ABB DRIVES AND CONTROL SYSTEM FOR HOT FLAT ROLLING MILLS IMPROVES YIELD AND QUALITY[1]

Lars Mjörning[2]

Abstract

ABB have through the years delivered a large number of drive and control systems to rolling mills in the steel industry, helping mill crews to produce rolled material with a higher effiency and improved yield and quality. ABB have developed software applications covering most advanced control applications in Rolling Mills supporting all mill crew to optimize quality and utilization of the mill. Those applications are implemented in the newly developed control system 800xA. ABB's new generation of control is an open system that provides a complete integration of advanced process control, supervision of equipment, production planning and follow up. Rolling mill drive systems must meet very demanding requirements. To fulfill those, ABB has developed a new type of converter to feed synchronous or induction AC-motors. The new DTC (Direct Torque Control) Drive control improves dynamic performance by magnitudes compared to conventional solutions. The converter has a unity power factor loading of the power supply, why no SVC is required.

Key words: Rolling mill control; Main drives.

[1] *42º ABM Rolling Mill Seminary, October 25 to 28, Santos, SP, Brazil.*

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Rolling Mill control system

Software architecture

ABB's System 800xA has a unique software architecture known as AspectObjects. This organizes the automation system into Objects and each of which has characteristics defined as Aspects.

- **Objects:** are devices, products, orders, etc..
- **Aspects:** are real-time properties that relates to the object.

Actually, you may have already had some experience with these concepts.

Most of you have had the experience of installing a new printer for your PC. A job made much easier since all the information you need (fonts, drivers, diagnostic software, etc.) is provided with the product on a CD ROM. (See Figure 1)

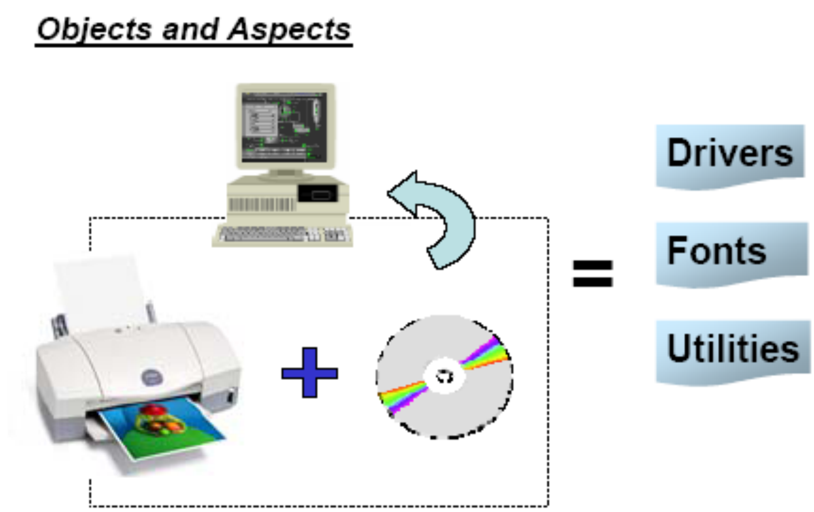

Fig. 1

These various files are the **Aspects** of the printer.

The architecture is developed so that information from automation systems from other suppliers can be easily integrated into the ABB System 800xA. The Objects are arranged in a Plant Explorer structure based on either functionality or geographic location. This provides the big advantage for the mill crew that all information about the process objects such as drawings, descriptions, handbooks, maintenance statistics, etc. are immediately on hand when required. No more searching for documentation while production is waiting. Additional information can be added into the system for the most part irrespective of the form of the information. The basic goal of System 800xA is to enable many products to work together in truly seamless fashion, creating a total solution that is far greater than the sum of its parts, much the way the various programs on your PC work together to make the job easier.

