AUTOMATIC CRANES & YARDS: TECHNOLOGICAL BASIS AND WHY TO MOVE TO THIS TECHNOLOGY*

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Abstract
The vision of Danieli is not only to improve the operating conditions of the cranes and operators, but to offer complete control of operations sequencing, data monitoring and storing, crane data processing and preventive maintenance, and to transform the cranes into authentic, automatic unmanned tools: the intelligent operational “hand” of plant and production scheduling software.
Keywords: Automatic crane, automatic yard, Volumetric system, material handling, safe yard, material tracking, automatic operations, unmanned crane, dark yard.

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1 INTRODUCTION

The safety risks and operative costs of warehouses have been head-aching the plant managers worldwide since 2000s, while safety-oriented production was growing its importance. Those costs are only the first and easiest problem to identify, while analyzing the proficiency of the complete plant.
More difficult is the cost estimation of crane operator's wrong movements, static storing plans, unnecessary intermediate movements and unreliable material tracking.
Moreover, huge efforts have been lavished on technology innovation towards the improvement and optimization of steel processes (primary, secondary metallurgy and casting) and less in the area of warehouses, where the predominant factor was the logistics management and material handling. Nowadays this point of view is changing and even the coils or slab yards are becoming areas where the technological innovation and process digitalization is effectively and profitably applied.

Why to move to automatic yards? There are plenty of good reasons, which can be summarized in 2-digit OpEx savings, plant improvement and zero safety risks.

We used to feel cranes as service equipment but they are not! They are process core devices. Nothing different than the EAF, the rolling mill strands, the cooling beds. No crane, no metals.

Figure 1. Automatic Crane in an automatic pipe intermediate storage at TMK Seversky, Russia.

2DISCUSSION

2.1 Crane as unmanned tool linked to plant scheduling software

The first concept applied is: crane as a storage tool. It means to equip the crane of every necessary equipment to allow a complete autonomous management of its operations, following a mission schedule. The crane receives and executes the mission by its own.
To perform automatic sequencing, the crane has to be equipped with specific features such as:
— Inverter controlling crane movements for the necessary accuracy in positioning and picking up sequencing;
— PLC-based automation architecture;

— Wireless connection to yard management system;
— Sensors to detect the presence and the correct grabbing of the load;
— Accurate and reliable positioning system, to allow crane's fine positioning and a real-time information for the distance travelled.
Several systems have been progressively introduced, including the latest novelties about absolute encoders, limit switches, radar, laser, magnetic bars, and GPS radio technologies. The selection of the correct system (or some combination) is the critical point where know-how and experience makes the difference. It is clear that only a perfect fit-up between machine mechanics, control, and sensors can guarantee a reliable result.

An Automatic Yard is the connection of an automatic crane with a plant scheduling software. The software communicates in real time with crane, receiving its status and progress and generating the missions to load/unload the storage.
The Yard Management System (YMS) is collecting data from all levels of automation related to the yard, especially with MES and ERP systems, to collect material delivery schedule and production plans.
Based on the above conditions, considering the yard organization, rules and yard availability, the YMS is creating missions for the cranes in the yard, choosing the fastest and more convenient combination operations to deliver the material.

The material is tracked since it enters the yard until it leaves by truck or by train. All the movements (pick up and deposits) of the material are logged in the database together with the data that characterize the material: dimensions, weight, steel grade. The system generates alarm messages if there are inconsistencies in the loading or unloading position.
All crane movements are precisely tracked, on X (bridge) and Y (trolley) direction. Normally contact-free sensors, such as lasers, radars, magnetic bars are preferred. The reason why these types of sensors are chosen is their reliability and accuracy of position reading. Unlike other systems, there is no need to recalibrate the zero of the measurement when there is slipping of the measuring rollers, and there are no measurement errors due to deformations and vibrations of the runways that can occur with the use of laser systems with reflectors.

The weighing system is also fundamental in the process of pick-up confirmation, to guarantee a safe and reliable operation.
From the screen of the remote pulpit, it is possible to track all the movements of the materials (and therefore of the cranes) within the yard. The aim is to perform statistical analysis on movements and verify the efficient use of cranes.

Figure 2. Remote pulpit room of the Automatic Crane for slab yard at ArcelorMittalDunkerque, France.

