Metallurgical Plant and Technology G 25074

ISSN 0935-7254

MPT INTERNATIONAL

5
October
2012

Internet-PDF from „Metallurgical Plant and Technology“ 05 / 2012, pages 70 – 77

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Warehouse management system eliminates bottlenecks

In 2011, Hoesch Hohenlimburg implemented a warehouse management system in the coil store downstream of the two pickling lines. The system enables targeted storage and efficient use of the available storage space. It optimizes crane movements, avoids unnecessary shifting – and the associated risk of damage – and speeds up loading for shipment. It creates transparency as it makes all information readily available and all activities intuitively comprehensible. Additionally, the system guarantees a high safety level.

German flat steel maker Hoesch Hohenlimburg GmbH produces medium-wide hot-rolled special strip, which is up to 685 mm wide and between 1.5 and 16 mm thick. A finished-product store (bay No. 6) at the exit of the push-pull and continuous pickling lines serves as dispatch store for all pickled coils **(figure 1)**.

The yield of the two pickling lines has constantly risen at Hoesch Hohenlimburg what in general is a good sign. However, for that reason the coil bay No. 6 transformed into a bottleneck, especially since there is no dispatching at weekends. The dynamic capacity of the warehouse was becoming increasingly constrained by the confined space conditions and the growing necessity to shift coils. This was the reason for the management of Hoesch Hohenlimburg to take measures aimed at cutting the times required for placing and removing the coils, reducing the number of crane movements and, as a result, making storage and shipment in general more efficient.

A peculiarity of the coil store in bay No. 6 is that there are no individual coil cradles but racks of 10 m length carrying up to 50 coils placed closely side by side. Therefore the two gantry cranes, which handle the coils, cannot operate with gripping tongs. Instead, C hooks are used to transport the coils – up to five at a time, depending on their weight.

The coil store used to be operated without a warehouse management system. Coils ready for shipment were marked with chalk. The coils were stored in two layers due to the limited space available. This required frequent and time-consuming shifting of coils. Moreover, searching for coils of which the position was not exactly known also demanded a lot of time and effort. Another objective was to enhance safety.

Finally, the decision was made to invest in a warehouse management system, and several offers were invited. The new software was expected to map all processes from the pickling line exits all the way to the shipment activities. At the same time it was considered very important to create acceptance of the system among the workforce. Therefore intuitive, easy operation and clear visualization were aspects of crucial importance.

Figure 1. Storage area for the coils coming from the two pickling lines

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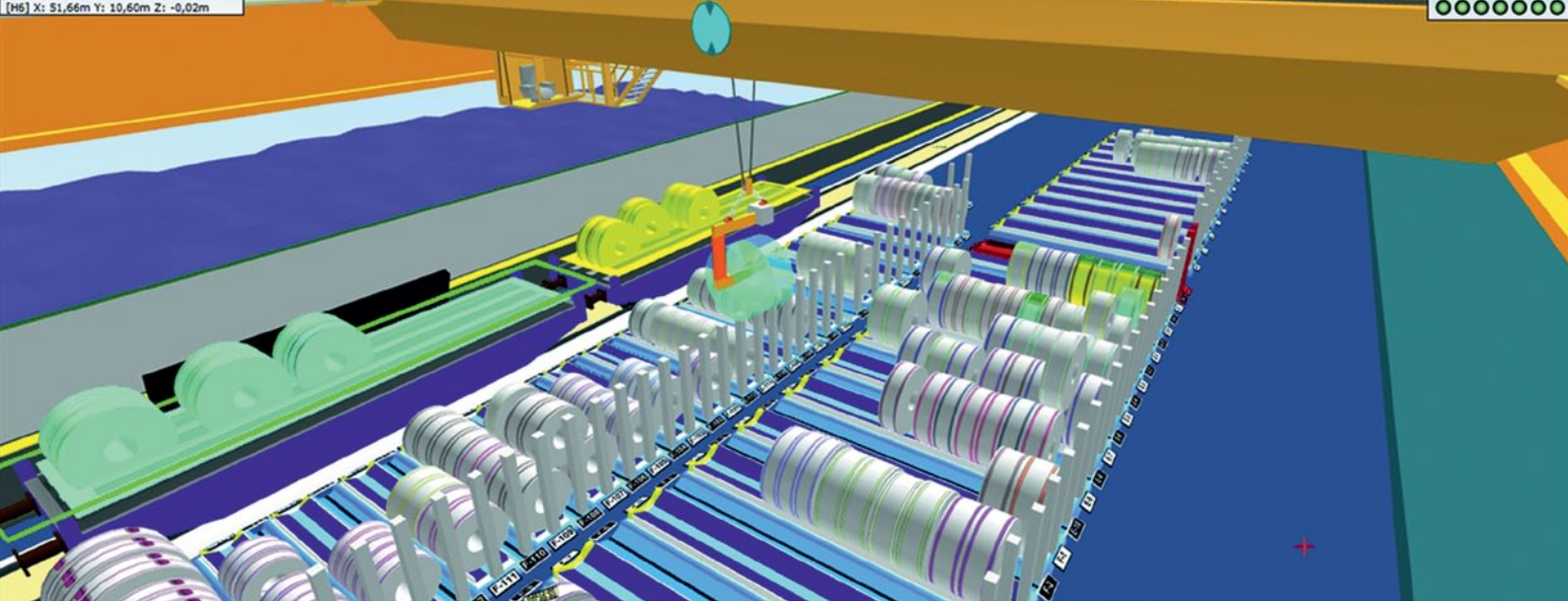

