Importance of Simulation and Modern Logistics in Project Management

Digital technologies are transforming industry at all levels. Steel has the opportunity to lead all heavy industries as an early adopter of specific digital technologies to improve our sustainability and competitiveness. This column is part of AIST's strategy to become the epicenter for steel's digital transformation, by providing a variety of platforms to showcase and disseminate Industry 4.0 knowledge specific for steel manufacturing, from big-picture concepts to specific processes.

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A project is an irreversible process needing micro-planning to be successful. Modern project management calls for an advanced simulation study on a logistics perspective integrating yard management systems, automated storage and retrieval systems and Internet of Things (IoT)/Industry 4.0 to save on life cycle cost. A simulation study with special software could advance every stage of the project and production to cross-check the risks and threats during the execution of the project and process with reference to technology, interfacing aspects, resources and the time scale well before the investment. With a simulation study, the right material flowhow concept could be configured toward enhanced productivity, quality and safety. During a simulation study, the latest modern logistics and IoT could be considered up front to decide on the benefit of automation for material handling, tracking, packing and storage including manless shipping feasibility options. A simulation study is detailed in this article with a case study at a stainless steel plant in the U.S.

The main objectives for the configuration and simulation study with feasibility analysis in a steel plant with the hot rolling mill along with cold rolling mills, process and finishing lines are:

- To find optimization and rationalization for the product (coils) logistics and handling within the plant in a safe and economical way with minimum buildings, manpower and material handling equipment with specified convenient phases of implementation.
- To evaluate an essential potential to cut costs related to product (coils) automatic handling, storing, packaging and shipping with enhanced plant efficiency minimizing manual operations.

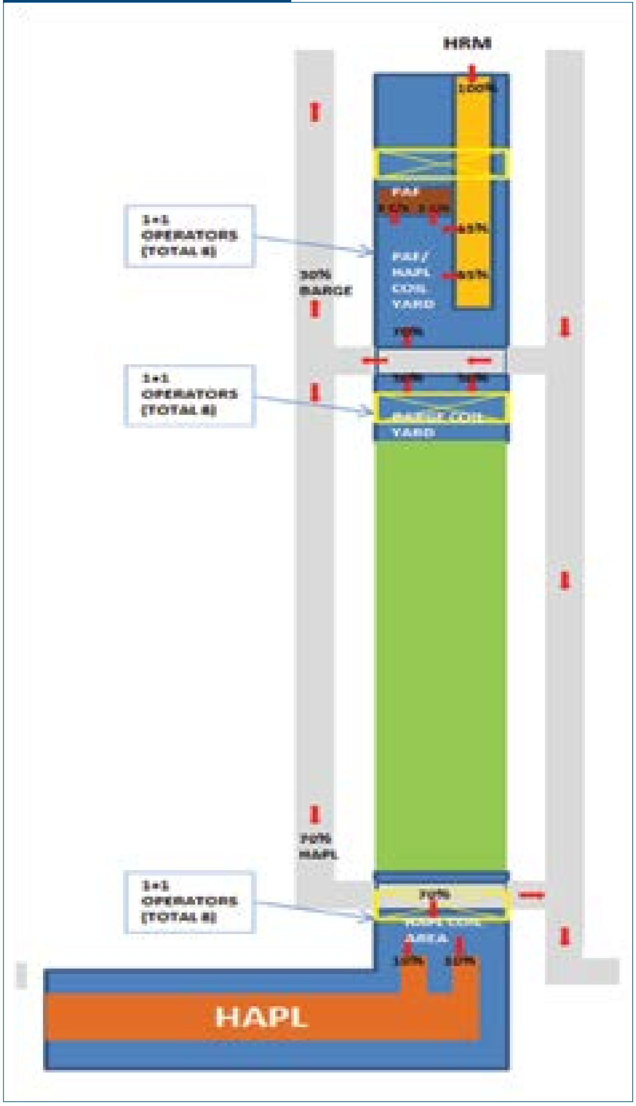
An analysis with a typical case study will be made in this article at a stainless steel mill to understand the benefits of such an advanced scientific study.

Outokumpu Calvert Stainless Steel Plant: Objective

A. New material flow concept for transfer of hot-rolled coils from hot rolling mill (HRM) pallet conveyor to the (hot-rolled coils annealing and pickling line (HAPL)) without the connecting bay building, avoiding trucks and manpower.
B. Capacity requirement: Annual production 900,000 metric tons of coil off hot strip mill factory layout and essential information of buildings.
C. Internal coil transfer from HAPL to the cold rolling mills, intermediate pickling lines and finishing lines.

In this case study, the issue of transfer of hot-rolled coils from the hot rolling mill to the HAPL without need for any building or truck transfer or manpower is discussed.

