Fatigue and Static Strength of Hot and Cold Straightened EHS-Steel with Subsequent Shot Peening

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ABSTRACT

Processes for hot straightening of the EHS-steel Domex 590 XP with induction and gas heat have been developed. The processes do not much affect the yield or tensile strength of the material. Besides, the hot straightening processes yield a higher fatigue strength (due to the following shot peening) than the permitted cold straightening (without following shot peening).

Both cold and hot straightening decreased the fatigue strength compared to the untreated material. The fatigue strength can be restored, though, with shot peening.

Yield and tensile strength is almost unchanged when Domex 590 XP is heated to temperatures below 600 °C. When heated to above 650 °C both yield and tensile strength will fall.

KEY WORDS

Fatigue strength, static strength, hot straightening, cold straightening, EHS-steel, shot peening.

Background

JOSAM lastbilteknik AB in Sweden, with about 20 employees, is a company specializing in straightening of truck frames. On a smaller scale they straighten bus frames and crane frames as well. JOSAM METOD AB is responsible for education and development of new straightening methods.

Practically all truck manufacturers in the world recommend cold dressing as the only straightening process. This means that no heat may be conveyed to the material. Sooner or later the cold straightened material might "regress" and as JOSAM lastbilteknik AB is anxious to deliver the trucks to their customers with an adequate straightening result hot straightening is preferable.

The alternative to straightening a part is to exchange it altogether. The cost of straightening is often only 30 % of the cost of exchanging the part. Truck owners and insurance companies would be able to lower their costs in connection with repairs if (hot) straightening could be used to a larger extent.

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Objectives

In a co-operative project between JOSAM METOD AB, JOSAM lastbilteknik AB, AB Volvo Teknisk Utveckling, SSAB Tunnplåt AB and The Swedish Institute of Production Engineering Research (all Swedish companies) processes have been developed for hot straightening of the EHS-steel Domex 590 XP. This steel is low-alloyed, thermomechanical and rolled with a yield strength of 590 MPa. The steel should not be heated to temperatures over 600 °C for more than short periods of time.

The most important objectives have been:

- to increase the knowledge of hot straightening.
- to develop processes for hot straightening of the EHS-steel Domex 590 XP using both induction and gas heat which gives just as good or better properties regarding the tensile strength and the fatigue strength of the material.
- to inform truck manufacturers (as well as manufacturers who use EHS-steel) about the hot straightening processes that are developed.

Presentation of Accomplishment

The material tested was Domex 590 XP, 7 mm in thickness. Both tensile strength and fatigue strength were determined for

- untreated material
- cold straightened material
- hot straightened induction heated material
- hot straightened gas heated material.

To begin with all test probes, that were straightened, were cold deformed about 5% by means of hydraulic pressure, see Figure 1.

Fig. 1: At Josam's training centre in Örebro all test probes were cold deformed by means of hydraulic pressure before the straightening. A bending tool with a radius of 80 mm is equivalent to 5% deformation.
In order to check the time-temperature curve on the test bars the "ivf quenchotest" was used. The "ivf quenchotest" is an equipment that registers temperature very precisely. In the test bars holes were drilled in which the thermoelement was placed. In that way the temperature could be measured inside the material. No holes could be drilled in those test bars that were tensile and fatigue strength tested due to the fact that holes give stress concentration factors which affect the strength. During the induction heating the temperature was controlled by letting the induction heat work for a certain amount of time, empirically determined in advance. During the gas heating the temperature was controlled through a combination of a visual checking of the surface colour and a measurement of the surface temperature using a thermoelement.

![Induction heating of test bar before straightening.](image)

**Results**

Processes for hot straightening of the EHS-steel Domex 590 XP with induction and gas heat have been developed, see Appendix 1. The processes do not much affect the yield or tensile strength of the material. Besides, the hot straightening processes yield a higher fatigue strength (due to the following shot peening) than the permitted cold straightening (without following shot peening).

**Static strength**

Figure 3 shows that the yield and tensile strength is practically unchanged when Domex 590 XP is heated to moderate temperatures, i.e. below 600 °C. During heatings above 650 °C the yield and tensile strength decreases.
Fatigue strength

Both cold and hot straightening decreased the fatigue strength compared to the untreated material. Hot straightening with subsequent shot peening resulted in a considerably increased fatigue strength compared to that obtained with cold straightening with subsequent shot peening.

Figure 4 presents the results of the fatigue tests.

Fig. 4: Comparison of fatigue strength for different treatments of Domex 590 XP. Hot straightening (both gas and induction heat) with subsequent shot peening have been carried out according to the processes described in Appendix 1.
The intensity of the shot peening equipments

Two shot peening equipments with different intensity were used. They are called V blaster and P blaster respectively in Figure 4. The intensity of the shot peening equipment probably affects the fatigue strength considerably (see Figure 4, the two columns to the right).

The equipment with the highest intensity resulted in a fatigue strength comparable with that of the untreated material, see Figure 4.

The intensity of the equipments was measured according to the so called Almentest, see Figure 5.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>A-measure V. blaster (mm)</th>
<th>A-measure P. blaster (mm)</th>
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<tr>
<td>30</td>
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<tr>
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<tr>
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<td>0.36</td>
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</tbody>
</table>

Fig. 5: The intensity of two different shot peening equipments was measured according to the so called Almentest.

**Conclusions and Recommendations**

- Hot straightening of Domex 590 XP should be carried out in accordance with established procedures, see Appendix 1.
- Hot straightening carried out in accordance with the procedure in Appendix 1 gives a higher fatigue strength than cold straightening.
- Cold straightening is approved as a straightening process by the truck manufacturer. Consequently, hot straightening performed in accordance with the above mentioned procedures ought to be officially accepted.