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VENTILATED BRAKE DISCS FOR COMMERCIAL VEHICLE PURPOSE

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Abstract:

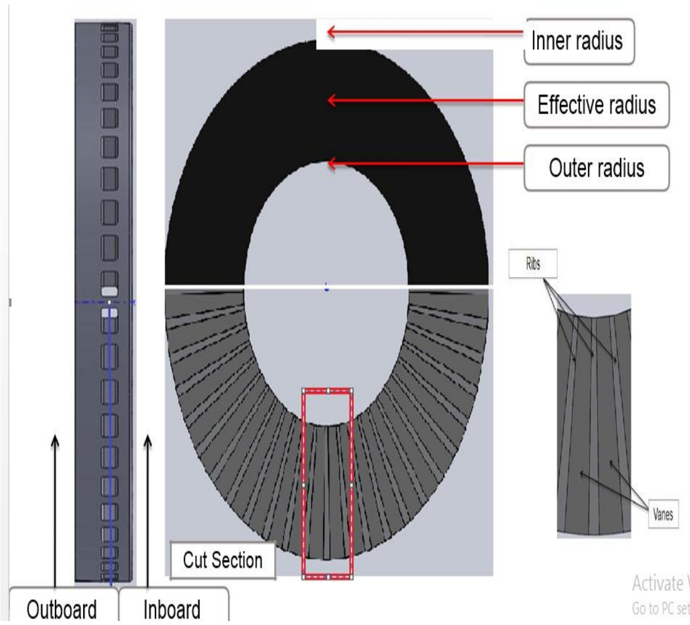
The main objective of this study is to assess how brake discs dissipate heat by taking an example of a Radial vane brake disc which is made in Solid works 2010 version. The assessment has been carried out for the radial vane brake disc in experimental on a test rig and computational forms using ansys 12 cfx package. Results were obtained and verified.

KeyWords

Brake Disc,Test Rig,Radial vane,Air Jet

1.Introduction:

The main objective of this study is to assess how brake discs dissipate heat by taking an example of a Radial vane brake disc which is made in Solid works 2010 version. The assessment has been carried out for the radial vane brake disc in experimental on a test rig and computational forms using ansys 12 cfx package. Results were obtained and verified.



2.Patent survey:

Year: Year of patent.

Description: A brief description of design and terminology in the particular brake disc design.

Prior Art: Prior Art of a patent constitutes all information that has been made available to the public in any form before a given date that might be relevant to a patent's claims of originality.

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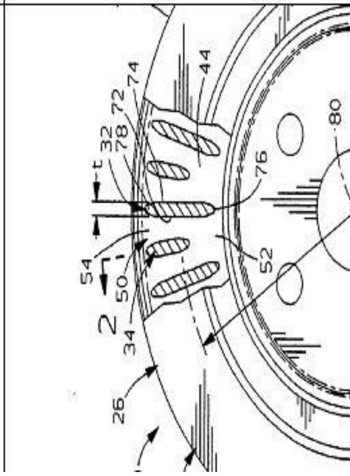
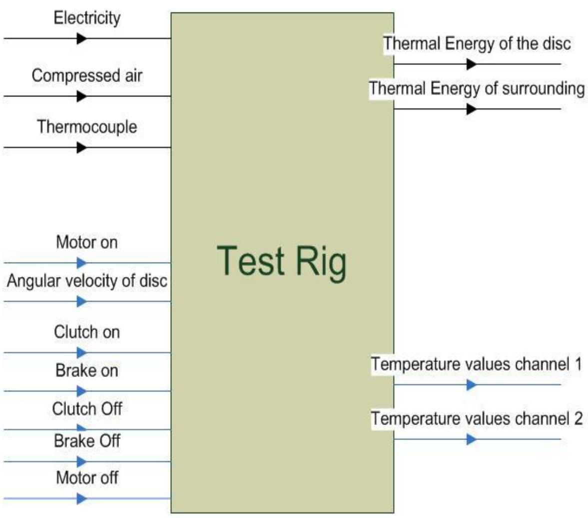
Patent No	Year	Patent Description	Diagram	Prior Art
US 5492205	1996	A brake rotor exhibits improved air flow cooling characteristics and includes an optimum number of vanes, a passage profile designed to reduce flow restrictions and an alternate **longer-shorter vane configuration to accommodate the rotor air flow regime.**		**Conventional brake rotors generally include a pair of mutually spaced-apart annular disks which present two opposed external surfaces for the application of a braking actuator.** The space between the disks typically includes a number of vanes with flow passages that extend between the disks from their inner diameter to their outer diameter disposed between each pair of adjacent vanes. Rotation of the rotor causes the vanes to induce air flow through the flow passages from the inner diameter to the outer diameter of the disks providing increased heat transfer from the rotor. Brake rotor design plays an important role in brake cooling. **A brake rotor is generally designed for use within a particular application where surrounding structures impact the rotor's size.** Constraints exist on the outer and inner diameters of the rotor's air flow area and on the total rotor thickness between

