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Mathematical modeling, analysis of dynamic properties, and fabrication of thermally-sprayed ceramic-metallic bulk composite materials

The 21st century is full of remarkable achievements. One of them was **the invention of "printers"** that can not only fill the surface of a sheet of paper, but can also print **three-dimensional elements**, the so-called 3D printers. Since the inception of the first concepts, research groups have outdone each other in inventing newer and newer 3D printing techniques, and one of them is **the spraying method**. Importantly, in this technique, the material used for printing can be not only polymers, but also metals, and metals combined with other materials, e.g. ceramics. It is the material resulting from the spraying (at high temperature) of the metallic material in combination with the particles of ceramics that constitutes the research material in this grant, the so-called thermally sprayed ceramic-metallic bulk composite materials. More precisely, we are interested in how to design such a material that, after production, has a strength that exceeds known materials produced in a traditional way.

The research is divided into three complementary and overlapping tasks. The first task is devoted to the production of the materials mentioned above. This is a very important stage, because the method of controlling the spraying process has still not been fully recognized, and it is of key importance for the strength of the 'printed' material. The second task is testing the materials obtained from Task 1. The planned strength tests are not, however, standard tests. We are talking about the use of unique stations that allow you to learn about the properties of materials in extreme conditions similar to those that prevail during a road accident, demolition of buildings or a bullet impact. The last and third task is based on the previous two and concerns proposing "mathematical formulas" that will reflect the experimental observations. These "mathematical formulas" may be a tool for future engineers.

Therefore, the conduction of the grant will contribute threefold to society. First, new materials will be created (perhaps they could be used for fixing for example, damaged agricultural and mining machines, spacecraft). Secondly, we will be able to predict the strength of such new materials, knowing the chemical composition of the native materials from which they will be made, what is more, such materials may have different strengths depending on the direction from which we "act" on them. Thirdly, the engineering of the future needs design procedures for such materials, and here we need mathematics (it is the queen of sciences!). Without it, as Professor Huber wrote, "the quantitative results of experiments are similar to the materials taken at the construction site ...".