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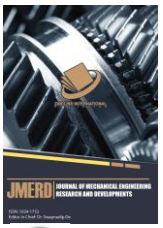

FERROFLUID LUBRICATION OF A LONGITUDINALLY ROUGH ROTATING CIRCULAR STEP BEARING

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ABSTRACT

This investigation tries to examine the effect of magnetic fluid lubrication on the behaviour of a longitudinally rough rotating circular step bearing resorting to the stochastic model of Christensen and Tonder. The magnetic fluid flow model given by Neuringer Rosensweig is used here. The pressure distribution is obtained by solving the Reynolds type equation associated with the bearing system. Then the load carrying capacity is calculated. The graphical results presented here establish that the magnetic fluid lubrication offers significant help to the longitudinal roughness pattern to enhance the performance of the bearing system. This assistance of magnetic fluid became more favorable when the plates rotate in opposite direction.

KEYWORDS

Step bearing, roughness, ferrofluid, rotation, load carrying capacity

NOMENCLATURE

r	Radial coordinate
r_o	Outer radius
r_i	Inner radius
R	$= \frac{r}{r_o}$
k	$= \frac{r_i}{r_o}$ =Radii ratio
h	Lubricant film thickness
$\dot{h}$	Squeeze film velocity
μ_0	permeability of the free space
$\bar{\mu}$	Magnetic susceptibility
μ	Absolute viscosity of the lubricant
μ^*	$-\frac{h^3 \mu_0 \bar{\mu}}{\dot{\mu} h}$ = Dimensionless magnetization parameter
p	Lubricant pressure
P	Non-dimensional pressure
P_s	Dimensionless supply pressure
ρ	Density of lubricant
S	Non-dimensional rotational inertia
Ω_u	Angular velocity of upper plate
Ω_l	Angular velocity of lower plate
Ω_r	$\Omega_u - \Omega_l$
Ω_ϕ	Ω_l / Ω_u – Rotation ratio
w	Load carrying capacity
W	Dimensionless load carrying capacity

