Parametric Study of Braking Torque for Magneto Rheological Brake

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ABSTRACT

The proposed brake consists of multiple rotating disc immersed in Magneto Rheological Fluid and an enclosed electromagnet .when current is applied to electromagnet ,Magneto Rheological fluid solidifies as its yield stress varies as function of magnetic field .This controllable yield stress produces shear friction on rotating disc which generates Braking torque. The braking torque value depends upon number of parameters like 1.current 2.Magnetic field3.Rotor Radius 4.Surface area 5.Volume of MR fluid 6.No.of disc 7 Magneto Rheological fluid Type 8.Gap Size 9.Use of heat removal Technique 10.Angular velocity. In order to minimize the stopping distance to 10mm at response time of 5 sec. the brakes need to have generate maximum torque upto level of 200 N/mm2 to have maximum braking torque .It is required to optimize the values of above parameters to get minimized stopping distance.

Keywords***: Shear stress, Magneto Rheological Brake,Magneto Rheological Fluid, strain rate, Braking Torque***

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1. INTRODUCTION

The yield stress of Magneto Rheological Fluid can be controlled by varing the applied current [1] .The torque characterstics of Magneto Rheological Brake are Controlled by regulating yield stress of Magneto Rheological fluid[2].On application of Magnetic field ,Magneto Rheological fluid changes its state from Liquid to semi-solid particle aligns themselves in strong chain,due to such a chaining yield strength of fluid increases which opposes friction between stator And rotor and hence fulfills braking function[3]A dynamic yield stress is function of the magnetic field B and exponentially increases with respect to magnetic flux density.[4]The torque transmissibility of An Magneto Rheological Brake depends much on properties of magneto Rheological fluid such as dynamic yield stress and viscosity.[5]

To model behavior of Magneto Rheological fluids the Bingham plastic model is used.[6]Magneto Rheological Braking torque depends upon material used, effective working surface,Magneto Rheological fluid,applied current density and viscous torque of fluid.[7] The design and experimental evaluation of Magneto Rheological Brake has been done by Li and Du[8] A new structure of Magneto Rheological Brake with waveform boundary of disc that generate dmore resistance torque than conventional one[9] A dynamic finite element analysis was performed to study effect of appling repeated cycles of pressing and resisting brake on heat build upand showed that operating temperature can be intermittently reach outside Temperature range of fluid.[10]. The limitations of gap plays a significant role in shear rate .In many researches, the particle gaps are typically 0.25 to 2 mm for Ease of manufacturing and assembly[11]

Since aluminium ring is magnetically non-conductive It prevents Magnetic circuit shorting around coil and forces it to go though Magneto Rheological fluid gap.[12]In order to reduce weight and size of Magneto Rheological Brake the preferred ratio of Ri/Ro lies between 0. 7 To 0.99[12].The performance of Magneto Rheological devices is relatively insensitive to temperature over a broad temperature range.[13]

1.1 Input Current

Table No.1

Input current (Amp.)	Output torque(Nm)
1	25
0.8	20
0.6	15
0.4	10
0.2	5

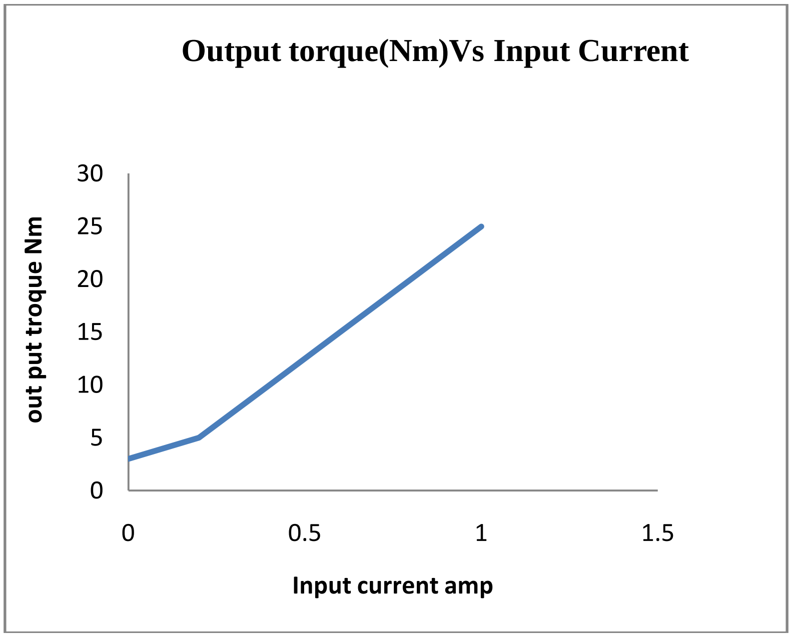

Fig.No.1

Torque increases with Input current linearly at Maximum 1amp current we get 23 Nm of Maximum Torque through Magneto Rheological Brake.