2.2The machine must “know” the real geometry of things

In a fully automatic yard the crane is a smart tool inside an ideally unmanned environment, where the machine must “know” the real geometry of things. The core improvement to get such result is the “object vision” which let the crane know the actual load shape and position for safe engaging, lifting and deposit. In the past, several tentative have failed due to poor selection of sensors or their improper implementation, so that operations finally required human supervision.
The reason is that in a real environment such as a steel shop, there are many challenges to overcome!
For example, the truck on which an automatic crane is expected to deposit a rebar bundle may not be parked exactly in the requested position or a slab that needs to be picked up is rarely an ideal geometric parallelepiped.
It is most probably a bent object, which means a lot when you have to grab it with crane tongs.
Facing this “real world” means equipping the crane with intelligent sensors not only able to detect objects, but also to characterize them by means of image processing software.
The solution, implemented in Danieli automatic slab yards, is the installation of laser scanning systems, which can recognize the real position of the slab to be picked up, but to also confirm each slab identity by analyzing its geometry. All data are transmitted to the yard management system, which stores all positions and information in the data base and interacts directly with the production management software.

Figure 3. The “automatic crane package” at ArcelorMittalDunkerque, France, recognizes the real position of the slabs to be picked up, and also to positively identify each slab for tracking purposes.

2.3The cost is not that much; the OpExis reduced, and the risk is eliminated

But which is the investment cost to automatize a yard? By considering that practically any crane can be updated, the answer is not that much, actually. It has then been proven that an OpEx saving of about 30% is not unrealistic, and becomes more and more important when the number of cranes increases.
But there is a further question to be considered: which would be the cost of personnel injuries I can completely eliminate with an automated yard?
Crane-based storages typically require personnel both on board the crane and on field. They are often busy areas, where accidents are frequent. Stackers, the operators in charge of tracking the goods and guide the crane driver to the pickup point, are definitely necessary. On the contrary, automated yards are segregated areas because there is no need for workers inside. It is the YMS who knows the exact location of every item and guides the crane to pick it up and transfer it in the safest possible way. The risk is not reduced, is definitely eliminated.
By the way, if a human entrance should be needed for any reason, this can be managed by advanced geo-localization systems (i.e., Danieli SafeStar^{TM}) which deviates cranes movements to the safest path with the minimum impact on the production. Again, risk eliminated without operation consequences.

So, why to move to automatic yards?
We could say there are many advantages, as the optimization of spaces, the solving of bottlenecks, the predictability of maintenance, the materials tracking, the speed up of shipping activities, etc.
But at the end of the story, the answer looks quite simple: they perfectly fit with the dream of increasing productivity, reduce operating costs, and increase workspace safety. At the same time.

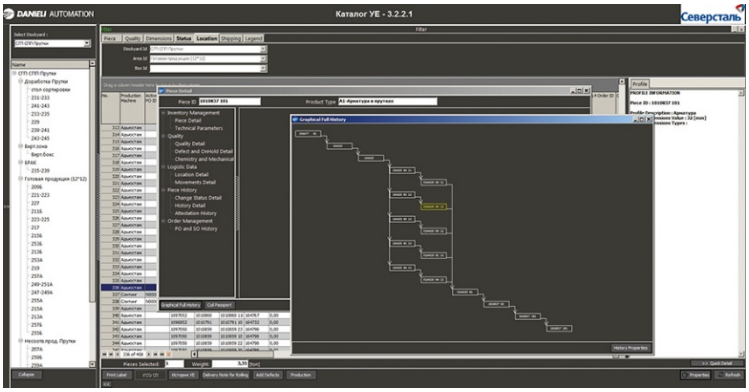

Figure 4. Example of HMI screens reporting Piece Catalogue and Properties, Piece History, and Stockyard Map.

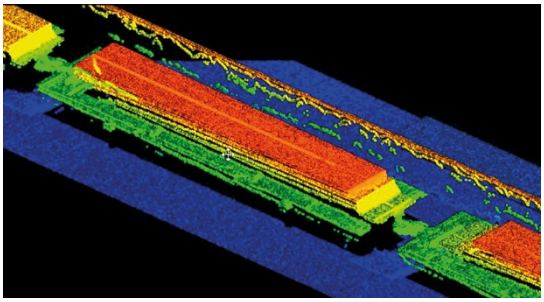

Figure 5. Intelligence algorithms and artificial vision technologies are used to recognize material position, volume, shape, and configuration

REFERENCES

1 Lorenzo Bacchetti, Daniele Stelluto, Automatic yards and cranes: reasons to move to this new technology. Danieli Technology Book 2017 “Ideas for a New Normal metals consumption period”, Issued on the occasion of the Fourth Danieli Innovaction Meeting, held at Danieli headquarters in October 2017.