MODERN AUTOMATION TECHNOLOGY IN SERVICE OF INTEGRATED STAINLESS STEEL MILL

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Abstract: Outokumpu Stainless Oy has an integrated stainless steel mill in Tornio, Finland. This mill consists of FeCr-production, stainless steel melting shop, hot rolling mill and cold rolling mill. Latest project to double the previous capacity consisted of second melt shop line, modifications in hot rolling mill and RAP5-line in cold rolling mill. The production capacity of Tornio works is 1,7 mt/a stainless steel products thus being the largest single production unit in the world at time being. High level of automation is utilized to guarantee high quality of products and improve productivity. Process automation provides efficient tools for operators to control processes and automate auxiliary tasks using robots, manipulators and other sophisticated solutions. *Copyright © 2005 IFAC*

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1. INTRODUCTION

The ferrochromium production was started in Tornio in 1968 and stainless steel production in 1976. Since those days the mill has grown to largest single production unit in the world. Modern production technology with modern automation and IT-systems has been applied from the beginning. Latest investment step of 1 Billion Euro was to double the production to 1,7 Million ton/a.

When compared to labour-intensive industries the stainless steel industry can be seen very capital intensive, thus the role and applications of automation are often different. Instead of totally automated production lines automation is widely used to improve controllability of processes, quality of products and automated auxiliary tasks such as material handling.

2. PROCESS CONTROL SYSTEMS – 4 LEVELS OF AUTOMATION

The process control and automation is defined in 4 levels :

- Level 1 (L1) process control and field instruments,
- Level 2 (L2) process models and diagnostics,
- Level 3 (L3) shop floor and quality management,
- Level 4 (L4) order-supply chain management

The L1 automation utilizes more and more modern field instruments, Remote I/O's, field busses and graphical interfaces. In processing lines and rolling mills the modern AC-drives provide new tools to advanced speed and torque control. Also the utilization of servo hydraulics has provided new improved possibilities to control steel production in wide range from continuous casting machines to small manipulators. Generally the L1-systems today are capable to handle more and more complex MIMO- and cascade-systems with improved accuracy.

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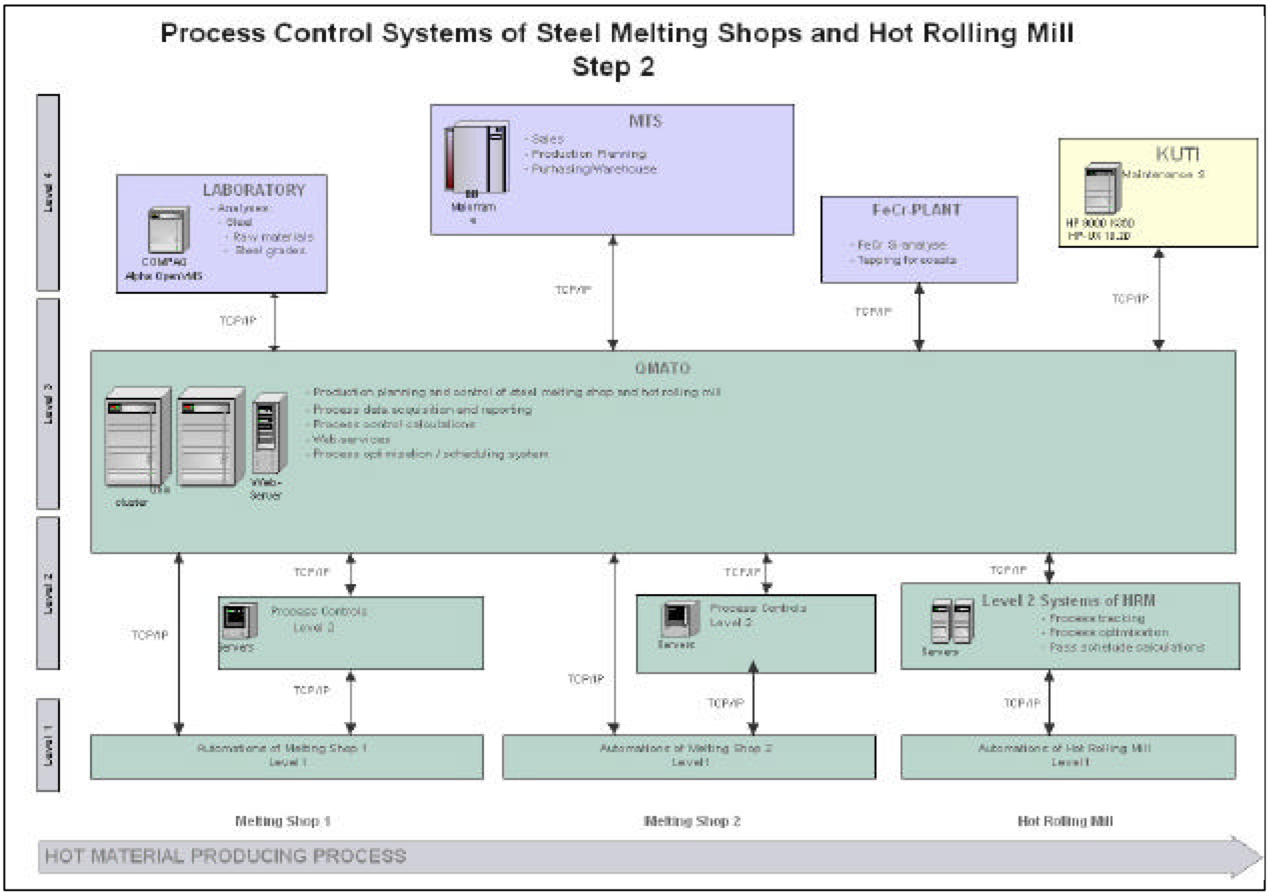

