**Motivation**

Topology optimization (TO) is used as a design tool for innovative and optimal components. In most cases, these components are non-machinable and new techniques of additive manufacturing (AM) can overcome this issue [1].

One can however pinpoint some limitations:
- Design stage requires too many steps
- Non-functional parts obtained with classical TO

**Objectives of the Thesis**

Three themes are explored in this work:
- Contributions to stress-based TO embedding fatigue failure constraints — improve the solution method.
- Dealing with manufacturing constraints specific to AM within the optimization procedure, e.g. residual thermal stresses.
- Optimal structures with variable density machinable with AM techniques. Application to shocks absorbers (e.g. lattice structures).

**Additive Manufacturing Constraints**

Numerous constraints are needed to be taken into account when machining parts with AM technology. In this work, we will focus on:
- Supports within the optimization problem to optimize the use of (support) material (a) [2]
- Thermal consideration to prevent residual stresses within the components (b) [3]

**Large Deformations & Lattice Structures**

- Definition of the optimal sub-structure of the original optimization problem (a) — Structures with variable porosity [4].
- Design of structures able to sustain shocks, that is to solve a highly dynamically loaded TO problem (b) but for the continuous case [5].

**Stress-based TO for Fatigue Design**

Bruggi and Duysinx (2012) and Bruggi and Duysinx (2013) have proposed a scheme of stress-based topology optimization which can be extended to consider fatigue constraints:

\[
\begin{align*}
\min_{x_{e}: 0 \leq x_{e} \leq 1} & \quad W = \sum_{N} x_{e} V_{e} \\
\text{s.t.} & \quad K(x) U = F, \\
& \quad C / C_t \leq 1, \\
& \quad ||\sigma|| \leq 1,
\end{align*}
\]

where $||\sigma||$ is a relevant fatigue criterion such as Sines, Crossland or Goodman.

When dealing with Stress-based TO embedding fatigue constraints some specific features can be pointed out:
- More CPU time required due to the high number of active constraints
- Thicker members of the structures (heavier structures) but with more rounded shapes — purpose of fatigue design in mechanical engineering

Stress-based TO with fatigue failure constraints needs to be solved more efficiently:
- New structural approximations, or
- New optimization algorithms.

**References**

1. EADS (Airbus Group) bionic bracket

**Acknowledgements**

The author, Maxime Collet, would like to acknowledge the Belgian National Fund for Scientific research (FRIA) for its financial support.