FAN OPTIMIZATION FOR IMPROVED AEROELASTIC AND AERODYNAMIC PERFORMANCE

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Keywords: flutter of fan, structural optimization.

When designing a compressor blade, designers should not only consider its aerodynamic performance, but also ensure its flutter stability. In this study, in order to improve the flutter stability for the first flap(1F) mode of a ducted fan at 85% design speed, the blade's natural frequency is increased by manually adjusting the radial thickness distribution of the fan blade and the twist-to-plunge ratio is reduced by optimizing the sweep shapeof the fan. The twist-to-plunge ratio is defined in Equation (1) which can be found in reference [1]:

$$\alpha = \frac{xLE - xTE}{0.5(xLE + xTE)}, \qquad (1)$$

where xLE and xTE are the magnitudes of displacements at the blade leading and trailing edges, respectively. During the twist-to-plunge ratio optimization, the maximum equivalent stress is set as the constraint. The frequency and twist-to-plunge ratioofthe 1F mode of the fan at 85% speed before and after the optimization are listed in table 1.

Table 1 – The frequency and twist-to-plunge ratio of the fan at 85% speed

	Initial	After adjusting the radial thickness	After optimizing the sweep shape
Frequency (Hz)	194.52	216.47	215.14
Twist-to-plunge ratio	0.44	0.51	0.48