ABB's commitment is to provide similar information in standard electronic formats with our motors, drives, switchgear, instruments, etc. Depending on the product, up to 20 or more Aspects (characteristics) might be provided. Either directly with the product or via online links to other platforms. A common software program (.pdf for instructions; AutoCad for 2-D drawings, etc.) will always be used for each type of aspect. (See Figure 2)

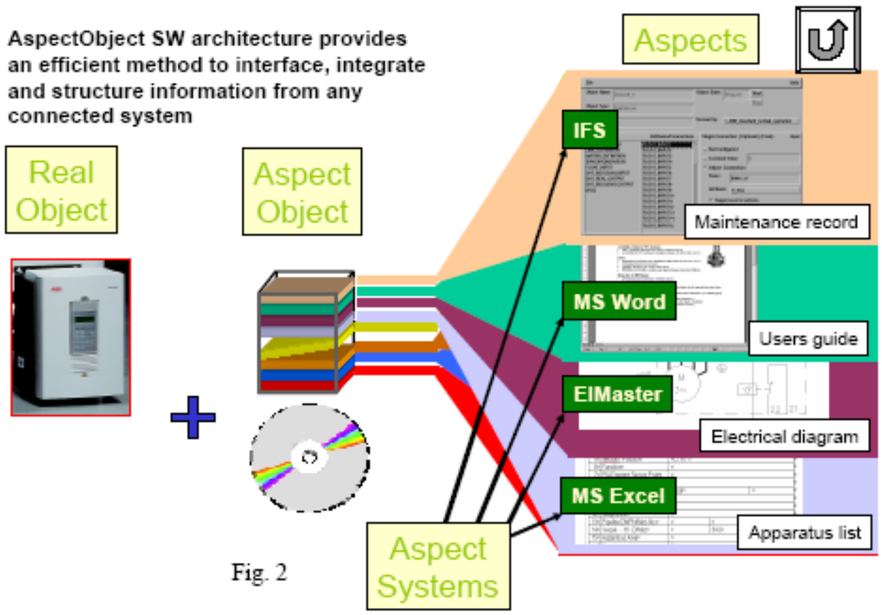

Fig. 2

Together, these Aspects form a dynamic “model object” containing links to all the important information. In System 800xA terminology, this is called an ObjectAspect.

Let’s take a closer look at some examples of ObjectsAspects.

Data need be entered only once for use throughout the system, and real-time information on each Object is just a “click” away. (See Figure 3)

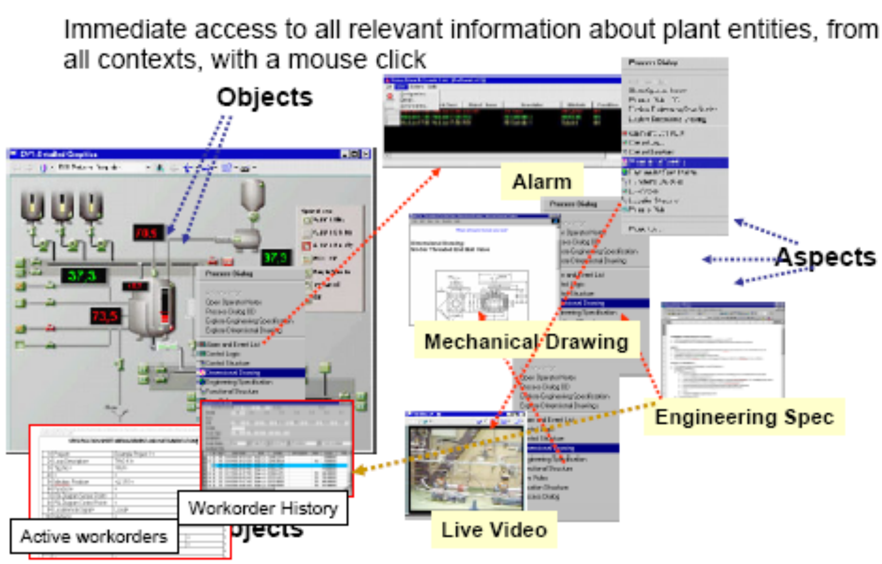

Fig. 3

In addition to managing system devices as shown here, the System 800xA architecture will also support management of Aspect Objects based on end products.

For example, each slab, coil, or plate has real-time characteristics such as raw material composition, end customer, lot number, delivery date, etc.

Integrated systems

Thanks to the multi-faceted System 800xA architecture (See Figure 4), this added value will extend across many dimensions of the business enterprise. The same 800xA components will offer:

- Vertical integration from the most basic devices to management decision support
- Horizontal integration to ensure a consistent approach to similar tasks across the plant
- Lifecycle support for business assets, from idea and installation, through operation and maintenance
- And even Supply Chain integration that lets the user reach beyond their own business to interact with their own customers and suppliers.

