Effect of the heat generated during deformation at high strain rates on the structure and properties of high manganese steels with twinning as the dominant deformation mechanism

One of the most current scientific issues today is a detailed knowledge of the deformation mechanisms taking place in high manganese steels, assigned mainly for the automotive industry. This refers to the martensitic transformation of retained austenite induced by the deformation (TRIP effect), mechanical twinning (TWIP effect) as well as slip and the formation of austenite shear microbands (MBIP effect) and shear bands. Among the mentioned steels, the ones with the TRIP effect are the best recognized, despite the fact that the process of their production at an industrial scale is very difficult. The MBIP effect can be obtained only in steels with high stacking fault energy and thus a very high content of Mn, which makes also it metallurgical difficult to obtain such steels. **In the analysis of the technological difficulties as well as the current knowledge of the mentioned steels, the TWIP steels seem the most interesting and promising in the aspect of both science research and application, especially due to their very high work hardening, ensuring high strength in combination with good deformability.**

Due to the fact that these steels are to be applied for energy absorbing elements, most of the research should be performed for high deformation rates. Unfortunately, such investigations are usually carried out under static conditions and analyzed without the consideration of the fact that, with an increase of the deformation rate, large amounts of heat are generated, which significantly change the high work hardening as well as the final properties of the product. **The literature includes many scientific studies of TWIP steels, yet they mostly refer to deformation under static conditions. There are only a few studies performed under dynamic conditions, while there is no research carried out which would consider the heat generated during the deformation at high strain rates in steels with the TWIP effect. Significant strain localization within the shear bands and adiabatic heating can cause the simultaneous decrease of both ultimate tensile strength and elongation-to-failure and finally energy absorption.**

The main scientific objective of this research project is the explanation and description of structural phenomena occurring in manganese steels with TWIP effect during dynamic deformation, taking into account the heat generated during the deformation and structure changes taking place in high manganese steels depending on the stacking- fault energy (SFE) affected by chemical composition. It has been assumed that the ability to activate different deformation mechanisms, such as mechanical twinning - TWIP effect in high manganese steels is determined by the SFE value affected primarily by the chemical composition of steel and the strain rate due to heat generated during deformation.

So far, no systematic research of the TWIP effect under the conditions of dynamic loads with the consideration of the heat generated during deformation has been performed anywhere in the world. Such investigations have only been carried out partially for TRIP steels, also by the authors of the project. In particular, the pioneering character of the project is expressed by the following:

- Explanation of the complex effect of Mn and C on the stabilization of austenite in the function of temperature and deformation rate,
- Quantitative description of the microstructural properties in steels with the TWIP effect, including those containing microadditions Nb and Ti,
- Application of the proposed scientific methodology of samples with grid (used to measure the deformations in different areas) as well as application of a temperature measuring system, especially for dynamic tests.
- Determination of the effect of the heat generated during deformation on the structural transformations taking place in the examined materials
- Description of the relation between the energy consumption and the chemical composition (SFE) as well as the deformation rate.
- Determination of the influence of the heat generated during deformation on the change in the deformation mechanisms. Determination of the conditions of the transition from deformation through twinning to the formation of shear bands and microbands assistant