Influence of high frequency direct induction preheat temperature on decrease in susceptibility to liquation cracking and microstructural changes in high volume gamma prime nickel based superalloy

Nickel based alloys used in high homologous temperature applications are the most advanced metallic materials. The unique combination of high temperature mechanical properties and excellent oxidation resistance makes it an indispensable group of materials in key industries, namely military and civil aviation as well as conventional and nuclear power plants. Nickel alloys are also called superalloys due to unreachable for other materials extremely high strength at elevated service temperature. High quantity of alloying elements (eg. chromium, cobalt, molybdenum, aluminum, tungsten) and manufacturing technology ensure desired properties that cannot be achived even in advanced high alloy steels.

Alloy 108 is a newly developed nickel based cast superalloy. The ability to work in aggressive corrosion environment under thermomechanical loading is achieved through precipitation strengthening. The main area of application of the Alloy 108 can be critical components "hot path components" in energy gas turbines and turbofan aircraft engines, where it could successfully replace presently used superalloys eg. Inconel 713C. The development of today's trend is to design complex constructions where it is necessary to join castings with wrought alloys, as well as to create layers that improve wear properties. One of the main problem characterizing precipitation strengthened nickel alloys is the high susceptibility to liquation cracking (propagated in heat affected zone). The aforementioned effect is undesirable and leads to premature degradation of material. So far, investigations have been conducted on a small group of superalloys that indicate that the cracking is initiated by constitutional liquation of intermetallic γ' phase. **Most importantly, there is lack of information on the susceptibility of Alloy 108 to cracking, microstructural changes induced by welding processes and how the physicochemical properties of alloy change with temperature rise.** Due to the fact that the Alloy 108 is a newly developed material and there is a prospect of replacing currently used other alloys, it is necessary to determine the tendency to cracking, microstructural changes after welding, and how to modify microstrucutre before welding in order to eliminate problem of cracking. In the papers on the susceptibility of nickel superalloys to cracking during welding (also prepared by the Author of Proposal) it was indicated that the γ' strengthening phase determines both the high mechanical properties as well as the abovementioned tendency to crack. It was mentioned that the initiation of the cracking is essentially related to the change in superalloy behavior during rapid heat cycles relative to equilibrium heating rate. It is necessary to consider change the heating rate in order to reduce the negative effect of high heating rate and connected with this constitutional liquation. **The research conducted so far has not focused on the possibility of decrease in the volume fraction of the γ' phase by increasing the temperature just before the start of the welding process. A fully innovative way to perform this procedure may be high frequency induction preheating.**

Nowadays, there is no available data on microstructure evolution, change of properties and tendency to cracking of nickel based superalloys (including Alloy 108) by modification of the thermal cycles by magnetic induction. **Hence, the original and fully significant contribution to the existing state of knowledge will be the realization of the basic purpose of the project, which is the experimental evaluation of the influence of high frequency induction preheating on the tendency to liquation cracking during the welding process and the evolution of the microstructure as well as properties of Alloy 108.**

The described purpose of the project will be realized by plan and execution research using basic and advanced techniques such as: light microscopy (LM); scanning (SEM) and transmission (TEM) electron microscopy; energy dispersive X-ray spectroscopy (EDS); electron back-scattered diffraction (EBSD); x-ray diffraction (XRD) and high temperature X-ray diffraction in situ; dilatometry (DIL); differential scanning calorimetry (DSC); differential thermal analysis (DTA); Vicker's microhardness (μHV).