Physics-Based Preconditioning for Anisotropic Flow

Fluid flow inside the air gap is characterized by strongly anisotropic velocity components, with the azimuthal velocity exceeding the axial and radial components by several orders of magnitude. When solving the resulting linear system, this difference in magnitude can lead to a stronger influence of the dominant velocity direction on the solution and potentially weaker resolution of the smaller velocity components. To this end, the use of preconditioners can help to improve the conditioning of the linear system and thus stabilize and accelerate the solution process.

Since the dominant flow inside the air gap is known, special preconditioning methods may be employed which make use of this physical information. In addition to physics-based and block preconditioners, approaches exploiting dominant flow directions, multigrid methods adapted to anisotropic problems, and modifications on the discretization level may provide possible solutions to this issue. At the same time, transformations of the linear system should maintain the physical interpretation of the resulting solution, including dimensional consistency and, where applicable, consistency of the associated system energy.

Therefore, numerical strategies will be discussed based on the ability to exploit the known anisotropic flow structure to improve the conditioning and solution of the resulting linear systems while maintaining consistency with the physical dimensions and relevant energy norms of the underlying problem.