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Design of internal expanding brake system for controlling high end rpm of turbines

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ABSTRACT
In this concept the internal expanding brake system works on the principle of centrifugal force (under no load condition). This internal expanding brake system is similar to that of mechanical brake system, which is used to control the speed of the turbine when it is rotating at its maximum speed ranges from 5000 to 6000 rpm. The main advantage of this new brake system is to reduce the vibrations by proper balancing of the mass on both sides by use of brake shoes and there will be no sudden impact because as this brake type used is disc & drum type system. This brake system can be applied to any high speed rotating devices or machines. This paper unfolds the steps involved in the design of brake system for controlling high end speeds based on centrifugal action.

Keywords: Internal expanding brake system, centrifugal force, Turbine, solidworks2014, Tension spring.

1. INTRODUCTION

1.1. Brakes

Still other braking methods even transform kinetic energy into many other forms, for example by transferring the energy to a rotating flywheel. Brakes are generally applied to wheel, rotating axles or turbine shaft, but may also take other forms such as the surface of a moving fluid. Since kinetic energy increases with velocity, an object moving at some speeds has 100 times as much energy as one of the same mass moving at low speeds. Friction brakes on automobiles or other high speed devices store braking heat in the drum brake or disc brake. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also reduces the speed of wheel. Since analysis of solution is not possible with both combination of loads with varying contour of the brake drum, so finite element approach is done to evaluate the accurate stresses on the internal expanding brake of this shoe is a kind of brake are contained within the drum and expand outwards when the brake is applied. This type of brakes is used in medium heavy-duty vehicles [1]. In conventional brake system they used to take asbestos as the brake material but by eventually rise in the standards of technology there were certain developments undergone for manufacturing of brake material using different materials. which leads to increase in the standards and working of the brake systems. So they have considered contemporary dry and wet friction pads and shoes for better standards and differentiated them according to their standards and efficiency [2]. They studied on the comprehensive review of works on disc brakes squeal, so they have conducted studies on vibrations produced due to mechanical action on disc brake in order to make understand the problem to many people and several disc brakes have been considered for a review on squeal produced in disc brake system [3]. This is designed and modified from the existing brake model [4].

1.2. Working Principle of Brake

A force, arising from the body's inertia, which appears to act on a body moving in a circular path and is directed away from the centre around which the body is moving (fig.1).

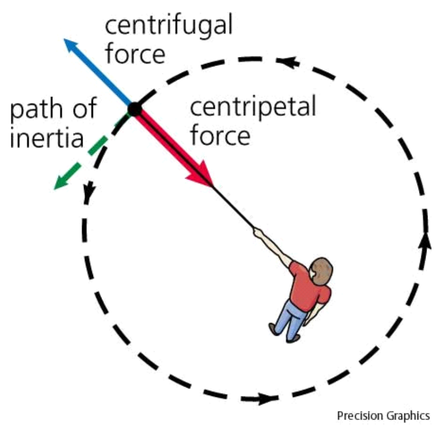

Figure 1 Concept of Centrifugal

Due to centrifugal action, the shoes move away and try to hit the drum which is fixed to slow down the turbine. This system activates only when the turbine reaches 5000 rpm to 6000 rpm (fig.2).

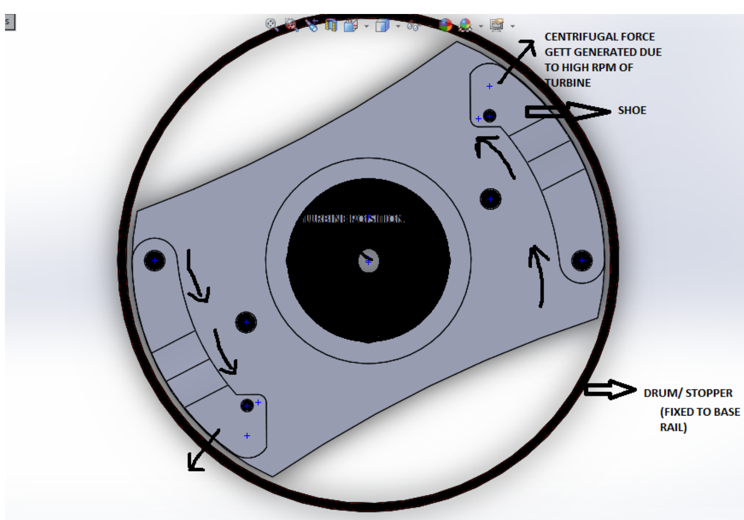

Figure 2 Working and labelled

1.3. Specifications

- DESIGNED TO CONTROL SPEED - 5000 TO 6000 RPM
- MASS - .45 kg (assumed)