1.2 Rotor Radius

Table No.2

Rotor Radius(mm)	Output Torque (Nm)
29	29
37	37
42	42
45	45
50	50

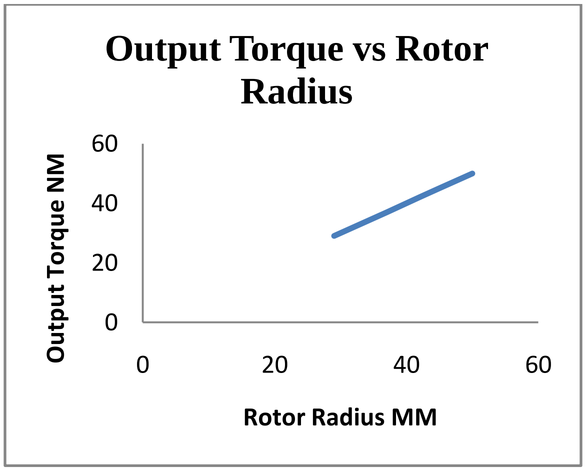

Fig.No.2

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Output Torque Increases with rotor radius exponentially at 5omm Rotor radius we get 25 Nm of Torque.

1.3 Number of Disk

Table No.3

Number of Disc	Output Torque
7	100
6	85
5	70
4	50
3	38
2	22
1	10

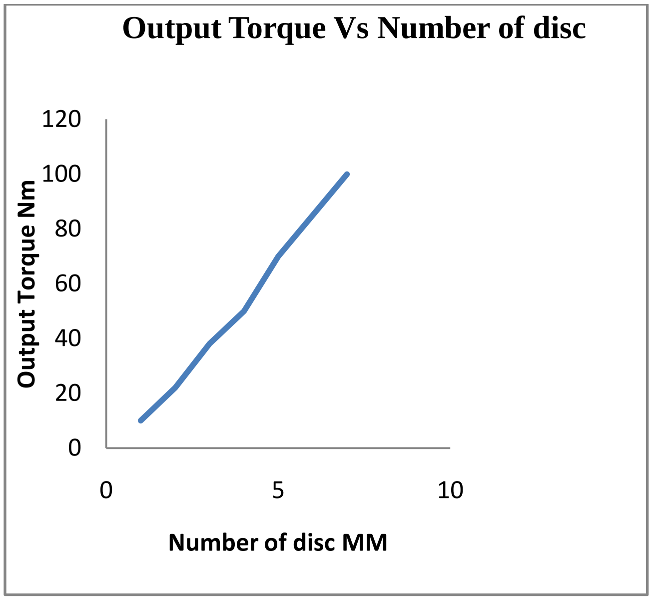

Fig.No.3

Torque increases exponentially with increase in number of disc.Magneto Rheological Brake can generate 10 Nm torque with seven disk.

1.4 Number of Disk

Table No.4

Gap size(MM)	Output Torque(Nm)
0.005	12
0.01	8
0.015	6
0.02	5
0.025	3

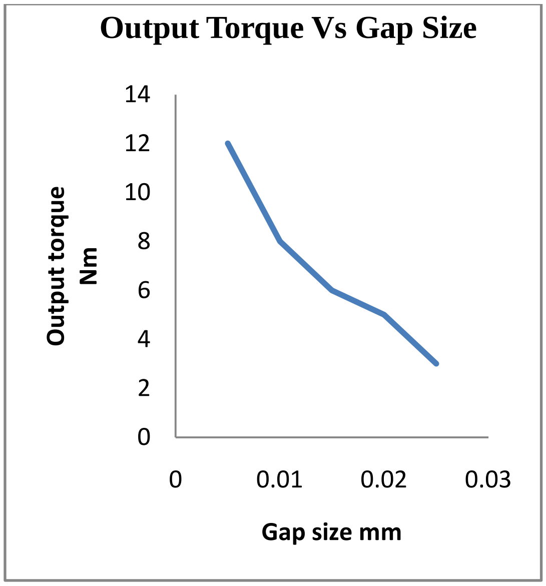

Fig.No.4

If Gap size is decreased Braking torque get decreased as braking torque is inversely propotional to Gap size.

