Deep rolling and geometry evaluation of butt welds

Christian Dänekas¹, Peter Schaumann¹, Elyas Ghafoori¹, Steffen Heikebrügge², Bernd Breidenstein²

¹) Institute for Steel Construction, Leibniz University Hannover – ForWind Hannover
Hannover, Lower Saxony, Germany
²) Institute of Production Engineering and Machine Tools, Leibniz University Hannover
Garbsen, Lower Saxony, Germany

ABSTRACT

The increase of fatigue resistance by applying post weld treatment methods offers great potential for reducing the use of materials and costs for monopiles. Specifically, in the automated monopile manufacturing chain, automated processes such as deep rolling are a suitable option. This paper presents results of deep rolling as a new post treatment method to increase the fatigue strength of welds. In order to quantify the influence of deep rolling on the weld geometry, measurements of a laser line sensor are presented. With the help of this new evaluation method, a correlation between the initial weld geometry and the effectiveness of deep rolling can be demonstrated.

KEY WORDS: Post weld treatment; deep rolling; fatigue; welds; laser scanning; local notch geometry

INTRODUCTION

The "European Green Deal" presented by the European Commission on December 11, 2019, envisages reducing net greenhouse gas emissions to zero by 2050. In Germany, this cannot be achieved without a massive expansion of wind energy (Schaumann and Böhm, 2020). New knowledge and technical innovations for offshore wind energy converters (OWEC) are mandatory for achieving the energy policy goal as well as sustaining the national wind energy industry. A significant potential for savings lies in optimizing the design, manufacturing and installation processes of OWEC foundation structures.

Due to the high dynamic loads to which offshore structures are subjected, the design is usually fatigue driven. Due to increased stresses, the weld seams in particular represent fatigue-critical points and the local weld seam geometry has a significant influence on fatigue life (Lieurade et al., 2008).

To improve the fatigue life, various post weld treatment methods like high frequency mechanical impact treatment (HFMI) were investigated in the past. HFMI is carried out manually and is therefore time-consuming and expensive. In contrast to HFMI, deep rolling is a completely automated process and bears the potential to be easily integrated into the production chain of monopiles. In the field of mechanical engineering, deep rolling is an industrially established and cost-effective process with high efficiency. Compressive residual stresses can be induced and thus the subsurface properties can be improved by deep rolling. As deep rolling has not been considered as a post weld treatment method for steel structures, the influence of deep rolling on the weld geometry and fatigue resistance of welded joints have been investigated in this study.

Fig. 1: Principle of the deep rolling process with the resulting mechanical strains in the workpiece surface layer