- CENTER OF MASS - X = 0.09, Y = 3.50, Z = -0.04
- BRAKE ENGAGEMENT - Friction
- BRAKE TYPE - Disc , Drum
- MATERIAL ACCORDING TO SAE STANDARDS -

  SAE J431 — Grey iron castings.
  SAE J101 — Performance and durability of wheel cylinders for drum brakes.
  SAE J1713 — Determining strength and fatigue life of disc brake system for vehicles.

2. DESIGN CALCULATION AND OBSERVATIONS

2.1. Parameters to be considered

M – Mass

R – Radius

N – RPM

K – Spring rate/ spring constant

X – Displacement

F – Brake force

ω – Angular velocity.

From the formula $F = mr\omega^2$, we calculate the brake force at different rpm's as shown in (TABLE 1) and then by considering F and X values we evaluate K(spring constant), (fig.3).

Table 1 Representation of Force's developed at various RPM's

RPM	Mass (kg)(assumed)	Radius (mm)	Force (N)
1000	.45	51.71	255.178
2000	.45	51.71	1020.714
3000	.45	51.71	2296.609
4000	.45	51.71	4082.857
5000	.45	51.71	6379.465
6000	.45	51.71	9186.430

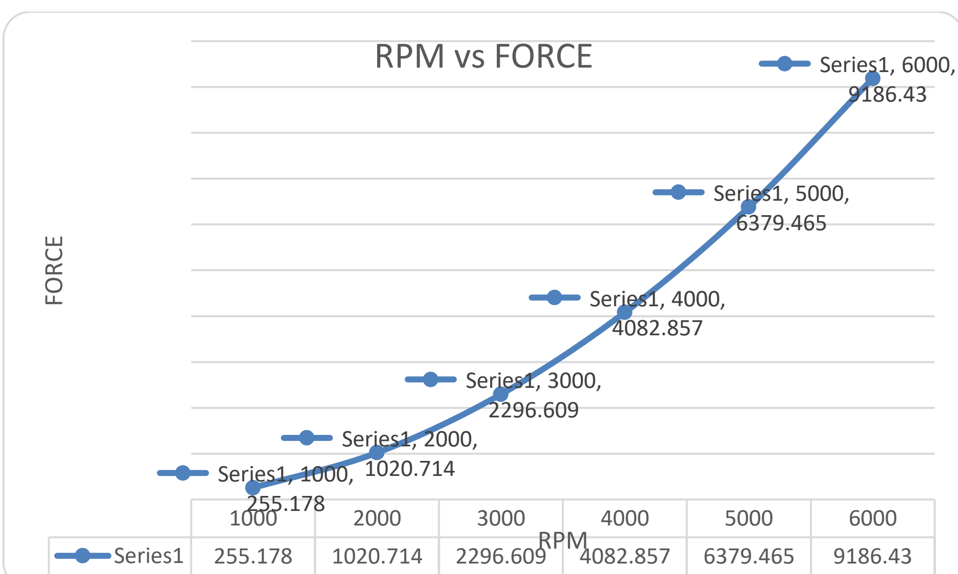

Figure 3 Graph between RPM vs FORCE

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Now we calculate the spring rate at different "X" values, which is seen in (fig.4).

