AUTOMATIC CRANES IN TO THE PROCESS, REDUCING BOTTLENECKS BY EMPOWERING LOGISTICS*

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Abstract
Automatic yards with ad-hoc WMS (Warehouse management software), are the key for a modern and efficient warehousing which can face today logistic challenges. WMS boosts the traceability of material while optimizing the storage space. The operations in the yard are safer and logically organized according to algorithms that are specifically adjusted case by case. WMS can easily handle multi-cranes yard avoiding conflicts and increasing accuracy of positioning with decreased number of movements. The synergy of automatic cranes and WMS reduces bottlenecks and speeds up the preparation of deliveries with an overall improvement of warehousing and shipping scheduling.
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1 INTRODUCTION

Considering a Steel Plant, a defined and stand-alone unit, and simplifying it down to its main processes, we may notice that it is macroscopically interacting with the related customers and suppliers by a single defined unit: the warehouse.
Mainly, three types of warehouses could be identified in the main process: raw material, like scrap and iron ore, semi-finished product, billets/slabs and hot bands, and finished products.

Inventory management of these warehouses plays a vital role in supply chain management.
It represents an important asset fully related to company competitiveness. It has a direct impact on the cost of the product sold, response time to the market, on-time delivery and other indexes.
For these reasons, having an optimized, well-performing inventory management system is a key component that impacts overall company performance.
An always predictable, stable, optimized and well-performing inventory management could be the ground-braking key factor for company's market.

The operations in the yard are safer and logically organized according to algorithms that are specifically adjusted case by case, improving traceability of material while optimizing the storage space. WMS can easily handle multi-cranes yard avoiding conflicts and increasing accuracy of positioning with decreased number of movements.
The synergy of automatic cranes and WMS reduces bottlenecks and speeds up the preparation of deliveries with an overall improvement of warehousing and shipping scheduling.

While a functioning Warehouse Management System (WMS) is not an innovative plant feature anymore, the possibility to predict timing and results of material flowing between yards and machines, while guarantying their stable functioning is a new feature, given by automatic yard system.
A holistic system composed by an intelligent mind, such as the WMS, and properly sized and programed robots, like cranes.
These are the two main-players in a system composed also by supportive tools such as: RFID Readers, GPS tracked vehicles, interactive upper and lower automation layers.

2 DISCUSSION

To properly address the actual problems on-going in the steel plants, we decided to go through the typical solutions and decisions taken during a stockyard engineering.
The typical efficiency of a crane operator is normally estimated at 70-75% of its working time, it leads obviously to a first over-dimensioning of handling equipment of 25-30%.

Given the presence of an operator per each machine and given the necessity to coordinate and schedule the material flow for steel processing, at least one yard operator every 4-5 machines should be assigned to yard management.

The presence of these two human figures, which manually coordinate and schedule a plant hub such as the stockyards, led all the smart systems and devices installed down to an *analogic process*, not smart and not even properly integrated. The operations, even if technologically supported and recorded, are still manually driven.
The digitalization is not completed along all its process, but it's human paced, in its positive and negative side.

An analog system is, by its definition, an infinite resolution and high quality system, but heavy and inflexible at the same time. In a stock-yard, where missions and decisions are largely defined, a slow, infinite solution system may not be the proper solution to put in place.

Even the presence of a typical WMS is not the answer to coordination and scheduling problems of cranes and flow of material through-out the plant.
Knowing each slab position inside the plant is, from the process stand-point, meaningless if not properly coordinated with downstream machines, and upper systems like plant MES and/or plant ERP.

2.1 Sizing the problem

The critical amount of material, and so investments, stored in plant warehouses, is becoming a dangerous asset for businesses aiming to be flexible and "predictable".
Flexibility, continuous optimization, predictability are common adjectives of latest industrial revolution, driven by such requirements.
Keep running an "old-engineered" solution, where warehouses are manned and people-driven, is creating a weakness point in a process which instead is gearing to become a full digitalized and optimized process.

2.2 Basis of Solution

The solution foresees the installation of a central hot-redundant server, which hosts the WMS application, communicating with upper systems through a Database to Database table, and including the main intelligent functions for yard management, such as:
> Yard Storage optimization
> Intermediate task generation
> Crane movement optimization
> Multi-crane bay coordination
> Crane downtime and maintenance management

Furthermore, the application is also including several functions for cranes-to-transport-device handling, such as:
> Wagon Automatic loading and unloading
> Trucks Automatic loading and unloading
> Transfer Car Automatic loading and unloading
> Roller Table Automatic loading and unloading

All these functions are involved in the main algorithm of WMS, the Crane Task Generation. Further than piling and safety rules, the WMS is examining step-by-step

each constrain and looking for optimized position, based on future processes schedules.
Each mission, before its delivery to crane schedule, is simulated in time domain and it is ensured that could be ended prior to any process critical delivery. The simulations is the most accurate possible, using the latest statuses coming from cranes.

