OVERVIEW OF DEVELOPMENT OF RAILWAY VEHICLES IN KRALJEVO

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Abstract: *This paper presents some of the achievements in the development of railway vehicles in Kraljevo. The main carriers of this development are the Wagon Factory Kraljevo and the Faculty of Mechanical Engineering in Kraljevo, today's Faculty of Mechanical and Civil Engineering in Kraljevo. In addition to them, it is important to emphasize the contribution of individuals outside these two institutions, such as Eng. Dobrivoje Božić. In order to provide the best possible design and control of finished products, various methods of calculation and testing of railway vehicles and their components have been conquered. The total creativity of engineers and workers from Kraljevo contributed to improvement of railway traffic in Serbia and around the world. Nowadays, the railway vehicle industry in Kraljevo is in transition phase. However, established laboratories, successfully realized projects and achieved results are great potential and ground for successful scientific researches and restart of industry of railway vehicles in Kraljevo.*

1. INTRODUCTION

Interest in railway traffic in Kraljevo has lasted for more than a century. The first noted results in this area are reflected in the activities of individuals. Realizing the necessity and importance of railway traffic, the procurement of the necessary equipment for the maintenance of railway vehicles was started. At that time, there was no railway line Kragujevac-Kraljevo, so the procured equipment was unloaded in Niš. Engineers and workers from Kraljevo had been gaining their first work experiences in Niš. At the same time, very significant results were achieved, which led to the establishment of a railway workshop in Kraljevo in 1925.

The most significant result in that period was achieved by engineer Dobrivoje Božić (Fig. 1) from Kraljevo, by designing and production a new system for braking of railway vehicles [1]. The International union of railways - UIC, after numerous tests (Fig. 2), approved Božić's system for international use in 1928. Its system, based on three pressures, is the basis for braking even today's railway vehicles. Božić sold his patent to the Czechoslovak company Škoda. A copy of Škoda's locomotive with built-in Božić brakes is also in the museum exhibition of VTU "Todor Kableshkov" in Sofia (Fig. 3). Otherwise, Božić's patents are numerous, more precisely there are more than 70 patents registered in 18 countries.

Fig. 1. Eng. Dobrivoje Božić

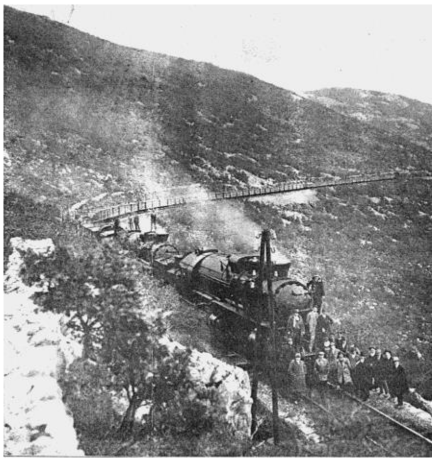


Fig. 2. Detail from testing of Božić brake

a) Locomotive with Božić brake **b) Božić's distributor**

Fig. 3. Museum exhibition at VTU „Todor Kableshkov“, Sofia

Based on the significant initial successes, in 1936 the Kraljevo Wagon Factory was founded, which specialized in the production of freight wagons. Knowing the fact quality business is impossible without qualified engineering staff, in 1960 the Wagon Factory is initiated the establishment of the Faculty of Mechanical Engineering in Kraljevo.

2. OVERVIEW OF ACHIEVED RESULTS

Based on the afore-mentioned approach, the Wagon Factory Kraljevo became a giant in the production of freight wagons [2]. Kraljevo had capable engineering and other personnel, as well as all the necessary capacities for independent design, construction and production of railway vehicles. In terms of volume, assortment and quality of its products, quickly it became one of the most famous manufacturers of freight and special wagons. Even today, its wagons running on the railways of Europe, Asia, Africa, Australia, North and South America. The display of export of freight wagons from Wagon Factory Kraljevo is shown in Fig. 4.