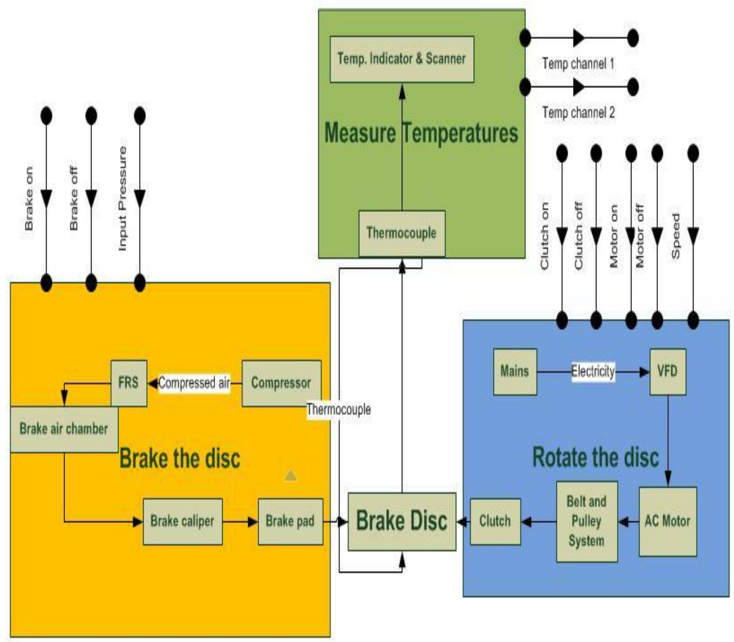
3.The Test rig:

A test rig was used as a standard that could measure temperatures on the surface of the disc with respect to variable parameters like disc rotational velocity, brake force etc. The functional requirements were taken into account before proceeding..

The major functional Requirements such as the rotation of the disc, braking of the disc, temperature along with the Inputs & Outputs to System are required initially to start the experiment. A black box representation of the rig is shown below comprising of various inputs and outputs for various conditions



The schematic of the test rig involving all the parameters are shown in a more detailed manner in the figure as shown.



The inputs are in both the figures involving conditions on clutch and compressed air is used for the testing along with a thermocouple to measure the temperature. The clutch on and off represent the engaging and disengaging of the brake. The electricity shown as an input represents the pneumatic braking of the disc.

There are certain pros and cons associated with the test rig experiment. The advantages are that is has a good braking system, economical and works at

varying rpm and pressures. The disadvantage is that it cannot produce temperatures in real time magnitude.
The test was conducted for four different cases for 10 cycles i.e

