

Optimal use of available floor space at a new storage location for steel coils

Use of mathematical modelling of a new steel coil storage/distribution warehouse has generated storage space for 300 additional coils and results in an 8-10% greater potential throughput than pre-modelling designs indicated.

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Major investment decisions in the business sector are often accompanied by major uncertainties. For logistics projects, these uncertainties often relate to the dependencies between different parts of the logistics systems. Additionally, arrival patterns are, in practice, not nicely distributed according to an exponential distribution. There is variability over time in the various production processes, and one has to deal with peaks and failures. A simulation model of the logistics process can clarify this uncertainty by simulating the entire process, with all dependencies and relevant parts of the logistics included in the model.

A good example of an application for a simulation model is the LA warehouse project of Tata Steel IJmuiden. In collaboration with Systems Navigator BV, Tata Steel started the construction of a simulation model in early 2018 to analyse and optimise the logistics of a planned new steel coil warehouse. The coils are stored in cradles in the warehouse, but certain cradles are only suitable for some of the roles, so it is important to choose these cradle dimensions well and to place them smartly on the available floor space.

THE COMPANIES

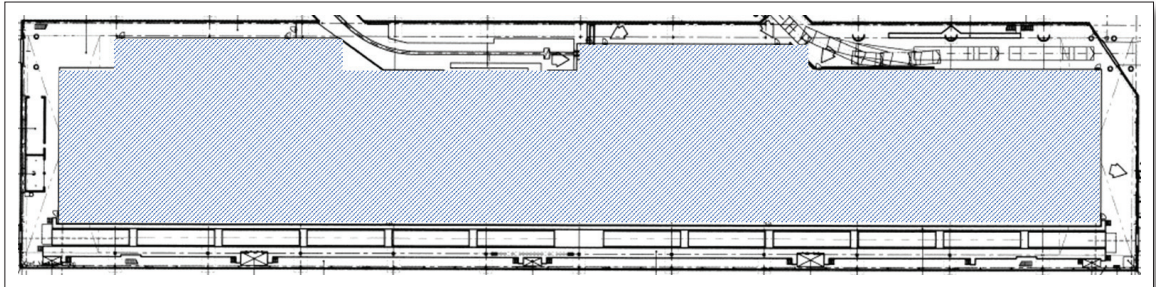
Tata Steel produces, manufactures and distributes high quality steel for products in various industries, such as automotive, packaging and construction. At Tata Steel in IJmuiden more than 9,000 employees work on an annual steel production of almost 7Mt/y.

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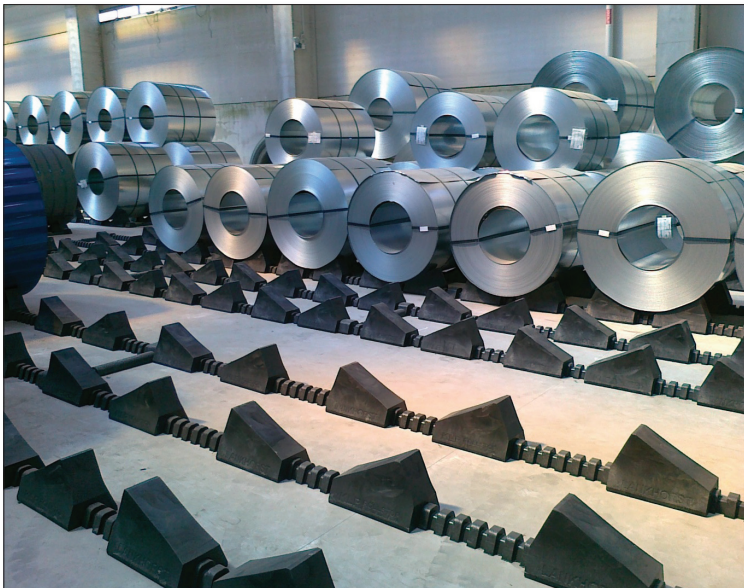
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Fig 1 Phase three of the LA warehouse under construction



ⓐ Fig 2 Floor plan of LA warehouse



ⓐ Fig 3 Cradles and coils

THE LA PROJECT

Tata Steel is continuously working on improving its (logistics) processes, and the construction of a new storage warehouse for high-grade steel coils, the so-called LA warehouse, is part of this improvement process. The LA warehouse will be used for the temporary storage of finished steel coils prior to dispatch to customers. The finished coils enter the warehouse via trains or a cross-transfer system and are stored pending delivery to the customer. To minimise the number of manual operations the coils are transported by two automatic cranes which are controlled by a warehouse management system. The layout is very important for the efficiency and storage capacity of the warehouse. *Figure 1* shows phase three of the warehouse under construction during the first months of 2018. *Figure 2* shows the floor plan with the rail on the south side and the cross-transfer at the left top side. The dimensions are approximately 220 by 40 meters.

The warehouse layout, a so-called cradle set-up, is the focus of this article. A cradle is a simple device that locates

a coil and ensures that it does not roll away. However, certain cradles can only be used by coils that meet certain conditions in terms of width, diameter and weight. In addition to these technical limitations, it is not advisable to make all cradles suitable for every coil size since each cradle must then be suitable for the largest coils, which means that space is lost if only a small coil is placed on it.