Statuses and crane communication is ensured through a typical TCP/IP communication, both on event (such as mission task messages) or on time bases (such as crane status message). On Crane side, a dedicated Communication Processor is installed on the Crane PLC main rack.
Typically, the communication is handed over by a wireless communication.

2.3 Coordination in process

A coordination system, which is not timely reporting plant scheduling updates to its schedule, brings an established minimum delay of 5-8 minutes every scheduling update (8-13% of inefficiency in an hour). Typically, this is the time an operator requires to re-plan manually missions for 4 cranes.

A time frame of 5 to 8 minutes, in steel plant logistic of such dimensions, could lead to an unwilled delivery of 24 slabs or 12 coils. Now, scale this calculation to your number of cranes. Results could be pretty impressive.

In this case, WMS and automatic cranes together could avoid completely this inefficiency, using above intelligent algorithms and updating in real-time the mission lists of each crane.

2.4 Real-time Inventory under control and 3D map of yards

The material is tracked since it enters the yard until it is delivered. All the movements (pick up and deposits) of the material are logged into the database together with the data that characterize the material: type, dimensions, ID, chemical composition, process note.
The system also allows the operator to query and report movements or verify which were the suppliers of materials melted in a specified heat (useful for claims management against suppliers).
All crane movements and material deliveries are precisely tracked.

From the screens of the operator station it is possible to track all the movements of the materials (and therefore of the cranes) within the yards, displaying the status of yards by interactive 3D Maps, which operator could enquire to know all details about selected slab or coil.

Below we see few examples of screens of warehouse management system including scrap yard management and coil yard management. It is highlighted the possibility to use some filters in coils visualization, like: free spots, type of coil, location of coil, temperature of coil, production date, customer, etc.

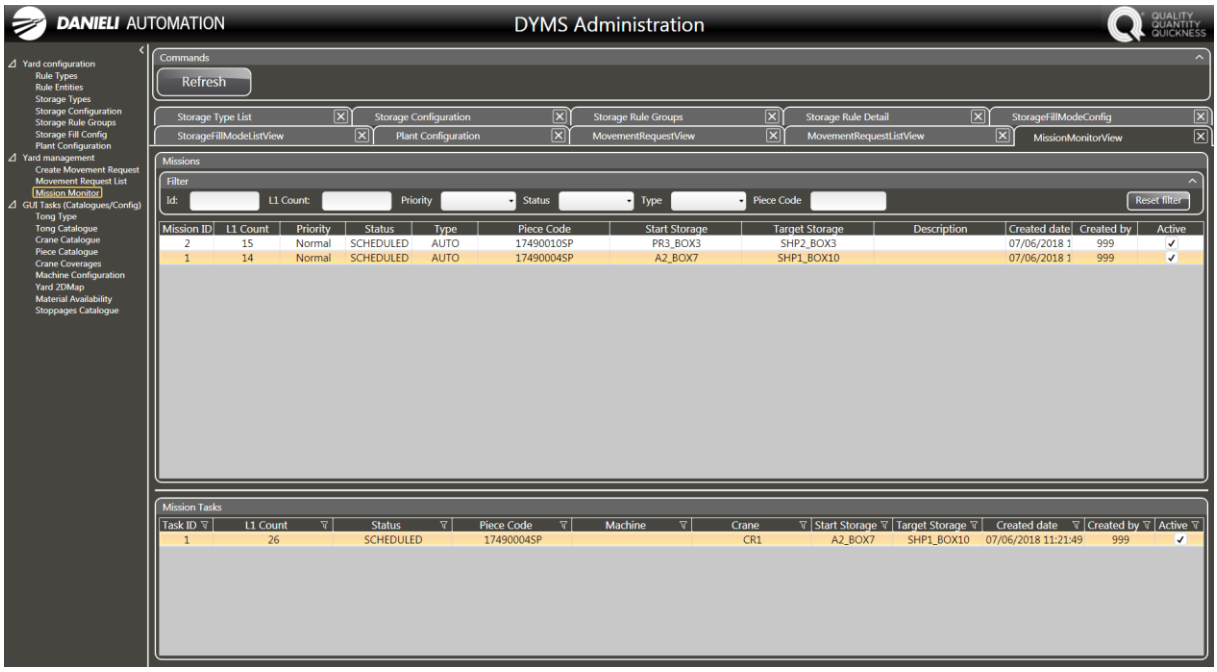

Figure 1. Overview page for missions monitoring inside a coil yard.

