Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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PhD information	
Title	Design, realization and study of bimetallic and metallic based composite materials with controlled architecture obtained by mixed process: additive manufacturing/foundry/powder metallurgy for heat exchange in braking systems
Main topics regards to CSC	Metallurgy, heat transfer, characterization of

list (3 topics at maximum)	materials
Required skills in science and engineering	Metallurgy processes and materials Metals characterization Capacity for computing (hard and software)

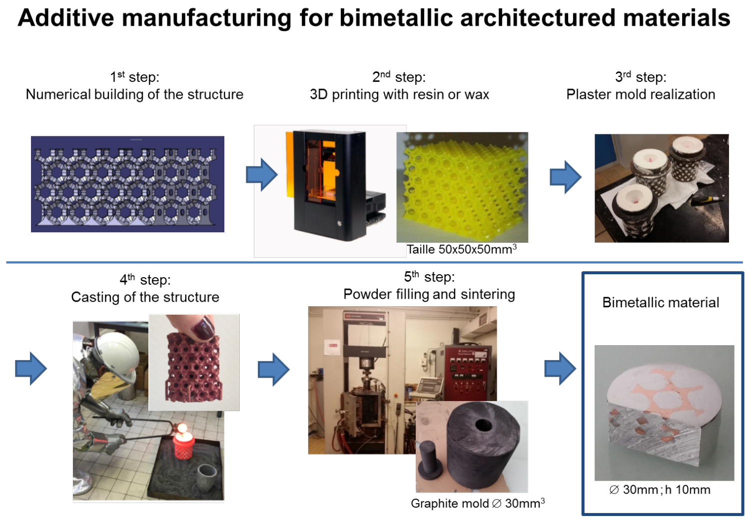
Subject description (two pages maximum)

Context and objectives:

The industry always research materials having improved properties which can sometimes seem to be opposed. For example, a braking disks for car, trucks or train, have to present at the same time tribological properties to dissipate the mechanical energy of the vehicle, thermal conductivity to avoid rising to a temperature that can damage their physical integrity and vibration damping to avoid noise generation during braking. The usual solution is to define a well global geometry of the part to optimize cooling and vibration. However this requires numerous and expensive stages of manufacturing. In this study, we propose to work directly on the microstructural architecture of the material. Two ways are proposed to produce materials answering to the braking problematic.

Firstly, the idea here is to fill a metallic structure, with high thermal conductivity, by some metallic materials or composite materials (namely with graphite that is a great vibration damper) to give to this global material tribological and vibration damping properties also. Previous studies in our team have led to develop the technique for structure production (lost model technique) and for filling it with another metals (see figure below). The structure is 3D printed with resin. This part in resin is used to produce a plaster mold. During the preheating of the plaster mold, the resin is burned. The liquid metal is then pouring in the hot mold. Finally, the plaster is removing to obtain the structure. In a second step, this metallic structure is filled with metal and reinforcement material (graphite) in powder, compacted and heated in order to sinter the metallic matrix. In a final step, this material can be extrude and/or heat treated to modifiy morphology and phases. The actual limit of this solution is the size of the structure we are able to produce and we don't known exactly the relationship between this size, the morphology and the evolution of all the properties targeted.

The second ways consists to create a composite material directly from reaction during solidification by controlling texture and anisotropy of the microstructure. For example, during grey cast iron solidification, graphite can be generated in the ferrous matrix. If we increase the amount of graphite and if we control its shape, we hope to increase thermal exchange and give it some anisotropy. In the same time, by adjusting the amount and shape of graphite, we hope so increase the vibration damping. In our team, we are able to produce special cast iron and to apply treatments (on the liquid metal, during or after solidification, see figure below) in order to control the amount and size of the graphite. The limit here is to obtain the graphite in the appropriate amound and morphology.



Devices for metal melting by induction and thermal analysis measurements

Figure: The two process for build the material of this study

Work of the CSC program student:

A first step is to define the well design of the micrography and of the structure. This approach has to be done by using appropriate software for heat exchange and vibration representations. Because we plan to extrude the material in order to give more anisotropy, we have to calcul the shape before and after extrusion.

Secondly, the techniques used for material production have to be developed. For example, the casting of the small structure and the control of the graphite morphology. The materials can also following additional treatments as heat treatment or extrusion for improve their properties.

Finally, the materials produced have to be well characterized in terms of microstructure and properties (mechanical, heat exchange, vibration damping…).

The candidate have to present skills in experiments and characterization of metals. An experience in numerical simulation will be appreciated.

Laboratory:

The team of metallurgy of UMET – UMR CNRS 8207 laboratory (MPGM team) has acquired a know-how in the realization of metallic matrix composite materials, by using additive manufacturing, foundry, powder metallurgy, extrusion… and in all the characterization techniques. This team is working in collaboration with clother labs to develop heat exchange and vibration damping simulation and to test the materials for braking.