In addition, as illustrated in *Figure 3*, coils can be stored on top of other coils to maximise space utilisation. To stack these coils, they have to meet certain stacking rules, which are based on the width, diameter and weight of the coils on the cradles and the corresponding coil that needs to be stacked.

In order to maximise warehouse capacity and efficiency, it was important to smartly decide on the number, the size and the placement of the cradles before storage operations commenced because, if it turned out to be wrong, adjusting it later would mean that parts of the warehouse would have to be emptied and operations stopped.

In order to do this, the possible changes in the characteristics of the coils that will be stored and the variability of the incoming stream have to be considered. Thus the aim should be to create a layout in which as many potential incoming streams with different types of coils can be efficiently dealt with.

WHY SIMULATE?

There are many factors that influence the quality of a layout, such as:

- ⓐ Order of arrival of the coils
- ⓐ Availability of trains and employees
- ⓐ Variation in the type of coils that enter the warehouse
- ⓐ Coil dispatch priority
- ⓐ Prioritisation of the cranes
- ⓐ Dimensions of the different cradles
- ⓐ Number of cradles
- ⓐ Placement of cradles in the warehouse
- ⓐ In which order/batch size the coils enter the warehouse

Optimising a problem with so many complex variables and factors is a seemingly impossible task, which is why

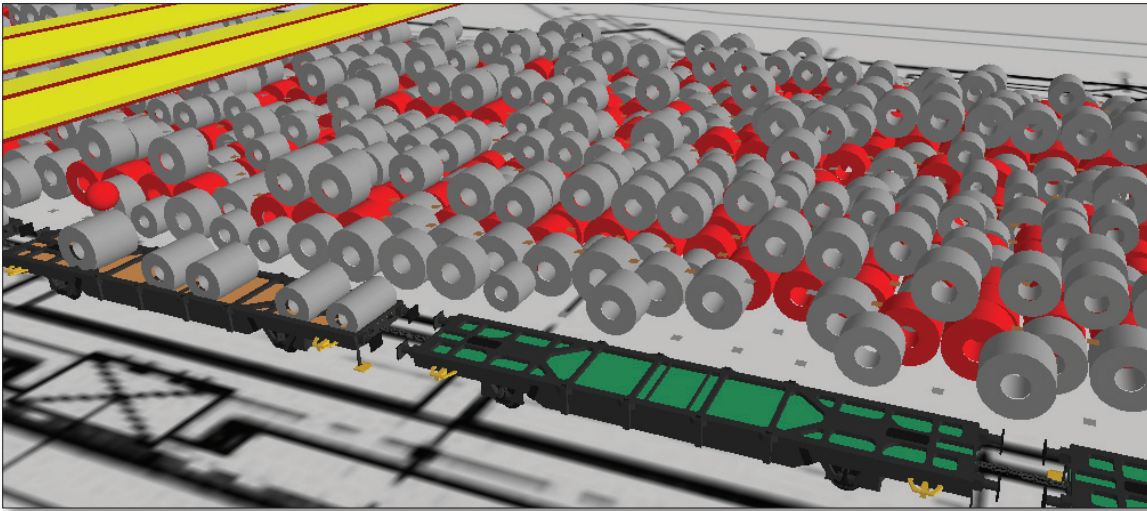


Fig 4 Simulation output example

the project team opted for an approach using discrete event simulation.

THE SIMULATION MODEL

The solution space of possible warehouse divisions has been researched by drawing up a set of layouts with specific characteristics and comparing them by simulation. From an analysis of these simulation results, a conclusion can be drawn that optimises the solution.

The simulation model for the LA warehouse was made in the software package Simio. Simio works on the basis of discrete event simulation and is object-oriented, allowing intelligent objects to communicate with each other and exchange their information. For example, if a coil is to be picked up, this pick-up request is communicated to the cranes which will then decide between themselves which crane will pick up the coil. Thus there is no need for an overlapping process that does the steering of the processes. Simio works with a 3D environment where real distances, times and speeds are taken into account and thus realistic object movements and transport times are guaranteed. An example of the model output is shown in Figure 4 which shows coils in the warehouse and the rail transport line. The coils that are blocked by a stacked coil are coloured red in the visualisation. The stacked coil has to be moved first, before the blocked coil (on the cradle) can be moved to an outbound modality.

NO OUTPUT WITHOUT INPUT

In any simulation model the value of the output relates to the value of the inputs (garbage in, garbage out). For many investment projects there is historical data of a process that is somewhat similar to the process that is being simulated. For example, historic ship arrivals at an oil terminal can be

an excellent representation for future ship arrivals when this terminal invests in an additional quay or storage tank.

For the LA warehouse project, the project team looked at a dataset of all coils that were stored at the Tata Steel site in 2017. With this dataset as a basis, the project team analysed the coils that would potentially have gone to the LA warehouse if the warehouse had already been available. In this way a representative set of 90,000 coils was compiled. Other parameters in the model included technical specifications of the warehouse, train loading and truck loading. Accompanying restrictions and transport-out schedules to Tata Steel's customers were also examined.