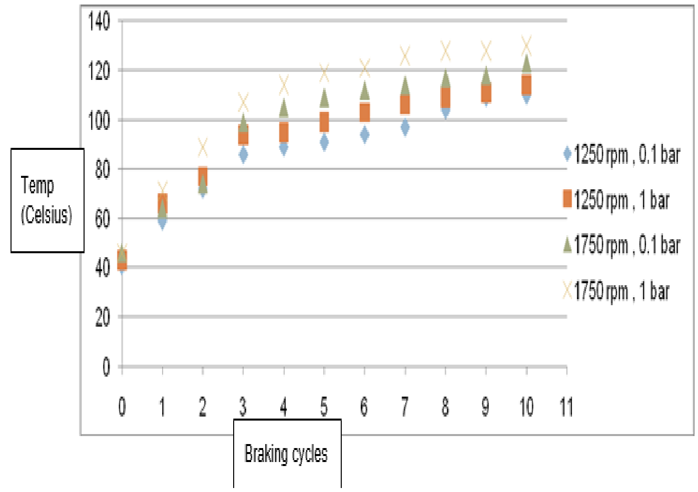
a) at a speed of 1250 rpm at 0.1 bar
b) at a speed of 1250rpm at 1 bar
c) at a speed of 1750 rpm at 0.1
d) at a speed of 1750 rpm at 1 bar .

Test Conditions	Variables	Measuring Locations	Required Parameter
Number of braking cycles.(n) (Braking cycle= Disc from rest to required rpm + braking back to rest.)	• Angular velocity of disc •Brake pressure	Effective radius, ie (r1+r2)/2	Limiting Temperature

4.Results:
The temperature at the effective radius on inboard side after 10 cycles at different speeds and brake pressures are obtained as shown .

Number of cycles (n)	rpm	Brake pressure (bar)	Temperature at eff. radius on inboard side , after 10 cycles (Celsius)
10	1750	0.1	123
10	1750	1	130
10	1250	0.1	110
10	1250	1	114

The output obtained was for 10 braking cycles are plotted on a graph and noted and shown in figure on the right side.



Based on the output values we can draw inferences regarding angular velocity, pressure and temperature.

We can say the temperature increases with both angular velocity and brake pressure increase. The temperature increase decreases over time. Also, the temperature increase reduces as we move forward from cycle to cycle.

***Computational Model– Radial vane Brake Disc*:**

The main problem of braking and stopping a heavy brake disc on a test rig is the great input of heat flux into the disc in a very short time, in this case braking down from the maximum speed of 1250-1750 rpm to a standstill. The initial temperature of the disc and the surrounding is 35°C. The goal is to find out the temperature increase that is produced on the disc surface as a result of braking.
The airflow through and around the brake disc was analyzed using the ANSYS 12 CFX software package.
Model for calculation represents a 7.5° sector region of the brake disc section with rotational symmetry and fluid enclosure.

The computational approach is done using ansys 12 software cfx package with the following assumptions:
1)Transient analysis over one braking stop with uniform deceleration.
2) Fluid enclosure.
3) Rotational symmetric sector.
4) Input angular velocity.
5) Input heat flux.

5.Mesh and Material:

A tetrahedral mesh was used for both the disc body and the fluid. Element sizing was 2 mm for the fluid and the solid body. As the brake disc is made from sand casted grey cast iron, the thermal conductivity is taken to be 52 W/m-C.

6.Boundary conditions:

A transient simulation in time steps of 0.05 seconds was recorded for the braking period stop. The temperatures on surface 1 and 2 were recorded at the effective radius, inboard side were recorded.
The following is a sample input for the case (1750 rpm, 0.1 bar):