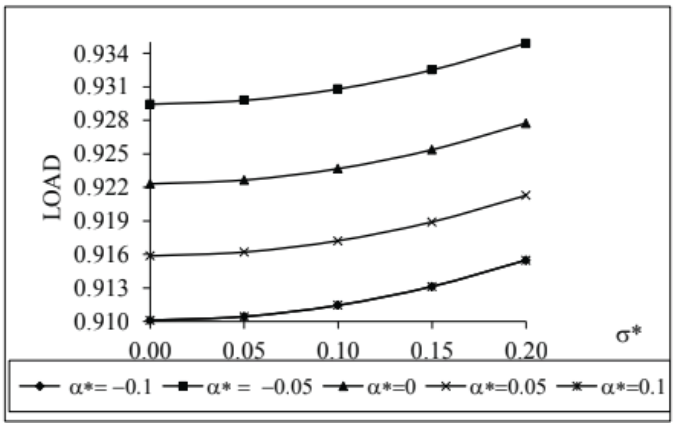

Figure 6: Variation of load carrying capacity with respect to σ* and α*

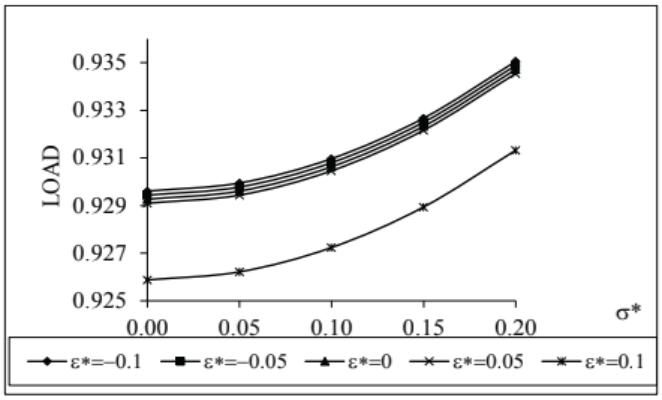

Figure 7: Variation of load carrying capacity with respect to σ* and ε*

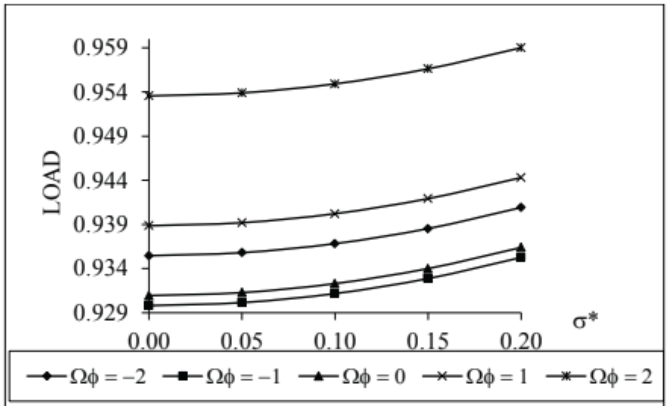

Figure 8: Variation of load carrying capacity with respect to σ* and Ω_{φ}

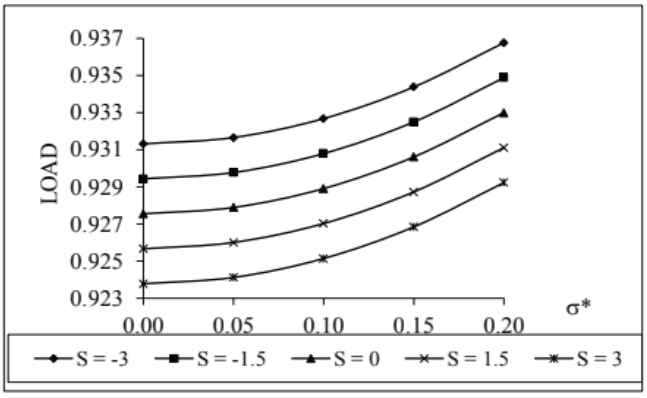

Figure 9: Variation of load carrying capacity with respect to σ* and S

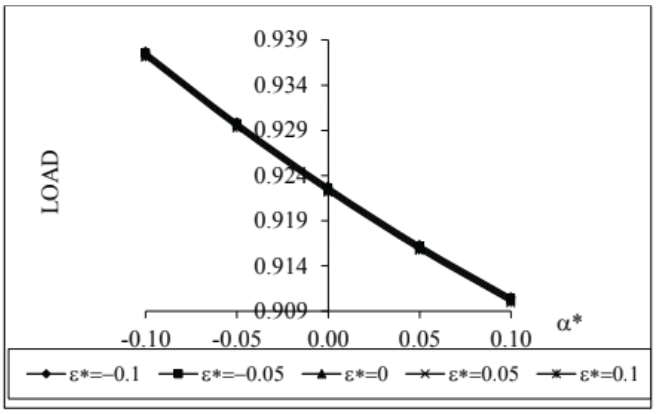

Figure 10: Variation of load carrying capacity with respect to α* and ε*

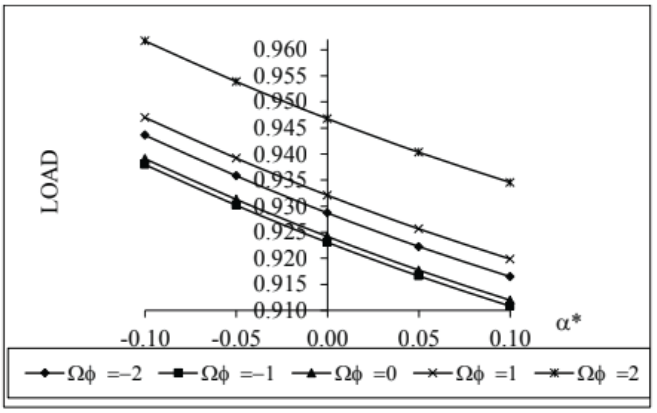

Figure 11: Variation of load carrying capacity with respect to α* and Ω_{φ}

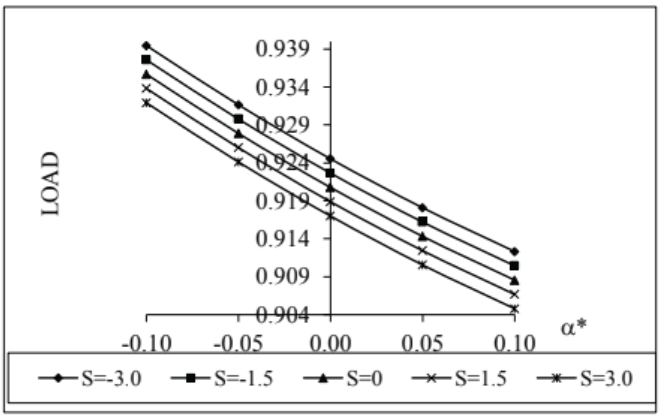

Figure 12: Variation of load carrying capacity with respect to α* and S

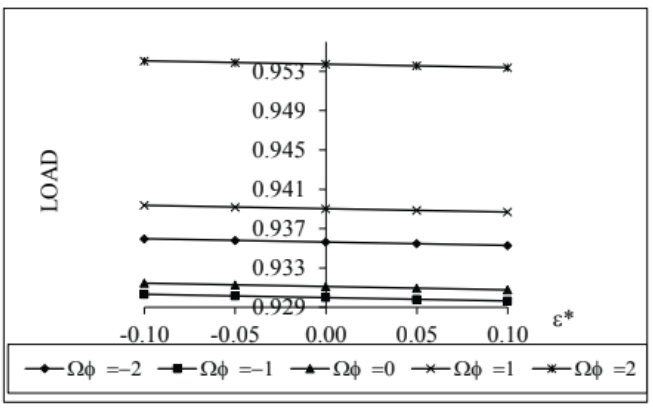

Figure 13: Variation of load carrying capacity with respect to ε* and Ω_{φ}

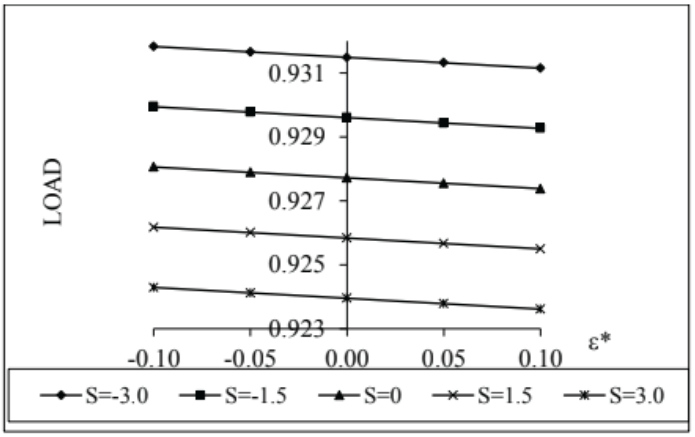

Figure 14: Variation of load carrying capacity with respect to ε* and S