Figure 2. **The coil store can be visualized from any perspective**

3D visualization makes tables and charts superfluous

Already at the first project meeting, 3tn – provider of industry software – presented their pseudo-realistic, three-dimensional graphical visualization solution as shown in figure 2 (while others were proposing systems that were still based on charts in which each coil was represented by a line). The specific conditions in bay No. 6 were taken into account, especially the many peculiarities of the warehouse in terms of confined storage situation and the small coil width called for a flexible, easily adaptable software. In the summer of 2010, Hoesch Hohenlimburg awarded the order of a warehouse management system for the finished-product store to 3tn. Installation started in December 2010, and since March 2011 the system has been running under regular operating conditions.

Industry software provider 3tn has already been known a reliable supplier to Hoesch Hohenlimburg. In 2006, Hoesch Hohenlimburg had commissioned a 3tn warehouse management system for the slab store, which has proved highly efficient ever since. Also for this first project the small slab width turned out as a special challenge. When individual slabs were to be removed in an inclined position, it was not sufficient to only measure the position of the crane. Instead, it was necessary to measure exactly the position of each individual slab. Only that guaranteed that each slab was correctly logged in the system. Initially, it was considered impossible to implement this high-precision position measurement. But 3tn solved the problem by scanning the topography of the "mountain range" by laser scanners.

Optimal use of storage space

The task of the warehouse management system is to generate transport orders which ensure:

- that the coils are removed from the exit areas of the pickling lines in a timely manner,
- that they are stored in optimal positions and
- that they are correctly picked and taken to the dispatch area and loaded on truck or train.

The warehouse management system takes over as soon as a coil leaves one of the two pickling lines. Henceforth it controls the activities all the way down to the loading of the coils on trucks or trains. Therefore 3tn has not only mapped the warehouse management in bay No. 6 but also the complete dispatch activities. These include the issuing of delivery notes, proper preparation of the goods for shipment on trucks or wagons as well as the consignment and optimal loading of the goods.

The warehouse management system receives the coil data from a host computer and sends a "removed from the store" message to the host computer as soon as a coil has been shipped. The coils leaving the pickling lines are automatically booked into the warehouse management system with the correct coordinate. Only in exceptional cases the operators do identify them with hand-held scanners and mobile terminals.

In more detail, the operating procedures of the software are structured in three subsequent steps. The warehouse management system first determines which areas of the warehouse are generally suitable for a particular coil. After this preliminary selection, it checks each one of the available empty spaces in these areas for its general suitability as a storage location for that coil. This includes taking into account restrictions that may either be in connection with the specific situation of the storage space – for example, the maximum allowable outside diameter or the remaining available space on a coil rack – or with coil-specific storage rules – for example, whether the coil is oiled or has been blocked. For the second layer additional restrictions apply. For example, the maximum outside diameter of the upper coil may exceed that of the lower one only by a certain amount.

