ESRF	**Experiment title:** Residual Stresses Due to Laser Surface Treatment of a High Nitrogen Steel	**Experiment number:** HS - 779
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Report:

Using a laser beam, heat treatments with heating rates of more than 1000 K/s are feasible. If the maximum temperature reached at the surface of the steel is below the melting temperature, the laser heat treatment in combination with the quenching effect of the surrounding cooler material brings about a rapid heat treatment of materials. This rapid heat treatment generates a surface layer with properties that are distinctly different to those of the initial microstructure and the microstructure after conventional heat treatments.

In case of martensitic high nitrogen steels [1-4] that are used e.g. for bearings and thread gears in aerospace applications, a laser hardening with rapid heating and cooling rates is supposed to achieve a hard surface with compressive residual stresses in the near surface layer. This should improve the fatigue and wear resistance while maintaining the high corrosion resistance typical for the high nitrogen steels.

If the maximum temperature is less than A_{c1b} only thermal tensile residual stresses are built up. In case the maximum temperature exceeds A_{c1b}, due to the increase in volume caused by its martensitic transformation, the laser track is under compressive residual stresses (fig.1).

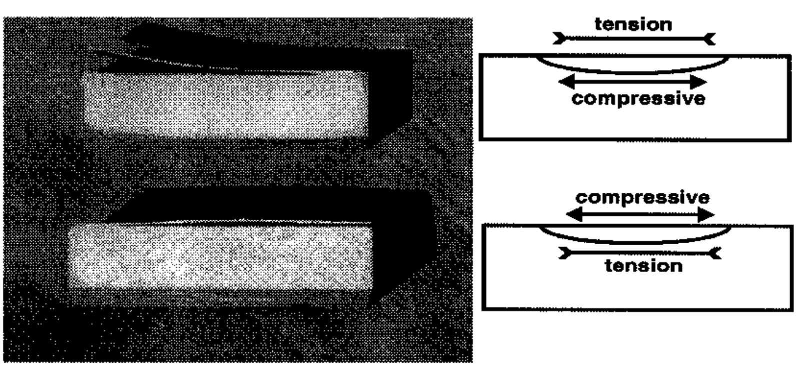

Fig. 1: Deformation due to cutting of the hardened surface layer of the high nitrogen steel.
Top: T_{max} = 850°C
heating up rate = 1150 K/s
Bottom: T_{max} = 950°C
heating up rate = 1290 K/s

The investigation of a laser-hardened layer heat treated with a maximum heat treatment temperature T_{max} = 950°C and a heating-up rate of 1290 K/s is shown in fig.2. In the laser track the residual stresses are compressive due to a martensitic transformation, while the balancing tensile residual stresses are present in the heat affected zone. Fig.2 reveal a steep residual stress gradient in-plane and out of-plane. This steep residual stress gradient is present at the surface as well as in a the depth of 90 µm in the heat affect zone. Further on there is a strong in-depth gradient of the residual stresses. In the near of the surface there are compressive residual stresses reaching up to –500 MPa. In a depth of 50 µm there are no more compressive stresses but tensile residual stresses. Especially high tensile residual stresses are present in the heat affected zone.

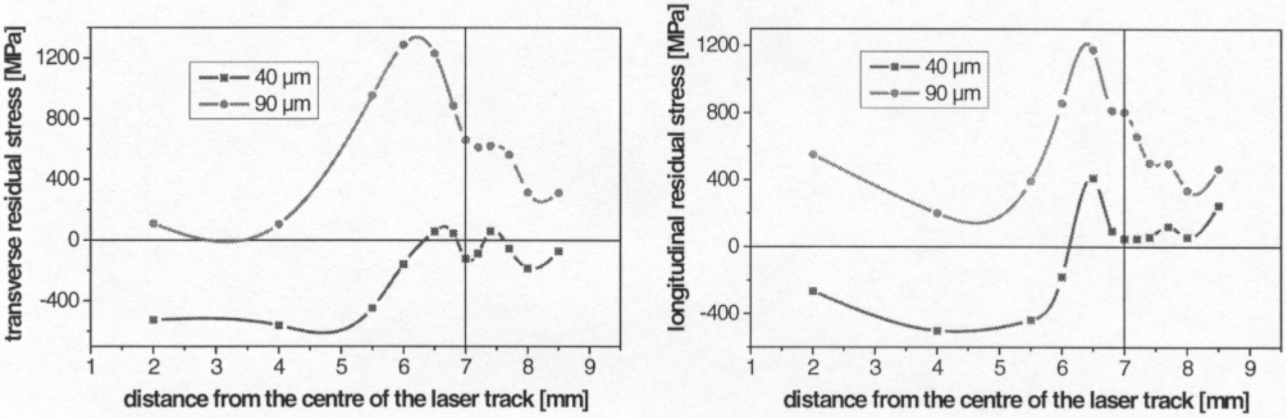

Fig. 2: residual stresses in the depht, T_{max} = 950°C, heating up rate 1290 K/s
left: transverse residual stress
right: longitudinal residual stress

The residual stress profile of the samples strongly depends on their retained austenite content. The volume content of retained austenite in the samples using high energy synchrotron radiation can be determined non-destructively and simultaneously with the residual stresses (fig.3). Fig. 3 show the spectra obtained in different depths of a sample laser heat treated with a maximum heat treatment temperature of 1000°C and a heating-up rate of 1360 K/s. At the surface of the layer the retained austenite content is 36%, in a depth of 100µm there is a retained austenite content of 4% which equals the retained austenite content of the parent material.

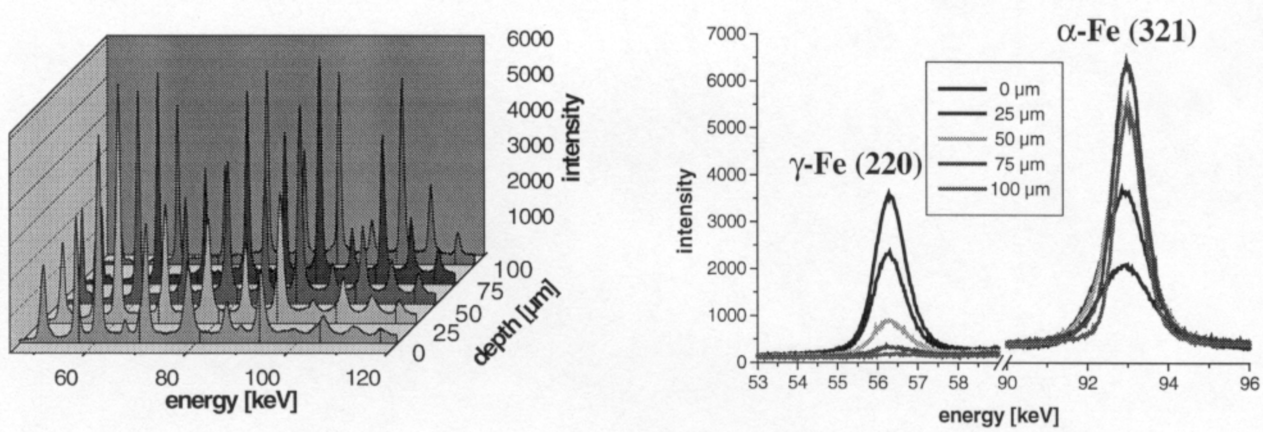

Fig. 3: retaint austenite content in the depht, T_{max} = 1000°C, heating up rate 1360 K/s

left: example for diffraction pattern

right: two-dimensional detail of fig. 3