COMPARISON OF BRAKE PERFORMANCES OF FREIGHT WAGONS WITH THE CLASSIC BRAKE AND COMPACT FREIGHT CAR BRAKE

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Abstract – Contemporary design of the freight wagons requires lightweight and compact design of all subassemblies and components (e.g. bogies, brake systems etc.). Because of that several manufacturers of railway brake systems have developed a compact brake system having all major components located within bogie. This system despite the more complex construction than standard have more advantages (lower mass, reduced air consumption, higher efficiency of brake rigging etc.) This paper presents results and conclusions obtained by testing of two freight wagons of the same type equipped with classic brake system and compact freight car brake system (CFCB). The testing included brake performance test i.e. stationary test and slip brake test.

Keywords – railway, bogie, brake, testing.

1. INTRODUCTION

Development of the freight cars goes toward lightweight design (the minimum tare mass) and to the increased speed. Consequently, manufacturers started to develop compact brake systems for freight cars, in which the complete system is located within bogies. Such systems have lower mass and take up less space in comparison with standard brake systems. Obligatory application of the composite brake shoes type K accelerated development and introduction of the compact brake systems, because their higher friction coefficient, compared to cast iron shoes, made possible massive use of one-sided braking shoes.

In this paper we presented brake performance obtained by calculations and tests of the two rail cars type Falns equipped with standard brake and compact freight car brake (CFCB).

1.1. Compact freight car brake characteristics

The CFCB makes the operation of freight cars increasingly economical and efficient [1]. Due to its modular design, the CFCB is reduced in weight, simple to install and reduces costs. It offers low maintenance and low air consumption while being highly efficient and delivering low life-cycle costs.

This leads to an increased performance, which brings benefits to both, vehicle manufacturers and the operators.

The main advantages of CFCB are:
- Optimum kinematics
- Modular design (block force is adjustable by changing the internal ratio, without changing installation space or interface to the bogie and reduced installation time)
- Low noise (use of steel-rubber-steel sleeves)
- Low LCC
- Low air consumption
- Can be equipped with bogie-mounted and car body-mounted manual parking brake
- Low weight (4-axle wagon weight is decreased for cca. 1 t)
- Preassembled and ready to install
- High efficiency (brake rigging efficiency is cca. 0.95 and does not change between two maintenance inspections and it is independent of brake cylinder pressure
- Low maintenance (there is no maintenance between the revisions).

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2. TEST WAGONS

Figure 1 shows analyzed freight wagon type Falns.

Fig.1. Wagon type Falns

Main characteristics of wagon are [2], [3]:

- Vehicle mass (empty): 20800 kg
- Vehicle mass (loaded): 90000 kg
- Number of axles: 4
- Bogie type: Y25
- Axle distance within bogie: 1800 mm
- Wheel diameter: 920 mm
- Maximum speed: 120 km/h

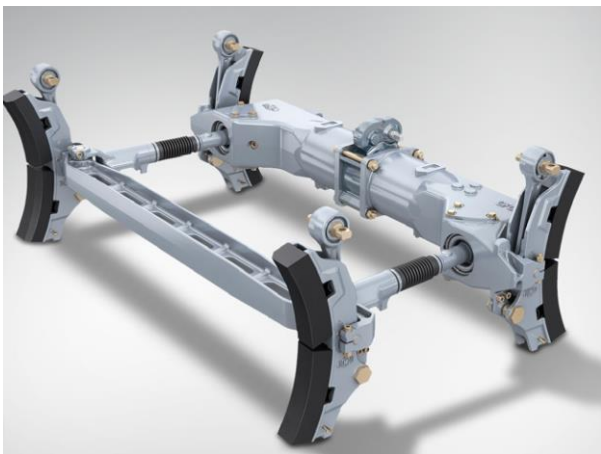One wagon is fitted with a classic braking system and the other with a CFCB (Fig. 2). [1]

Fig.2. CFCB Knnor Bremse

Tab.1. Brake cylinder pressure

			Classic brake	**CFCB**
Brake cylinder pressure	bar	Empty wagon	1.36	1.09
		Loaded Wagon	3.80	3.60
Brake block force	kN	Empty wagon	8.36	7.31
		Loaded Wagon	29.41	28.84

Both wagons brakes are with automatic change of brake force vs. wagon mass and equipped with composite brake shoes type K.