Finally, the warehouse management system determines the optimal storage position from the remaining number of suitable available spaces. This is done by evaluating each free space against optimization targets, for example:

- "Optimize for short transport routes",
- "If possible, place coils from the same manufacturing lot together on one rack",
- "If possible, place coils for the same customer in the same storage area",
- "Fill the racks with coils of the same or similar outside diameters" or
- "If possible, place large coils in the first and smaller ones in the second layer".

For generating a transport order, the warehouse management system goes through a total of nine prioritization routines. A dynamic prioritization scheme has been implemented for the pickling line exits. This means that in a situation in which the exit area fills up above a certain limit the priority for coil removal from the exit area is raised in order to avoid bottlenecks in the pickling process.

Figure 3. **Real-time in-cabin monitor view**

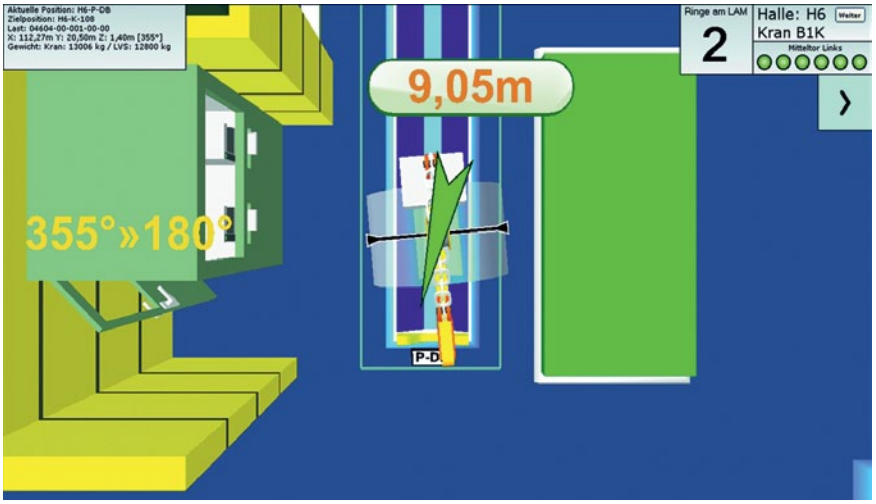

Figure 4. **The cabin monitor shows the coil from a perpendicular perspective**

Clearly structured visualization

A central element of the system is the real-time 3D visualization of the warehouse situation in virtual reality **(figure 2)**. A three-dimensional view is implemented on the client terminals in the control pulpits and in the offices. The users can freely move about this display and view the warehouse from any perspective. If they want to see where a certain coil is located, they can zoom in on it from the total view. In this way, any coil can be exactly localized in a matter of seconds.

In the crane cabins visualization is generated always from the current perspective **(figures 3 and 4)**. Arrows guide the crane operators from one position to the next. All information they need for processing an order is being displayed to them.

The cranes are equipped with a C hook as load carrying device, a load pin and a slewing gear with angle transducer. When picking up coils with the C hook, the crane operators are sometimes faced with the challenge that it may be necessary to first lift the coil or coils up just a little bit and pull them forward to a certain point before they can actually lift them all the way up. In these cases, it was not sufficient to only have a weight recognition system. Therefore, 3tn additionally supplied a position recognition system from Lase GmbH, equipped with two lasers to exactly measure the current position of the coils on the C hook. The thus obtained information is related to the coil weight and the current crane position for a plausibility check.

In all displays, the coils are shown complete with specific coil information, such as the coil ident, and highlighted in different colours depending on whether they are to be loaded on a truck or wagon or whether they have been blocked. Assignment of the coils to the individual shipments can already take place before the trucks or wagons arrive at the warehouse. Based on the colour of the coils, the crane operators can pre-allocate the coils to individual shipments to cut loading times **(figure 5)**. Also for these coil shifting operations, the warehouse management system determines a new, optimal storage location for each coil.

When the empty truck has been weighed, the host computer sends the data of the delivery note to the warehouse management system. These data include the registration number of the truck, type of delivery note, tare weight of the truck and shipment file number. On the basis of these data, the warehouse management system can plan the truck loading. In doing this, the system takes into account many conditions, for example, whether the coils must be loaded in a certain sequence or whether the shipments are to be split between various delivery notes.

