Towards robust calculations in axial blade/disk attachments

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Abstract

The aim of this work is to extend the calculations used for power transmissions to the technology and design of high-pressure turbine blade-disk attachments. In this context, the use of a mixed method combining semi-analytical formulations with a limited number of finite element computations has significantly reduced computation times compared to conventional methods relying on full finite element modelling. However, the current modelling approach is based on simplifying assumptions aimed at testing the feasibility of the method and estimating the reduction in computation time.
Given the geometry of the parts under study, several surfaces of the blade will be simultaneously in contact with other surfaces of a sector of the disk. So, one of the first challenges of this work will be to be able to solve several contacts at the same time by starting from a model that solves one contact at a time between two surfaces.

To answer this question, we have chosen an approach that decouples the effect of the global structural deformation due to the flexion of the part from the effect of the local deformation on the pressure distribution due to local contact. This type of approach is often used to calculate load sharing on gears and splines (1).

To compute the local deformation due to contact, we use a scale separation approach between the global scale associated with the attachment and the local scales related to the contact areas. An initial equilibrium is established between the local variables used to control the various contacts calculated upstream and the contact pressures obtained at the output of the semi-analytical (SA) model. This SA model has already been employed in several previous studies, such as the prediction of fretting and wear in blade-disk attachments (2). Then, a second equilibrium is achieved between the contact pressures and the applied load in the global frame using an iterative numerical method until full load equilibrium is reached.

The numerical method is then tested under loading conditions representing the various types of forces that can be applied to the attachment during operation. Finally, the results obtained from the local contact resolution are compared to those from an existing code that also isolates the structural deformations.

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To account for the effects of structural deformation, the SA model will later be coupled with a finite element model isolating only the effects of global structural deformation. This will provide a structural displacement that will be added to the local displacement to obtain a complete model as in (3).

Further work is planned to take account friction in the contact using Coulomb's law, plasticity, inertial effects due to rotation and thermal effects, in order to make the modelling more robust and realistic.

References

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