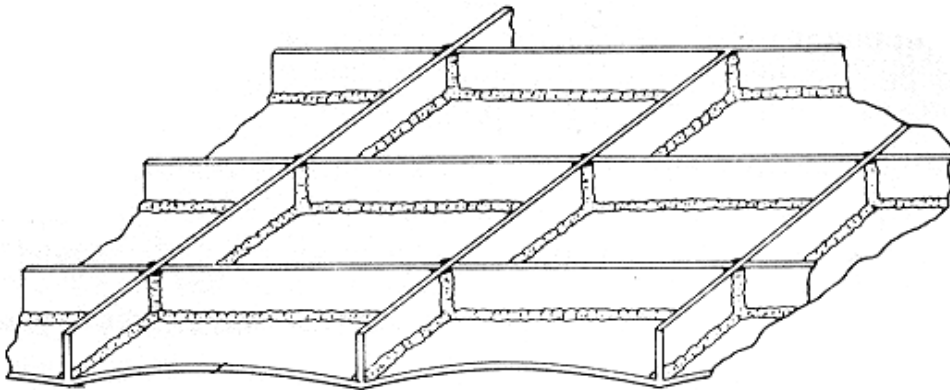


Fig. 2. Welded structure with stiffeners

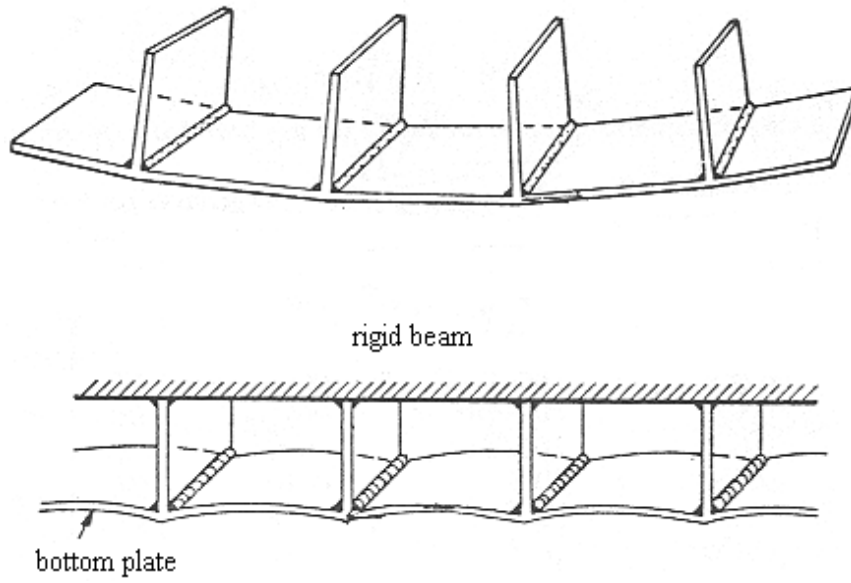


Fig. 3. Types of distortion in fillet-welded structure

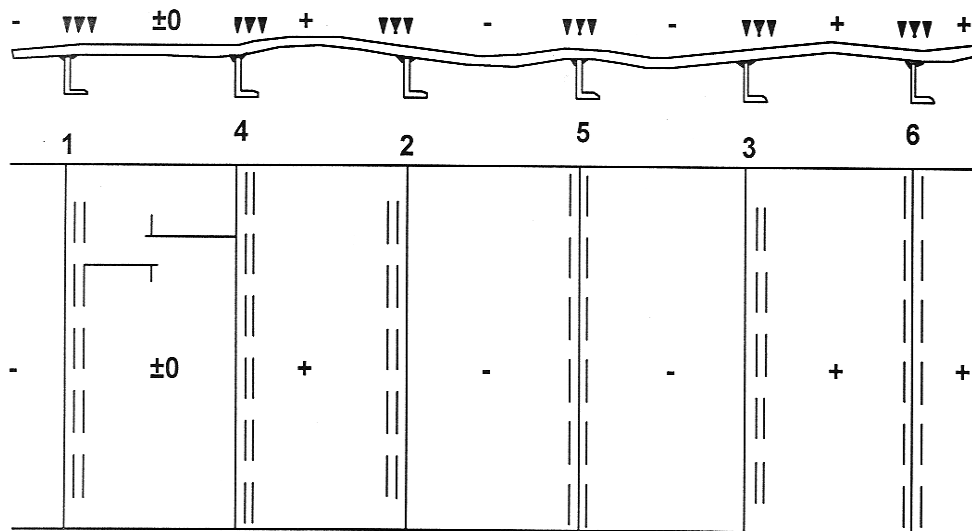


Fig. 4. Sheet straightening

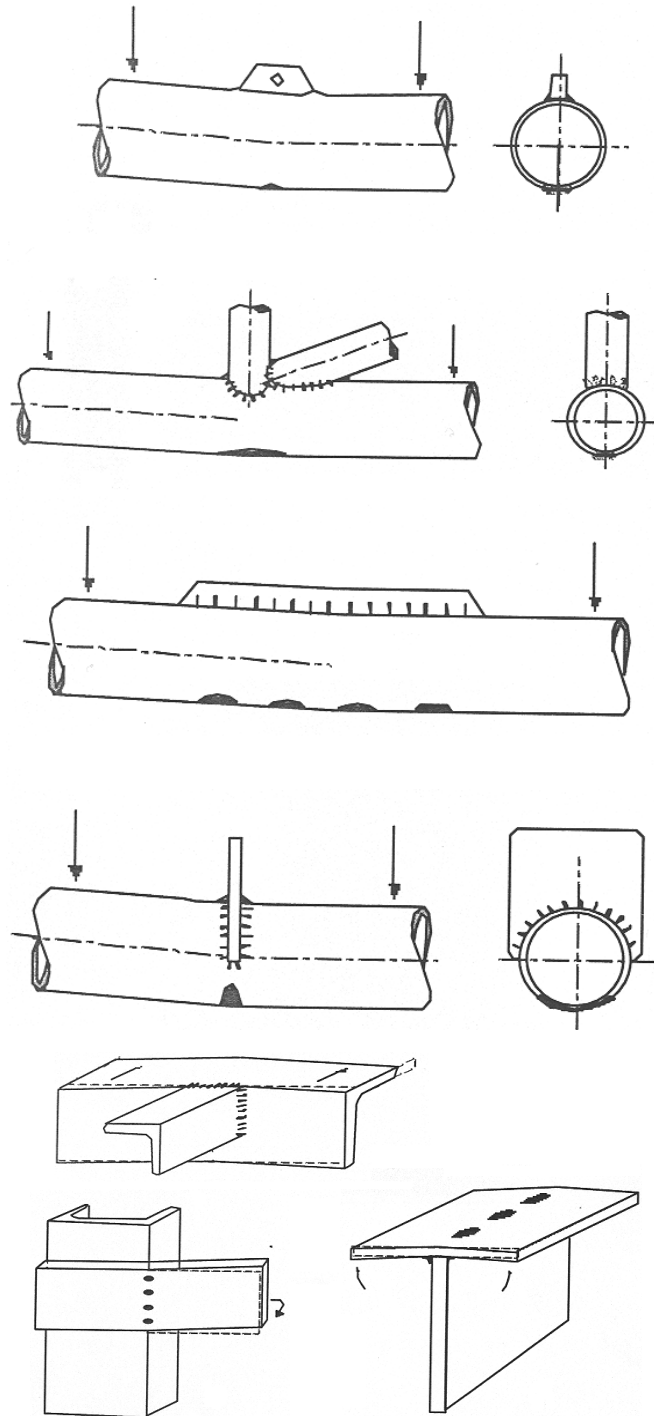


Fig. 5. Straightening of various types of welded structures

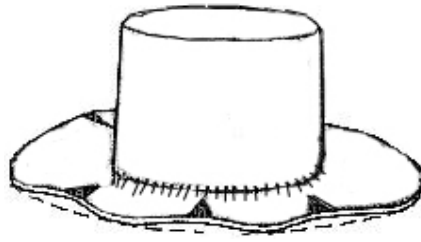


Fig. 6. Straightening of flange

References

- [1] Alpsten G.A., Tall L., Residual stresses in heavy welded shapes, *Welding Journal* 1970, 39(3), Research Supplement, 93-105.
- [2] Bentley K.P., Greenwood J.A., McKnowlson P., Bakes R.G., Temperature distributions in spot welds, *Brit. Weld. Journal* 1963, 613-619.
- [3] Brust F.W., Kanninen M.F., Analysis of residual stresses in girth welded type 304-stainless pipes, *ASME Journal of Materials in Energy Systems* 1981, 3(3).
- [4] Eager T.W., Tsai N.S., Temperature fields produced by traveling distributed heat sources, *Welding Journal* 1983, 62(12), 346-355.
- [5] Hess W.F., Merrill L.L., Nippes E.F. Jr., Bunk A.P., The measurement of cooling rates associated with arc welding and their application to the selection of optimum welding conditions, *Welding Journal* 1943, 22(9), Research Supplement, 377-422.
- [6] Jeong S.K., Cho H.S., An analytical solution to predict the transient temperature distribution in fillet arc welds, *Welding Journal* 1997, 76(6), 223-232.
- [7] Jhaveri Pravin Moffatt W.G., Adams C.M. Jr., The effect of plate thickness and radiation on heat flow in welding and cutting, *Welding Journal* 1962, 41(1), Research Supplement, 12-16.