Fig. 4. The display of export of freight wagons from Wagon Factory Kraljevo

The established Test Center into wagon factory, in cooperation with the Faculty of Mechanical Engineering in Kraljevo, was equipped and capable for all types of testing of products from the program of the factory, according to the relevant regulations EN and UIC [3]. The following methodologies for testing of railway vehicles have been fully conquered and mastered: Static tests; Test of torsional stiffness; Impact tests; Dynamic testing of quiet running and running safety; Brake tests at rest and at running. Some of these tests are shown in the figures below.

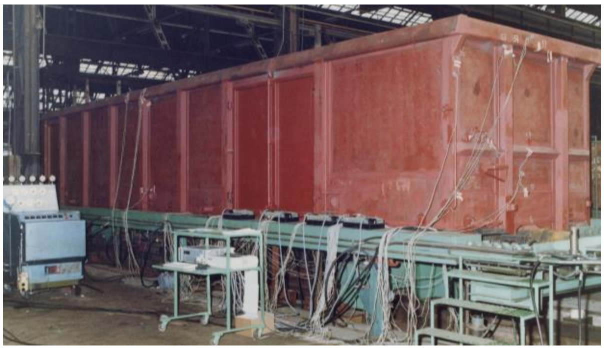


Fig. 5. Wagon's static tests

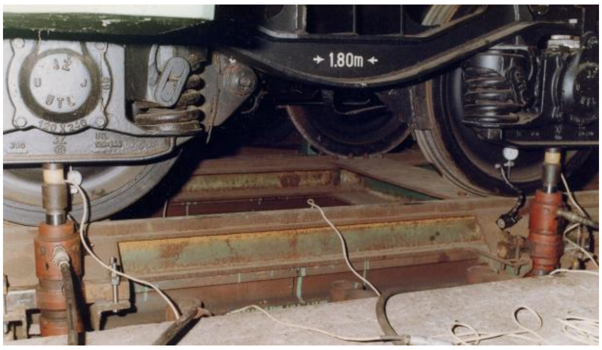
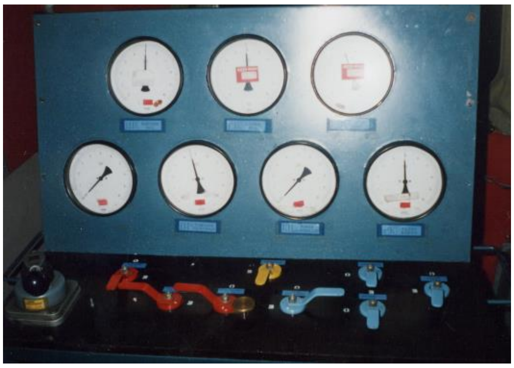


Fig. 6. Test of torsional stiffness

Fig. 7. Testing of wagon's impact

Fig. 8. Testing of quiet running and running safety



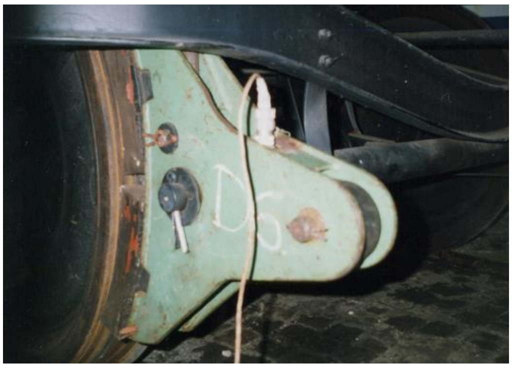
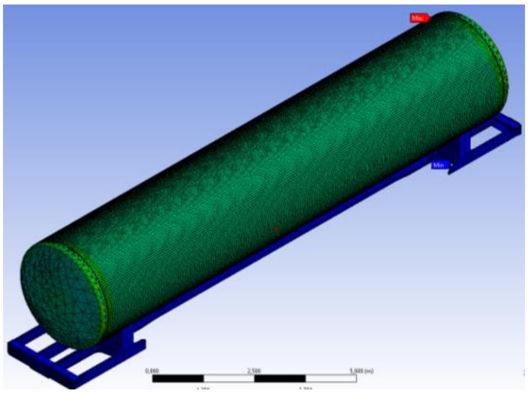


Fig. 9. Device for brake testing at rest **Fig. 10. Convertor for measurement of braking force**

In addition to experimental methods, methods of static and dynamic calculations of wagons and their appropriate elements and assemblies were developed [4, 5]. Some of examples are shown in Figs. 11-14. For that purpose, software such as Auto Cad, Solid Works, Ansys, etc. were procured.