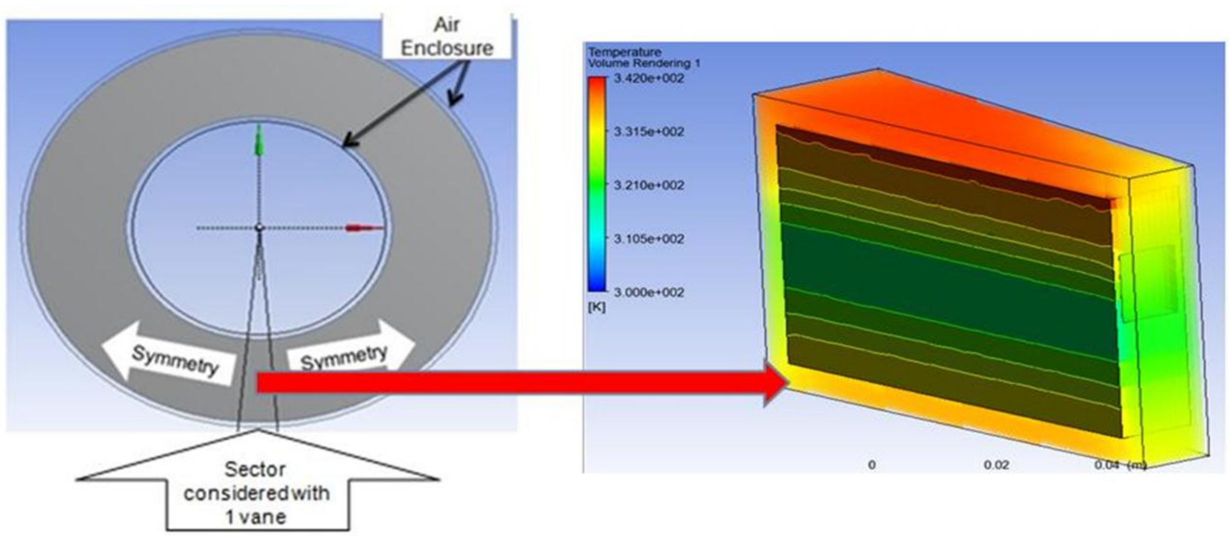
Time for stopping recorded t_{stop}	$t_{stop} = 6\ sec$
Angular velocity imparted to disc $\Omega(t)$	$\Omega(t) = 1750\ rpm * (1 - \frac{t}{t_{stop}})$
Lever Amplification, (a)	Lever length /Eccentric Shaft Offset = 7 cm/0.5 cm = 14
Input pressure, P	10000 Pascal
Diaphragm Area (A)	24 sq. inch
Coefficient of friction (μ)	0.4
Effective radius, $r_e = (r_1 + r_2)/2$	0.145 m
Area of braking $Ar = \pi(r_2^2 - r_1^2)$	0.076 sq. m

7.Formula:

Lever amplification	A=L/e
Braking force(Normal):	$F_b = P * A * a$
Braking force(Frictional):	$F_f = F_b * \mu$
Instantaneous angular velocity of disc:	$\Omega(t) = \Omega_{ini} * (1 - \frac{t}{t_{stop}})$
Velocity of disc surface:	$v(r) = \Omega(t) * r$
Instant heat flux entering the disc surface	$Q(t) = F_f * \frac{v(r,t)}{Ar}$
Averaged Instant heat flux	$Q(t) = F_f * \frac{v(r_g,t)}{Ar}$

9.Results:

1Brakingcycle	CFD analysis(Celsius)	Experimental approach (Celsius)
1250rpm,0.1bar	66	59
1750rpm,0.1bar	72	64



8.Inferences:

We thus infer that the results show less than 15 % error compared to the experimental values. Boundary conditions for another ventilated design will remain the same. Thus, this model can be used to test the performance of new designs before fabricating them for testing in the test rig.Then they will be tested in the rig and taken forward if they perform better.

10.References:

- Air jet Cooling of Brake Discs by O.F.P.Lyons, D.B.Murray and A.A.Torrance,
- Dept. of Mechanical & Manufacturing Engineering, Trinity College, Dublin 2, IRELAND.
- Aerodynamic Cooling of Automotive Disc Brakes by Arthur Stephens , RMIT University
- Ansys Workshop Manual , Transient Brake Rotor.
- Numerical Analysis of Brake Disc considering cooling,
- Pevec, M.; Lerher, T.; Potrč, I. & Vranešević, D. ,
- ADVANCED ENGINEERING, 4(2010)1, ISSN 1846-5900.
- Analysis of air flow and heat dissipation from a high
- performance passenger car front brake rotor, Palmer, Edward, Mishra,
- Rakesh and Fieldhouse, John D, University of Huddersfield repository.