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PLANT WIDE OPTIMIZATION BY APPLYING MES[1]

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Abstract
In order to stay competitive, Iron & Steel companies are facing the challenge of more flexible production, higher demands on product quality and reducing costs. These goals can only be reached by investing in cost-effective production processes, using state-of-the-art technologies. Individual processes have already been automated and optimized so far, that there is only little room left for improvement. The ERP (Enterprise Resource Planning) systems are limited with regard to general production planning. The knowledge of the actual plant status and the technological constraints of the production process are not available in an ERP system. Therefore modern plants need new technologies as important part of enterprise IT which is able to link the various individual processes to form an optimum process chain and connect the automation- and the process-level with the management level (horizontal and vertical integration). According to the definition of MESA (Manufacturing Execution System Association) MES deliver information that enables the optimization of production activities from order launch to finished goods.
Key words: MES; Manufacturing Execution System Association.

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1 INTRODUCTION

A solution for metal industry shall provide transparency from the enterprise level down to the current shop floor situation. It also ensures a continuous, seamless flow of process information, thus keeping operators, engineers and managers equally informed. As a result, a good solution must provide a platform for plant-wide production planning and scheduling – a solid basis for reliable quality and minimized operating costs.

2 METHODOLOGY

As a comprehensive industry-specific solution for metal industry, it should integrate all the functions and services needed for sustained maximization of the plant performance.
To achieve these goals the following directions of integration are necessary:

- *horizontally* improve all production processes, e.g. from ore and liquid metal to final material.
- *vertically* integrate the company's information flow end-to-end, helping corporate management to make better-founded decisions; and
- *chronologically* enable maintenance and come with assured further development over the entire life cycle of your plant.

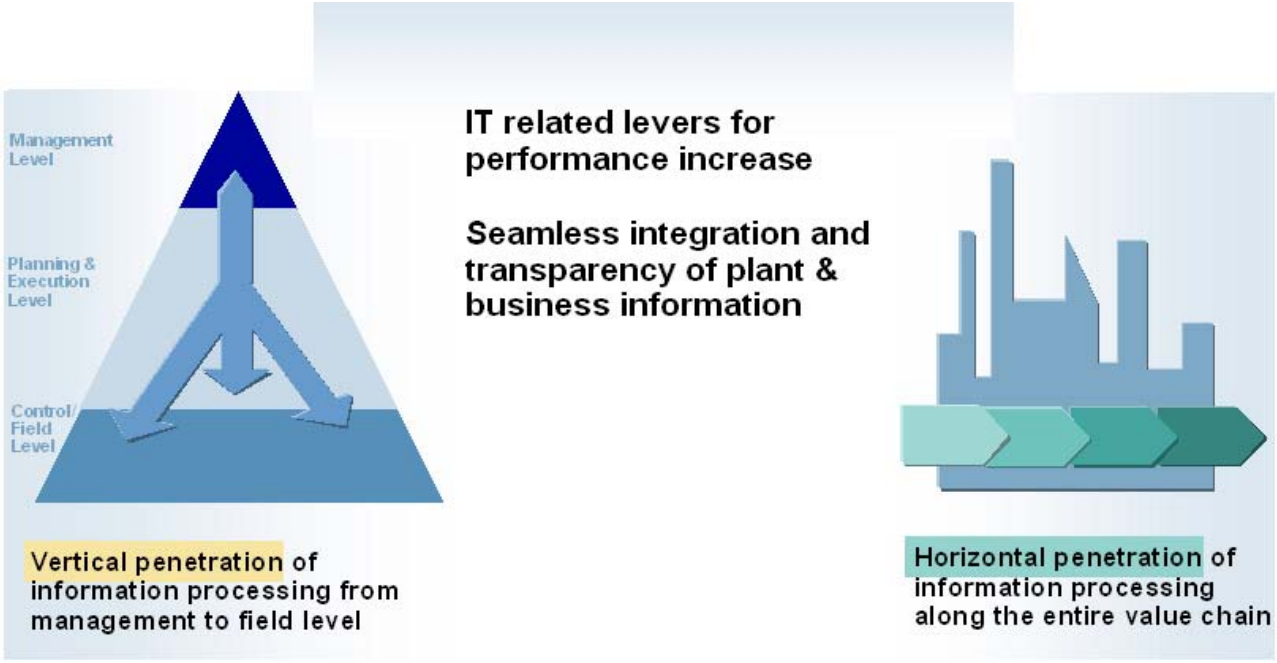

Figure 1: vertical and horizontal integration by MES.