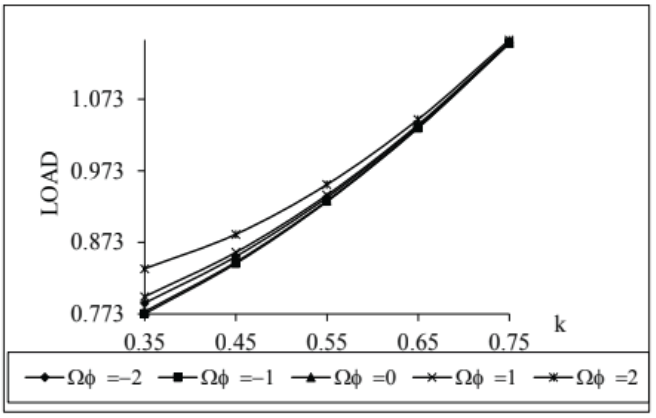

Figure 16: Variation of load carrying capacity with respect to k and Ω_{φ}

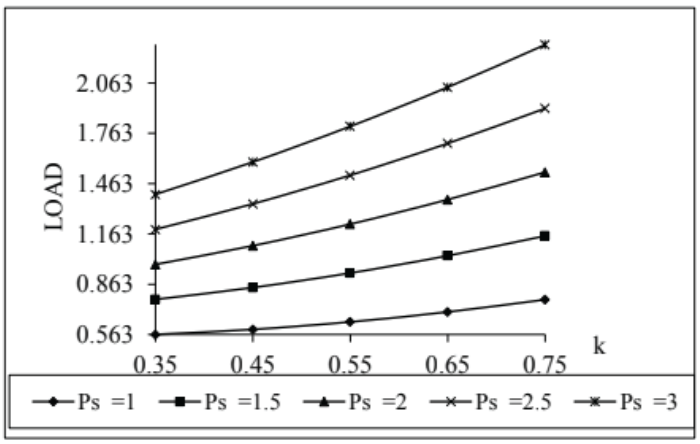

Figure 15: Variation of load carrying capacity with respect to k and Ps

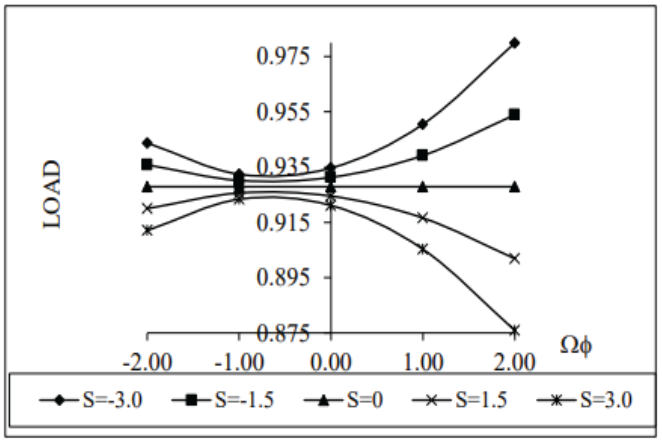

Figure 17: Variation of load carrying capacity with respect to Ω_{φ} and S

Table 1: Variation of load carrying capacity for various values of μ*and k

	Ps=1	Ps=1.5	Ps=2	Ps=2.5	Ps=3
μ*=0.0000	0.63357185	0.92524835	1.21692484	1.50860133	1.80027783
μ*=0.0010	0.63357560	0.92525209	1.21692859	1.50860508	1.80028157
μ*=0.0100	0.63360932	0.92528581	1.21696231	1.50863880	1.80031529
μ*=0.1000	0.63394651	0.92562301	1.21729950	1.50897599	1.80065249
μ*=1.0000	0.63731846	0.92899495	1.22067145	1.51234794	1.80402443

Table 2: Variation of load carrying capacity for various values of μ* and Ps

	Ps=1	Ps=1.5	Ps=2	Ps=2.5	Ps=3
μ*=0.0000	0.63357185	0.92524835	1.21692484	1.50860133	1.80027783
μ*=0.0010	0.63357560	0.92525209	1.21692859	1.50860508	1.80028157