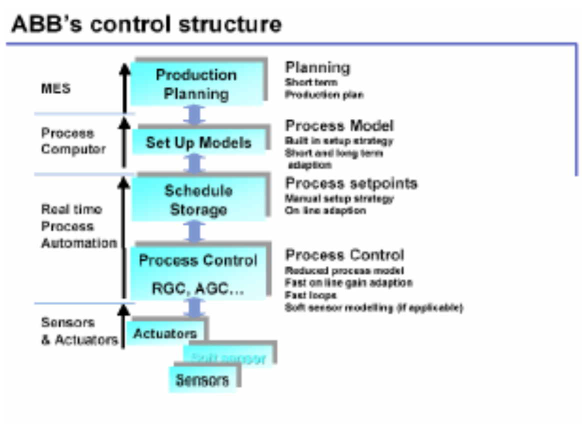

Fig. 4

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In the near term, System 800xA will bring significant benefits to the users, ranging from easier deployment of "information enabled" products to easier integration of products from multiple business areas.

Along the way, customers will find their plant operation is simplified through access to real-time information.

Fewer installed products will provide more choices, and productivity will be optimized, as System 800xA products interact and "learn" from each other. In longer term, we believe the extension of 800xA to other product producers will offer customers a far greater choice of compatible technologies.

Control system for Hot Rolling Mills

The application software is built by a number of SW standard modules. The principle is shown in Figure 5.

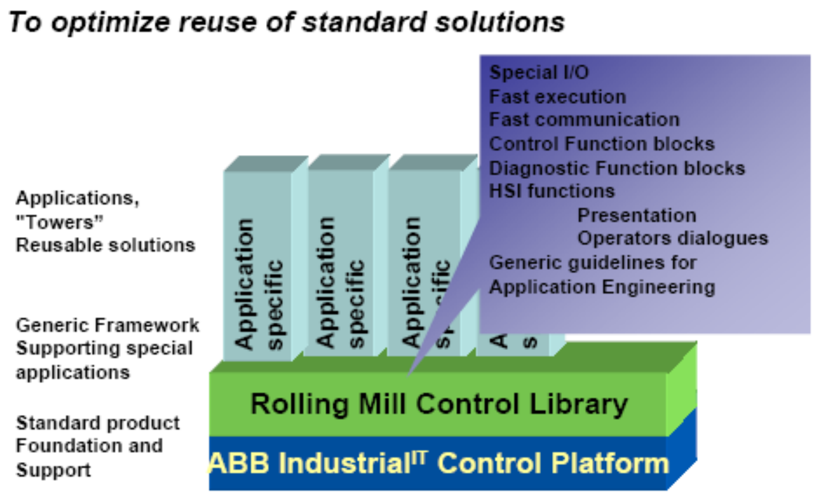


Fig. 5

A few examples of such standardized application modules are shown in Figures 6 and 7.

