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DESIGN SPECIFICITY OF EAMS-Z SELF-PROPELLED WAGON

Saša RADULOVIĆ [1]
Dražen VIDOVIĆ [2]
Goran SIMIĆ [3]
Snežana GOLUBOVIĆ [4]

Abstract – *Self-propelled wagon Eams-Z inteded for bulk material transportation provides enhancement in railway infrastructure construction and maintenance. Its main advantage is possibility of manipulation along tracks and construction material discharging without use of locomotive. Thus this car saves energy, human resources, and shortens the time of transportation and unloading. The car has two crates with the possibility of side and frontal inclining using hydraulic cylinders. These cylinders provide controlled and precise unloading of cargo on 3 sides without need of any extra man or machine power. Power pack, consisting of diesel engine, hydro transmission and two small wheels without flange is positioned in the middle of the car between the bogies. In the self-propelled regime wheels lower down to rails providing traction force needed for wagon manipulation. This car type requires special attention during design and calculations in order to achieve safe manipulation in all regimes.*

Keywords* ±*Five key words suggested. At least one of them should be from the field of Railways.

1. INTRODUCTION

Considering tendencies of restructuring of state railways authorities using some of existing and accepted models and methods, e.g. dividing them into a several independent private or state owned companies (infrastructure, passenger traffic, cargo traffic, maintenance providers etc.) each innovation and/or solution that provides some level of independency between these companies for realization of some activities are very welcome, due to possible simplifications in organisation and speeding up their realization.

This paper presents freight car marked as Eams-z manufactured by Factory ″RŽV Čakovec″, Croatia, intended for transportation of the gravel in the process of track maintenance. The project is the result of three year work of the international consortium, co-funded by EU within Eco-Innovation Programme [1]. Comparing to other standard freight cars inteded for this purposes, this wagon has ability independently to move along tracks during load discharge using power pack installed between load crates. Also, it has special tilting mechanism and openings with doors for controlled and batched unloading of bulk material using hydraulic cylinders and own power.

The wagon operates in the two modes (regimes):

1. Transport mode when it operates in the regular train composition as standard freight wagon,
2. Working mode during load discharging, which enables it independently to move along tracks at lower speeds during gravel discharging and without need to engage shunting locomotive or other external power drive.

In the final phase of the wagon development for obtaining the licenses for operation i.e. TSI certification [2], wagon passed series of the stationary and running tests.

In the next paragraphs are presented wagon design specificities and some of the performed tests and calculations required for this type of wagon.

2. CARBODY AND POWER PACK

The wagon is equiped with two standard Y25L series of bogies [3]. The maximum operational speed is 100 km/h. Its tare weight is 37.34 t and the maximum payload capacity 52.5 t. Payload is distributed in the two separete boxes – cargo crates with total volume of 50 m^3. Cargo crates and power pack are placed on the carbody frame (Fig.1).

[1] University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, 11000 Belgrade, sradulovic@mas.bg.ac.rs
[2] Railway carriages factory Čakovec Ltd., Kolodvorska 6, HR-40000 Čakovec, drazen.vidovic@rzv.hr
[3] University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, 11000 Belgrade, gsimic@mas.bg.ac.rs
[4] University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, 11000 Belgrade, sgolubovic@mas.bg.ac.rs

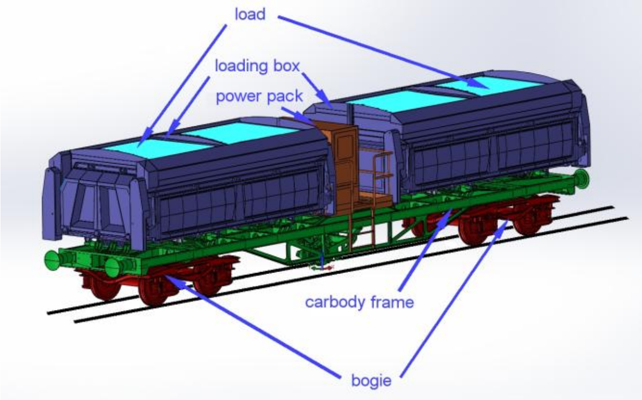

Fig.1. Eams-z wagon design

Each cargo crate has the possibility of side and frontal lifting (tilting) and thus controlled and precise unloading of bulk material on 3 sides using built-in hydraulic cylinders and power pack (Fig. 2).

