Indeed, there were some axial compressors with shrouded stators. The paper studied the influence of shrouded stator seal-tooth leakage on axial compressor performance in detail and gave sound conclusions. However, there is an unsolved problem: Does the existence of stator shroud influence performance markedly? The paper did not answer this problem directly since it had not tested the compressor with unshrouded stator and compared the experimental results. Nevertheless, according to the explanation of Figs. 3 and 4, it seems the answer of the authors was no evident influence. Indeed, there were some axial compressors with shrouded stators whose performances were acceptable. But Jefferson and Turner (1958) did report the negative influence of stator shroud on the aerodynamic performances including efficiency and stall margin.

The discusser had an opportunity to take part in developing a 4500 hp class gas turbine locomotive in China in the 1970s. The design of the compressor was based on a widespread prototype 11-stage unshrouded subsonic compressor, which had been successfully applied in many cases in China. The design philosophy of the prototype was very common in early years; for example, the profile of blades is similar to C-4, the reaction is a little larger than 0.5. The only modifications to the prototype were: shrouding all stators for mechanical considerations, adjusting the size exactly to scale to suit the demand of flow rate (power output), adding an extrapolating stage in front of the original prototype to raise the pressure ratio. Except for the shrouding stator, other modifications had a successful record, so the gas turbine was manufactured without testing the compressor beforehand.

Contrary to everyone’s expectation, the aerodynamic performance of the compressor, especially the stability performance, deteriorated seriously. The slope of characteristics in the pressure ratio—reduced mass flow rate diagram became much gentler and the surge line went down a lot compared with the design characteristics, which can be seen in Fig. D1. At first, we did not believe it was caused by shrouding stators, and adjusted it with many regular approaches, for example, adjusting the rotating inlet guide vane, optimizing the air inlet system to lower inlet distortion, minimizing the shrouded stator cavities and labyrinth seal-tooth leakage, and so on. But no apparent improvement occurred. At last, after we changed the mechanical design and only resumed the cantilevered stators, then the compressor characteristics became very close to the original design condition (see Fig. D1), and the gas turbine locomotive could be developed successfully and run in the Chinese railway.

Owing to conditions in China at that time, we could not study these phenomena in detail. However, it was assumed that the improvement after discarding the shroud was due to the alleviation of stator hub secondary flow caused by the rotating rotor surface, since the rotating direction of rotor is opposite to the hub secondary flow. Then, some stator shroud treatments were proposed to eliminate the negative influence of shroud on aerodynamic performance but maintain the positive influence on the mechanical design.

The detail had been reported in a journal published in Chinese and was not well-known in the world. In the late 1970s and early 1980s, several Chinese gas turbines and jet engines with shrouded stators and poorer stalling performance were changed to cantilevered stators according to above-described discovery. Improvement to varying degrees on stalling performance was obtained; however, it was not as evident as shown in Fig. D1.

Therefore, the influence of stator shroud on the compressor performance, especially the influence mechanism, has not yet been studied thoroughly. Why is the influence strong for some cases but negligible for other cases? The turbomachinery theory and experimental ability have advanced greatly. It is the right time to research it in detail.

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Ruixian Cai

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