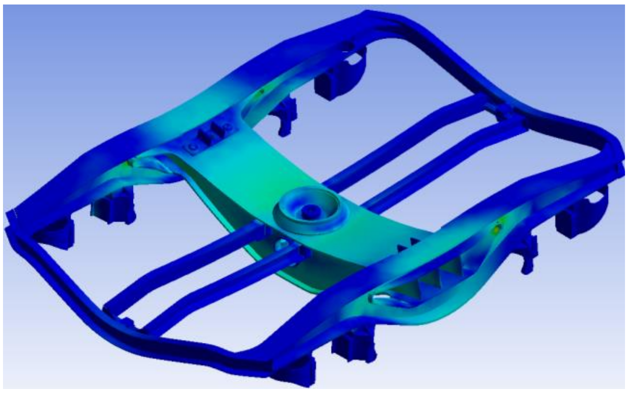
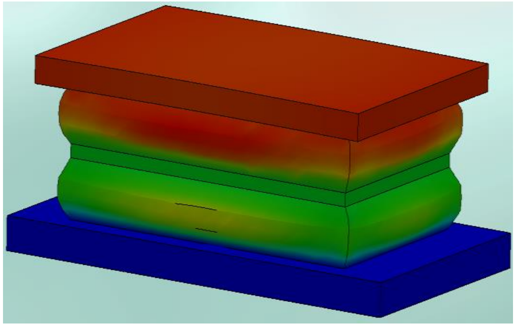


Fig. 11. FEM calculation of carrying structure **Fig. 12. FEM calculation of bogie frame**



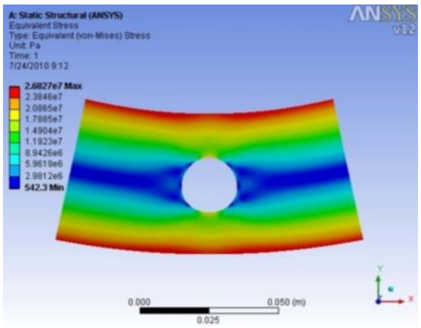


Fig. 13. FEM calculation of rubber element **Fig. 14. FEM calculation of stresses around circular hole**

The conquered methodologies for calculation and testing of railway vehicles have been applied to other industries, especially for the needs of the road vehicles, process and chemical industry, as shown in Figs. 15-18.