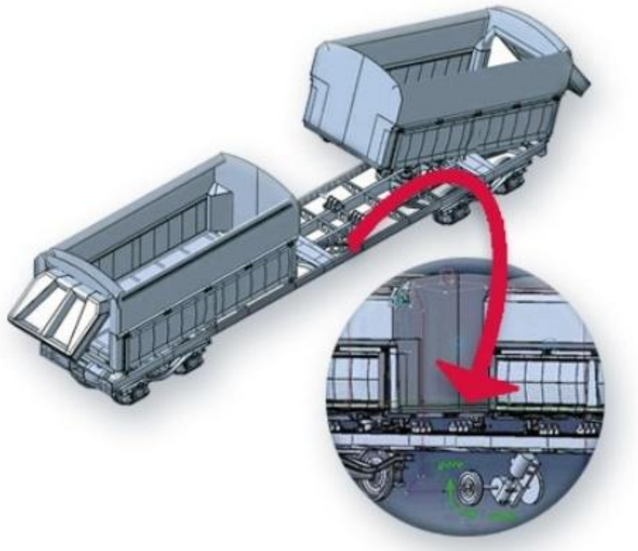

Fig.2. Cargo crates kinematics [1]

Tilted cargo crate in the lifted position during side discharging is presented in Fig. 3.

Fig.3. Lateral tilting of the cargo crate for side discharging

Independent movement in the working mode is achieved using power pack, consisting of 55 kW diesel engine and hydraulic transmission connected with two wheels with small diameter and without flanges. In the working mode these wheels have the ability to lower to rails (Fig. 2).

Control of the wagon movement and operation of the doors for load discharging is possible either from the vehicle, or from the track side, using remote control device.

Thus this car saves energy, human resources and shortens the time of transportation and unloading.

3. CALCULATIONS AND TESTS

Considering wagon Eams-z specifities i.e. that it operates in the two regimes, during wagon design and development one of the main task was to achieve wagon properties that clearly categorize it as a standard freight car when used in the transport mode. Otherwise the wagon would have to pass additional tests of derailment safety, as well as other tests that must be performed in the case of standard traction vehicles (locomotives, motor units, trolleys etc.)

This paragraph presents some of the performed tests required for standard freight cars:

- Stationary brake test,
- Carbody static strength test,
- Determination of the carbody torsional coefficient,
- Brake performance test,
- Buffing impact test, etc.

Fig. 4 presents stationary brake test performed in the ″RŽV Čakovec″ factory. The test was performed by Instute Kirilo Savić [4] in accordance with appropriate TSI and UIC norms.

Fig.4. Stationary brake test [4]

Running brake performance test [5] was performed on the track section Koprivnica- Mučna Reka (Fig. 5) The test was performed in accordance with TSI WAG (321/2013). Stopping distances were measured during slip brake test at 100 km/h for empty and loaded wagon. Corrected measured stopping distances were used for determining mean value. From this value are calculated the braked weight percentage and braked weight B for empty and loaded wagon.

Fig.5. Brake power running test [5]

Static strength test was perforemd in GOŠA Rolling Stock Factory Ltd., Smederevska Palanka [6]. The test was performed in accordance with EN 12663-2: Chapters 5, 6 and 7. Fig. 6 presents combined load case with maximum vertical load and compresive force 2x1000 kN applied over buffers axes.

Fig.6. Carbody static strength test [6]

Fig.7. Buffing impact test – wagon end with installed force and displacement transducers [8]

Buffing impact test [7] was performed on the connecting tracks between the Railway station in Čakovec and Factory ″RŽV Čakovec″. The test was performed in accordance with EN 12663-2, points 8.2.2, 8.2.3 and 8.2.4 trough the series of impacts at speeds upto 12 km/h (Fig.7).

In order to meet the requirements for safety against derailment on the twisted track for standard freight cars, Laboratory of rail vehicles of Faculty of Mechanical Engineering- Belgrade, performed measurement of torsional stiffness coefficient of the carbody [8]. The test was performed according to Annex C of EN 15839.

One out of four supporting points was lifted and lowered, thus to simulate appropriate wagon twist considering wagon geometry (wheelbase, centre pin distance, support points distance etc.). During this process resulting change in force reaction at four supporting points was measured and served for calculation of the torsional stiffness coefficient.

