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Unconventional Thermomechanical Treatment of Advanced High Strength Low-Alloyed Steel

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Abstract – Modern advanced high strength steels processed in unconventional ways of heat or thermomechanical treatment can reach substantially better properties compared to conventional treatments. This paper presents new possibilities of thermomechanical treatment for the 42SiCr steel. Through the conventional treatment very high strength can be reached, but the ductility drops down to lower values. The aim of this experiment was to design and test an unconventional thermomechanical treatment procedure in order to reach the yield strength to 2000 MPa with ductility over 10%. For this purpose, the Q-P process was modified and optimized in several steps. The stability of retained austenite was determined by means of neutron diffraction under cold deformation. The influence of the technological process parameters on the structure development was documented via metallography and the resulting mechanical properties were measured.

Conventional approaches such as quenching and tempering have long been used to achieve good mechanical properties, particularly toughness in the martensite structure. For newer types of materials, the majority of which are, for economic reasons sparingly alloyed, it is essential to use new treatments. For example, isothermic quenching has recently been used to attain excellent properties for bainite. These newer processes include intercritical annealing when treating TRIP steels or long-term annealing on bainite. To acquire even higher hardness values, isothermic quenching moved into the area in intervals between M_s and M_f. This is the quenching and partitioning process (Q-P Process). Our experiment concentrates on the Q-P process, as it can be used to attain an attractive combination of hardness and ductility.

This experiment was focused on the development of a thermomechanical treatment (TMT) for the advanced high strength low-alloyed steel 42SiCr. In order to reach valuable mechanical properties it was necessary to determine an accurate temperature interval to perform the thermomechanical treatment in. The initial information about phase transformation was taken from CCT and CCCT diagrams constructed upon experimental data. Based on the knowledge of the transformation temperatures a model termomechanical treatment with integrated Q-P process was designed (Figure 1). This treatment was then successively parametrically optimized. The model thermomechanical treatments were carried out on a thermomechanical simulator, which allows to control and record the temperature and deformation courses for steep gradients of changes (Figure 2). As a result multiphase structures composing of martensite, approx. 14 % of retained austenite and a very small amount of ferrite (Figure 3) were obtained. In some of the performed treatments tensile strength of about 2000 MPa with ductility over 10% was achieved.

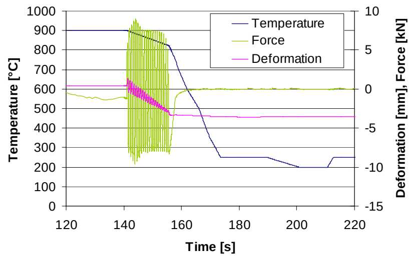

Figure 1: Structure of AHSS steel 42SiCr after TMT

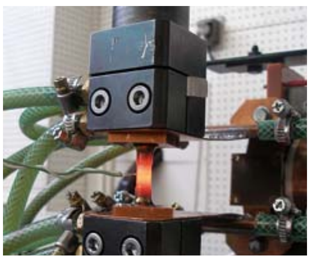

Figure 2: TMT of AHSS 42SiCr with integrated Q-P process

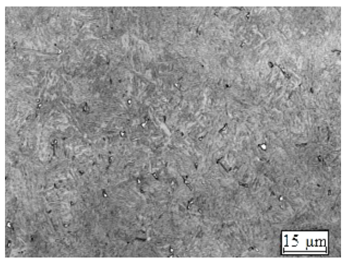

Figure 3: Structure of AHSS steel 42SiCr after TMT

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