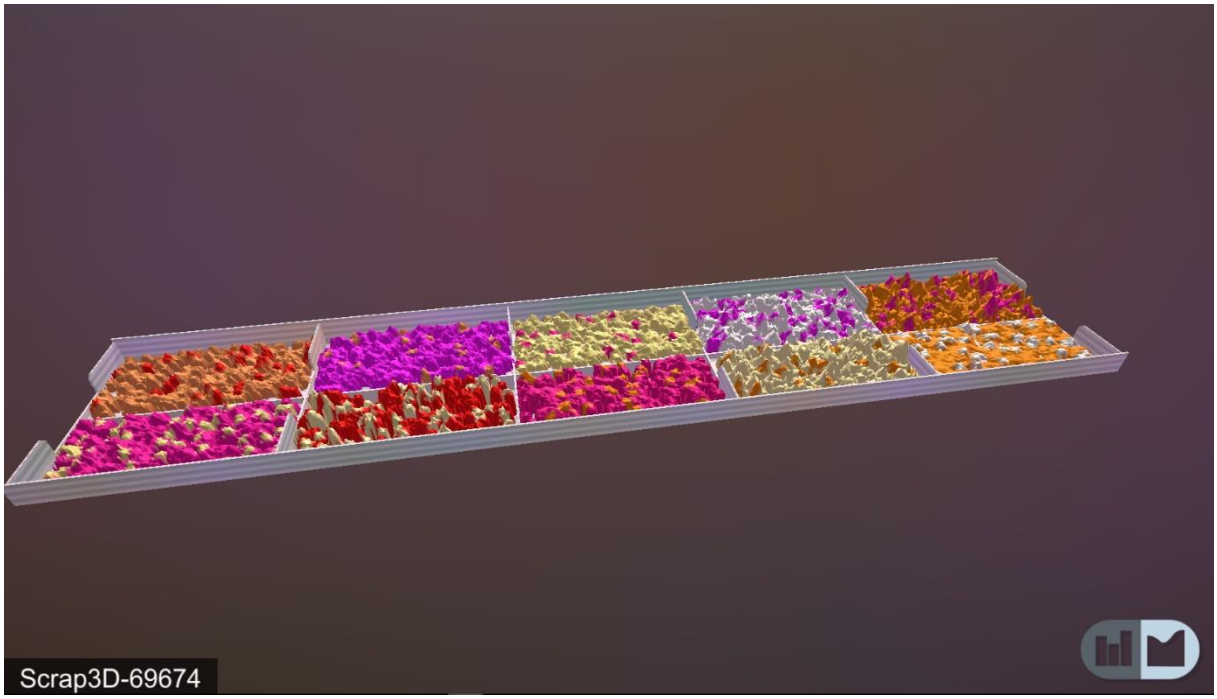

Figure 2. 3D map page of the scrap yard.

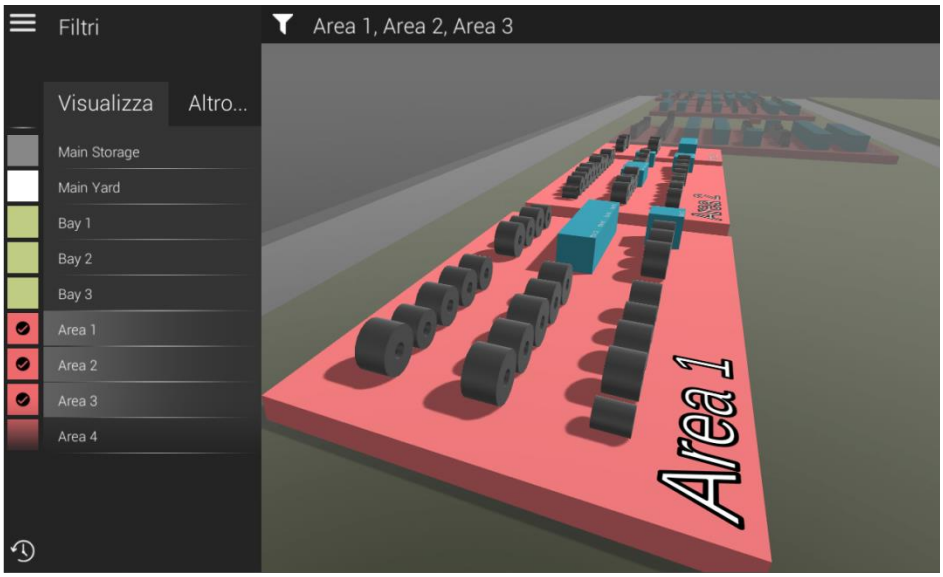

Figure 3. 3D map page of coil yard with Area filter.