2.1 Functions and Features

ISA S95 is a standard that defines the most important functionalities and requirements for the production management. A product or an implementation based on S95 should allow easily customization according to individual processes and plants. According to S95 the following functionalities are required for an efficient production management.

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- **Production Modeling** according to ISA S95 together with industry-specific plant libraries is used:
  - to create customer-specific plant models
  - to define equipment capabilities
  - to build business rules using a graphical workflow
- **Material Management** for tracking and tracing different material types, from raw material to a semifinished product, and to the final product, including full genealogy
- **Quality Management** is provided for different stages of the production process. This guarantees that quality requirements are met.
- **Inventory & Equipment Handling** increases and keeps production and quality at a high level. Functions are available to identify the status, current locations and history of the equipment.
- **Production Order Execution** gives an overview of all production order steps during production. This module keeps track of all production.
- **Production Planning & Scheduling** on different planning levels can be provided. This can be plant-specific, real-time scheduling, and company-wide production planning.
- **Product Definition Management** specifies how semi-finished or final products shall be produced, including routing and equipment parameters and process set points.
- **Production Data Archives** are available to store real-time production data redundantly for trending, reporting and data analytics.
- **OEE & Downtime Management** provides real-time information about status and efficiency of equipment and delays during production.
- **Maintenance Management** for important production units and equipment like ladles, tundishes, rolls etc., to monitor the life cycle and performance of these resources.
- **Logistics** for inventory and transport control in stock yards like slab, coil, plate etc. storages.
- **Statistical Process Control** to control the process based on various statistical calculations presented in graphical charts.
- **Laboratory Information Management System** to organize labs for chemical and mechanical analysis
- **Standard interface connectors** for easy integration in the IT infrastructure of the plant.
- **Enhanced Reporting Tools**

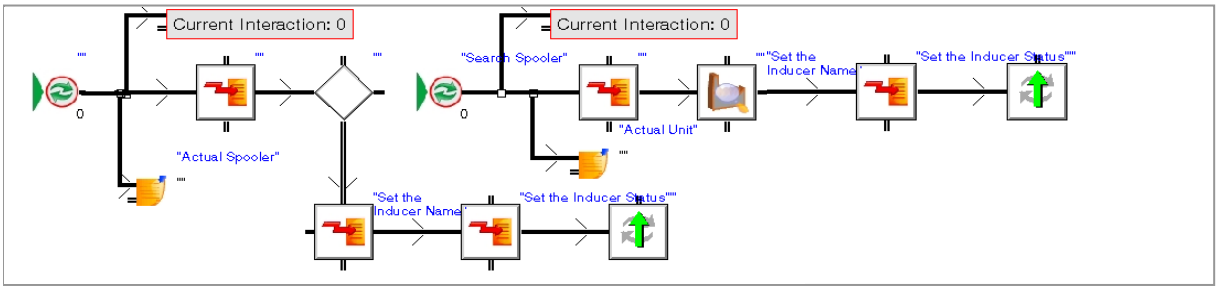

Figure 2: Production Modeling – build business rules using a graphical workflow.

