International Research Training Group IRTG 2657
Computational Mechanics Techniques in High Dimensions

Numerical Modeling of Wear in Conforming Contact Joints

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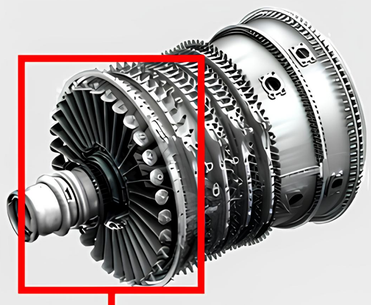
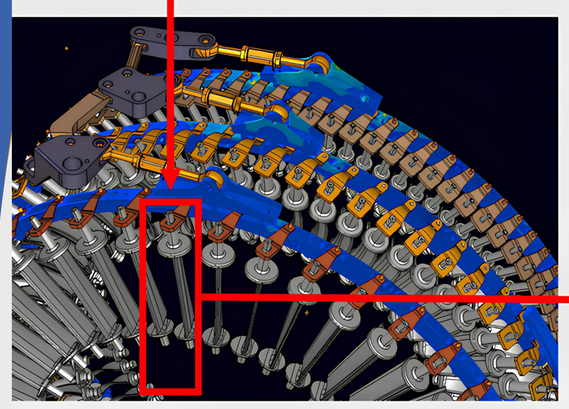
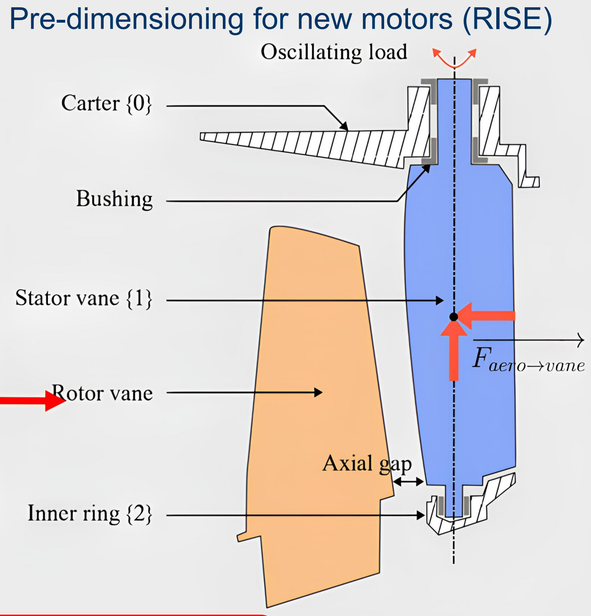
Second Cohort – Starting Date: 04/11/2024, CIFRE Project with Safran Aircraft Engines

Motivation



- VSV (Variable Stator Vane) system improves high-pressure compressor efficiency
- Helps reduce the risk of compressor surge
- System includes critical parts such as bushings
- VSV (Variable Stator Vane) vanes are subjected to localized oscillating loads
- Bush wear is difficult to detect and leads to significant compressor degradation
- Predictive maintenance for current motors is capital
- Pre-dimensioning for new motors (RISE)



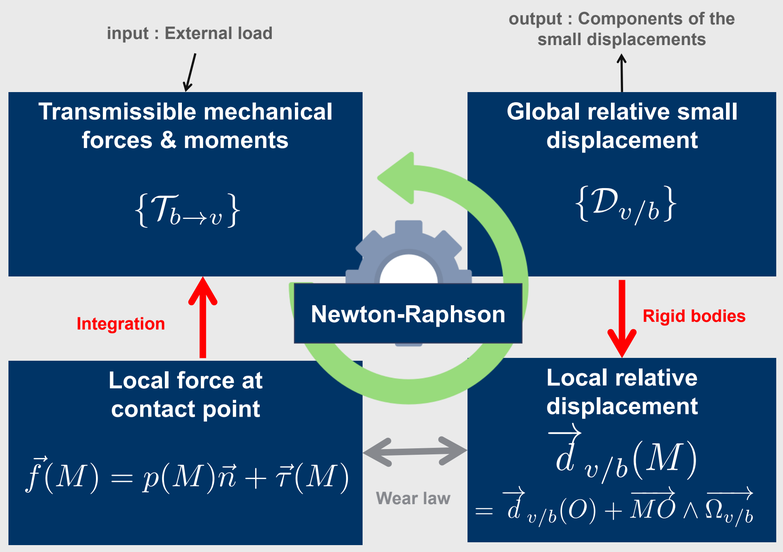


Need a pre-design tool to predict shop visit and reduce time development

[Kato et al. 2014]

- Multiple contact systems (a stage of compressor)
- Simulation of a large number of flight cycles
- Fast and reliable computation in order to accelerate the design process of new generations of motors (RISE)
- Alignment with engineering office needs and constraints (In collaboration with SAFRAN Aircraft Engines WRS YRMS)

Method



Assumptions

- Rigid bodies
- No roughness
- Wear law: based on Archard law
- Constant effective sliding velocity
- Newton-Raphson : analytical or numerical jacobian

[Harnafi et al. 2024]