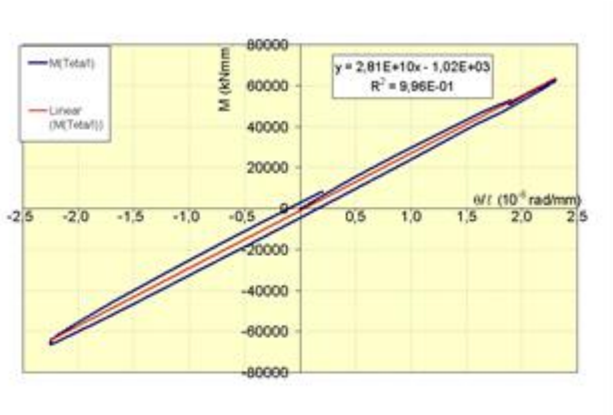

Fig.8. Torsional torque vs. torsional angle per mm of the carbody length

Fig. 8 presents test diagram of measured parameters that serve for determination of the torsional stiffness coefficient.

Based on measured value of the torsional coefficient, along with the fact that the wagon is equipped with running gear of established type Y25L and that calculated parameters of the carbody are within acceptable limits, it was concluded that Eams-z wagon meets the required criteria stipulated in CR TSI WAG and EN 16235 for dispensation from running dynamic behaviour tests according to EN 14363 [8, 9] in the transport mode of use.

In the working mode of use, wagon operates as a working track vehicle at low speeds, under supervision of trained railway staff using auxiliary power pack at isolated track sections. Therefore in this mode of use do not apply standard criteria.

Vehicle gauge calculation in this case was focused on the power pack traction wheels. In order to avoid contact with infrastructure, in the transport mode these wheels are in the lifted position. Gauge calculation [10] was performed in accordance with TSI WAG 2013 considering reference kinematic gauge G1 and according to EN 15273-2:2009 gauge GIC1 for lower parts. Considering wagon vertical movements caused by suspension system deflections under load, vertical dynamics and wear of wheels and other elements, as well as roll coefficient value, roll centre height and possible clearences, permissible vehicle gauge was calculated for the mid cross-section (Fig.9). In order not to jeoperdise vehicle gauge in transport mode power wheels should be securly locked 243 mm above the TOR (top of rail). In the working mode of use, when the wagon operates as a track maintenance vehicle, out of public traffic, the lowered wheels of the traction system are out of gauge GIC1 for lower parts, which is acceptable.

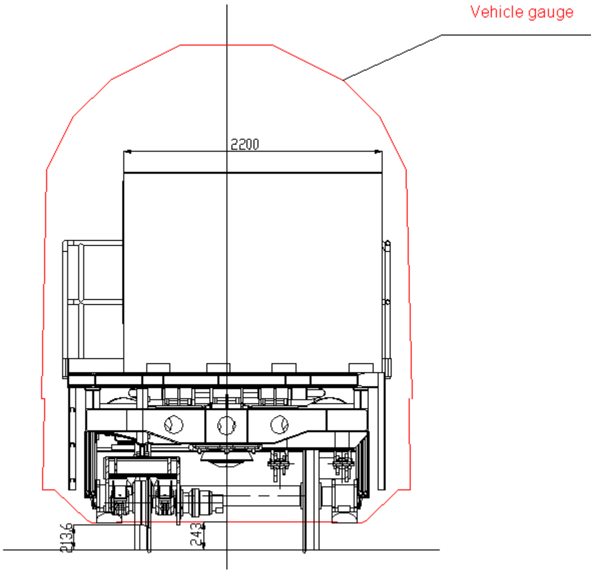

Fig.9. Vehicle gauge in the middle between centre pins at the traction wheels location [9]

4. CONCLUSIONS

In the proces of introduction the new type or non-standard type of vehicle, even in the phase of development and design, engineers should consider valid regulations and norms that define tests and calculations, required for issuing licenses for traffic according to TSI. In the case of standard freight wagon this task is quite clearly defined. Opposite, in the case of non-standard wagons, such as Eams-z self propelled wagon, depending on technical requirements, it is necessary to study wider range of regulations and existing similar vehicles’ designs, in order to stay in the planned time schedules and within available funding. In the case of this wagon, apart from the standard tests, which are already expensive and complicated, traction system design required performance of some additional tests and calculations in order to prove wagon’s funcionality in both regimes, transport mode of use and when it is used as track maintenace machine.

ACKNOWLEDGEMENT

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