Figure 1



Current material flow at Outokumpu Calvert.

Discussion

The current material flow at Outokumpu Calvert for hot-rolled coils to reach the HAPL is shown in Fig. 1.

Issues with current handling system:

1. Duplicate handling operations.
2. Cost involved in multiple truck movements.
3. Delays in transfer of coils from HRM to HAPL.
4. Most of the operations are manual.
5. Safety challenges.
6. Quality challenges due to multiple handling by cranes.

By having the connecting bay built with electric overhead traveling (EOT) cranes, multiple truck handlings could be avoided. The CapEx for building the connecting bay is high and the operation cost remains the same except for the truck charges.

To overcome these issues, the feasibility study was made jointly and the outcome is discussed in the following.

Proposed Modern Logistics Systems Out of Simulation Study

Option 1: High-Speed Coil Car System With Yard Management System

System Description:

- PAF loading and offloading: Pit annealing furnace (PAF) loading and offloading is done manually by an existing EOT crane. When the coil is processed by the annealing line, it is moved onto coil skid by an EOT crane. An automatic coil car is used to move the coil from the coil skid to storage.
- In-feed to storage: Coils are first moved from the HSM conveyor onto the coil skid by an automatic coil handling device. An automatic coil car is used to move the coil from the coil skid to storage.
- In-feed to HAPL: Coils are first moved out from storage by coil car. The coil car moves the coil onto the automatic coil skid equipped with rotating and vertical movement. An automatic coil skid lowers the coil to the same level with HAPL walking beam conveyor so that the coil can be moved to the line entry.
- Barge loading: Coils are first moved out from storage by coil car. The coil car moves the coil onto the coil skids inside the HAPL building. An EOT crane is used to load coils from the coil skids to the truck.

Table 1

New Equipment: Option 1

Equipment	Amount	Description
Automatic coil handling device	1	Offloading coils from hot strip mill (HSM) conveyor
4-way coil car	4	Coil transportation and storing
Automatic coil skid with rotation and vertical movement	2	Coil loading to hot-rolled coils annealing and pickling line (HAPL)
Coil skid	25	coil buffering
Coil racking	1	Coil storing
Automation of existing EOT	1	Barge loading

Table 2

Storage Dimensions and Capacity: Option 1

Specification	Value
Type	Floor storage
Storage area	Connection bay
Storing capacity — Stage 1	324–680 (depending on coil width)
Storing capacity — all stages	952–2,000 (depending on coil width)
Storing equipments	Coil cars

Figure 2

Layout of high-speed coil car system with yard management system.

Merits and Demerits:

- Merits
  - Storing capacity depending on coil width.
  - Relatively good payback time.
  - Gentle handling of coil (coil handled underneath; coil being telescopic does not affect).
  - No safety risk of coils carried over personnel heads.
  - Easy and safe maintenance.
  - Relatively low OpEx.
- Demerits
  - Relatively expensive to increase storing capacity.
  - Storing of full width coils reducing maximum storing capacity.
  - Open storage, vulnerability to weather conditions.

Option 2: High Bay Automatic Storage and Retrieval System

System Description:

- PAF loading and offloading: PAF loading and offloading is done manually by an existing EOT crane. When the coil is processed by the annealing line, it is moved onto the coil skid by an EOT crane. An automatic coil car is used to move the coil from the coil skid to storage.
- In-feed to storage: Coils are first moved from the HSM conveyor onto a coil skid by an automatic coil handling device. An automatic coil car is used to move the coil from the coil skid to the high bay storage entry skid. Stacker crane inside storage is used to move the coil inside storage racking.
- In-feed to HAPL: Coils are first moved out from storage by a stacker crane. A coil car moves the coil from the storage exit skid onto an automatic coil skid equipped with rotating and vertical movement. An automatic coil skid lowers the coil to the same level with the HAPL walking beam conveyor so that the coil can be moved to the line entry.
- Barge loading: Coils are first moved out from storage by a stacker crane. A coil car moves the coil onto the coil skids inside the HAPL building. An EOT crane is used to load coils from the coil skids to the truck.

