STRESS DISTRIBUTION MONITORING AND REHABILITATION IN FERROUS STEELS

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Abstract. Stress distribution monitoring and rehabilitation in ferrous steels, offering faultless steel production and manufacturing (FASTEP) represents a new method and technology for surface and bulk stress distribution monitoring and rehabilitation in steels. The quality of the steel and corresponding products depends on the distribution and level of stresses in its volume and surface, since stress gradient is responsible for steel cracking generation & failure.

The existing technology in stress monitoring concerns either surface stress distribution monitoring instruments with unacceptably high uncertainty, or point surface stress sensors, or surface and bulk laboratory techniques not able to operate in industrial environment. Therefore, a method to provide stress tensor distribution monitoring on the surface and in the bulk of steels would be the feedback system to not only monitor stresses but actually to achieve stress rehabilitation.

FASTEP solution in achieving stress distribution monitoring in steel production, manufacturing and use, is related to a new method and technology, currently pending for patent, offering stress tensor distribution monitoring on the surface and the bulk of steels, steel welds and products based on them. The achieved uncertainty has been <0.1% for surface or bulk stress measurements, with speeds as high as 10 □s per point of measurement, compared to ~10% uncertainty and speed of 1-10 s per point of the existing state of the art, thus opening a new era in diagnostics & therapeutics in steel industry. Such a technology can be the feedback system for automated stress rehabilitation (annihilation or strengthening) process in steel production and manufacturing, as well as in installed steel structures (end-user applications).

The research breakthroughs of FASTEP are related to the unique ability to monitor the stress tensor on the surface and in the bulk of ferromagnetic steels, as well as to rearrange the stress fluctuation on the surface and the bulk of the steel. This way, the steel producers (steel coil producers) and the steel manufacturers (shipyards, welding industry, etc.) will have a unique tool to:

- Control the quality of the raw materials for their production line. In other words, the shipyards will be able to control the stress distribution in the in-coming steel coils, point by point
- Control the stress distribution and non-uniformity in the produced steel coil or the manufactured steel product (pipeline, ship etc.)
- Test and possibly re-arrange the stress distribution in existing steel structures, like vessels under pressure, nuclear station domes, steel structures, ships, trains etc.

The problems to be solved in the steel industry are summarized as follows:

- Quality of boat manufacturing (shipyards) is not excellent yet. FASTEP can be used to provide a solution, like a portable or stationary welding machine, including welding, stress monitoring, stress rehabilitation by localized RF heating, and quenching strengthening when needed, as well as final total quality control and certification.
- Power losses in electric steels for transformers and motors are as high as 10k USD/W, after Prof Moses [1], an expert in electric steels. These losses are governed by the localized stresses and their distribution, affecting the magnetic properties and therefore the losses in the devices based on them, namely transformers and most importantly electrical machines, which are one of the key elements of electric cars.
- Furthermore, as the quality of heat exchangers should be holistically tested along the whole volume of the used steel, the stress distribution should be monitored along the whole length of the material. A company employed in pipeline manufacturing and welding processes will implement the FASTEP method for the faultless production of heat exchangers.
- Quality of the other steel production and manufacturing lines is not excellent yet. FASTEP is able to provide stress monitoring and rehabilitation in all steel production & manufacturing lines. The sensors and rehabilitation systems can have the shape of the steel product (flat or circular).

The mentioned sensors can be used in end-user applications, like constructions, ships, trains, railway rails, powder stations, bridges etc.

Figure 1 illustrates the excellent agreement between magnetic parameters (mainly magnetic permeability) and stresses monitored by X-Ray Diffraction Bragg-Brentano set-up. According to this inductive, contactless type of stress monitoring, the proper amount of induction heating can be locally applied to the steel under investigation in order to annihilate the local stresses.

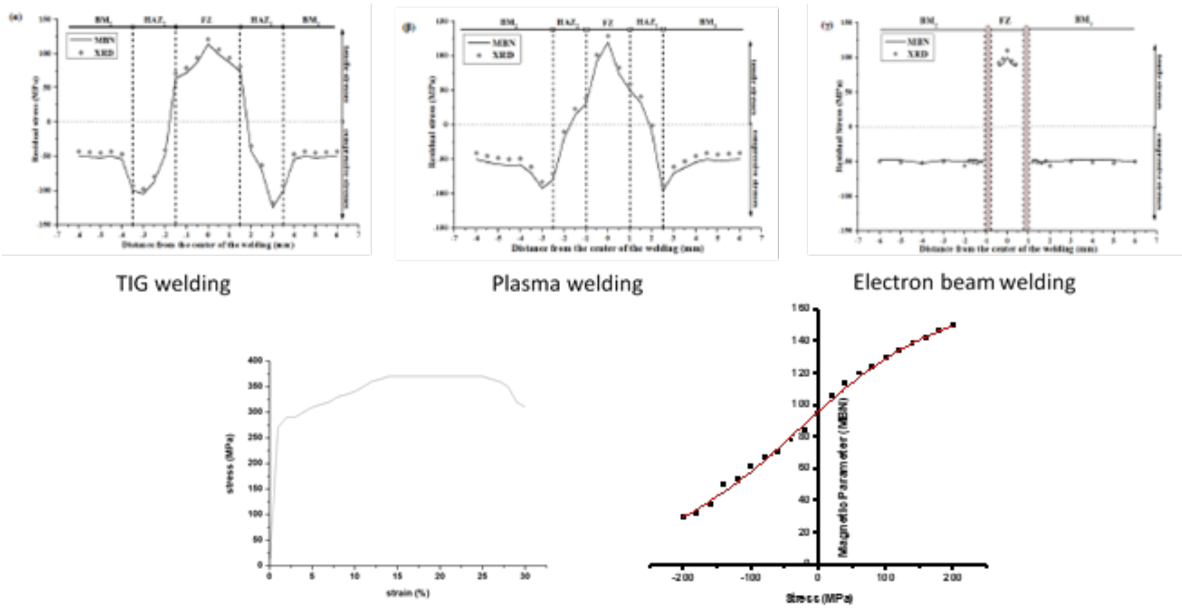

Figure 1: Example of comparison of stress components and magnetic permeability in autogenously welded steel (upper part). In this case steel has been AISI 1008, welded with TIG, Plasma and EBW. From these pairs of values the magnetic stress calibration curves are extracted.

References

[1] Shahrouzi H., Moses A. J., Anderson P.I., Li G., Hu Z. Comparison between measured and computed magnetic flux density distribution of simulated transformer core joints assembled from grain-oriented and non-oriented electrical steel, AIP Advances, Volume 8, Issue 4, 1 April 2018.