When the truck has arrived at the warehouse, the loader triggers the loading process in the warehouse management system. The corresponding transport orders are immediately displayed to the crane operator. The coils to be loaded are highlighted in colour on the monitor. Arrows indicate the pick-up positions to the crane operator **(figure 6)**. When the coils have been picked up, arrows now signal which truck is to be loaded.

The loading of railway wagons works in a similar way: The host sends the wagon data to the warehouse management system. The sequence of wagons of one train is entered manually. A wagon management feature has been implemented in the warehouse management system in order to take into account specifics of individual wagon types, for example, their dimensions or the maximum permissible weight. The warehouse management system suggests a wagon for each coil to be shipped. However, the final decision is made by the loader, as there might be

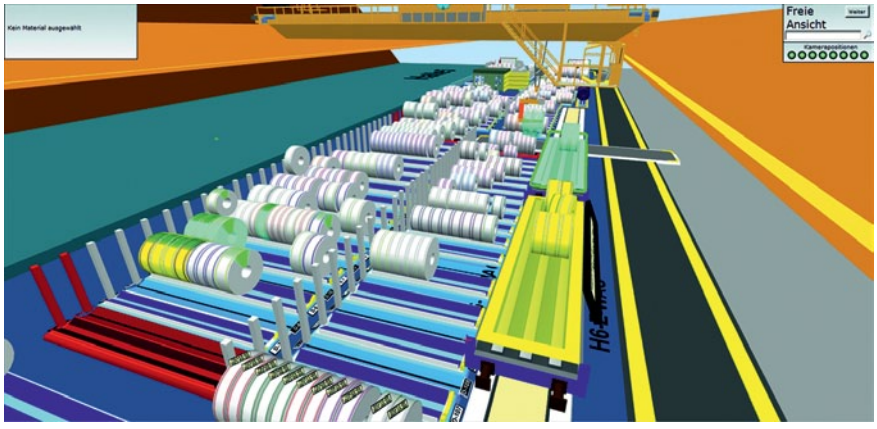

Figure 5. **The yellow and turquoise coils will be loaded on wagons of the same colours**

restrictions that the warehouse management system does not know.

High acceptance among users

In a first phase, only the system part for the warehouse management was commissioned. The loading management was added later. During the commissioning phase, the warehouse management system initially ran in parallel with the manual activities. The switchover date was April 26, 2011. For a period of about three months every third rack was left empty. This made it possible to have at any time free access to all racks to visually check the position of any coil in the warehouse. Also the crane operators checked each individual coil in the initial phase. This is no longer necessary today as the system has proved its reliability long since.

Commissioning went smoothly, last but not least due to the fact that 3tn specialists were present either on site or via remote data line and due to the constructive collaboration between 3tn and Hoesch Hohenlimburg.

In parallel with the installation of the system, 3tn trained the crane operators and their stand-ins in cooperation with the coordinating personnel. The system users were involved at all times and their suggestions were implemented as part of the adaptation of the system to the works-specific situation and processes. Thus the system quickly met with the operators' acceptance. Also older operators and those without prior computer experience soon got accustomed to the new practice.

If in the event of a temporarily unstable host connection the coils cannot be booked, the warehouse management system buffers all warehouse activities taking place during that time and automatically synchronizes the data at a later point in time.

Since the summer of 2011, the system has been running entirely stably under routine operating conditions. To date there has been only one reboot after a software update. Many procedures are faster and more efficient now. Additionally, the warehouse management system prevents errors because it warns at an early stage when there are signs of restrictions being violated.