Wagon with CFCB system had the maximum brake cylinder pressure adjusted to 3.6 bar unlike 3.8 bar regularly used with standard freight brakes. Lower pressure causes reduction of wear of the shoes.

On the basis of the calculation, the following parameters of the brake system were selected (Tab. 1).

3. COMPARISON OF BRAKE PERFORMANCE

3.1. Brake rigging efficiency

One of the basic difference between the classic and the compact brake is rigging efficiency. In the calculations its value for classic brakes is selected as 0.83 and corresponds to mean rigging efficiency between two inspections [5], while for CFCB this value is considered to be perpetual and equals 0.97.

For tested wagons brake rigging efficiency was determined based on the brake cylinder pressure and the measurement of force between the shoe and the wheel (Fig.3).

Fig.3. Brake shoe force tranducers

The values of the measured efficiency are shown in Table 2 and the graphical diagram of the development of the brake force is shown in Figure 4.

Tab.2. Brake rigging efficiency

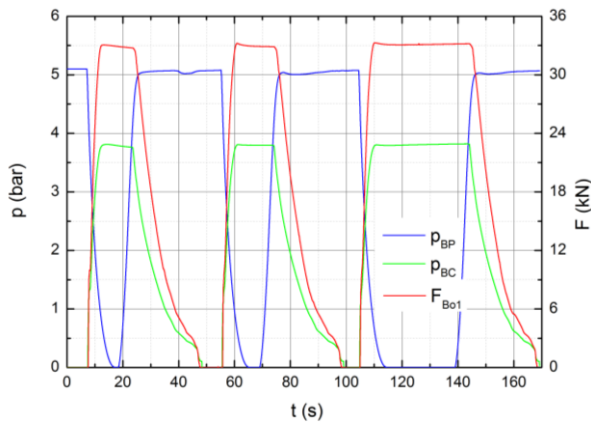|			**Classic brake**	**CFCB**
Calculated brake force ($\eta=1$)	bar	Empty wagon	10.07	8.45
		Loaded wagon	35.43	33.58
Measured brake force	kN	Empty wagon	8.69	8.32
		Loaded wagon	32.96	32.20
Effieniecy		Empty wagon	0.86	0.97
		Loaded	0.93	0.96

Fig.4. Brake shoe force, axle 4, loaded wagon, with classic brake

3.2. Brake weight

Braking performance of rail vehicles can be expressed via braked weight. Brake weight is the basic braking performance parameter expressed in integer numbers of tons.

Brake weight of these wagons was determined based on the slip test according UIC 544-1.

The first test results do not fulfill the minimum braking performance from CR TSI WAG 2013, table C.3 for the wagon equipped with the variable relay valve.

With nominal cylinder pressure 1.36 bar resulted in following results:

s_{corr}=395 m, λ=138% for 100 km/h and

s_{corr}=505 m, λ=147% for 120 km/h.

where are:

s_{corr} – corrected stopping distance

λ - brake weight percentage.

Also, at nominal designed cylinder pressure of 3.8 bar in the partially loaded condition with m=59.7 t, first two tests resulted in following results:

s_{corr}=405 m, λ=120.5% for 100 km/h

s_{corr}=575 m, λ=126.5% for 120 km/h

Measured brake weight percentages were above allowable values according to EN 14198.

Brake cylinder pressure was decreased by using relay valve to 1.2 bar for empty wagon and 3.4 bar for loaded wagon.

With new values of brake cylinder pressure was performed slip test and the following results were obtained (Table 3) where:

m – wagon mass

v – initial speed

s_{corr} – corrected stopping distance

λ – brake weight percentage

B – brake weight

B_{uic} – rounded brake weight that will be marked on the wagon.

