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RAILWAY SHIPPING OF THE LARGEST ENERGY TRANSFORMER IN THE BALKAN

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Abstract: *The paper displays the realization of the railway transportation of the biggest step-up transformer, not only in Serbia but in the southern part of Europe, rated 725 MVA, from thermal power plant TENT B in Obrenovac to the ABS Minel Transformatori factory in Ripanj, where the general overhaul of this energy transformer is under way. The transportation and manipulation process of energy transformers during the overhaul is particularly complex, since it is specified as the railway freight of oversized capital product cargo.*

Energy transformers fall under the category of capital electric energy equipment that have an exploitation period of over 30 years on hydro energy and thermal energy plants or high-voltage substations. Depending on the power and voltage level, the mass of an energy transformer can be up to 400t, while the price can reach as much as a million Euros. The overhaul of energy transformers of great power is a very specific technological process that is carried out in specially equipped factories.

Key words: *Railway transportation, manipulation processes, energy transformers*

INTRODUCTION

Since the exploitation period of energy transformers is very long, and as there are over 140 energy transformers in operation for over 30 years at the facilities of the Serbian Electric Power Industry and the Serbian Transmissions System and Market Operator, this diminishes the reliability of operation of the facilities in the production of electric energy, which destabilizes the electric power system of the country. A breakage on an energy transformer is fatal because the operation of the entire energy unit must be stopped on the thermal power plant or hydro power plant until the broken down transformer is taken off the grid and a spare one is put in its place. However, during the replacement of a transformer that is out of commission, costs are incurred because the power unit stops working, that are multiply greater than the price of the transformer. That is why it has been put into practice that there are spare transformers in all energy units which would be placed on the grid in case of accidents. Spare transformers should be in the power plants because of quick replacement, since its transport is quite specific and can take a while to ship it from another location. Each energy transformer has designed technical characteristics that comply with the characteristics of the generator and high-voltage grid, making it almost impossible to move them from one energy unit to another.

In March 2010 on thermal power plant TENT B in Obrenovac, there occurred a heavy accident occurred on the step-up transformer of French producer CEM, type TR – 9208, No. H26602, 410/21 kV, 1020/19930 A, 725 MVA, connection group Yn, d5 and 490 tons in total weight. The weight of

the transformer oil is 90 tons, and the transport weight is around 360 tons. This step-up transformer has been in exploitation since 1983 (figure 1), when thermal power plant TENT B with two 620 MW power units was let into operation. This is one of the biggest energy transformers in the Balkans, transforming an eighth of the total electric energy produced in the Republic of Serbia.

Fig.1 *Step-up transformer CEM 725 MVA, in thermal power plant TENT B in Obrenovac*

RAILWAY TRANSPORT OF A 725 MVA STEP-UP TRANSFORMER FROM THERMAL POWER PLANT TENT B TO THE ABS MINEL TRANSFORMATORI FACTORY IN RIPANJ

The value of a 725 MVA step-up transformer is around EUR 5 mn and its rail transport from the transformer box in thermal power plant TENT B in Obrenovac to the ABS Minel Transformatori factory in Ripanj (where the overhaul is being performed) costs around EUR 300.000. All the energy transformer factories in the world are built on locations with good possibilities for rail or water transport, so lower transportation costs would enable competitive prices for the clients. Transformers of lower rates are transported via road on trucks with trailers for oversized cargo, on distances where there are no possibilities for railway transport. Given that the 725 MVA step-up transformer from Obrenovac could be transported via rail to the factory in Ripanj, this was executed.

The project analysis for this transport was done, with defined manipulation processes for freighting the transformer from the transformer box to the place of loading, the manner of loading and all questions related to the railway transport to the factory in Ripanj, the unloading and placement at the position of disassembly in the assembly hall of the ABS Minel Transformatori factory. Transport was organized according to all the standing railway transportation regulations with all the necessary permits and special examination of the railway gauges by an authorized institution, which also prescribed the repairs that need to be performed on individual sections of the railway track, as well as all other security measures that need to be taken.

Since this is a transport of oversized cargo of great value, it's important to know the permitted transport profiles on the railways that are defined by the regulations of all national railways through which the transport is taking place. The railway transport of energy transformers is performed by using

special wagons of great carrying capacity, depending on the power and transport weight of the energy transformer (figure 2).

