Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals of DAAAM International

RESEARCH CONCERNING THERMAL STRESS OF BANDAGES ON BLOCK BRAKING IN CASE OF BRAKING STOP

DUNGAN, L[uisa] I[zabel]; IONEL, I[oana]; DUNGAN, M[ircea] A[drian] & CIOABLA, A[drian] E[ugen]

Abstract: *During operation of electric locomotives there is the possibility of wheel spinning on the discs bandages. The main cause leading to rotating bandages is their thermal request during braking failure of locomotive while operation. Kinetic energy in the locomotive braking is converted into heat which is transmitted to the bandage and derailed. Because of overloading of the bandaged wheels there appear the bandages weakening combined with tread defects. This danger exists especially when braking on slopes long lasting and with high gradients. The aim of the paper is to determine by calculation the maximum temperature incurred during braking so as to tread depth and tire, both for new and for used bandages in the case of stopping when braking.*
Key words: *braking process, bandages, stopping braking, tread*

1. INTRODUCTION

Being in fierce competition, continuous and long-term with other means of transport, modern rail transport has an important share in most countries worldwide with an increasing trend in traffic speeds, hauled tonnages and offered competitive costs.

Continuous growth of velocity on the railway imposed special security issues regarding guiding rail safety in general.

One of the problems in the operation of railway vehicles equipped with wheels with bandages and brake blocks is the appearance of bandages rotating on disk and disk without the axle without axial displacements and axial movement without hammering strange sounds (Stoica, 1998).

To determine the causes leading to these spins there was examined the aspect of the tire and wheel heating through thermal calculation for the bandages in case of stopping braking.

2. BRAKING WITH BLOCKS FOR RAIL VEHICLES

2.1 General information

Braking facility holds the most important role in ensuring the movement of railway vehicles in safety conditions for the traffic. It is necessary for:

• Stopping the train (rail vehicle) within the limits of braking space;
• Partial reduction of speed;
• Lowering maintenance train on the slopes;
• Train (rail vehicle) immobilization after stopping it.

In the first two cases, inside the braking process was dissipated the kinetic energy stored in the train's speed. In the third case, the potential energy was dissipated, which is stored on boarding ramps and in the latter case the role of the brake is related with preventing movements that could be caused by external factors.

To ensure necessary braking space becomes a problem more difficult with increasing speed of movement, which is explained by the fact that with the axle speed increase, the coefficient of friction of cast iron brake blocks suddenly shrinks and pressure on the blocks is limited by the potential wheel lock. Also, on increasing the normal load force, its increase the wear degree and the danger of turning blocks of bandages on the centre of the wheel will become bigger (Cartigny, Dufrenoy &Desmet, 2004).

2.2 Establishing the computational relations for brake blocks for braking stop

At brake stopping, from a thermal point of view, heat transmission occurs in non-stationary process, the amount of heat changing over time. In this case, heat transmission is calculating using Fourier's differential equation (Talambă & Stoica, 2005) and for simplicity it was considered that the heat is transmitted only in a direction perpendicular to the running surface:

$$\frac{v(\Delta v)}{v_t} = a \cdot \frac{v^2(\Delta v)}{v \cdot x^2} \cdot \qquad (1)$$

Starting from this relationship, for stop braking it was obtained, for the raising of temperature Δv , the relationship:

$$\Delta v = \frac{q}{\sqrt{\pi} \cdot \sqrt{\lambda \rho g c} \cdot \sqrt{t_b}} \cdot e^{\frac{-x^2}{4at_b}}, \qquad (2)$$

where: λ (coefficient of heat transmission), ρ (specific mass in kg / m), c (specific heat in J / kg degree C) and a (temperature index) are quantities that depend on the material which were made pad and bandage (STAS'99, 1999), (STAS 112/1-80, 1980);

t_b - breaking time;

x – distance from the braking surface to the interior of the bandage.

By integrating equation (2) as a function of t and x its result relation (3) for determining the temperature increase, for braking stop:

$$\Delta v(x,t) = \frac{2q_a\sqrt{t} \cdot e^{\frac{-x^2}{4at}}}{\sqrt{\pi} \cdot \sqrt{\lambda \rho g c}} \cdot \left[1 - \frac{2}{3} \cdot \frac{t}{t_b}\left(1 + \frac{x^2}{4at}\right)\right] - \frac{q_a x}{\lambda} \cdot \left[1 - \Phi\left(\frac{x}{\sqrt{4at}}\right)\right] \cdot \left[1 - \frac{t}{t_b}\left(1 + \frac{2x^2}{12at}\right)\right] \qquad (3)$$

3. TEMPERATURE VARIATION CALCULATION INSIDE THE BANDAGE FOR BRAKING STOP

One of the cases frequently encountered in practice is the braking stop and the most disadvantageous type of braking is emergency braking from maximum speed to zero. Braking deceleration on the railway range varies with speed because of friction shoe-binding and binding-track.

To simplify calculations it's considered that the deceleration is uniform throughout the brake. In the calculations were admitted the following:

○ for deceleration: 1.3 m/s^2 ;
○ for wheel diameter: 1.250 m (new bandage) and 1.170 m (maximum used bandage);
○ environment temperature: 20 °C;
○ braking time: from 0 to 60 sec.;

○ circulating speed : 120 km/h;
○ mass factor: 1.2;
○ wheel load: 10 MPa.

Temperature variation in bandage, brake off, was calculated in the following situations:

- new bandage, used block, deceleration of 1.3 m/s^2;
- used bandage, used block, deceleration of 1.3 m/s^2 .