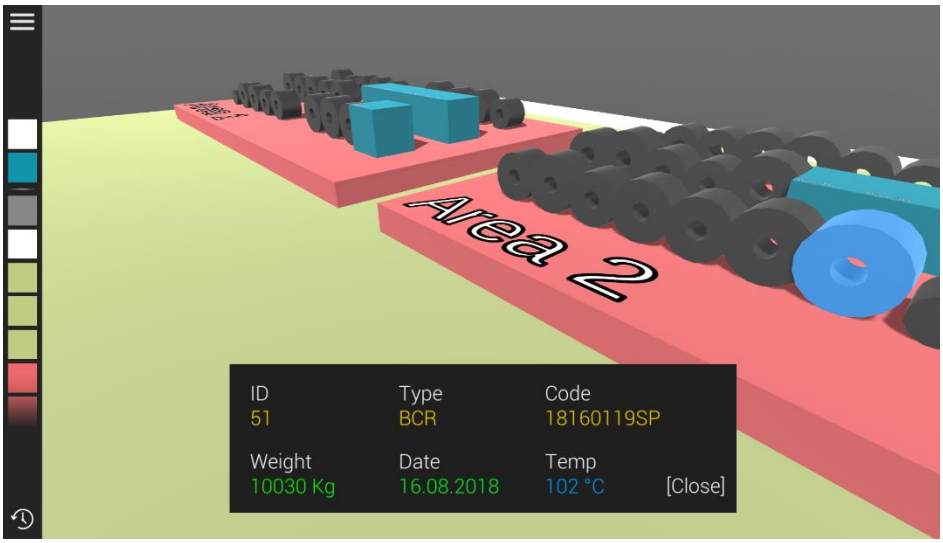

Figure 4. 3D map of coil yard, with selected coil details.

Figure 5. 3D map of coil yard with filters activated and selected coil details.

2.5 Process-pace guarantor

The ultimate target of a WMS is to keep the main process of the plant going in the most efficient way, with less movements possible. Nothing is crucial as an on-time delivery of the proper slab or billet.
As well as it's crucial to deliver the proper information about the loaded material to the next process.
The complete tracking is not only a guarantee of quality along all process, but it is also a necessary step toward prediction of material storage, since their arrival in the yard.
The predictive storing of material in the proper position is a comprehensive saving, including time, money and cranes operations.
Saving in crane operations, automatically leads to a dramatic increasing of storage capabilities.

Based on historical data, timing and process type, the WMS is automatically generating missions for the automatic crane, evaluating the fastest and cheaper overall movement for the incoming material.
The fastest and cheaper movement is not only evaluated on the first crane movement on incoming material, but it is including the overall transporting time, up to material delivery.

Having a predictive deposit position, it's not only a saving from crane's operation point of view, but it is a key advantage for the complete plant.
It allows a complete flexibility in production plan changes, permitting an almost cost-free market adaptation.

2.6 Improvements over the years

A side problem to the analogical solution (read it: human operator) is given by difficulty to transpose what learned over the years to new generations of operators, keeping the system in a slow improvement curve and relentless to commit the mistakes of the past again.
A problem which is not only overcame by a digitalized system, but it becomes the key for a constant improvement for the company.
Collection of data along the logistic process for years, create such a big quantity of data to be used for system enhancing, by Business Intelligence software and Solution providers.

3 CONCLUSIONS

Upgrading a typical manned warehouse to an automatic unmanned solution, using WMS and automatic cranes solution, leads to the following main advantages:

> Minimization of dependency on operators' unpredictable solution on yard bottlenecks
> Maximization of yard occupancy
> Increase of operation throughput
> Real -time yard inventory
> Usage of real scrap recipes in Electric Arc Furnace process

> Reduction of lead time preparing slabs or billets for the mill
> Reduction of lead time between production plan changes
> Any loss of material or duplicated IDs
> No lost tracking between casting and mill or between mill and delivery
> Increase of plant user confidence, due to improved on-time delivery
> Total logistic cost prediction before production
> Minimization of personnel in the yard management
> No-Man in the yard and no safety related issues

Applying this solution since the engineering of the yard, is leading to other key advantage, such as:
> Avoid over-dimensioning of cranes and crane operators' crews
> Lower CAPEX for the same amount of stored material
> Lower Power requirements, due to less equipment installed

This technology is acting not only as an Industry 4.0 application itself, but it is mainly an ENABLER for new improvements and new methods to run a plant and process steel.
It is opening new frontiers in business evaluations and strategies, which takes in account HOW MUCH steel we have in storage and WHERE it is stored.
A further step toward a complete predictive production.

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