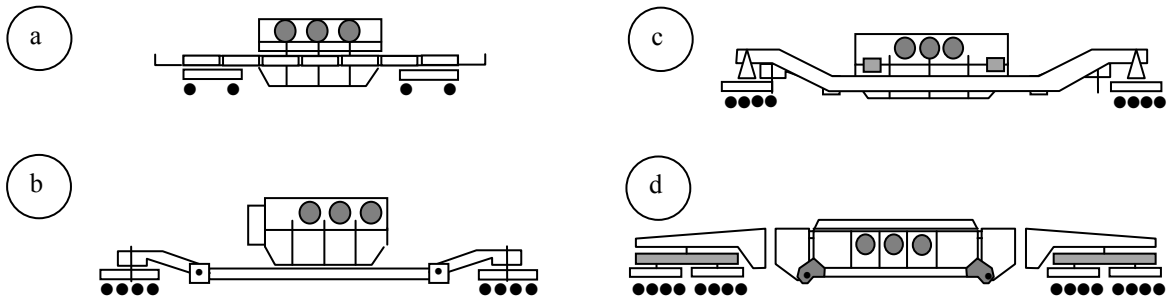

Fig.2 *Types of railway wagons for the transport of energy transformers*
a) flat wagon b) tank wagon c) wagon with carrying construction d) "Schnabel" wagon

Flat wagons are placed on two rotary traps which are used for loads of up to 50 tons, tank wagons, used for loads of up to 100 tons, wagons with carrying constructions, used for weights of 200 – 250 tons and a special multiaxial Schnabel wagon – a wagon with a beak that is used for the transportation of energy transformers of the biggest loads.

An energy transformer of great power and load must be specially constructed for railway transportation, with elements for tying it to the wagon, which must withstand horizontal or vertical tension in places of hydraulic supports. The special, Schnabel wagons are constructed with 24 and 32 axles depending on the carrying capacity, fluctuating from 300 to 500 tons. The wagons themselves, without the cargo, are over 50 m long, so hydraulic devices are necessary for moving the load sidewise against the axial movement, in order to return it to the axle of the transport profile.

For the transport of the 725 MVA step-up transformer was provided the special "Schnabel" wagon with 32 axles, which no transporter on the territory of the former Yugoslavia possesses. The only authorized transporter for oversized cargo transport in Serbia is company "Bora Kečić" of Belgrade, which reserved the wagon for the first week of February 2011 and rented it in Austria with its own crew of 6 wagon operators (figure 3). The annual timetable of the use of these wagons is prearranged, so that a timely planning of transport is a very important activity in the dynamic plan of the transformer's overhaul.

The transformer is specially prepared for transport, by disassembling all the parts that exceed the permitted loads, which are technologically finally assembled at the very facility, and which reduce the transport weight (insulators, conservator, cooling system, domes, joining pipes, control cabinet, motor drive of the voltage regulator). The disassembled parts are packed into closed containers and transported separately. To reduce the transport weight the insulation oil is transported separately. When transporting a new energy transformer, nitrogen is placed into the case and a device for maintaining the overpressure in the container, to prevent the penetration of external air into the transformer container and disable the moisture from penetrating into the cellulose insulation.

The transport was finally realized on February 6th, 2011 by loading the step-up transformer onto the Schnabel car and shipping it via the TENT railway from Obrenovac to Divci. From Divci to Belgrade the transport was realized via the Belgrade-Bar railway, to finally ship it from Belgrade to Ripanj via the Belgrade-Nis railway.

During transport, the entire railway traffic was stopped, while on the Belgrade-Nis track, traffic was halted for an entire 6 hours because of an intervention on the railway switch to the ABS Minel Transformatori factory. The factory tracks are not connected to the railway track by a standard switch but the intersected railway track was moved to the right and the railway tracks welded to the factory's tracks. Such a prepared switch (figure 4) was in function for only a couple of hours, to get the transformer into the factory, unload it from the wagon and return the wagon onto the Belgrade-Nis railway track.

Fig.3 *Transformer 725 MVA on the loading position for the "Schnabel" wagon at thermal power plant TENT B in Obrenovac*

All this was done in less than 6 hours, in order to maintain regular railway transport on the Belgrade-Nis line (figure 4). The transport of energy transformers is carried out by the Schnabel wagon being drawn by a diesel engine, because due to electromagnetic phenomenological occurrences that can arise between the contact grid and the active part of the transformer, the electric contact grid for charging the electric locomotive must be shut down.

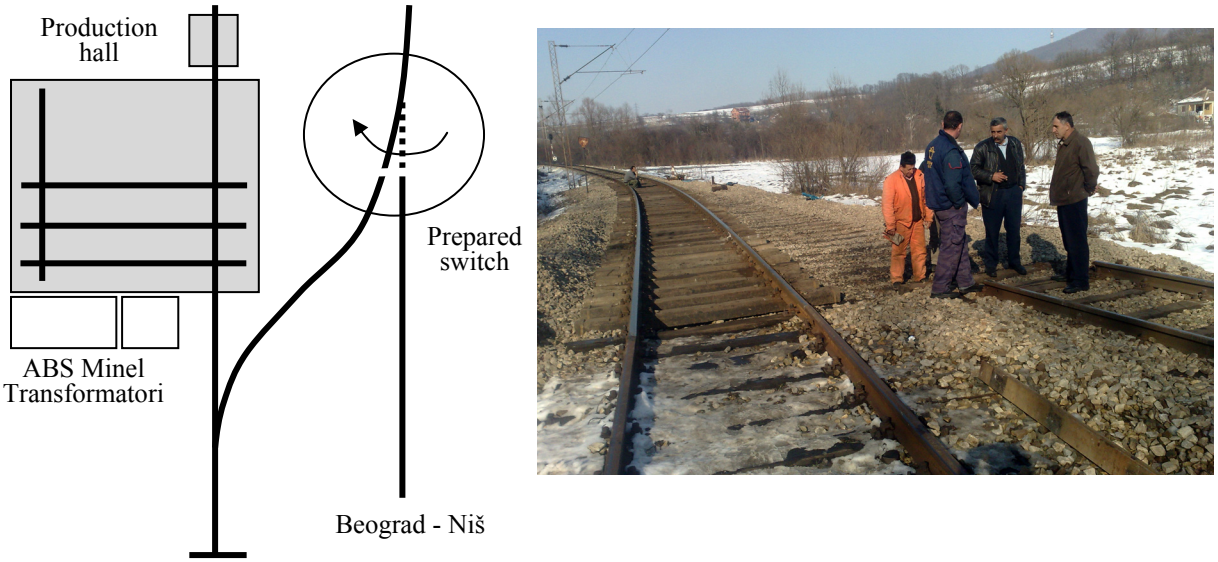

Fig.4 *Switch from the Belgrade-Nis track to the ABS Minel Transformatori factory in Ripanj*

By shipping the step-up transformer onto the ingoing/outgoing factory track of ABS Minel Transformatori in Ripanj (figure 5), the entry of the transformer into the assembly/disassembly hall of the factory was enabled. Here, the unloading took place and the unit was placed on a special cart wheel to transport it inside the hall. Upon unloading the transformer, the Schnabel wagon was prepared for no-load stroke and returned via rail to Austria.

Fig.5 *Entrance of the Schnabel wagon into the ABS Minel Transformatori factory in Ripanj*

Disassembly was performed upon completed transport, to establish the detailed damages because of the accident, test the functional characteristics and damages of the step-up transformer, so as to make the final decision on its revitalization and general overhaul. It was decided for new LV and HV coils to be made, to install new insulation arrangements and to fit in a new magnetic circuit because of damages that were identified on the magnetic circuit's insulation. The costs of overhauling this step-up transformer of capital worth for the TENT B thermal power plant in Obrenovac and the Serbian Electric Power Industry are around EUR 3.5 mn.

CONCLUSION

The transport of the 725 MVA step-up transformer, from Obrenovac to Ripanj, is a great technological and transportation venture, primarily because for the first time, the 32 axle Schnabel wagon moved across Serbian railways, transporting a 360ton load. The overhaul of the biggest energy transformer in the Balkans is an extreme technical and technological venture not just for the ABS Minel Transformatori in Ripanj but any factory in the world.

The company that realized the transport, "Bora Kečić" of Belgrade is the only company in Serbia that has the equipment and capacity to safely realize such a responsible and complex transportation project. The Schnabel wagon doesn't exist in Serbia and Bora Kečić, thanks to the requirements of the ABS Minel Transformatori factory in Ripanj, has arranged for the production of a 32- axle "Schnabel" wagon with the Wagon Production Factory in Kraljevo, for the requirements of their business in the area of oversized transport of energy transformers in Europe. It's safe to say that the design and production of the Schnabel wagon will significantly affect the development of wagon-building in Serbia.

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ПРЕВОЗВАНЕ ПО ЖЕЛЕЗНИЦИТЕ НА НАЙ-ГОЛЕМИЯ ЕНЕРГИЕН ТРАНСФОРМАТОР НА БАЛКАНИТЕ

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Ключови думи: *железопътен транспорт, манипулационни процеси, енергийни трансформатори.*

Резюме: *В статията е показана реализацията на превозването с железопътен транспорт на най-големия трансформатор не само в Сърбия, но и в южната част на Европа – 725 MVA, от топлоцентралата TENT B в Обреновац до фабриката ABS Minel Transformatori в Рипан, където се извършва генерален ремонт на този енергиен трансформатор. Процесът на транспортиране и манипулиране на енергийни трансформатори по време на ремонт е особено сложно, тъй като това се определя като превоз на извънгабаритни товари на капталов продукт.*

Енергийните трансформатори попадат в категорията на капитално електроенергийно оборудване, което има период на експлоатация над 30 години в хидроенергийни централи и топлоцентрали или подстанции с високо напрежение. В зависимост от силата и нивото на напрежение, масата на трансформатора на енергия може да бъде до 400 т, докато цената може да достигне до един милион евро. Основният ремонт на трансформатори на енергия с висока мощност е много специфичен технологичен процес, който се извършва в специално оборудвани фабрики.