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1.5 Angular Velocity

Table No.5

Angular velocity (RPM)	Output Torque (Nm)
100	0.4
200	1.2
300	1.7
400	2.8
500	3.2

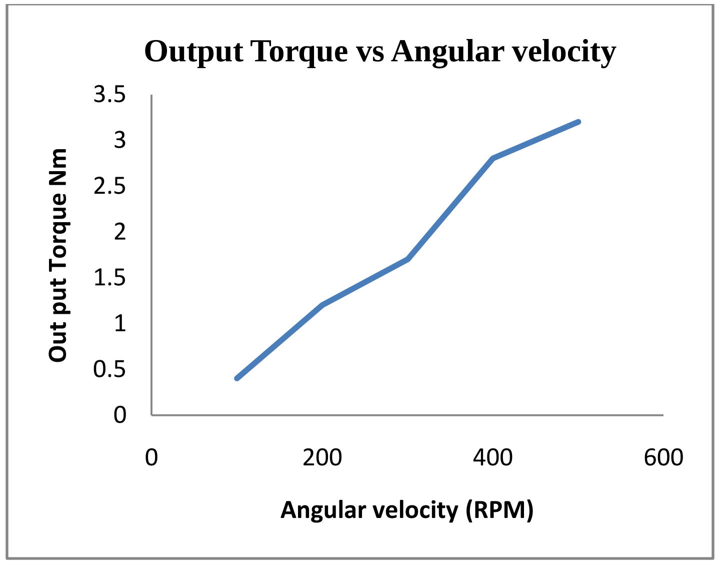

Fig.No.5

Torque increases with increase in angular velocity linearly.

1.6 Temperature

Table No.6

Temperature	Time
25	0
26	20
27	40
28	60
33	100
35	120

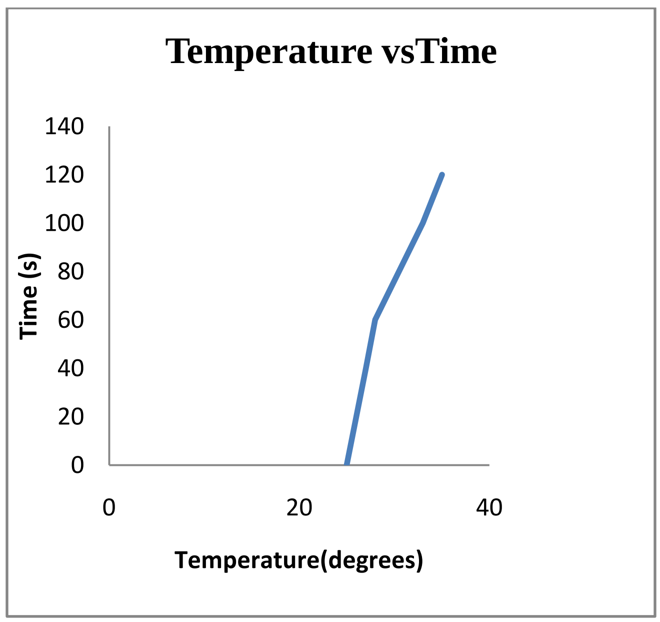

Fig.No.6

The operating temperature range of Magneto Rheological fluid is -40 to 130 degrees

Magneto Rheological Brake can work efficiently for period of 100s for speed upto 500rot/min. and For higher dpeed like 1420 rot/min.device can work for only 60 sec.The viscocity of fluid decretses with increase in temperature

$\mu = Ae^{ßt}$

2. Braking Torque

This can be stated by Bingham model as The yield strength can be controlled by current in coil.

$$\tau=\tau H+\mu p \hat{\upsilon} \quad (1)$$

For four plane disks Magneto Rheological Brake configuration equation number (1) can be modified by integrating yield stress over entire surface of disk having inner radius Ri and Outer radius Ro. Magnetic field on rotor surface will be different at different radius

$$T= 2*3.14/3 * \tau\ y*h*(ro^3- r\ i^3) +3.14/2h*N*\mu P(ro^4-ri^4)ws \quad (2)$$

Where ws is the rotational speed of the disk(s).

Table No.7 Calculation of Braking Torque

Ri(m)	Ri(m)	t (m)	Tyd (mPa)	Viscosity (Pa-s)	Velocity (Rad/s)	No. of disk	Torque (N-m)
0.1	0.025	0.05	10000	0.214	44.7	1	22.69
0.1	0.025	0.05	10000	0.214	44.7	2	42.37
0.1	0.025	0.05	10000	0.214	44.7	3	62.07
0.1	0.025	0.05	10000	0.214	44.7	4	81.75

3. CONCLUSION

From above graphs t is found that Braking torque value depends upon current supplied,Number of disks and Rotor radius and inversely proportional to Gap Size.

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