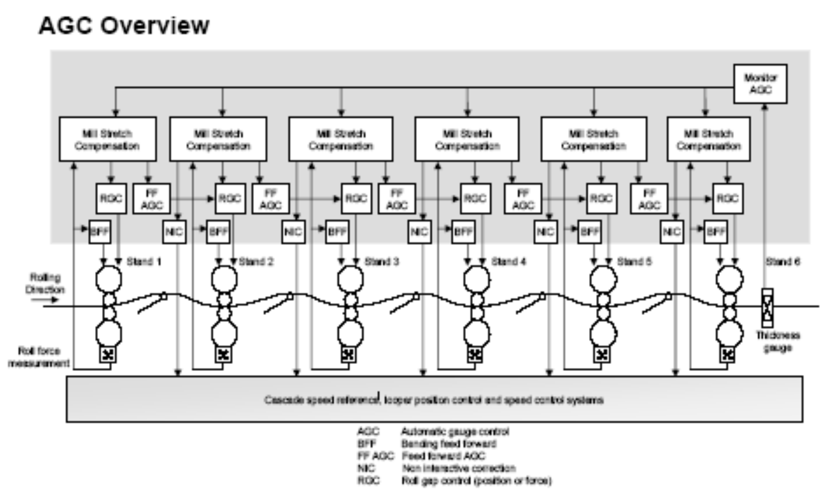


Fig. 6

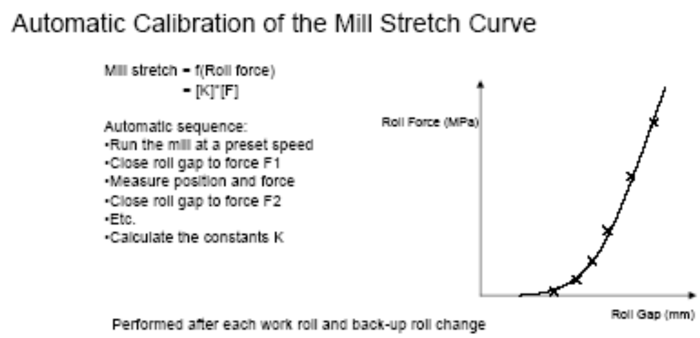


Fig. 7

A typical basic configuration for a rolling mill application can be seen in Figure 8.

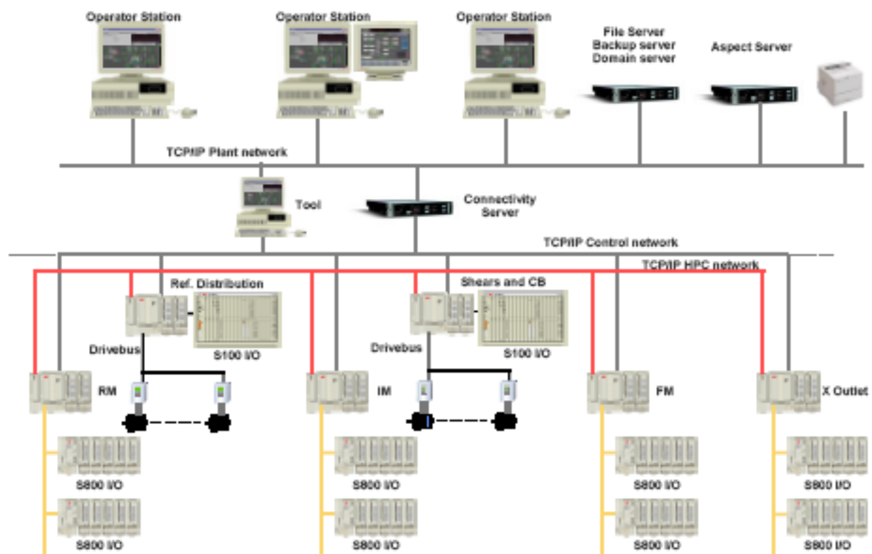
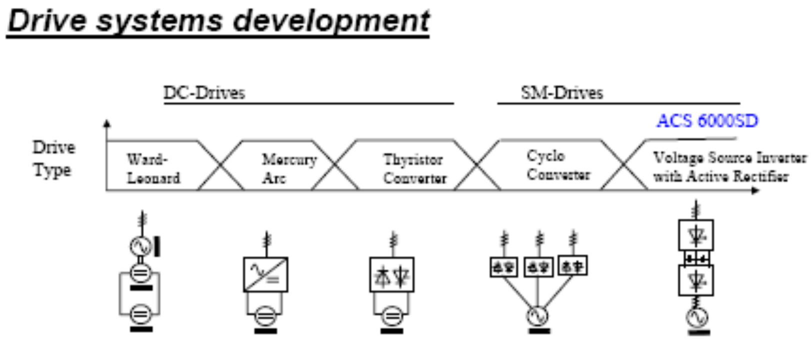


Fig. 8

Rolling Mill Main Drive Technology

History



	Ward Leonard	Mercury Arc	Thyristor Converter	Cyclo Conerter	ACS600 SD VSI & AR
Drive Dynamics	Poor	Improved	Improved	No Change	Outstanding
Harmonic distortion	Low	High	Improved	Deteriorated	Low
Power factor	Unity	Poor	Poor	Deteriorated	Unity
Common supply section	Yes	No	No	No	Yes
Totale efficiency	Poor	Improved	Improved	Improved	High
Maintenance cost	High	Improved	Improved	Low	Low
Drive Reliability	Good	Good	Improved	Improved	Excellent