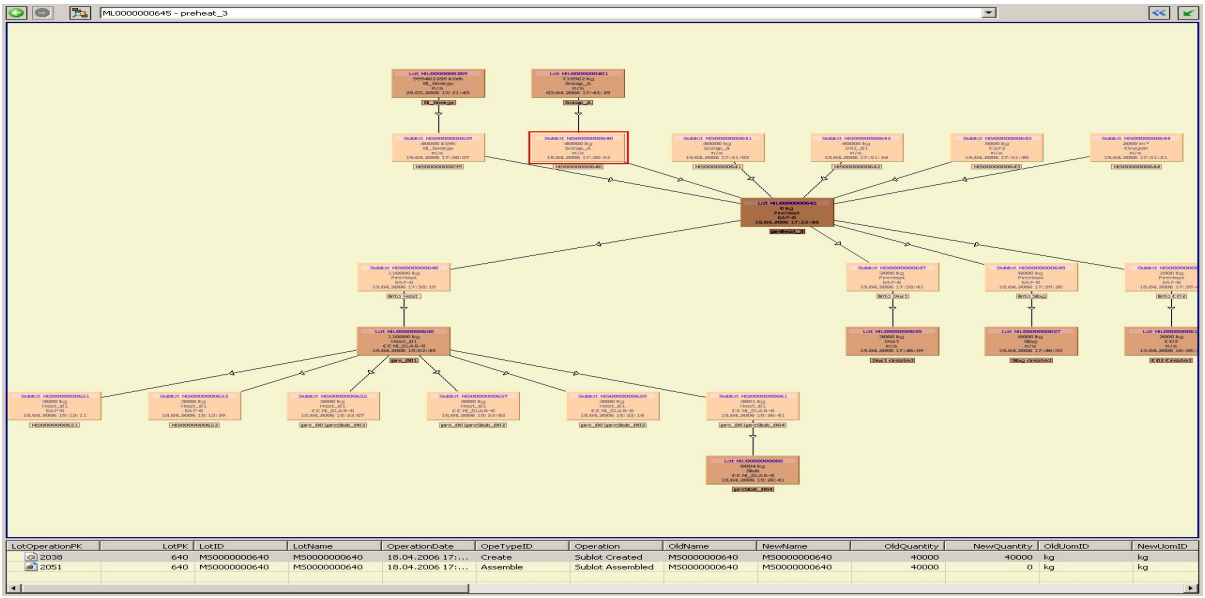

Figure 3: Material Management - Tree View Genealogy.

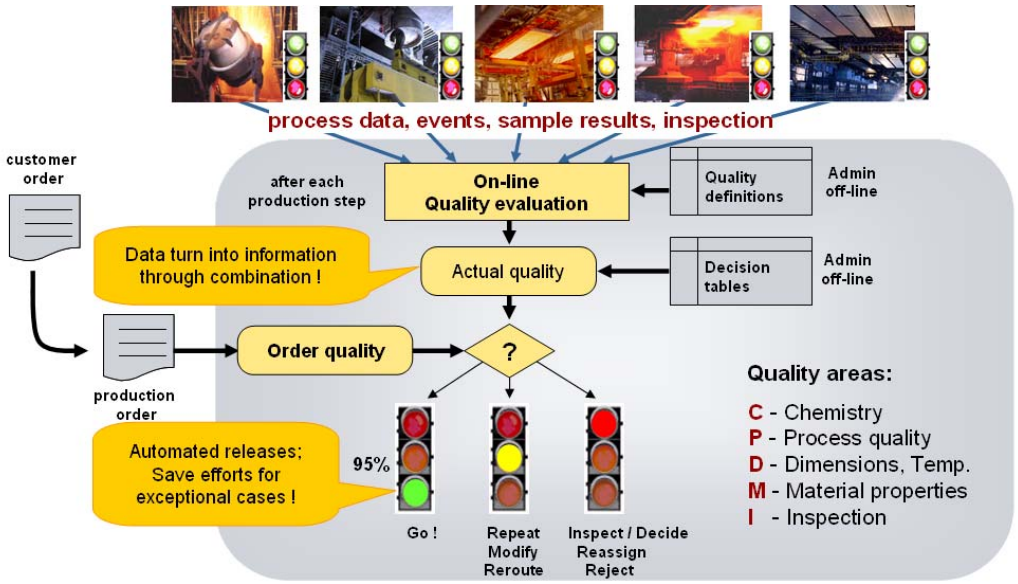

Figure 4: Quality Management – workflow.