Merits and Demerits:

- Merits
  - High maximum storing capacity.
  - Gentle handling of coil (coil handled underneath, coil being telescopic does not affect).
  - No safety risk of coils being carried overhead.
  - The storage automated storage and retrieval system (ASRS) is with rack supported

Table 3

New Equipment: Option 2

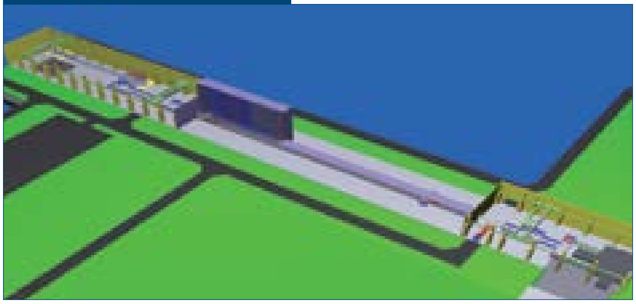
Equipment	Amount	Description
Automatic coil handling device	1	Offloading coils from HSM conveyor
4-way coil car	4	Coil transportation
Stacker crane	2	Coil storing to high bay storage
Automatic coil skid with rotation and vertical movement	2	Coil loading to HAPL
Coil skid	25	coil buffering
High bay coil racking	1	Coil Storing
Automation of existing EOT	1	Barge loading

Table 4

Storage Dimensions and Capacity: Option 2

Specification	Value
Type	High bay storage
Storage area	Connection bay
Storing capacity — Stage 1	324
Storing capacity — all stages	2,348
Storing equipment	Stacker crane

Figure 3



Layout of high bay automatic storage and retrieval system.

building with covered storage and transport with least weather risks.
 – Least operation expenses with faster ROI.
 – Maximum efficiency.
 – Least or no manpower required.
- Demerits
  – High CapEx compensated by the low or nil operating life cycle cost.

Option 3: EOT Floor Storage

System Description

- PAF loading and offloading: PAF loading and offloading is done manually by an existing EOT crane. When the coil is processed by the annealing line, it is moved on the floor.
- In-feed to storage: EOT cranes are used to move the coil from the HSM conveyor on floor storage located in the connection bay.
- In-feed to HAPL: After the cooling coils are moved to the storage end near the HAPL building by an EOT crane, the existing EOT crane in the HAPL building is used to move the coils to the HAPL entry walking beam conveyor.
- Barge loading: After the cooling coils are moved to the storage end near the HAPL building by an EOT crane, the existing EOT crane in the HAPL building is used to load the coils onto barge trucks.

Merits and Demerits:

- Merits
  – Relatively inexpensive to increase storing capacity if the building is not required.
  – High maximum storing capacity but the whole area is required.
- Demerits
  – Payback time on normal and low production level.
  – Handling of telescopic coils might be an issue.

Table 5

New Equipment: Option 3

Equipment	Amount	Description
EOT crane	2	Coil storing to connection bay
Coil skid	324	Coil storing in connection bay
Automation of existing EOT	2	1: Coil storing in connection bay 2: Barge loading and HAPL feed

Table 6

Storage Dimensions and Capacity: Option 3

Specification	Value
Type	Floor storage
Storage area	Connection bay
Storing capacity — Stage 1	324 (single layer)
Storing capacity — all stages	1,465 (double layer)
Storing equipment	Automated EOT crane

Figure 4

Layout of EOT floor storage.

 – Fully open storage area might not be viable in practice.
 – High CapEx in covered version.
 – Automation of EOT cranes still rare.
 – Safety risk of coils carried over personnel heads.
 – Risk of conducting maintenance at high elevation.
 – More manpower required.
 – Very low efficiency.

Option 4: Gantry Floor Storage

System Description

- PAF loading and offloading: PAF loading and offloading is done manually by an existing EOT crane. When the coil is processed by the annealing line, it is moved on the coil skid from

Table 7

New Equipment: Option 4

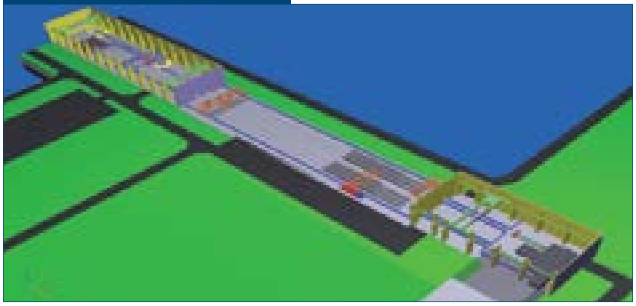
Equipment	Amount	Description
Automatic coil handling device	1	Offloading coils from HSM conveyor
Coil car	4	Coil transportation
Gantry crane	4	Coil storing in connection bay
Automatic coil skid with vertical movement	2	Coil loading to HAPL
Coil skid	324	Coil storing in connection bay
Coil skid	8	Coil buffering for coil cars

Table 8

Storage Dimensions and Capacity: Option 4

Specification	Value
Type	Floor storage
Storage area	Connection bay
Storing capacity — Stage 1	324 (single layer)
Storing capacity — all stages	1,350 (double layer)
Storing equipment	Automated gantry crane

Figure 5



Layout of gantry floor storage.

where the coil car can move it toward the storage area.