Fig. 1. Example of automation levels in Steel Melting Shops and Hot Rolling Mill

The L2 includes process models, automatic material handling, tool setting, packing and other auxiliary systems. L2-automation utilizes physical process models to supplement the L1-control giving calculated set-values to L1 process control. The process monitoring and diagnostics play also important role in L2 systems.

The L3 contain scheduling and delivery status monitoring features. The Steel Melt Shop and Hot Rolling Mill are managed in common L3-system. Hot rolled coils are transported to Cold Rolling Mill having it's own scheduling, delivery and quality monitoring system.

The L4 connects customer orders and material and makes capacity allocation to production. This complex ERP-system is used to manage the complete order-supply-chain follow-up and documentation.

3. AUTOMATIC MATERIAL HANDLING

Full information of production material in internal storages and in storages for finished material is in L2 Material Handling System (MHS). MHS manages and gives tasks for automatic and manual transporting systems. L2 MHS gets its tasks from L3 Real Time Plant Production System (RETU, Level 3) based on production planning and plant optimisation.

3.1 AGV-system in CRM1

The internal transporting of production material is mainly done by 16 Automatic Guided Vehicles (AGV´s) at the Cold Rolling Plant #1. There are two type of AGV's : a carrying-type AGV´s and a mandrel-type AGV's. These AGV's get their tasks from MHS and transport the coils to next process step.

The routes of AGV´s are fixed and each AGV follows magnetic field of two separate electric wires embedded to the floor concrete. The routes are divided into segments to position any AGV on the route accurately. Each AGV has a Programmed Logic Controller (PLC, level 1) to control driving, steering, lifting and safety of the AGV.

Fig. 2. A carrying-type AGV

3.2 Automatic storages and cranes

There are automatic work-in-process coil storages for production optimisation and timing as well as buffer for processing lines. The production material is transported to coil storages by the AGV's. AGV picks up and leaves a coil to one of the special designed ramps. An automatic crane then picks up the coil and transfers it to specified storage position. Unloading coils from these automatic storages is done the same way. The driving and lifting motors of automatic cranes utilize vector controlled inverters and PLC to control crane operations and safety. Coil management system is linked with the crane automation for each automatic storage.

Fig. 3. The internal product storage

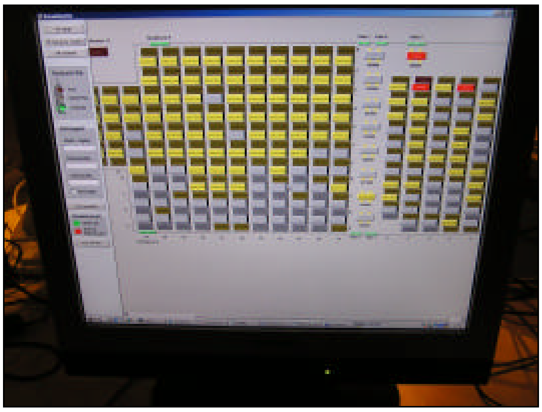

Fig. 4. Coil management map in MHS (L2)

3.3 Automatic sheet and coil packing

Automatic sheet and coil packing are implemented with manipulators and robots. The Automatic Sheet Packing (ASP) is used to pack the sheets to customer and deliver the finished packages to despatching high bay storage. ASP gets information of packed sheets and their dimensions, packing materials and packing type from Real Time Production Control System (RETU, L 3). Similar system is used also for Automatic Coil Packing (ACP). The difficulty in both applications is due to non-standard dimensions of customer packages and different package types. Thus traditional solutions were not applicable.