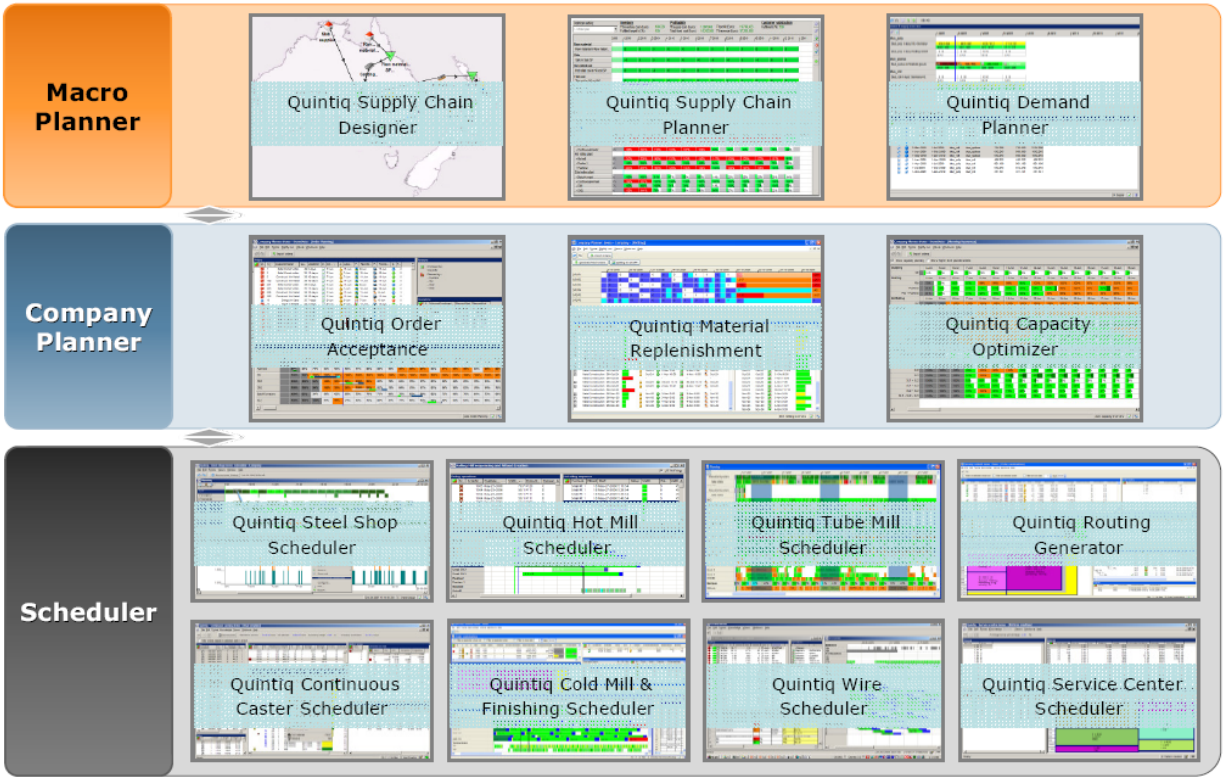

Figure 5: Complete set of planning and scheduling solutions.