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μ*=0.1000	0.63394651	0.92562301	1.21729950	1.50897599	1.80065249
μ*=1.0000	0.63731846	0.92899495	1.22067145	1.51234794	1.80402443

Table 3: Variation of load carrying capacity for various values of σ* and k

	k=0.35	k=0.45	k=0.55	k=0.65	k=0.75
σ* = 0.00	0.75935967	0.83463388	0.92491164	1.03035116	1.15019558
σ* = 0.05	0.76026377	0.83521797	0.92525209	1.03052121	1.15026120
σ* = 0.10	0.76297609	0.83697025	0.92627344	1.03103133	1.15045804

σ* = 0.15	0.76749660	0.83989071	0.92797569	1.03188154	1.15078610
σ* = 0.20	0.77382533	0.84397936	0.93035884	1.03307184	1.15124539

Table 4: Variation of load carrying capacity for various values of σ*and Ps

	Ps=1	Ps=1.5	Ps=2	Ps=2.5	Ps=3
σ*= 0.00	0.63323515	0.92491164	1.21658814	1.50826463	1.79994112
σ*= 0.05	0.63357560	0.92525209	1.21692859	1.50860508	1.80028157
σ*= 0.10	0.63459695	0.92627344	1.21794994	1.50962643	1.80130292
σ*=0.15	0.63629920	0.92797569	1.21965219	1.51132868	1.80300517
σ*=0.20	0.63868235	0.93035884	1.22203533	1.51371183	1.80538832