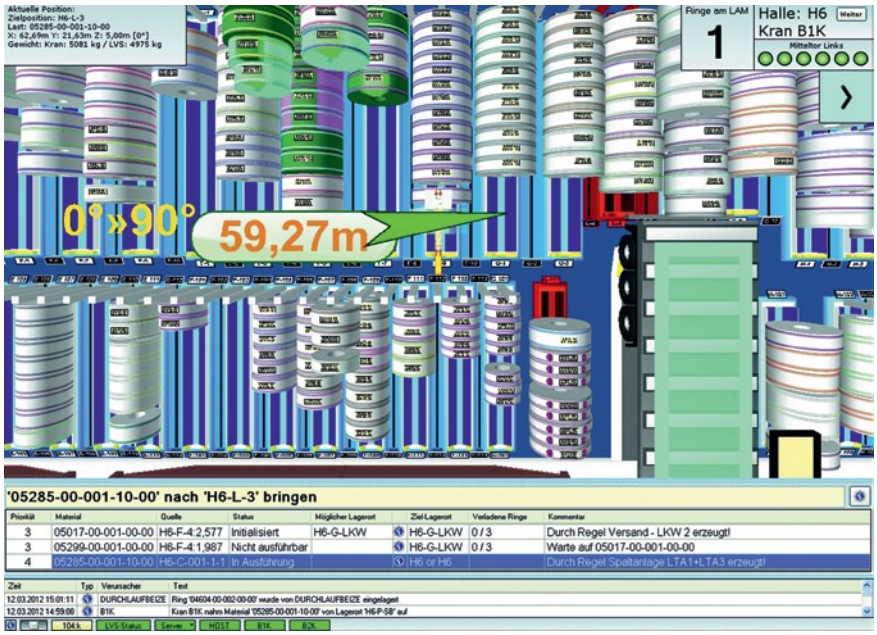

Figure 6. Current position and the destination of any coil stored can be indicated

All users have direct access to the data from their work places. The dispatchers, for example, no longer need to physically walk to the warehouse to check the storage position of a particular coil.

New level of transparency

The objective of being able to reliably indicate the position of any coil in the warehouse at any time has been reached. The system has become exceptionally well accepted among all users – not only among the crane operators but also among the dispatchers. Also the quality of the shipped coils has improved as a result of the smaller number of transport and handling activities resulting in a reduced number of blocked coils and less complaints due to coil damages. Another positive aspect is the higher safety standard achieved.

Before the warehouse management system was introduced, the loaders used to mark the coils manually and signal to the crane operator which coils were to be taken to which location. Today the entire storage situation in the warehouse is displayed on monitors. In the beginning, some of the users did not think that the pseudo-realistic visualization in 3D was making a great difference. But meanwhile the 3D visualization has proved to have largely contributed to the success of this project because it provides a so far unknown level of transparency for all processes. Today for all users this visualization is an absolutely indispensible feature of the system.

The warehouse management system passed the ordeal before the summer shutdown in 2011. The warehouse inventory had grown to a size that would have been impossible to cope with in a situation without the system. But thanks to the warehouse management system, production could be continued without restrictions. Even during that time of extraordinary workload, the storage situation was mapped correctly at any time.

The second major challenge was stocktaking in 2011. Before the warehouse management system was in place, employees had recorded all coils individually by scanning the coil idents and entering them into the host system. These activities had blocked 20 employees for one shift. Today stocktaking takes place at the push of a button. It is limited to just a few random checks performed by two employees, a procedure that was instantly approved by the auditors.

The history of each coil is recorded in a data base. It contains information such as the time of each event, the type and initiator of the event, the storage location, the storage coordinates and all master data. Also a history of each storage location is stored in the system.

The stored data are used to analyze warehouse processes. For example, records of the age structure of the ware-

house can be issued as well as records of the crane movements per day or the number of trucks loaded. Meanwhile the warehouse management system is used to analyze trends and optimize processes.

In addition to speeding up the processes in the finished-coil store, the warehouse management system also has positive impact on downstream production stages. Approximately 40 percent of the pickled coils are processed on slitting lines. The warehouse management system substantially accelerates and simplifies internal works transport as it pre-sorts the coils by bays, downstream processes and means of transport. The system has also proved its worth in the event of sudden changes to the slitting programme, as it enables swift reaction to changed conditions. In the past, the coils used to be marked with chalk. Whenever a programme was changed, first the existing markings had to be erased before coils could be marked anew. This procedure was not only time consuming but also prone to errors.

Conclusion

The warehouse management system has proved to have a major cost saving effect in many areas of the works. However, this effect is still difficult to quantify at this stage. But one thing is for sure: even in situations of heavy workloads the dispatch store is no longer a bottleneck.

All in all, the warehouse management system at Hoesch Hohenlimburg has formed the basis for further growth because in the past the works had repeatedly reached its logistical limits due to the situation in the finished-coil store. It is planned to also install a warehouse management system in the storage area behind the rolling mill where the medium-wide strip coils cool down. Further potential areas of application are the bays No. 5 as well as 0 and 4 where the slitting lines are located and very different products such as coiled narrow bands and strip coils will have to be managed. ■