Master of Aerospace Engineering - Research Project

HALE AEROECODESIGN

Progress Presentation – 20/05/2020

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SUPAERO

OUTLINE

- GOAL OF THE PROJECT
- MILESTONES OF THE PROJECT
- RESULTS
- CONCLUSION

GOAL OF THE PROJECT

- Refine a modified version of OpenAeroStruct presented in [1]
- MDO of a HALE to minimize the CO_2 footprint
  - MDO ➤ Multidisciplinary Design Optimization
  - HALE ➤ High-Altitude Long Endurance Drone
- Compromise solution between:
  - Convergence of the optimization ➤ Efficiency
  - Complexity of the model ➤ Realistic

Fig. 1: PHASA-35 HALE

[1] E. Duriez and J. Morlier, "Hale multidisciplinary design optimization with a focus on eco-material selection," ISAE Supaero, 2020.

MILESTONES OF THE PROJECT

- Task 1: Add a constraint on the wing surface ✓
- Task 2: Fix some design variables ✓
- Task 3: Turn material function into OpenMDAO component ✓
- Task 4: Set different materials for different parts of the wing
- Task 5: Introduce a more complex buckling model
- Task 6: Add engines as point masses ✓
- Task 7: Model a two dimensional discrete gust

ADD A CONSTRAINT ON THE WING SURFACE

- Reduce snowball effect ➤ Prevent the optimization from diverging
  - Maximum wing surface threshold ➤ 200 m^2

FIX SOME DESIGN VARIABLES

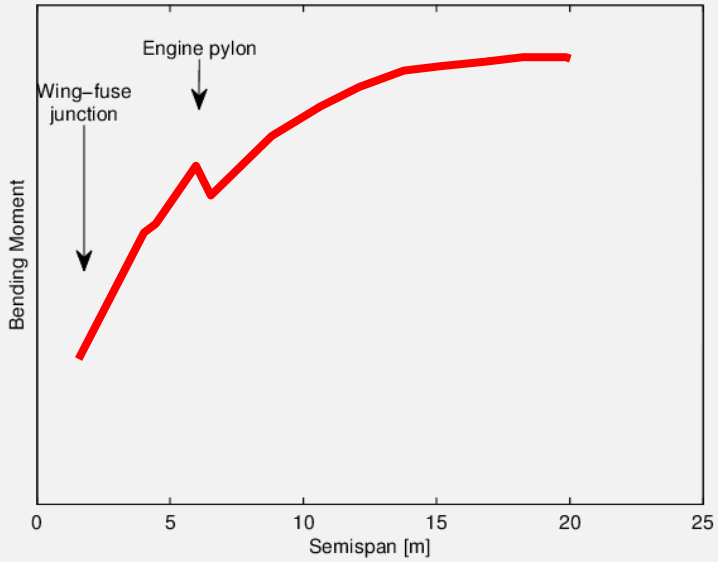
- Make the problem more computationally efficient
  - Fix some optimization variables ➤ tapper ratio, root chord…
  - Finally not used to compare the results in a better way

TURN MATERIAL FUNCTION INTO OPENMDAO COMPONENT

- Component ➤ More efficient for gradient-based optimization
- Replace the existing function by the component
- Access to material properties database and interpolate:
  - Young's modulus (E)
  - Shear modulus (G)
  - Failure strength
  - CO_2 emissions
- Get to know the OpenMDAO methodology

ADD ENGINES AS POINT MASSES

- Two symmetrical engines ➤ Two symmetrical point masses
- New design variable ➤ Engines location
- Same mass as FB single-boom HALE [2]
- Reduce the bending moment on the wing due to lift



[2] D. Colas, N. H. Roberts, and V. S. Suryakumar, "Hale multidisciplinary design optimization part i: Solar-powered single and multiple-boom aircraft," in 2018 AviationTechnology, Integration, and Operations Conference, p. 3028, 2018.

RESULTS

Table 1: Design variable values for validation case

Variable	Units	HALE of [1]	FB HALE [2]	Results w/o engines	Results w/ engines
Span	m	97.5	-	93.5	73.7
Root chord	m	1.4	-	1.4	1.4
Taper ratio	-	0.32	-	0.33	0.30
Total mass	kg	378	320	435	392
Wing surface	m^2	86.6	71.8	83.4	64.3
Aspect ratio	-	94	29	105	84
C_L^{cruise}	-	1.31	1.33	1.56	1.83
$(C_L^{3/2}/C_D)^{cruise}$	-	44.1	40.1	57.8	75.3

[1] E. Duriez and J. Morlier, "Hale multidisciplinary design optimization with a focus on eco-material selection," ISAE Supaero, 2020.

[2] D. Colas, N. H. Roberts, and V. S. Suryakumar, "Hale multidisciplinary design optimization part i: Solar-powered single and multiple-boom aircraft," in 2018 AviationTechnology, Integration, and Operations Conference, p. 3028, 2018.

RESULTS

Table 2: Performance values of the optimization for validation

Performance	Units	HALE of [1]	Results w/o engines	Results w/ engines
Cases	-	24	24	24
Convergences	-	7	12	9
Time	h	2	3	2

[1] E. Duriez and J. Morlier, “Hale multidisciplinary design optimization with a focus on eco-material selection,” ISAE Supaero, 2020.

CONCLUSIONS

- Without engines ➤ Better convergence and better results than in [1]
- With engines ➤ Worse convergence than without engines but better results
- Same differences with respect to [2] as in [1] ➤ Very high aspect ratio
- Need for 1-cosine gust and more complex buckling model

[1] E. Duriez and J. Morlier, "Hale multidisciplinary design optimization with a focus on eco-material selection," ISAE Supaero, 2020.

[2] D. Colas, N. H. Roberts, and V. S. Suryakumar, "Hale multidisciplinary design optimization part i: Solar-powered single and multiple-boom aircraft," in 2018 AviationTechnology, Integration, and Operations Conference, p. 3028, 2018.

THANKS FOR YOUR ATTENTION!

ANY QUESTION?