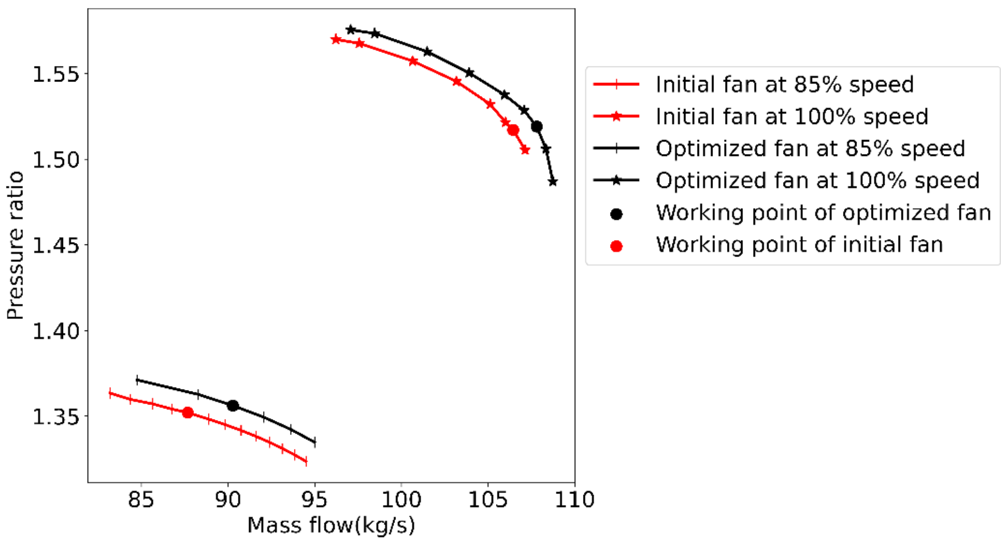

Fig. 1 – Pressure ratio characteristics

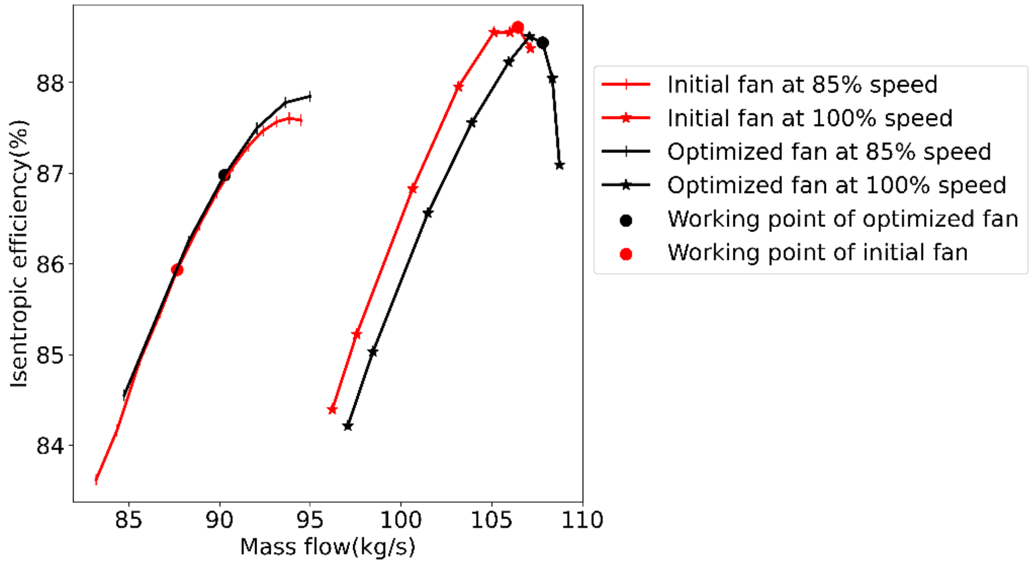

Fig. 2 –Isentropic efficiency characteristcs

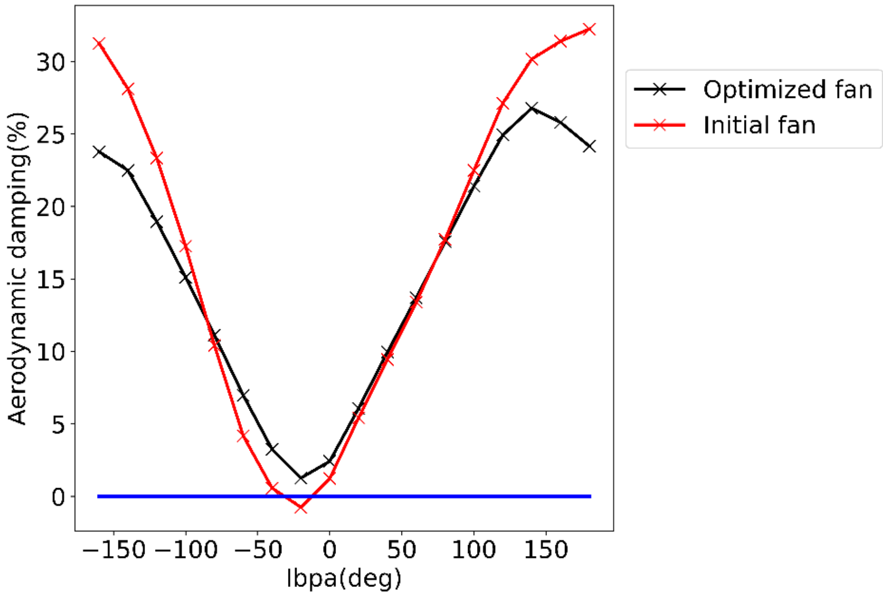

Fig. 3 – Aerodynamic damping

Then the aerodynamic performance of the modified fan is improved by changing some blade profile parameters through optimization. Pressure ratio of the core and bypass of the fan are maintained the same as that of the initial fan at two working points. The isentropic efficiency of the modified fan is improved after optimization at 85% speed. However, the isentropic efficiency is 0.2% lower than that of the initial fan at the working point at 100% speed. Figures 1 and 2 show the speed lines of the initial and optimized fans. It can be seen that the speed lines move to the right and the mass flow increases at the working point. Figure 3 shows the aerodynamic damping of the 1F mode with different ibpasat 85% speed. The minimum aerodynamic damping of the fan is increased to 1.265% from -0.755%, which means that the risk of flutter is eliminated.

References

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