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# Lifespan of static magnetic fluid seals and their recovery via shaft rotation: The interplay between magnetophoresis and hydrodynamics

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The lifespan of static magnetic fluid seals (MFS) is limited by the formation of dense particle packing under the seal tooth due to magnetophoresis. The only method to extend their service life is periodic shaft rotation, which can homogenize the magnetic fluid. Calculating such flows is challenging due to the complex description of viscosity, diffusion coefficients, and the resulting hydrodynamics of concentrated suspensions. Within the magnetic fluid volume of an MFS – specifically at sub-millimeter scales – fluid viscosity, particle mobility, and the thermodynamic factor can vary by orders of magnitude.

In this study, modified Russell, Carnahan-Starling, and Krieger-Dougherty relations were employed to describe these variations. The problem was solved numerically using the finite volume method. To ensure the conservativeness of the scheme, a MUSCL approach with van Leer limiters was implemented. It is shown that shaft rotation generates meridional flows near the rectangular tooth (Fig. 1c, d), which effectively mix the magnetic fluid (Fig. 1a, b). This leads to its gradual homogenization and significantly extends the durability of the MFS.

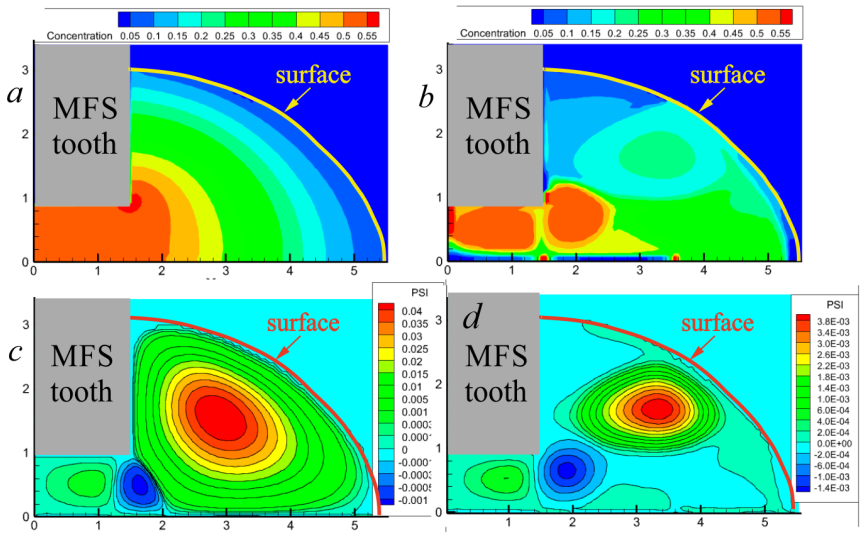


Figure 1: (a) Initial concentration distribution; (b) concentration distribution at $t = a/U_0 = 4200$ (a is the gap in the MFS, $U_0$ is the shaft velocity); (c) streamlines at $t = 1$; (d) streamlines at $t = 4200$.

**Type**:

Oral