POLITECNICO
DI TORINO
Distretto
di Ingegneria Meccanica
e Aerospaziale

Thesis Project Plan

Thesis Planning Documentation

Subject: *'Numerical Fatigue analysis of an Additive Manufacturing Liquid Rocket Engine Thrust Chamber with an innovative Metal Matrix Composite*

Relator: Prof. Raffaella Sesana.

Tutor: Ing. Matteo Crachi**.**

Starting Time: As soon as possible.

Working Time: 6 months**.**

Partners: Politecnico di Torino – Sophia High tech s.r.l. (https://www.sophiahightech.com/) – Italian Space Agency (ASI).

Contest: The present Master thesis is an important brick of a more complex project between Politecnico di Torino, Sophia High Tech s.r.l. and the Italian Space Agency (ASI). In particular, results will be able to provide a better explanation of the thermo-mechanical behaviour of a new patented innovative metal matrix composite material. Nowadays liquid rocket engines are looking for high thermal conductivity and high strength Additive Manufacturing materials. The New Space Economy is growing day by day and the scientific community need to keep updating skills and knowledges respect to both, new process technologies such as additive manufacturing and new superalloys such as Copper-Steel. The present master thesis aims to provide to the scientific community a deep numerical study in order to analyse the feasibility of using an innovative Additive manufacturing Metal Matrix Composite for Liquid Rocket engine Thrust Chambers.

Previous knowledge*: Additive Manufacturing Process, Science of Metals, Basic Material Mechanics**,** Low Cycle Fatigue models, plasticity models, numerical analysis (preferable: ANSYS Workbench/APDL).

*Previous knowledge are not compulsory. However the candidate should consider additional time in order to study theoretical gaps.

Theoretical Activities:

- State-of-the-art of Additive Manufacturing Copper/Copper alloys and Additive Manufacturing Maraging steel alloys mechanical behaviour;
- State-of-the-art of Additive Manufacturing Copper/Copper alloys and Additive Manufacturing Maraging steel alloys thermal behaviour;
- State-of-the-art of Additive Manufacturing Copper-steel composites behaviour;
- State-of-the-art of Liquid Rocket Engine failure mechanism;
- State-of-the-art of Liquid Rocket Engine life prediction;
- State-of-the-art of Liquid Rocket Engine life numerical analysis;

Experimental Numerical activities:

- Implementation material properties into the numerical analysis software:
  - Thermal properties;
  - Mechanical properties;
  - Fatigue properties;

- Calibration of quasi-static and cycling mechanical models:
  - Numerical calibration of traction tensile tests (room and high temperatures);
  - Numerical calibration of fatigue tests (room and high temperatures);

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- Simulation of Liquid Rocket Engine Main Combustion Chamber (MCC) thermo-mechanical behaviour:
  - Numerical time-dependent thermal analysis;
  - Numerical time-dependent nonlinear mechanical analysis;

- Life prediction of Liquid Rocket Engine Main Combustion Chamber (MCC):
  - Life estimation with 'classic' Low Cycle Fatigue approach;
  - Life estimation with Creep + Fatigue + Plastic instability approach;

Aims:

- To evaluate the potential gain in using the new Cu174PH6535 Additive Manufacturing Metal Matrix Composite for Liquid Rocket Engine Main Combustion Chamber;