DETERMINING THE CRADLE TYPES

The cradles are mounted on notched rails in which they are fixed (see Figure 3). This determines a specific number of possible cradle types depending on the number of notches that are left between the cradle. The distance between the two rails determines the possible width of the cradle.

From the data analysis, a scatter plot of the width/diameter of the coils from the dataset was produced, as shown in Figure 5a.

The first step was to determine which range of width and diameter groups performed best. Ultimately, it was decided to analyse six different combinations of width and diameter. For each of these six combinations the optimal group sizes were determined using the expected inventory level of these groups. By minimising the lost space (that quantity where a roll is smaller than the largest roll that would fit on the cradle), the optimal dimensions of the groups, given the number of groups, were found.

To determine the expected stock level per width/diameter adjustment, the analysis takes into account the number of arrivals and the residence time of the rolls in ▶

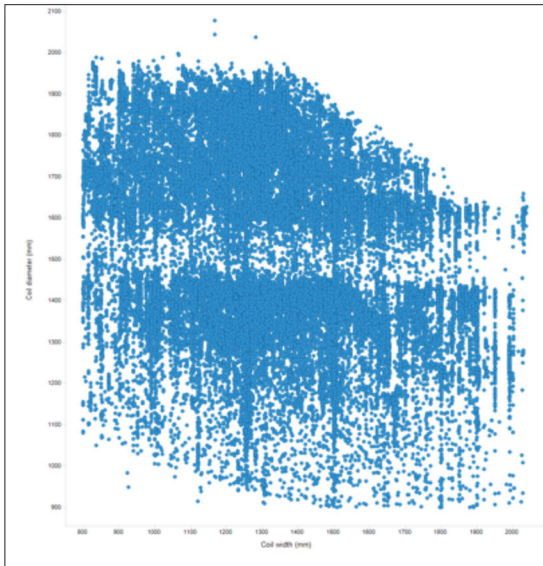


Fig 5a Scatter plot of width and diameter

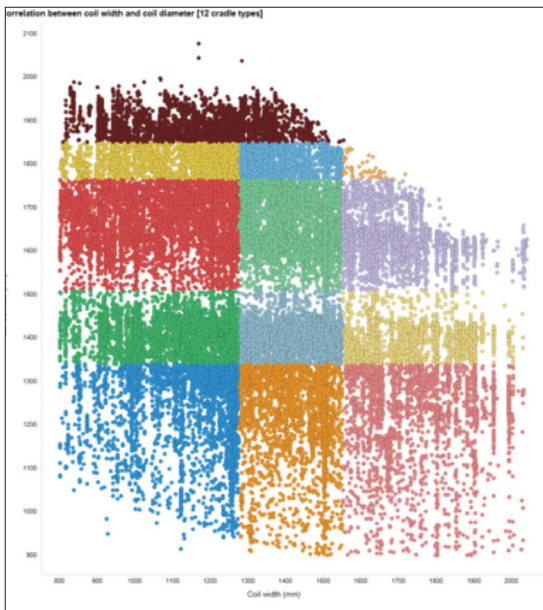


Fig 5b scatter plot with, as an example, a colouring based on 12 distinct cradle groups (3 width groups x 4 diameter groups)

storage. According to Little's law, the product of these two values gives the expected average required stock level per cradle type:

$$\begin{aligned} & \text{Expected number of coils in storage in the warehouse} \\ &= \text{Number of incoming coils per day} \\ & \quad * \text{average duration of stay in the warehouse} \end{aligned}$$

One can analyse the outcomes of the simulation on various chosen performance indicators, such as the number of coils that were not available, the average initial investment and the efficiency of the cranes. The analysis showed that a combination of 4 width groups x 3 diameter groups gave the best layout. This is illustrated in Figure 5b.

By analysing and improving the six optimised layouts with specific characteristics a number of times, the solution space can be reduced after each iteration. After about 10 iterations an optimised cradle solution was found and this advice was delivered to Tata Steel in the form of a layout ready for submission to the constructor.

ADDED VALUE

To test the added value of the simulation model, the initial cradle setup, (made on the basis of common sense and experience), was simulated and analysed. The results showed that in the optimised layout, 50 additional cradle positions fit in the warehouse, resulting in approximately space for 300 additional coils because of a higher stacking potential. This results in an additional 8-10% potential throughput. Additionally, and possibly more importantly, the final layout is also better able to accommodate greater variability in arrivals and potential future changes in coil dimensions.

CONCLUSIONS

The LA warehouse has been in full production use since October 2018 and is performing to expectations. The project has demonstrated that the use of a simulation model is an excellent way to obtain answers and advice for complex investment logistics systems projects, even before the construction of the project has started. The model is currently being developed further so that it can be used to support operational planning issues, such as assigning parking places for incoming trains, setting priorities for tasks, the deployment of operators, and the analysis of the use of space. **MS**

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