Smart Tamping – Fields of Application of the Turnout Tamping Assistance System

Plasser & Theurer's development of the turnout tamping assistance system "PlasserSmartTamping – The Assistant" has been an important step towards the further automation of tamping machines. The assistance system provides automated support for tamping works in turnouts and crossings. It recommends specific actions which must be confirmed by the operator before they are carried out. As a result, operators increasingly monitor processes, intervening manually only in exceptional cases. A new recording module allows for a completely new form of tamping documentation. It increases transparency, working quality and process reliability. For the first time, the turnout tamping simulator – not a tamping machine – was used to develop all of the software modules of the turnout tamping assistance system. In an extended hardware-in-the-loop application, the turnout tamping assistance system was developed and tested using the simulator.

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1. THE DEVELOPMENT

In modern track maintenance, the conventional distinction between track inspection vehicles and track construction and maintenance machines has increasingly been blurred. To optimise processes, track construction and maintenance machines are fitted with the latest sensor technology, turning them into "smart machines". Inertial track measuring systems, used up to now only on track inspection vehicles, have increasingly been installed on tamping machines. This makes it possible to use tamping machines for separate track measuring runs to calculate the required track geometry correction values.

The use of inertial track measuring systems optimises the track geometry quality. In addition, laser scanners and light section sensors make it possible to create a "digital track twin", which provides the data base of the turnout tamping assistance system.

2. THE OBJECTIVE OF THE TURNOUT TAMPING ASSISTANCE SYSTEM

Turnout tamping (Figure 1) requires considerable knowledge of several areas of expertise (track surveying, machine technology, track technology, regulations). The most important tasks include:

- → In the main tamping cabin: Controlling the tamping unit including the turntable, opening width and tilting motion of the tines
- → In the co-tamping cabin: Controlling the lifting and lining unit, the parts of the tamping units in the diverging track and the additional lifting unit

The turnout tamping assistance system complies with level 3 of the standard SAE J3016. The standard defines terms related to on-road motor vehicle automated driving systems and has been applied correspondingly. On the automation level 3 the system recommends specific actions which must be confirmed by the operator before they are carried out, with the operator as fallback. The design of the turnout tamping assistance system also allows for higher levels of automation. However, for reasons of liability, automation options such as remote control or robot operation are not offered.

The turnout tamping assistance system

offered to machine operators and infrastructure managers consists of four product parts in modular design:

- recording module for recommendations and operations
- operation assistant for the lifting and lining unit
- operation assistant for the additional lifting unit
- operation assistant for the tamping unit

The modular design makes it easier to put the turnout tamping assistance system into operation for the first time. In a testing phase, recording modes can be used to verify the accuracy of the recommended measures (comparison of the actual taming operations and the actions recommended by the assistance system). Upgrading to a higher level is possible if it has been taken into account in the design of the machine. The modules are activated step by step to allow staff to familiarize themselves with the assistance system and to coordinate the work processes.

FIG. 1: Operators of turnout tamping machines must meet high requirements

3. THE RECORDING MODULE "DIGITAL TRACK TWIN"

The first step is to develop the digital track twin. When selecting the hardware components of the turnout tamping assistance system (one rotation laser, four light section sensors and one colour camera), it was ensured that the hardware can be exchanged and that the software can be adapted modularly.

When designing the hardware components, a particular focus was placed on meeting the accuracy requirements. In addition, it was ensured that the system is highly robust and easy to maintain.

The recording module of the turnout tamping assistance system connects the digital twin of the track with the working parameters of the machine. As a result, the quality control of tamping works reaches a new transparency level. Infrastructure operators can easily access all parameters relevant to quality and work (such as the tine position, tamping depth or squeeze time) digitally and immediately when connected to the Internet.

