Numerical study of super-critical carbon dioxide flow in stepped-staggered labyrinth seals

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The structure of the stepped-staggered labyrinth seals

In this study, a new kind of axial labyrinth seals, called stepped-staggered labyrinth seals, has been described to reduce process gas escaping from the shaft end of SCO2 compressor.

This new seal uses stepped structure to avoid the assembly problem and form a staggered chamber in each step to reduce the shaft end leakage, which combines the advantages of stepped and staggered labyrinth seal.

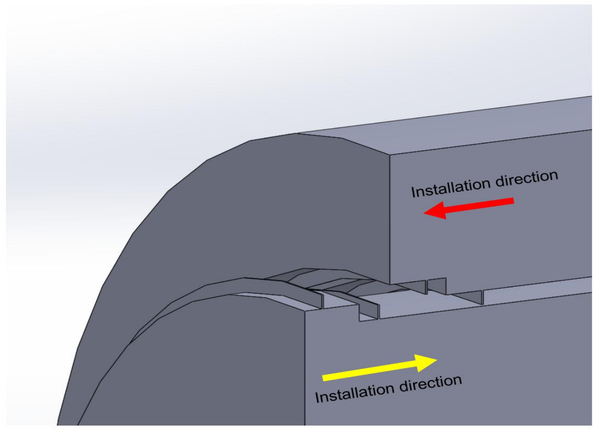


Fig.5 Stepped-staggered labyrinth seal

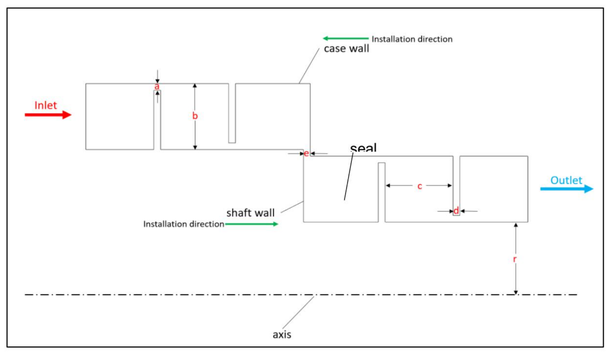


Fig 7 The structure of stepped-staggered labyrinth seal

Performance compared with see-through labyrinth seals

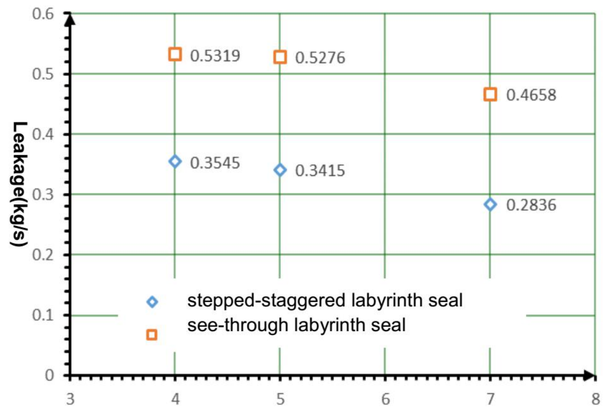


Fig 9 The numerical results of stepped-staggered and see-through labyrinth seal

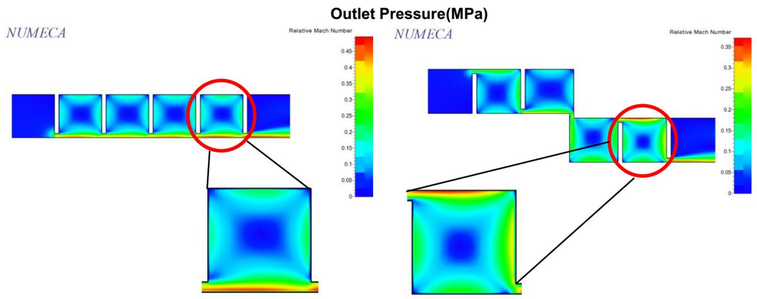


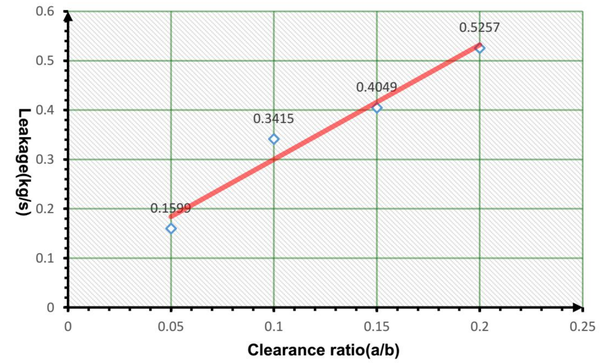
Fig 10 The relative Mach number distribution of stepped-staggered and see-through labyrinth seal

To compare the sealing performance of see-through and the new stepped-staggered labyrinth seal, we operate a five-tooth see-through labyrinth.

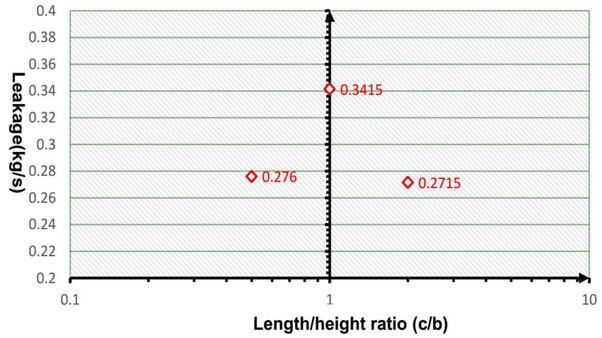
It can be concluded that the new stepped-staggered labyrinth seal has better sealing performance than see-through with the same seal clearance and sealing length.

From the CFD contour, the relative Mach number distribution of the new labyrinth seal is much more dispersive, which means a much stronger viscous dissipation occurring in seal cavity, so the Mach number is smaller and the seal effect is better.

The effect of different structure



a. The leakage rate increases with increase in radial clearance



b. The seal performance is worst when length/height ratio is equal to 1, and the sealing performance shows a good symmetry of geometric topology with length/height ratio

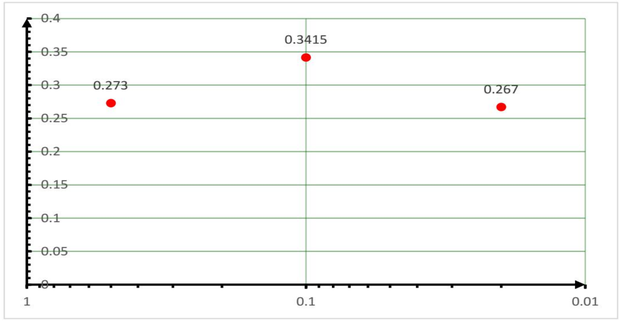


Fig 15 The numerical results of labyrinth with different tooth width/height ratio (in a log coordinate)

c. It may exist a best width/height ratio which will lead to the least leakage