- [8] Kasuya T., Yurioka N., Prediction of welding thermal history by a comprehensive solution, *Welding Journal* 1993, 72(3), 107-115.
- [9] Kawai T., A study on residual stresses and distortion in welded structures, *Journal of the Japan Welding Society* 1964, 33(3), 314.
- [10] Kawai T., Yoshimura N., A study on residual stresses and distortion in welded structures (Part 2), *Journal of the Japan Welding Society* 1965, 34(2), 214, and Part 3 1965, 34(12), 215.
- [11] Murray J.D., Welding of high yield point steels, *Welding and Metal Fabrication* 1966, 8.
- [12] Nagaraja Rao N.R., Esatuar F.R., Tall L., Residual stresses in welded shapes, *Welding Journal* 1964, 43(7), Research Supplement, 295-306.
- [13] Prokhorov N.N., Samotokhin S.S., Effect of artificial flowing off of heat on processes of developing internal stresses and strain in welding, *Avt. Proiz.* 1977, 5, 63-69.
- [14] Rabkin D.M., Temperature distribution through the weld pool in the automatic welding of aluminium, *British Welding Journal* 1959, 6(8), 132-137.
- [15] Rosenthal D., Cambridge M., The theory of moving source of heat and its application to metal treatments, *Trans. ASME* 1946, 68(11), 849-866.
- [16] Rosenthal D., The theory of moving sources of heat and its application to metal treatments, *ASME Trans.* 1946, 849-866.
- [17] Rykalin N.N., *Berechnung der Wärmevergänge beim Schweißen*, Verlag Technik, Berlin 1957, 68-69.

- [18] Rykalin N.N., Calculation of heat processes in welding, Lecture the presented before the American Welding Society 1961, April.
- [19] Rykalin N.N., Calculations of thermal processes in welding, Mashgiz, Moscow 1951.
