1. The objective of the project

In recent years the surface engineering, particularly coatings technology, is of high interest of industry as a high attention is paid to the quality of products. This is caused by the fact, the surface of the element is usually a place exposed to the highest and most complex loads and there is a need to enhance the surface properties. Furthermore, it is often impractical and uneconomical to produce components from expensive bulk materials in order to meet the requirements of its surface. In this case the use of dedicated coating is recommended. The application of coatings provides many benefits, e.g. increase of different material properties like: strength, wear resistance, hardness, heat resistance, corrosion resistance, electrical conductivity and many others. One of the mainly used method are plasma spraying technologies, in which coating-forming material is melted in plasma jet and deposited on the substrate. The greatest potential for the development in this area reveals Suspension Plasma Spraying (SPS) method, where the feedstock material is a liquid. The suspension is a mixture of fine-grained (even nanometer-sized) powder material, solvent and chemical additives. The use of suspension instead of conventional coarse powder allows to form fine-grained coatings of controlled thickness.

The use of suspension instead of dry powder substantially changes the spraying characteristic. Based on the previous studies it is concluded that the suspension preparation and its appropriate injection into the plasma jet significantly determines the spraying process, droplet and splat formulation but also the structure and properties of deposited coatings. In this proposal the characterization of: (i) suspension break-up during injection stage into the plasma jet (depending on its preparation and spraying parameters) and (ii) the interaction between powder particles and substrate materials will be investigated. The influence of mentioned phenomena on the microstructure and basic properties of coatings will be addressed too.

2. The scope of investigations

The analysis of mentioned phenomena is definitely a complex task, so the multidisciplinary studies are needed. The project includes: (i) the characterization of the powders and suspension prior to the injection, (ii) carrying out of real-time observations of droplet formulation during suspension injection (with various parameters of intake materials and different spraying parameters), (iii) real-time observations and numerical simulation of powder particles and substrate material interaction, (iv) the single-scan experiment and then full-spraying of coatings, (v) laser texturing and Thermal Barrier Coating production and (vi) testing of the deposited coatings.

The first stage of studies will be focused on the powders characterization with the use of scanning electron microscopy (SEM), determination of powder size distribution (granulometry test) and analysis of their phase composition (XRD). Suspensions will be determined in terms of sedimentation speed, Zeta potential, viscosity and surface tension. In the second stage, the analysis of plasma gases/powder particles/substrate contact will be carried out. The both phenomena will be investigated by: (i) dedicated vision control system and then (ii) confronted with the data obtained from the numerical simulation (by FEM – finite element method). The laser texturing will be implemented as well. The various substrate patterns will be created. This part of research will be completed with "single-scan" spraying, which enables to assess the size, thickness and the shape of single splats. Based on the results the spray experiment will be designed and full Suspension Plasma Spraying of Thermal Barrier Coatings will be conducted. In the last stage, the deposited coatings will be investigated in order to determine their microstructure (by using SEM, XRD and EBSD techniques), and selected thermomechanical properties.

3. Motivation of undertaken topic

Plasma spraying is very versatile method of coating deposition, as e.g. the process offers the widest range of possible materials that can be deposited. Nevertheless, the method proposed in this project, called Suspension Plasma Spraying, is one of the newest techniques of thermal spraying (patented in 1997). On the one hand, it proves the validity of proposal (topic is innovative and developing), but on the other – this complex process is highly dependent from many variables, which is not fully understood yet. One of the key element is the interaction of powder particles and substrate, especially if using designed substrate topography. Basing on the previous studies, it is proposed that the proper preparation of substrate (e.g. by laser microtexturig) and understanding of mentioned phenomena will increase the repeatability and the accuracy of process control. In this way, the implementation of SPS method could be possible in the wider range of possible applications and the transfer of this technology to the industry could be impelled.