Wear Law

[Archard 1953], [Fouvry 1996]

$$p(M,t) = \frac{1}{K_u |v_g(M,t)| \Delta t} \left\langle \overrightarrow{d}_{v/b}(M,t) \cdot \vec{n} - j - u(M, t-\Delta t) \right\rangle_+$$

$p(M,t)$: Contact pressure at point M and time t

K_u : Wear coefficient (experimental identification in collaboration with SAFRAN Aircraft Engines WRS YQ)

$|v_{g(M,t)}|$: Absolute value of the sliding

Δt : Time step

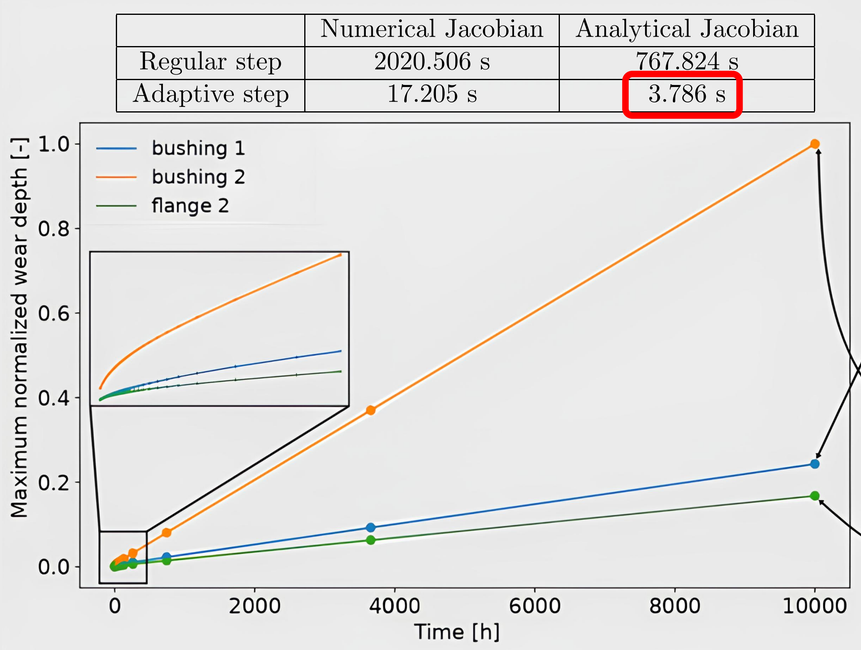
$\vec{n}$: Normal vector of the contact surface

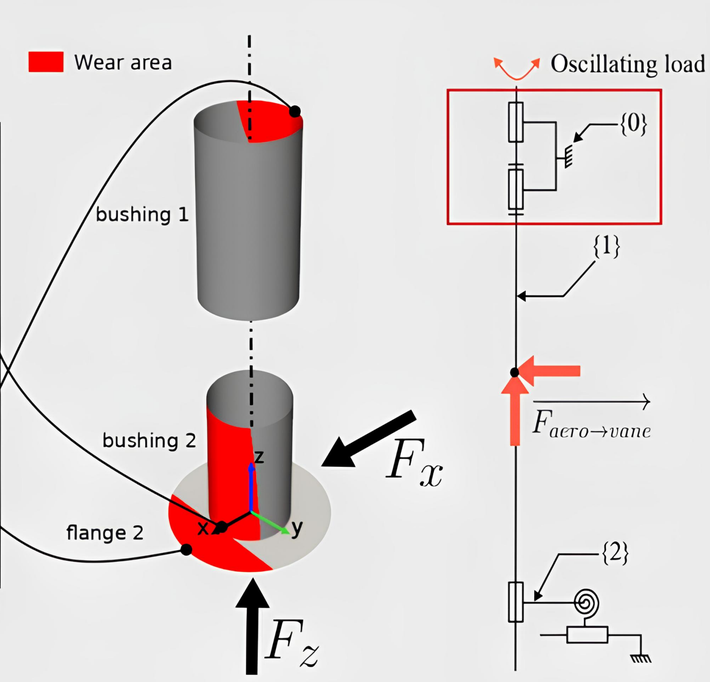
j : Initial gap

$u(M, t-\Delta t)$: Wear depth at point M and previous step time

Numerical Results

	Numerical Jacobian	Analytical Jacobian
Regular step	2020.506 s	767.824 s
Adaptive step	17.205 s	3.786 s





- Effect of inner ring is neglected for this simulation
- Evolution of wear is non-linear at the beginning of simulation
- An adaptive step algorithm based on the linearity of evolution of wear is used
- Regularization of the rigid bodies move is realized by artificial soft spring

Research Environment

- First IRTG Symposium August 2024
- IRTG Workshop April 2025
- Workshop CSMA Juniors 2025, Toulouse, France
- Participation in Colloque des assemblages, Saint-Ouen, France
- Participation in Congrès Français de Mécanique 2025, Metz, Franc

Next steps

- Extension to spherical joint
- Consideration of complex assemblies with defects
- Experimental identification & validation (in collaboration with SAFRAN Aircraft Engines WRS YQ)
- Integration in FEM code as a user element to simulate a complete VSV system

References

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Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation