Fig. 1. *Turnout R1200, 1:18.5 switch panel. Photo shows the MOT (first actuator), actuators #2, #3 and #4 and blade struts between actuators. HPU is installed on the right side of the track*
Source: own archive.

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High-speed Track Tec turnouts with Alstom SmartDrives

In 2018, after 1.5 year vacatio legis, new PKP PLK technical standards are becoming effective. The reason to implement new standards is to increase the maximum speed on the Central Trunk Line (CMK) for „Pendolino" trains up to 250 km/h. Currently, trains achieve the maximum speed of 200 km/h. This improvement requires careful examination of all system elements, especially the interaction of the rolling stock with the infrastructure, including the superstructure. Railway turnout is a particularly sensitive element of infrastructure as it contains movable elements. Trains going straight should pass a turnout with no need to slow down. Therefore, the maximum speed on a given line is 250 km/h, the speed on turnout main line should also be 250 km/h. We then use the full potential of the line.

The maximum speed on branch line depends generally on the radius of a turnout branch line and the angle between the axis of the main line and axis of the branch line. Turnouts are qualified both by radius R and tangent of this angle. Turnout design affects the maximum allowable forces acting both on the turnout and the rolling stock. The crossing is a section of the turnout where very

Fig. 2. *Turnout R1200, 1:18.5 crossing. Actuators, trailing controller, AREX turnout heating separation transformers, JVA terminal boxes and HPU*
Source: own archive.

high dynamic forces occur. For the high-speed railway system, it is appropriate to use frogs with movable noses which allows to reduce dynamic impact on the rolling stock wheel sets, improve the passenger travel comfort and extend the lifecycle of critical turnout elements. This means that the turnout with its maneuver and detection elements should be structurally adapted to the speed appropriate for a given railway line class.

Therefore, this article discusses the turnouts for main line speeds of v≥200 km/h. 200 km/h is a threshold speed to classify a modernized railway line as a high-speed line. We can assume that already right now, CMK belongs to the high-speed line category since the „Pendolino" trains achieve a speed of 200 km/h on a relatively long section. However, to be able to fully use the technical capacity of „Pendolino" trains, it is necessary to upgrade CMK line up to 250 km/h. To achieve this goal, the activities have been completed or started in area of traction power supply and signaling system (ETCS level I). Turnouts and switch machines are still to be modernised.

Technical parameters and certification

For high-speed turnouts, it is necessary to use, to achieve proper parameters (switch frame stiffness, locking withstand force) depending on the radius and tangent, several locks. The abovementioned new PKP PLK standards require that the forces are generated in a power unit at one place and should be transmitted to switching points by a hydraulic or mechanic system installed axially in the track. In case of a need of manual operation, such a system facilitates and accelerates turnout switching comparing to multi-drive systems. The new standards assume a requirement that the design of a turnout system should allow manual operation within no more than 4 minutes.

In order to satisfy the requirements of the new PKP PLK technical standards, Track Tec developed the turnout with a radius R = 1200 m, tangent 1:18.5, with a movable nose. The turnout is integrated with the SmartDrive hydraulic switch system by Alstom Ferroviaria (Italy). For this purpose an international project team of engineers from Poland and Italy has been appointed. Alstom is a world leader not only in building a high-speed rolling stock but also in broad understood railway infrastructure for the high speed railway system – TGV. Therefore, it was not accident it was deliberate that the turnout has got the SmartDrive system verified on the HST line in Italy (Alta Velocità), where more than 400 turnouts integrated with SmartDrive solution are in operation.

Another important reference for SmartDrive system is provided by the British Network Rail which is operated by more than 700 turnouts equipped with SmartDrive system known there as Hy-Drive. SmartDrive is tested and certified in Italy for the maximal speed of 300 km/h. Currently, the certification process is ongoing to increase the maximum speed on main line to 350 km/h, which requires dynamic tests with a speed of 400 km/h.

Structure and assembling

The switch frame – Fig. 1 is equipped with a actuator in hollow sleeper (MOT – Italian abbreviation), 3 intermediate actuators and 3 blade struts. The crossing is equipped with 2 actuators for movable nose and the trailing detector – Fig. 2. The switch and frog hydraulic circuits are powered from separate hydraulic power units (HPU).

A railway turnout requires high precision during installation so it was decided that the turnout would be fully assembled at the manufacturing plant and delivered to the construction site in blocks using the wagons for turnout transportation. As a standard, the system provides three separate blocks – switch panel, connecting rails and frog which are transferred to the construction site on the platforms and placed with a special railway crane. This allows for a very smooth transport and installation maintaining the factory geometric parameters. In case of a traditional method, transport of turnouts in parts may lead to damage of elements as a result of improper unloading which leads to changes in geometry between the turnout status during the technical acceptance at a manufacturer site and one installed in track. The reassembly in the field requires, for obvious reasons, much more time under the conditions that it does not allow to achieve proper precision. A switch panel

Fig. 3. *Switch panel prepared for installation*
Source: own archive.

Fig. 4. *Process of the turnout installation*
Source: own archive.

Fig. 5. *Special railway crane Gottwald GS 150.14TR during turnout installation at the Psary Station*
Source: own archive.

block has a mass of 25.4 t with a total length of 24.1 m, straight rail block weighs 29.7 t and is 25.7 m long, whereas the frog with a movable nose 24.7 t and is 16.8 m long. Fig. 5 shows the switch panel prepared for installation at the Psary Station.

In block technology it is necessary to use a special railway crane to transfer blocks from cars and lay them on prepared surface. The case in question used Gottwald GS 150.14TR (Bahn Technik Wrocław). Fig. 5 shows the operation of a block discharge with this crane.

R1200 turnout at the Psary Station was laid within few hours on a pre-prepared bed of ballast. After the welding works, hydraulic connections and electric connections for the detection circuits were done. According to the new standards, the terminal track side boxes and HPUs, were completely insulated from the ground with insulation bushes and their bodies were rail-bounded. The conventional JVA boxes were upgraded by replacing, inter alia, steel inlets for ground cables with flexible PMA corrugated conduits which have the homologation and references in many European railways. The connection of SmartDrive instead of five individual drives to the existing electronic EBILCOK-950 interlocking required changes in the application of the STC-1 object controller. The whole turnout with the drive connected to the EBILOCK-950 system was tested before putting into operation at the Psary Station by the Railway Institute specialists in domain of rail road, signaling and energy.

The operation principle of Alstom SmartDrive is different than in most point machines currently used in Poland. The hydraulic circuit is powered by a dedicated power unit (pump) placed in the HPU outside the track. The power unit provides stable oil flow towards the hydraulic circuitry with variable pressure. Each actuator connected with the hydraulic circuitry is designed to allow conversion of pressure into linear movement. To open the locks completely, the actuator cylinder must generate a force needed to rotate the electric contacts (detection lose), stabilization force and force required for locking. During the movement of blades, each actuator provides a force required to move a blade (or a movable frog nose). The actuators which face lower movement resistance will move the blades earlier so that they support the actuators which face higher resistance, thus improving the system's reliability. At the end of the switching phase is the locking phase. When all locks are closed, the oil pressure rapidly increases to the maximum value and the switching process is completed. After switching, the pressure in the hydraulic conduits drops to zero. The switch machine is a non-trailable drive. The MOT provides dual locking with a force of 100 kN. Intermediate actuators withstand the force of 40 kN. Position detection circuits are integrated with actuators and with special dedicated cables connected to the terminal track side boxes and ground cables leading to the track side cable cabinet and then to interlocking. Cabling and hydraulic system is intrinsically safe (SIL-4 - safety integrity level) and complies with the requirements of the relevant CENELEC standards.

The turnout no. 30 at the Psary Station was commissioned and put into operation. The speed on the main line is now 200 km/h and 100 km/h on the divergent track. After the dynamic tests with a speed of 275 km/h and other successfully completed field tests it is expected that the turnout integrated with SmartDrive will be homologated in Poland for a maximum speed of 250 km/h at the turn of 2018/2019.

Fig. 6. *Integrated turnout installation process at Psary Station*
Source: own archive.