Table 5: Variation of load carrying capacity for various values of σ* and k

	k =0.35	k =0.45	k =0.55	k =0.65	k =0.75
α*= 0.10	0.76898205	0.84085038	0.92853505	1.03216093	1.15089390
α*= 0.05	0.76026377	0.83521797	0.92525209	1.03052121	1.15026120
α*= 0.00	0.75335370	0.83075374	0.92265003	1.02922157	1.14975971
α*= 0.05	0.74824508	0.82745334	0.92072633	1.02826075	1.14938897
α*= 0.10	0.74493116	0.82531239	0.91947844	1.02763747	1.14914847

Table 6: Variation of load carrying capacity for various values of α* and Ps

	Ps=1	Ps=1.5	Ps=2	Ps=2.5	Ps=3
α*=-0.10	0.63685856	0.92853505	1.22021155	1.51188804	1.80356453
α*=-0.05	0.63357560	0.92525209	1.21692859	1.50860508	1.80028157
α*= 0.00	0.63097354	0.92265003	1.21432653	1.50600302	1.79767951
α*= 0.05	0.62904984	0.92072633	1.21240282	1.50407932	1.79575581
α*= 0.10	0.62780194	0.91947844	1.21115493	1.50283142	1.79450792

Table 7: Variation of load carrying capacity for various values of ε* and k

	k =0.35	k =0.45	k =0.55	k =0.65	k =0.75
ε* = -0.10	0.76071414	0.83550892	0.92542168	1.03060591	1.15029388
ε* = 0.05	0.76026377	0.83521797	0.92525209	1.03052121	1.15026120
ε* = 0.00	0.75981341	0.83492701	0.92508250	1.03043650	1.15022851
ε* = 0.05	0.75936305	0.83463606	0.92491292	1.03035180	1.15019583
ε* = 0.10	0.75891268	0.83434510	0.92474333	1.03026709	1.15016314

Table 8: Variation of load carrying capacity for various values of ε* and Ps

	Ps=1	Ps=1.5	Ps=2	Ps=2.5	Ps=3
ε* = -0.10	0.63374519	0.92542168	1.21709818	1.50877467	1.80045116
ε* = -0.05	0.63357560	0.92525209	1.21692859	1.50860508	1.80028157
ε* = 0.00	0.63340601	0.92508250	1.21675900	1.50843549	1.80011198
ε* = 0.05	0.63323642	0.92491292	1.21658941	1.50826590	1.79994240
ε* = 0.10	0.63306683	0.92474333	1.21641982	1.50809631	1.79977281

Table 10: Variation of load carrying capacity for various values of k and S

	S=-3.0	S=-1.5	S=0	S=1.5	S=3.0
k=0.35	0.76526781	0.76026377	0.75525974	0.75025570	0.74525167
k=0.45	0.83845081	0.83521797	0.83198513	0.82875229	0.82551945
k=0.55	0.92713642	0.92525209	0.92336777	0.92148345	0.91959913
k=0.65	1.03146236	1.03052121	1.02958005	1.02863890	1.02769775
k=0.75	1.15062435	1.15026120	1.14989804	1.14953488	1.14917173

Table 11: Variation of load carrying capacity for various values of Ps and Ω_φ

	Ω_φ =-2	Ω_φ =-1	Ω_φ =0	Ω_φ =1	Ω_φ =2
Ps=1.00	0.63960543	0.63395246	0.63508306	0.64299721	0.65769492
Ps=1.50	0.93128192	0.92562896	0.92675955	0.93467370	0.94937141
Ps=2.00	1.22295842	1.21730545	1.21843604	1.22635019	1.24104790
Ps=2.50	1.51463491	1.50898194	1.51011254	1.51802669	1.53272440
Ps=3.00	1.80631140	1.80065844	1.80178903	1.80970318	1.82440089

Table 9: Variation of load carrying capacity for various values of Ps and S

	S=-3.0	S=-1.5	S=0	S=1.5	S=3.0
Ps=1.00	0.63545992	0.63357560	0.63169128	0.62980696	0.62792263
Ps=1.50	0.92713642	0.92525209	0.92336777	0.92148345	0.91959913
Ps=2.00	1.21881291	1.21692859	1.21504426	1.21315994	1.21127562
Ps=2.50	1.51048940	1.50860508	1.50672076	1.50483644	1.50295211
Ps=3.00	1.80216590	1.80028157	1.79839725	1.79651293	1.79462861

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