- [20] Służalec A., Theory of thermomechanical processes in welding, Springer, 2005.
- [21] Sudnik W., Research into fusion welding technologies based on physical-mathematical models, *Welding & Cutting* 1991, 43, E216-E217.
- [22] Vogel L.E., Lyens J.V., Pumphrey W.I., Temperature and hardness distribution in welded Al-4% Cu alloy sheet, *Brit. Weld. Journal* 1954, 252-259, June.
- [23] Wayman S.M., Stout R.D., A study of factors effecting the strength and ductility of weld metal, *Welding Journal* 1958, 5.
- [24] Wilson W.M., Hao C.C., Residual stresses in welded structures, *The Welding Journal* 1974, 26(5), Research Supplement, 295-320.
- [25] Yang Y.P., Brust F.W., Welding-induced distortion control techniques in heavy industries, Symposium on Weld Residual Stresses and Fracture 2000, ASME Pressure Vessels and Piping Conference, Seattle, WA, USA, July 23-27 2000.
- [26] Yoshida T., Abe T., Onoue H., Residual stresses in circular-patch-welds, *Journal of the Society of Naval Architects of Japan* 1959, 105.
- [27] Opracowanie techniczne, Prostowanie płomieniowe, opracował K. Baran, LINDE GAZ POLSKA Sp. z o.o.

Abstract

The purpose of the paper is to analyze deformation problems in welded structures. The stresses resulting from thermomechanical loadings cause bending, buckling and rotation. The basic types of distortions in welding are analyzed. The paper has a review character.

Streszczenie

Naprężenia spawalnicze powodują skręcanie, zginanie i obrót elementów konstrukcji spawanych. W pracy przedstawiono główne typy deformacji konstrukcji spawanych. Praca ma charakter przeglądu.