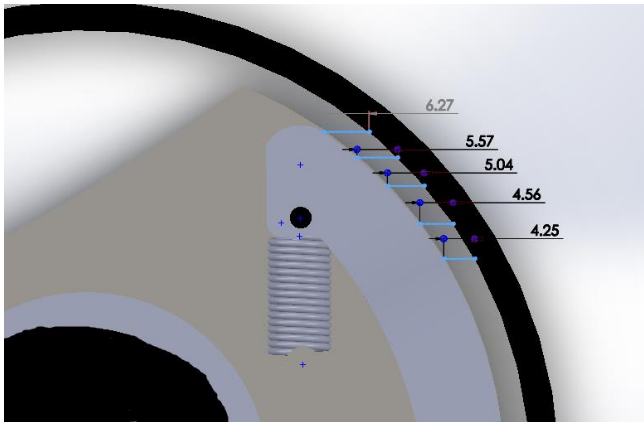
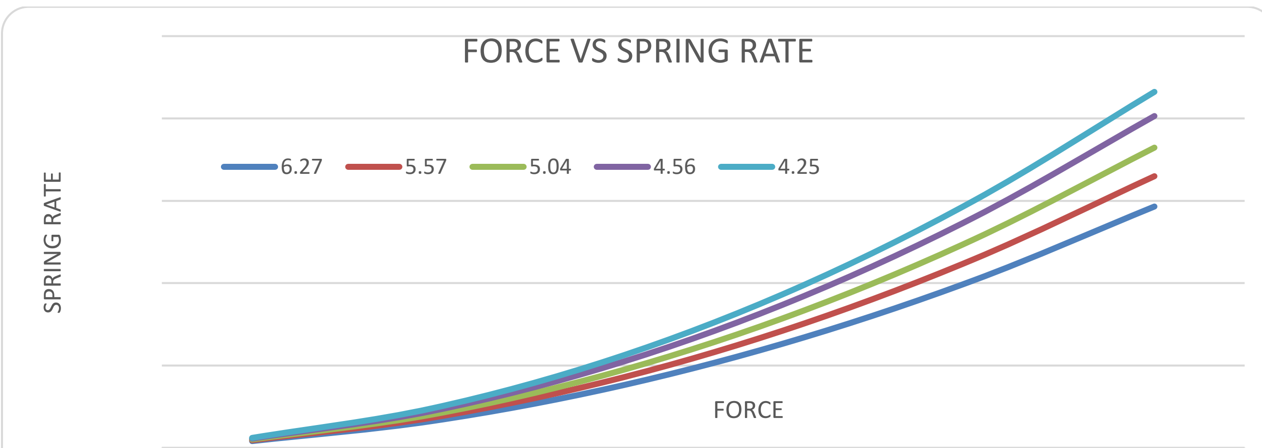


Figure 4 No.of iteration of value 'x' taken



	255.178	1020.714	2296.609	4082.857	6379.465	9186.43
6.27	40.6	162.79	366.28	651.17	1017.45	1465.14
5.57	45.81	183.25	412.31	733	1145.32	1649.26
5.04	50.63	202.52	455.67	810.09	1265.76	1822.7
4.56	55.96	223.84	503.64	895.36	1399	2014.56
4.25	60.04	240.16	540.37	960.67	1501.05	2161.51

Figure 5 Graph between FORCE vs SPRING RATE

Table 2 Representation of Spring rate w.r.t Force and Displacement

Force (N)	Displacement (mm)	Spring rate , K (N/mm)
255.178	6.27	40.6
	5.57	45.81
	5.04	50.63
	4.56	55.96
	4.25	60.04
1020.714	6.27	162.79
	5.57	183.25
	5.04	202.52

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	4.56	223.84
	4.25	240.16
2296.609	6.27	366.28
	5.57	412.31
	5.04	455.67
	4.56	503.64
	4.25	540.37
4082.857	6.27	651.17
	5.57	733.00
	5.04	810.09
	4.56	895.36
	4.25	960.67
6379.465	6.27	1017.45
	5.57	1145.32
	5.04	1265.76
	4.56	1399.00
	4.25	1501.05
9186.430	6.27	1465.14
	5.57	1649.26
	5.04	1822.70
	4.56	2014.56
	4.25	2161.51

Here, in the (TABLE 2) the value 'X' is inversely proportional to spring constant 'K'. And spring constant was calculated according to the force applied and the displacement obtained in the design. By this design, we say that at 5000 rpm the brake need to be activated and where the tension spring should reach the maximum rate of 1501.05 N/mm and minimum of 1017.45 N/mm (fig.5).

3. CONCLUSION

It is conclude that the brake which is designed gives no damage to the turbine when working at high speeds. Where it is better when compared with the previous model in terms like vibrations, mass, balancing and performance. So by installing this we have better working progress for longer period of time.

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Conflict of Interest:
The authors declare that there are no conflicts of interests.

Data and materials availability
All data associated with this study are present in the paper.

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