Tab. 3. Brake weight – classic brake

Brake regime	M	V	$s_{corr,2}$	λ	B	B_{UIC}
	[t]	[km/h]	[m]	[%]	[t]	[t]
P	20.8	100	432.1	112.3	23.4	23
		120	616.8	116.6	24.3	24
	59.70	100	491.6	97.5	58.2	58
		120	682.3	103.6	61.8	62
	89.85	100	699.3	65.6	58.9	59

Table 4 presents test results for the wagon with compact brake.

Tab.4. Brake weight – compact brake

Brake regime	M	v	$s_{corr,2}$	λ	B	B_{UIC}
	[t]	[km/h]	[m]	[%]	[t]	[t]
P	20.84	100	474.6	101.3	21.1	21
		120	650.3	109.6	22.8	23
	59.8	100	476.1	101.0	60.4	60
		120	668.4	106.1	63.5	63
	90.05	100	698.8	65.6	59.1	59

As an illustration, diagrams for two recorded tests are shown in figures 5 and 6. In the graphics, following designations are used:

p_{BP} - brake pipe pressure

p_{BC} - brake cylinder pressure

v - speed

s - distance traveled

The stopping distance was derived from the traveled distance data for each individual test, as a path traveled between the starting moment of pressure fall in main brake pipe to the moment when the speed reaches zero.
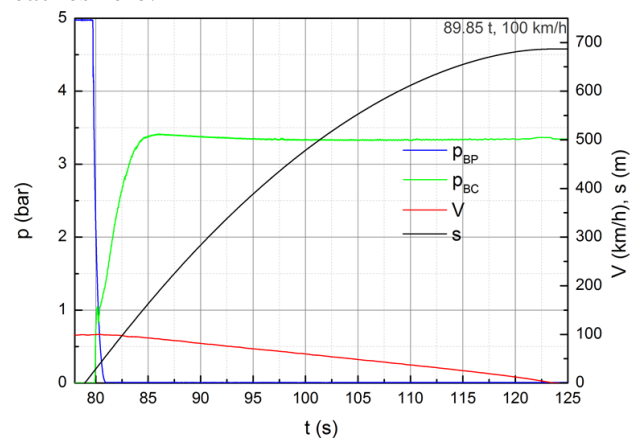

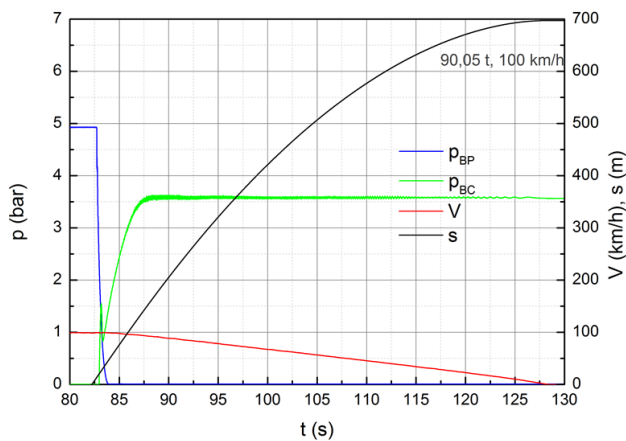*Fig.4. Slip test, wagon with classic brake*

Fig.5. Slip test, wagon with compact brake

4. CONCLUSION

Based on the results, it can be concluded and confirmed that due to the construction of the braking system, brake rigging efficiency of CFCB is greater than classic brake.

In addition, by using composite brake shoes, it is mandatory to determine the brake performance by testing, due to the variation in the value of the coefficient of friction of these shoes. The conducted testing showed that it is necessary to perform the adjustment of the braking system in order to obtain satisfactory results.

This could be done by changing the pressure in the brake cylinder or the brake rigging ratio. If there is need for changing brake rigging ratio, compact brake system has the advantage, because it is possible to be done more simpler, only by changing the internal ratio without changing installation space or interface to the bogie.

Because of all these advantages, all leading braking equipment manufacturers have developed and upgraded their compact brake systems and their massive use is expected, primarily on new wagons.

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