Fig. 5. The Automatic Sheet Packing

3.4 High bay storage for finished material

There are two high bay storages for finished products one for the Cold Rolling Plant #1 and the other for the Cold Rolling Plant #2. The finished material transported to the storages by conveyors. The special designed high bay storage cranes transfer the finished material packages to storage place. Unloading material from high bay storage for despatching is managed by these same cranes.

Fig. 6. Automatic high bay storage crane

4. AUTOMATIC ROLL GRINDING SHOP AND WORK ROLL CHANGE IN SZ-MILLS

4.1 The Roll Management System (RMS, level2)

All the information concerning the SZ-mill rolls is located to the RMS. There are positions of the rolls (storage places, roll change device, grinding history, roll damages etc.) and all the actual dimensions of the rolls.

The RMS controls the automatic storage of the work rolls, grinding of rolls and also the roll change device. The work rolls of Sendzimir-mills are located in automatic storages. A used roll is transported from storage to grinding and ground roll is lifted to roll change device by an automatic DC servo driven loader.

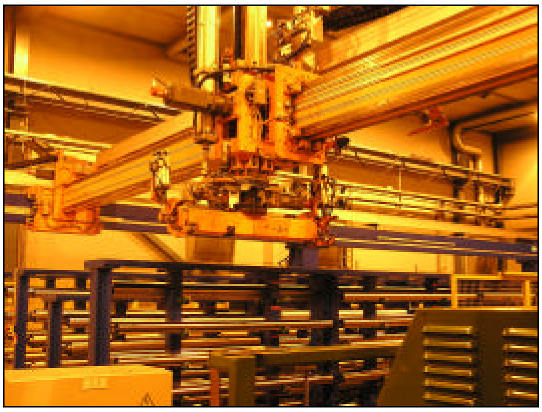

Fig. 7. The SZ-roll storage crane.

5. TOOL HANDLING FOR SLITTING LINE

Stainless steel coils are slit or cut to sheets for customers. The dimensions of slit coils as well as material properties vary greatly from order to order. There is need to change slitting tool settings many times per shift. This laborious job is nowadays fully automated by robots.
Each slitting tool set consists of the slitting tools and the support rings build on two shafts. There can be more than ten heavy slitting tool rings and several support rings in one slitting tool set.

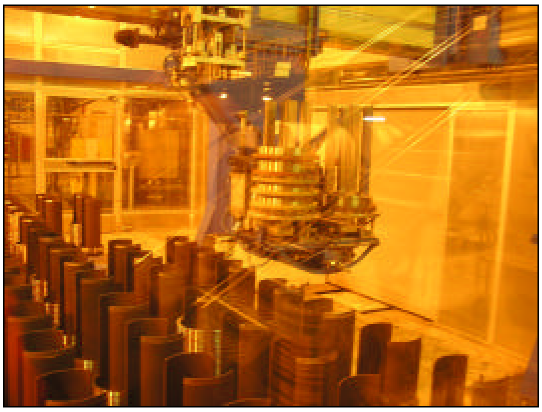

Fig. 8. The slitting tool assembly robot.

6. CONCLUSIONS AND FUTURE NEEDS FOR AUTOMATION AND PROCESS CONTROL

Stainless steel industry is very capital intensive industry with huge investments to production facilities and expensive raw materials. Special needs to product properties in new applications and shorter delivery times together with market fluctuation set continuous challenges to stainless steel producers.

IT-technology is today widely used in order-supply chain management. The needs to further improve the production control and scheduling as well as develop the delivery management to more transparent to customers is evident. The present ERP-systems do not support these functions properly.

To improve product quality and guarantee uniform product properties the process control with accurate measuring instruments are in key role. For process control reliability and accuracy are the main challenges; even in the extreme conditions of steel making.

Models are needed to improve the accuracy and use of L2-systems. Combining flow models with heat and material transfer models is needed in melting shop process improvements. Material models with phase transformation kinetics is needed to improve thermo-mechanical rolling processes. These are just few examples of the challenges to automation and process control in stainless steel industry.