Given that all of the heat is distributed between the wheel and block, the amount of heat will received at the wheel will be:

$$q_{aR} = \frac{q_a}{1 + \frac{1}{f_{0k}} \cdot \frac{\sqrt{\lambda_k \rho_k c_k}}{\sqrt{\lambda_R \rho_R c_R}}} \quad . \qquad (4)$$

3.1 The case: new bandage, used block, deceleration of 1.3 m/s^2

The necessary preliminary values in relation (3) are given in Table 1.

Crt. no.	Name	Notation	Calculating relation	Value
1	Braking time	t_b [sec]	$t_b = \frac{v}{v^{\bullet}}$	25.6
2	Wheel braking surface	F_{OR} [m^2]	$F_{OR} = \pi d_R \delta_k$	0.31415
3	Thermal loading	q_a [kJ/m^{2}h]	$q_a = \frac{\xi_M G_R v^2}{q F_{OR} t_b}$	5962972
4	Fourier coefficient for the block	F_{OK}	$F_{OK} = \frac{a t_b}{b^2}$	3.4
5	Correction factor	f_{FOK}	-	1.6

Tab.1. Preliminary values

Variation of temperature during braking bandage according to the distance from the braking surface toward bandage interior is given in Figures 1 and 2.

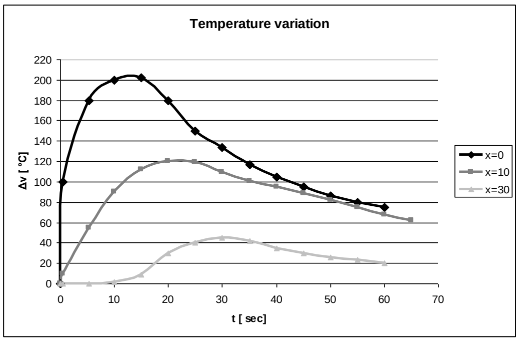

Fig. 1. Temperature variation for the bandage as a function of braking time

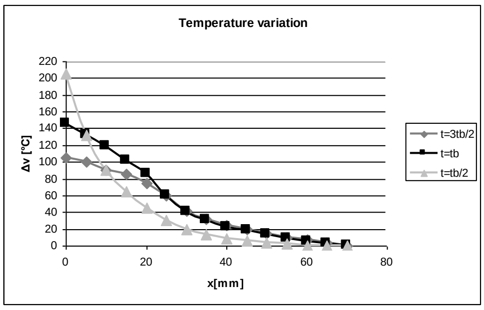

Fig.2. Temperature variation for the bandage as a function of the distance from the braking surface toward bandage interior

3.2 The case: maximum used bandage, used block, deceleration of 1.3 m/s^2

Preliminary values needed in equation (3) are all those from Table 1, only the thermal load has a value of q_a = 561 736 kJ/m^{2}h.

Temperature variation inside the bandage as a function of the duration of braking and distance from the braking surface toward bandage interior are given in Figures 3 and 4.

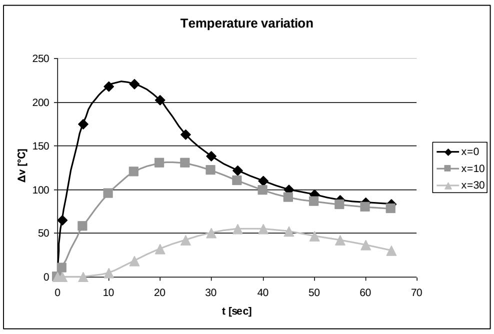

Fig. 3. Temperature variation for the bandage as a function of braking time

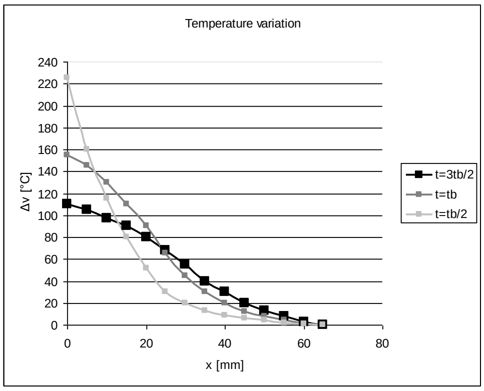

Fig.4. Temperature variation for the bandage as a function of the distance from the braking surface toward bandage interior

4. CONCLUSIONS

Due to the short time of acting braking power, temperature fluctuations occur at the beginning of the tread brake. Further, as approaching the stopping of the movement, braking power is reduced and, accordingly, variations in temperature are lowered.

In case of braking tread off at the bandage surface is obtained a maximum temperature of 244 °C for case 2 (worst case). This temperature creates a compression effort to tread of 48.5 daN/mm^2. Value of effort is far below the prescribed breaking effort for material bandages. Braking feature allows binding material to tread absolute temperature of 370 - 415 °C without the appearance of defects on the tread.

5. REFERENCES

Cartigny, F., Dufrenoy, P., Desmet, B., (2004). *A termal análisis of a new railway brake concept using liquid cooling*, Proceeding of the Institution of Mechanical Engeeners, Part F: Journal of Rail and Rapad Transit, Vol. 218, nr.2, ISSN: 0954-4097

Stoica, M. (1998). *Frânarea trenurilor*, Ed. Feroviară, ISBN: 973-97334-4-1, Bucureşti

Talambă, R, Stoica, M. (2005). *Osia montată*, Editura ASAB, ISBN: 973-7725-04-2, Bucureşti

*** STAS 112/1-80 (1980). *Aparate de rulare pentru vehicule de cale ferată cu ecartament normal. Bandaje pentru roţi. Condiţii tehnice generale de calitate*

*** STAS'99 (1999). *Vehicule de cale ferată cu ecartament normal. Saboţi de frână. Condiţii tehnice generale de calitate.* – SR 6289:1999, Bucureşti, Ed. Tehnică