In the future, the recording document will also include the rolling marks of the rails and the position of the aluminothermic welds. As the software is developed in-house, we can meet our customers' requirements flexibly (Fig. 2). For instance, it will be possible to export the "digital twin" for use on the tamping simulators. »

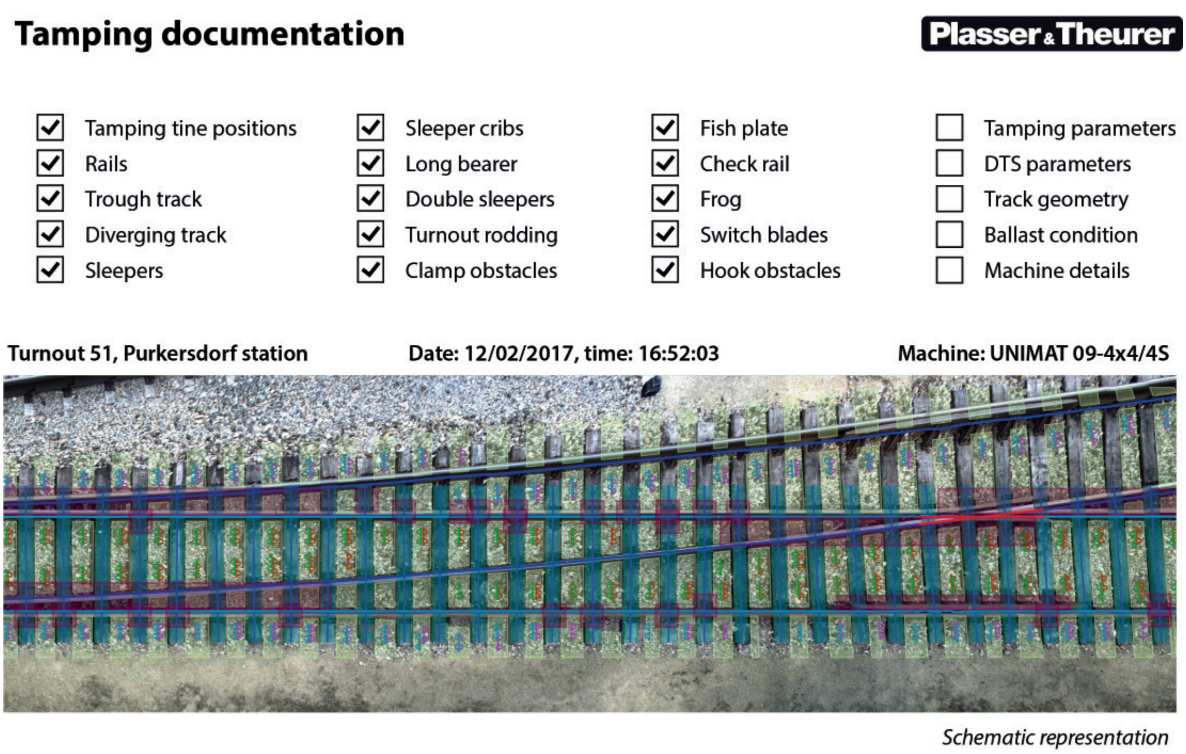

FIG. 2: Tamping documentation using multi-layer technology (schematic representation)

