A Framework for optimised welding of fatigue loaded structures
Applied to gas metal arc welding of fillet welds

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Abstract

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Welding is a key process for heavy steel structures, but it is also a weak link in the structure since fatigue fractures in welds are a common cause of failure. This thesis proposes several changes in order to improve the fatigue properties in a cost effective way, enabling reduced weight and reduced cost of welded structures. The main idea is to adapt the weld requirements and welding procedures to the load conditions of the weld. This approach ensures that the main focus in the welding process is the critical characteristics of the welds fatigue life properties. The fatigue life critical properties are most often related to the geometrical factors of the weld such as the radius at the weld toe or the penetration in the root.

The thesis describes a holistic view of the subject and covers fatigue, weld quality, weld requirements and welding procedures. It becomes evident that the traditional way of working without a direct connection to fatigue is not the best. With an adaptation to the load conditions and fatigue, it is possible to enhance the fatigue life and reduce the welding cost. The main challenge is to connect the welding process, weld requirements and fatigue life properties. It is needed for an optimised welding process of heavy structures subjected to fatigue and to get a predictable fatigue life. Welds optimised for enhanced fatigue life properties are not necessary accepted according to the requirements in a current standard.

Several welding procedures are proposed for improving the fatigue life properties of the weld, which indicate a high potential for enhanced fatigue life of fillet welds. The idea is to replace the “standard” fillet weld with three different weld types: (i) Welds with deep penetration, (ii) Welds with large weld toe radius and (iii) Welds produced with low cost. Together with customised requirements and reduced over-welding there is a vast potential for reduced weight, reduced cost and increased productivity.

The main contribution of this thesis work is the cross-functional studies including design, analysis, production and quality control. This gives a framework for improvements supporting reduced cost and reduced weight of welded structures without reducing the fatigue strength. Many shortcomings have been highlighted to change the welding from a state where welds are done in a way as they “always” have, by tradition, to a more contemporary situation where weld requirements and welding procedures are actively chosen to match the load conditions of the weld. This result in requirements and welding procedures which actually are connected to the fatigue properties as defined by the loading conditions, and where auditors with high probability can say that an accepted weld actually is better than a rejected weld.