- In-feed to storage: An automatic coil handling device is used to move the coil from the HSM conveyor onto the coil skid. A coil car moves the coil from the coil skid onto the coil skid in the connection bay. The coil is moved from the skid on the floor by a gantry crane.
- In-feed to HAPL: A gantry crane first moves the coil onto the coil skid located near the HAPL building. A coil car picks up the coil from the coil skid and moves it to the automated coil skid equipped with vertical movement. An automated coil skid lowers the coil to same level with the HAPL entry walking beam conveyor.
- Barge loading: Barge loading is done by gantry cranes in the connection bay.

Merits and Demerits

- Merits
  - Relatively inexpensive to increase storing capacity.
  - Relatively high maximum storing capacity.
  - Payback time on normal and high production level.
- Demerits
  - Handling of telescopic coils might be an issue.
  - Automatic handling with gantry cranes with a yard management system might be difficult.
  - Gantry cranes are not a good solution for bad weather conditions.
  - More manpower required.
  - Very low efficiency.

Summary

Summary of Each Option

- Coil car storage is a cost-effective option in cases where high storing capacity and small footprint are not required. Coil car storage offers low CapEx, which results in a short payback time and gentle coil handling because the coil is handled underneath. Weak points are maximum storing capacity for full-width coils and high cost of future storage extension because some steel structure is needed for coil storing. In this case, coil car storage is a strong contender if storing capacity of full-width coils and the cost of future storage extension is acceptable. The efficiency is low for multiple operations. The safety index is 3 on a 1-to-5 scale with estimated ROI of around 3 years.
- High bay storage offers high storing capacity with small footprint and great throughput capacity with high availability. With the high storage density requirement, the high bay storage is an ideal solution mainly despite the high CapEx due to lowest OpEx with total automation and nil manpower requirement. Heat load of hot coils has a large impact on costs because storage racking has to be reinforced. The safety index is 4 on a 1-to-5 scale with an estimated ROI around 3 years.
- EOT floor storage is a traditional storage solution that offers relatively high storing capacity, low cost of storage extension and high redundancy due to fact that EOT crane is an all-around device that can handle several tasks

like feeding the process line or loading the truck. But in this case, EOT floor storage is not an ideal solution because of high CapEx and uncertain automation. The efficiency is low and manpower required is high. The safety index is 3 on a 1-to-5 scale with an estimated ROI of around 3 years.

- Gantry floor storage is a cost-effective option that offers low CapEx but high OpEx. Maximum storing capacity is also in an acceptable level. There is some uncertainty with telescopic coil handling and automation. In this case, gantry floor storage is a strong contender if gantry cranes can be automated reliably and good solution for telescopic coil handling can be found. The efficiency is low and the safety index is 3 on a 1-to-5 scale with an estimated ROI of around 3 years.

Simulation Study and Simulation Parameters — The above findings have been programmed in a 3D simulation so as to witness the process in actual operation and observe the merits with respect to cycle time and throughput for easy evaluation. Simulation becomes essential as a demonstration of all the resources to optimize the same.

Results

The vertical storage system has the maximum efficiency with least or no manpower requirement. In this option, the coil storage and transportation path are covered to address the bad weather days. This system has lowest life cycle cost. The coils are to be preliminarily cooled to less than 500°C before being shifted to the ASRS. The other options have highest life cycle cost in the other three options namely the coil car system, EOT crane system and gantry crane system.

Conclusion

The study was made with each of the four options namely the coil car system, the vertical storage ASRS, the EOT crane system and the gantry crane system as a substitute for the connection bay building. The ASRS was found to be the most practical and economical system considering the low life cycle cost and efficiency. As the system could be automatic and weatherproof the same could be operative even during rains and high wind condition.

The gantry crane system is next preferred option due to lesser CapEx and the fact that the coils to be handled are hot-rolled coils with temperature >500°C.

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Did You Know?

JFE Steel to Test CO_2 Utilization Technologies in Two R&D Projects

JFE Steel Corp. recently announced it is moving forward with two R&D projects to develop technologies that will utilize CO_2 in steelmaking processes that are expected to help the company achieve carbon neutrality.

For one project, JFE will partner with the Research Institute of Innovative Technology for the Earth to optimize a system that uses CO_2 for methanol synthesis. For the second project, the company will partner with Ehime University, which is researching and developing "CO_2-fixing technology" based on the carbonation of steel slag.

According to an official press release, JFE Steel has approved the construction of test facilities for the use of steelmaking byproducts such as slag and combustible gases. Research initiatives will take place at facilities at its JFE Steel West Japan Works and East Japan Works.

R&D activities at the JFE Steel West Japan Works in Fukuyama will focus on the commercial launch of a large-scale carbon capture and utilization process. The research at JFE Steel East Japan Works in Chiba will focus on the assimilation of CO_2 generated by steelmaking processes.

Demonstration testing at both facilities is to be completed in 2025.