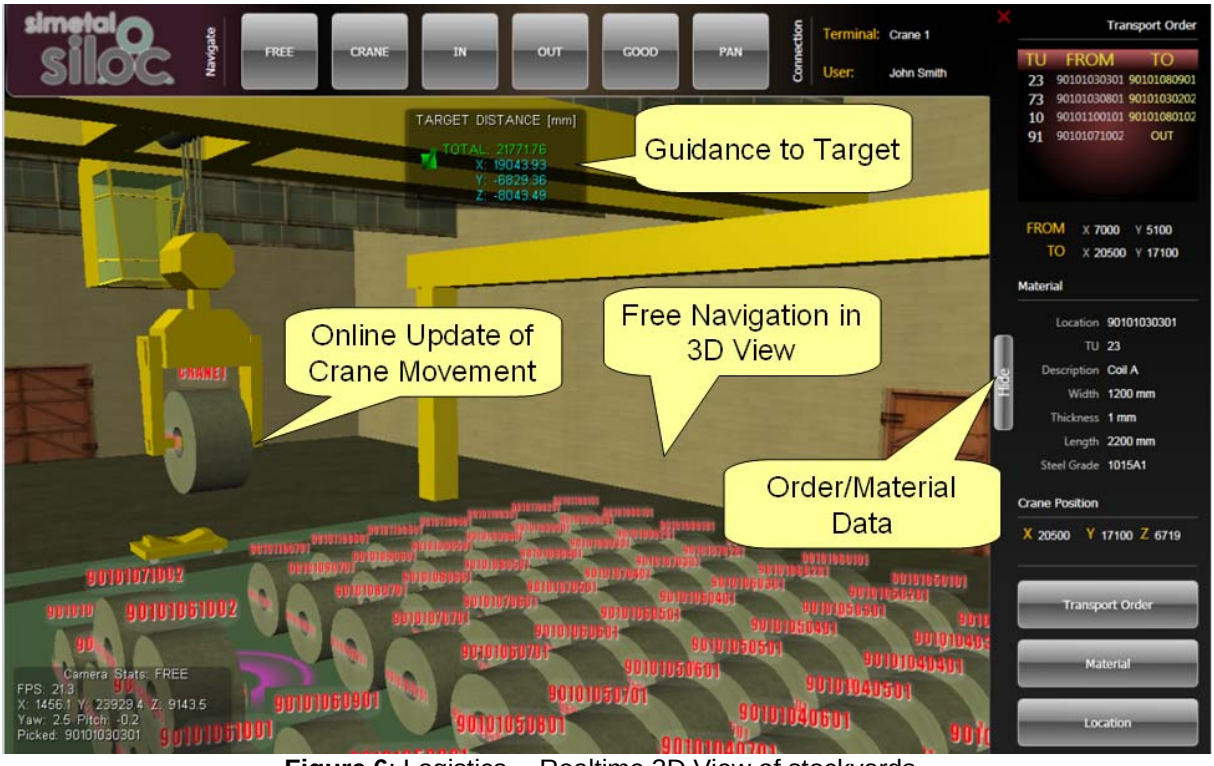

Figure 6: Logistics - ·Realtime 3D View of stockyards.

3 CONTINUOUS CASTING AND HOT ROLLING PLANT WIDE OPTIMIZATION

Based on the presented methodology and following the S95 patterns, several projects have been implemented with very good results achieved.
In Germany a plant Wide Optimization solution was implemented for an Integrated Continuous Casting and Hot Rolling at ThyssenKrupp plant. As a part of a huge supply of electrical equipment, Siemens AG, Industrial Solutions and Services, Dept. Casting & Hot Rolling Technology, designed, engineered and put into operation a MES for a combined Thin Strip Caster and Hot Rolling Mill at Thyssen-Krupp-Stahl AG in Duisburg/Germany.

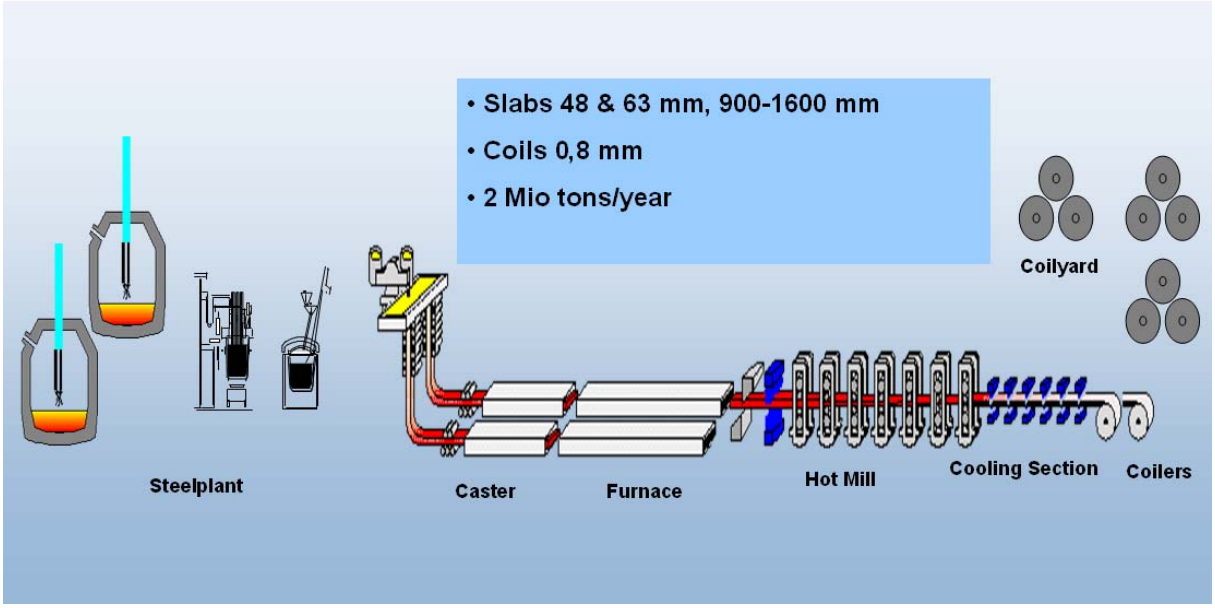

Figure 7: Plant lLayout.

