Master of Aerospace Engineering
Research Project

BWB Wingbox Design with Aeroelasticity Constraints

S2 Progress Report

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Starting date of the project: 29 Jan 2019 **Duration**: 14 Months

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1 Goal of the Project

This report is a record of the progress of a research project on BWB Wingbox Design with Aeroelasicity Constraints. The project has a duration of one year duration and will be conducted as part of the second and third semester of the Master in Aerospace Engineering.

The main goal is to create an innovative wingbox design that takes into account the aeroelasticity and apply it to a blended wing body design.

2 Project Issues

To achieve the goal of the project some problems will have to be overcome. The main problem on this project is on the starting point, because the codes needed for this project are in different programming languages. As of now ISAE-Supaero's work in topology optimization is coded in MATLAB by S. Coniglio and the work made in aeroelasticity by J. Mas Colomer is in a toolbox in Python. This language barrier dictates the first task of the project, which will be to translate the topology optimization codes to Python, for everything to be compatible.

3 State of the Art

Before starting the project a state of the art analysis was performed on the topic of topology optimization.

3.1 Topology Optimization

The main part of this project is topology optimization. According to Hayoung Chung (2019) topology optimization is a numerical method that computes an optimal structural layout with a set of objectives and constraints with the goal of getting a lighter structure and that uses less material so that it only has material on the most critical areas. In topology optimization there are some different methods being the most common method called SIMP (Solid Isotropic Materials with Penalization) where the material and void distribution in the design are optimized. On this method the design variable is the density of each finite element.

The paper by Sigmund (2001) presents and explains a 99 line code with a simple approach to topology optimization, the paper Andreassen et al. (2011) presents and explains a more complicated approach with only 88 lines of code, with the same output but more efficient. These papers are helpful when first learning topology optimization.

3.2 OpenMDAO

According to Hayoung Chung (2019) OpenMDAO is a platform developed by Nasa that can handle a large number of variables and disciplines. It is used to solve MDO problems in different fields of engineering and it will be used to build a MDO formulation to design the wingbox through topology optimization.

4 Milestones of the Project

The project is divided in several tasks, being all of them completely dependent on the previous tasks. The milestones are:

- Complete the State of the Art.
- Translate the topology optimization code from MATLAB into Python.
- Build a MDO formulation to design an innovative wingbox through topology optimization.
- Add aeroelasticity constraints with the toolbox developed by J. Mas Colomer.
- Apply the wingbox design with the constraints to a blended wing body design.

After the state of the art the first milestone of the project is finishing translating the topology optimization code, this task is predicted to take the entire semester. The rest of the milestones will be accomplished on the following semester. On this report only the work for the present semester will be explained in detail.

5 Topology Optimization Translation

After the state of the art the next step is translating the topology optimization code into Python, so that it will be compatible with the aeroelasticity toolbox.

5.1 Description of Work

The goal of this task is to translate a topology optimization code developed by S. Coniglio from MATLAB to Python.

To achieve this goal it is crucial to learn the basics of topology optimization and understand well every step it takes to implement it in a code. A lot of different approaches can be used, and to get the most efficient final code all of the different implementation approaches have to be studied.

5.2 Progress Made

After some weeks of work most of the basic knowledge on topology optimization has been learned by reading papers on the topic. To first understand the MATLAB code some other similar but less complicated codes were used. Multiple runs of these codes were made to deeply understand what each parameter is and what changes it can bring to the final structure.

Pure optimization in Python was also studied during this period to learn more about optimization in general, and to refresh the knowledge of Python.

5.3 Plan Versus Achievements

The project progress is on time with what was first predicted. Just as expected the general knowledge of topology optimization that was required to translate the code took long to acquire due to being a new topic.

5.4 Planned Work

The planned work for the rest of the present semester is to keep learning more about topology optimization by reading papers and understanding the simpler codes first.

The translation of the code is planned to start in the next month and it should take around one month.

By the middle of June the code will be finished and the project will be ready to implement the aeroelasticity constraints.

References

Andreassen, E., Clausen, A., Schevenels, M., Lazarov, B. S., and Sigmund, O. (2011). Efficient topology optimization in matlab using 88 lines of code. *Structural and Multidisciplinary Optimization*, 43(1):1–16.

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