PUBLIC DESCRIPTION OF THE PROJECT

1. Objective of the project

The main objective of the project is to investigate the possibility of obtaining friction welded joints of an ultrafine grained (UFG) metal with resulting strength which can be close to the strength of the basic UFG metal. Conventional welding methods based on local melting of edges of the joined materials cannot be used to join UFG metals due to degradation their microstructure by heat in the heat affected zone (HAZ). There is also no evidence in the literature, that innovative bonding processes, performed by mixing the friction-heated material in the solid state without reaching the melting temperature of the base UFG metal, can give consistent joints. Parameters of the bonding process are crucial for quality and properties of obtained joints.

The conducted initial tests of friction welding of ultrafine grained 316L steel have shown that the degree of HAZ being defected depends on the velocity of heating in the first phase of the friction stage and on the upsetting pressure in the last phase of this process. Upon the conclusions drawn from this preliminary research, the hypothesis was put that the character and range of recrystallization can be controlled. This control can be achieved by providing the ultra-high heating velocity obtained by friction of joined surfaces while assuring that the amount of heat input is limited to a level sufficient for exceeding energetic barrier for joining. The initial results of both experiments and numerical simulations indicate the potential for reducing the degradation of UFG structure in the HAZ by strengthening the positive impact on the properties of ultra-high speed of friction by controlled cooling of the welded material. Therefore, the project will focus on achieving the accepted joints of UFG metal mainly by enhancing parameters of friction welding, going beyond specifications available for universal continuous drive friction welding equipment. Detailed objectives are: (1) characterisation of initial UFG metal, (2) obtaining suitable parameters for friction welding, (3) influence of rotational speed on strength of the UFG metal joints, (4) understanding the mechanism of joining the UFG metal by correlating the properties of the joint with the microstructure.

2. Research project methodology

Electrolytic copper – nanostructured by using innovative mtECAP method – will be used to test friction welded joints of UFG metal with different microstructural characteristic. Friction welding will be conducted in a process which first of all is characterized by using ultra-high heating speed. Friction welding trials will be carried out using a high performance prototype machine that should operate at specification of process parameters and functionality which are not available for general purpose rotary friction welders. Prototype of a high performance friction welding machine will be used for welding. Specification of process parameters used for trials is not available for general purpose rotary friction welding machines. The parameters to be investigated on a specially designed experimental stand are: rotational speed, time profile of forging force, displacement profile of welded bar and its initial temperature. Samples of UFG copper will be investigated on each processing stage using microstructure observations and mechanical testing (tensile test, hardness measurement).

3. Why this research is important

Plastic deformation significantly influences the structure and properties of metals. There are various options to exploit plastic deformation in materials processing. One way is to improve properties by transformation of microstructure. The second one is to join metal parts continuously into a desired structure. The project aims to exploit synergic effect from both options. Background of main SPD processes is widely understand among research community and fundamental knowledge of UFG metals is well developed. However, after almost 50 years, since the first grain refinement of metal was made, UFG metals remain still unknown for industry. The major restriction in wide industrial application of UFG metals produced by SPD is the lack of a reliable welding process, which would give material continuity in the joint. The greatest practical interest concerns the SPD method in which large quantities of material can be deformed. However, the larger volume of the processed billets the higher is the cost of equipment. An alternative way for fabrication of barstock with the length long enough to facilitate mass production of UFG metals is an application of reliable welding technology to join separate UFG metal pieces into larger parts during manufacturing process. Understanding process parameters of bonding UFG metal – friction-heated, plasticized, locally deformed, and finally joined continuously – will diminish disproportion between academic and technical activities. Practical applications are after all the final goal of any development in materials science and engineering.