3.1 Planning and Scheduling

Goal of planning & scheduling is to generate optimized production plans for the plant in three shifts. The system supports order-based production with customer-specific delivery dates.
Planning base is the order pool of the current period, complemented by orders of future periods with low priority. The pool may contain orders for stock. From this pool the sequence planner, as an important part of MES, generates one or more casting and rolling programs including planned sequences, heats, and slabs for the caster with two strands.
The sequence planner can consider numerous technological restrictions like grouping of steel grades, rolling wide to narrow, roll changes, etc. besides the variety of the order attributes.
As it is generated by a sequence planner, the combination of steelplant, caster and rolling mill can be operated in an optimized manner. Otherwise independent planning of individual units typically results in a suboptimal production flow with substantial performance losses.

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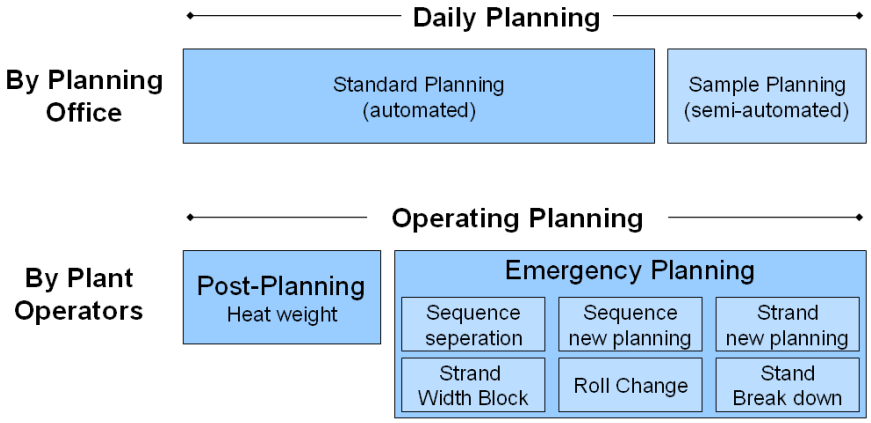

Figure 8: Overview Planning modes.

The Sequence Planner distinguishes two planning modes:

- **Daily Planning -** Creation of new production program by planning office. Planning operator can control the planning result by setting various parameters, like:
  - Selects the characteristic like mould width range, slab thickness, strip width range, main strip thickness range, tail strip thickness range (at end of rolls lifetime), intermediate rolls change (Yes/No), maximum allowed slab width decrease, and maximum heats per sequence.
  - Selects a group of steelgrade that can be cast together in one sequence. Cast groups are defined by master table dialogs.
  - The sequence planner uses mathematical approaches to find optimum overall "costs" of the generated sequences. Such costs are for instance setup times, mould changes, tundish changes, rolls changes, fill-up orders, required scrap for crops. The user can generate multiple versions of plans, compare them and decide for the best fitting one.
- **Operating Planning -** In case of emergency, like break of casting, unexpected roll changes etc., the sequence planner is able to update the previously generated production program. Various dialogs support the operator to maximize the result of emergency planning considering the actual plant situation. Operator can select various parameters. Emergency planning then is done automatically by the sequence planner.