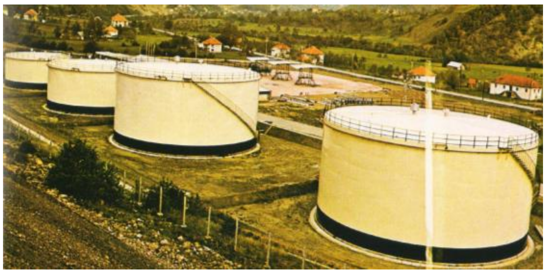


Fig. 15. Wagon for special transport **Fig. 16. Liquid fuel tanks**

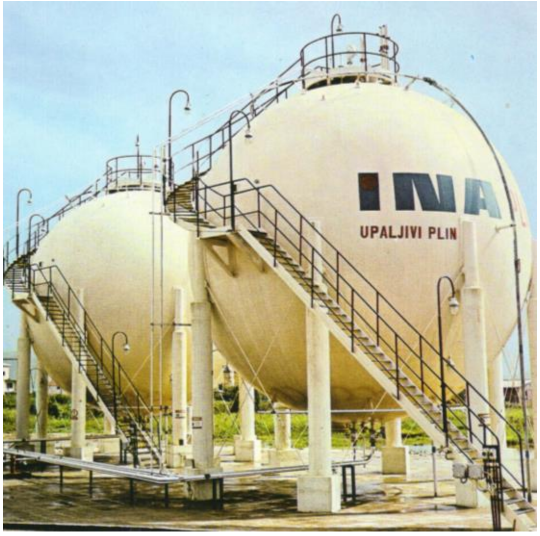


Fig. 17. Spherical gas storage tanks

Fig. 18. Tipper trailer

3. FURTHER RESEARCH AND DEVELOPMENT

The future development of railway vehicles in Kraljevo largely depends on the completion of the transition of the Wagon Factory Kraljevo. Regardless of that, the Faculty of Mechanical and Civil Engineering in Kraljevo is making efforts to continue research on the improvement of certain components of railway vehicles and other mechanical structures (one example is shown in Fig. 19). Also, significant efforts are being made in improvements of quality of education process from the fields of railway engineering and structures testing. For that purpose, a Laboratory for Railway Engineering and Structures Testing has been established (Fig. 20). It is part of the Center of the same name, which is intended for providing the services to all manufacturers of railway equipment in Serbia and the region.

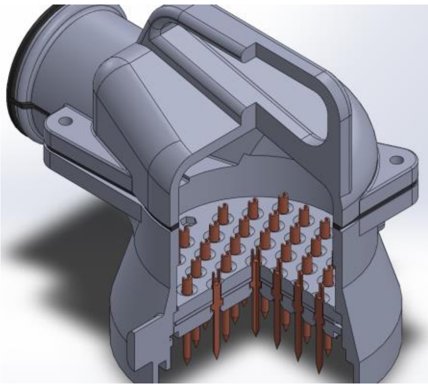


Fig. 19. Plug-in coupling for electric trains

Fig. 20. Laboratory for Railway Engineering and Structures Testing

The mentioned Laboratory is equipped with instrumented wheelset intended for testing of quiet running and running safety of railway vehicles. Within the Laboratory, methodology for experimental determination of wheel-rail contact forces and contact point position by using instrumented wheelsets has been developed [6]. The final goal of the previous activities is focused on the design and construction of the so-called "smart axle" of railway vehicles (Fig. 21).

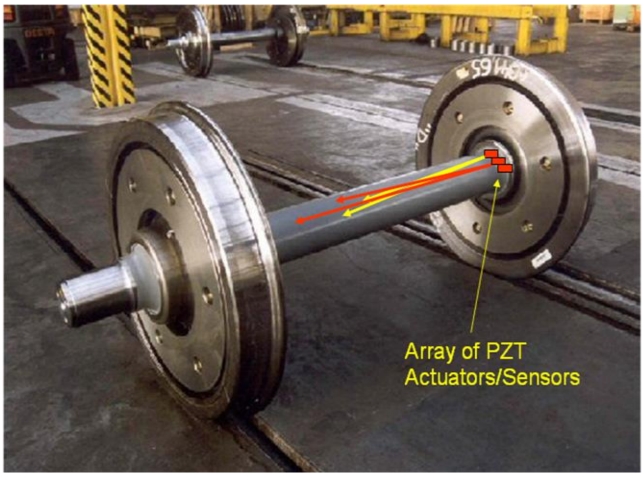


Fig. 21. Conceptual design of a smart axle

4. CONCLUSION

The basic orientation of further development is focused on domestic and international cooperation with research and development centers, universities, and factories, in order to increase the quality, productivity and safety of railway vehicles. The starting point is the assumption that the modernization of the railway is an imperative of economic trends in the world and that it must be addressed comprehensively. This includes the modernization of railway lines, traction and hauled railway vehicles, signaling and safety facilities, etc. In addition, a special attention should be paid to the continuous education of experts who need be capable to use, maintain and improve the achieved level of development.

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