OPTIMIZING EFFICIENCY OF FLEXIBLE TANDEM WINGS USING NON-LINEAR MODES

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INTRODUCTION

The aerodynamic performance of flexible flapping tandem wings in forward flight is evaluated using a novel non-linear modal superposition approach to carry the transient FSI analysis. It involves complex phenomena and the performance is very susceptible to changes in aerodynamic parameters [1]. An optimization targeting maximum efficiency is performed on three aeroelastic parameters: flexibility, flapping frequency and amplitude.

THE PROBLEM

The modal approach is based on superimposing the amplified vibrational modes of the structure. It is very powerful for Fluid Structure Interaction (FSI) problems but works only when displacements are very small, in the linear range. This is not the case of slender structures such as the wings of a dragonfly [2].

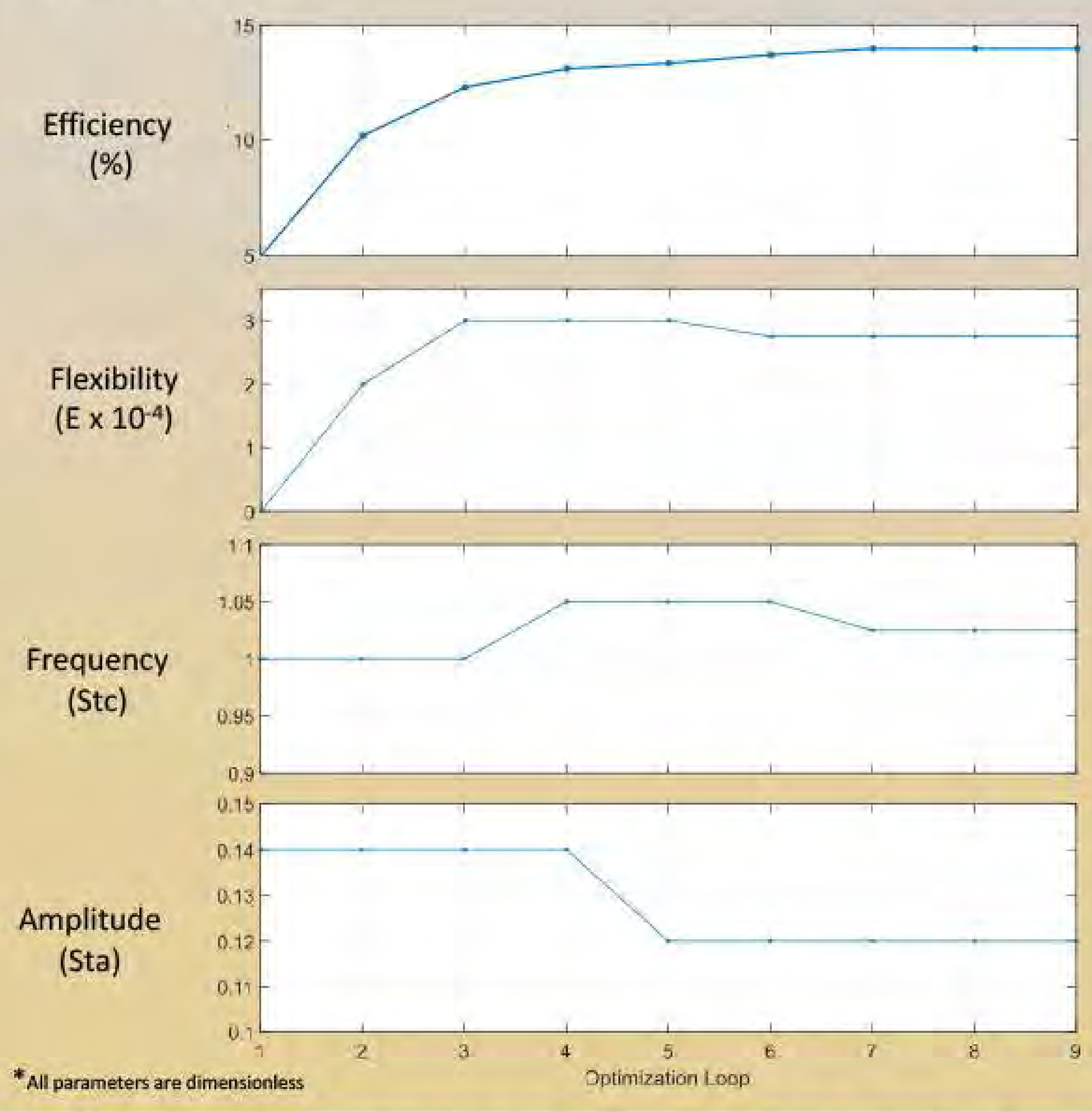
THE SOLUTION

A non-linear modal approach is obtained by creating corrector modes that act over the original linear structure. Corrector modes are obtained by geometrically preserving chord length and width, and by conserving the kinetic energy of the underlying linear modes. The result is a realistic wing deformation in the non-linear range of displacements, obtained as the linear superimposition of the original plus the corrector modes, following a Taylor expansion approach.

After the linear and the corrector modes are obtained, they can be embedded on the CFD solver using rbf™, precomputing each morphing field [3]. At this point a static or transient simulation can be achieved by morphing the mesh following a classic modal superposition approach.

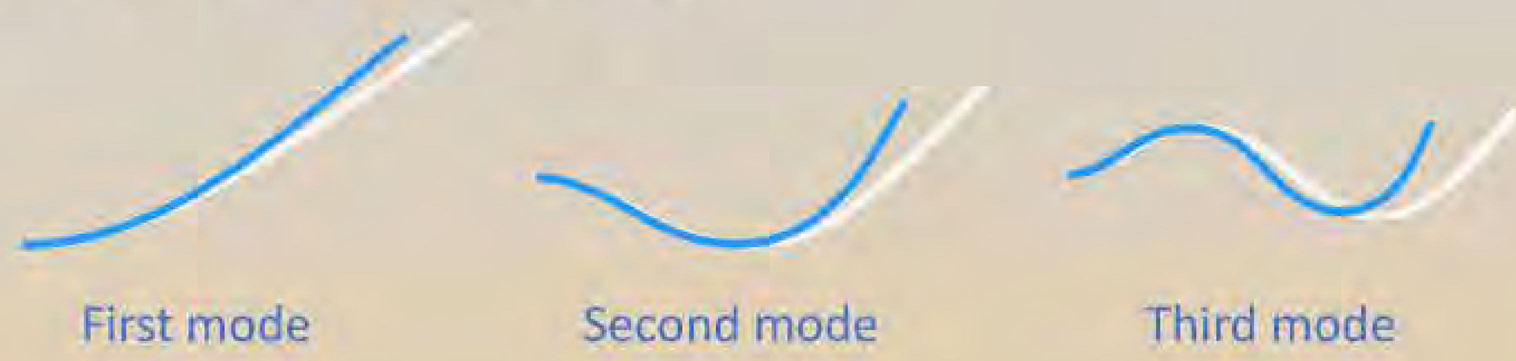
$$\underbrace{R(t)}_{\text{Deformation}} = \underbrace{\sum_{n=1}^{L} \beta_n \, q_n(t)}_{\text{Linear modes}} + \underbrace{\sum_{n=1}^{NL} \gamma_n \, p_n(t)}_{\text{Non-linear modes}}$$

OPTIMIZATION



*All parameters are dimensionless

LINEAR VS NON-LINEAR MODES



CONCLUSION

Propulsive efficiency is enhanced by tuning the aeroelastic parameters. The proposed method has allowed to optimize a non-linear FSI problem requiring limited computational resources.

REFERENCES

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