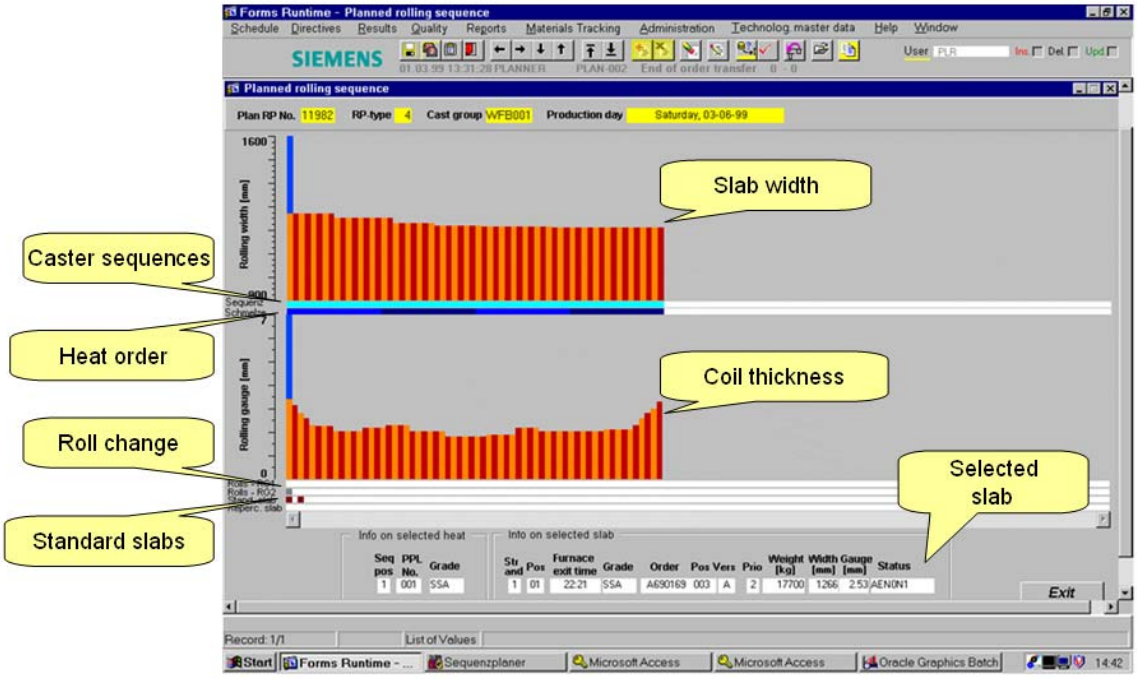

Figure 9: Graphical view of sequencing result.

3.2 Benefits for Thyssen-Krupp-Stahl AG Provided by the Implemented Solution

- High productivity
  Optimized production schedules that utilizes plant equipment in the best way and therefore increase throughput and shorter delivery times.
- Very flexible production
  Only our advanced scheduling tools enable the plant to control complex and numerous planning restrictions driven by customer orders. More different customer orders can be handled in an optimum way which is difficult or even not possible using manual planning methods.
- Fast reaction to emergency situations
  MES' implemented emergency planning tools in line with state-of-the-art HMI system increase the ability to continue production by reducing process interruptions and material losses.
- Increased profitability
  Reduction of non-allocated material in stockyard as quality management is able to reallocate customer orders automatically. Lower capital and handling cost due to advanced stock yard management.
- Higher customer satisfaction
  Fewer customer complaints through delivery of flawless products and decreased delivery times.
- Increased process knowhow
  Total process data storage and analysing tools enable plant operator to understand better the processes and even improve them.

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3.3 Important Facts

- Due to its knowledge of a fast return-on-investment, TKS AG decided to implement this MES from the beginning of plant operation.
- Main argument of customer from beginning of operation: “Without MES’ we cannot operate the plant. In case this system fails, we must stop production – plant wide”.
- Customer satisfaction is also shown by the fact that since the MES has gone into operation more functions were requested in order to optimize the overall process even more.

3.4 ThyssenKrupp Project Overview

Challenge

- Integration with existing TKS own ERP infrastructure
- Short startup time for “Go Live” (2 months)
- High demands on real time and automatic capability of MES
- Very Complex Production Planning and Quality Management requirements
- Huge amount of production data

Benefits

- Optimized integrated production schedule for casting and hot rolling
- Online Reaction on Plan vs Actual Deviations
- Optimized order based production
- Synchronized material flow
- Online coil yard management
- Optimium usage of production resources, like rolls, tundish, moulds etc.

Solution

- High sophisticated genetic algorithm based daily and emergency planning system considering all relevant technical constraints
- Online Quality assurance with automatic reassignment of material/orders
- Automatic tracking of coils in stock yard using laser based measurement system
- Production Data evaluation and archiving system

Figure 10: ThyssenKrupp, Integrated Continuous Casting and Hot Rolling, Plant Wide Optimization, project overview.

4 CONCLUSIONS

Throughout the last decades innovative MES solutions have been implemented including Production Planning, Scheduling, Control and Logistics in numerous plants in metals industry. Based on Siemens experience the main advantages of a S95 MES solution are:

- Transparency of entire Production in terms of raw materials that are planned and used for a production unit or production orders
- Overall production planning and scheduling to optimize the production flow in the plants
- Overall downtime analytic function with bottleneck detection
- Monitoring Material and energy consumption in each production step
- Full genealogy of produced goods in case of customer complaints
- Key performance indicators calculated online and automatically by the MES

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Solutions based on standard products which are customized to different plant needs can achieve the maximum benefit out of it and therefore ensure a fast Return-Of-Investment (ROI).

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