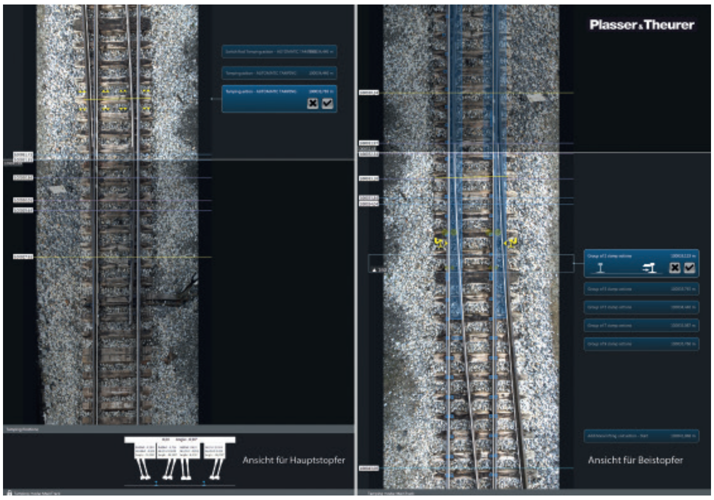

FIG. 3: Overview of the control recommendations

4. OPERATION ASSISTANCE

Based on their position at the time of recording, the individual scans and recordings are merged to form a 3D image of the reality, showing the exact position. At the same time, the position of the machine and every individual work unit is continually updated. As a result, a 3D image of the relevant machine parts is imported into the overall model, providing the basis for every decision of the assistant. The data is processed with the lowest possible latency and highly parallel data processing to ensure fast operation. The system recommends the respective actions several metres ahead of the tamping unit (Fig. 3), to provide the operators with sufficient time to analyse and modify the recommendation, if necessary. The recommendation of the assistance system is checked directly at the tamping position before the tamping unit is lowered. At the same time, the configuration of the lifting and lining unit (hock and tongue position) for the transfer to and the lifting operation at the next tamping position is checked prior to transfer travelling. At this point, the operator can take action at any time and further adjust the settings. The operation of the additional lifting unit is checked in a similar way.

Position for every sleeper crib	
	Tamping units
	Lifting and lining unit
	Clamp disks
	Hooks
Angle for every tamping/lifting operation	
	Turntable
	Tamping tine
	Additional lift
Activation of thrust flaps	

FIG. 4: Position sensors, angle sensors and actuators operated by the assistance system

To allow for tamping recommendations, the track sections requiring actions must be located in an automated process. To ensure this, different image processing systems are combined with artificial intelligence and connected systemically.

The basic tamping scheme was developed on the basis of regulations and specifications of German Federal Railway (DB), Austrian Federal Railways (ÖBB) and experience from practical operation. A specific adaptation to the infrastructure manager's requirements is possible.

Figure 4 shows a list of position sensors, angle sensors and actuators operated by the assistance system. The values of the lining adjustment, the lifting operation and the tamping parameters (multiple tamping, tamping vibration frequency, squeeze force, tamping depth) are not controlled by the assistance system.

The turnout tamping assistance system has been designed for two applications: In the first design version (the separate view), separate measures are recommended to the operators in the main tamping cabin and the co-tamping cabin. The second design version (the combined view) is the current development focus: Both assistance modules are merged into a combined view in the main tamping cabin, enabling the operator in the main tamping cabin to control the entire turnout tamping process by himself (Figure 5).

The application focus of the first generation of the turnout tamping assistance system is on turnouts that have not yet been fully ballasted. As a result, the surface of the sleepers is visible. Specific recommendations require a good view onto most of the turnout area, the sleepers and obstacles (such as switching contacts, turnout operating units).

In a next stage, we plan to fit the turnout tamping assistance system with sensors (eddy current sensors) for the detection of sleepers in ballasted areas (newly laid track).

Completed tamping works in turnouts can be duplicated using the machine control module turnout programming automation. In a combined application of the turnout tamping assistance system and the turnout programming automation it is, in principle, possible to scan turnouts in advance while they have not yet been fully covered with ballast, and to provide the turnout programming automation module with the recommendations to allow for their duplication. Turnout tamping machines with the integrated supply of new ballast generally allow for the use of the turnout tamping assistance system, as the turnout is not ballasted at the scan position at the front end of the machine.

The prototype of the turnout tamping assistance system was introduced to the expert audience at the trade show iaf 2017 in Münster. The positive feedback proves the great potential of the technology. In practical operation, the turnout tamping assistance system is currently prepared for series production for the work unit types "275", "475" and "4x4".

FIG. 5: Tamping cabin with the assistance system "PlasserSmartTamping – The Assistant"