Fig. 9

Rolling Mill Main Drive technology development

Figure 9 illustrates the history of speed controlled drives for large rolling mill drives where DC-motors was used until the beginning of the eighties when the introduction of the cycloconverter enabled the use of synchronous motors

The latest step, going from Cycloconverter drives to medium voltage source inverter drives were initialized by the introduction of a new generation of medium voltage power semiconductors, like the IGCT (Integrated Gate Controlled Thyristor). This was a great leap forward restoring some important features (like unity power factor operation, nearly sinusoidal loading of the power network, reactive power compensation capability and multi-drive capability or possibility to use common supply section). The prevailing large drive technology in all times is based on lowest total investment cost for the Rolling Mill owners. In the total investment cost the life time cost of power losses must be included.

Drive dynamics as fast torque and speed control has always been considered as a very important feature.
Together with the new drive technology represented by ACS 6000SD and its feature of DTC (Direct Torque Control that's gives an optimally fast torque control we are introducing RMD (Rolling Mill Drive) control, which replaces the conventional PI-speed control and conventional feed forward control techniques. The result is an optimally fast speed control based on the characteristics of the mechanical drive train.

The RMD control means that loading of the different mechanical parts of the drive train is lowered, which lowers the maintenance costs for the Mill owners.

The ACS 6000SD drive is a fuse-less drive available for reversing rolling mills. For Mill owners this means higher reliability since the fuses are suffering of thermal ageing, a phenomena where the root cause is the cyclic load of a reversing rolling mill, up to 250 % followed by no-load.

Impact on the power supply network

Medium voltage source inverter drives supplied by active rectifiers (active front end) is a major breakthrough, compared with cycloconverter fed synchronous motor drive.

In order to lower the forces on the mechanical system at threading, the speed is often lower than the desired rolling speed. The speed reference at threading can be between 30 – 50 % of nominal speed. At those speeds the power factor of the cycloconverter is really low, maybe cos φ=0,3.

Cycloconverters are always accompanied in these applications by SVC equipment. The traditional SVC is a number of passive harmonic filters and a TCR (Thyristor Controlled Reactor). The TCR is controlled so that it consumes the excessive reactive power produced by passive filters of the SVC. The idea with the SVC is to keep the power factor at unity independent of the actual load.

Efficiency comparison CC-SM vs. ACS 6000SD.

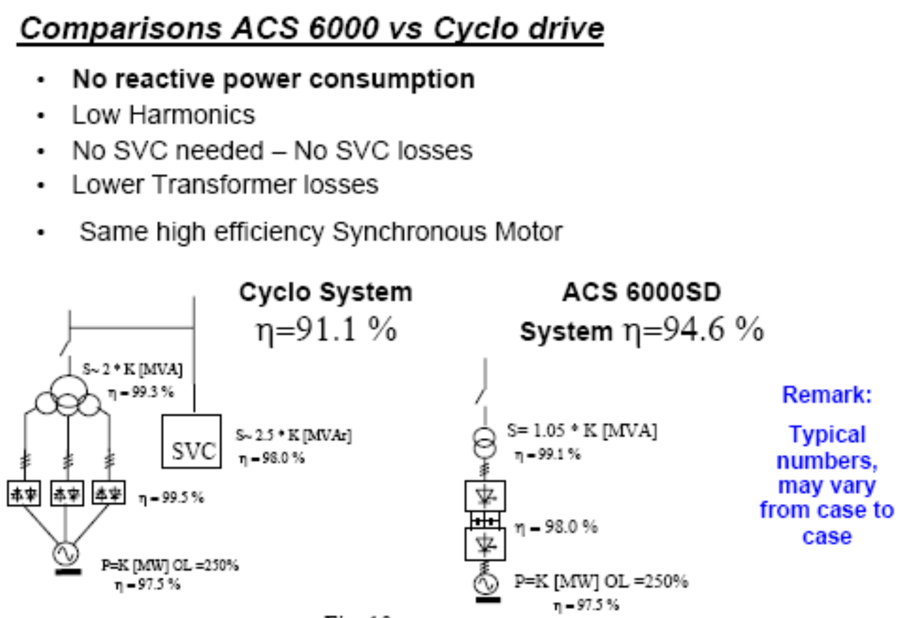


Fig. 10

ACS 6000SD based Hot Rolling Mill main drives

Configuration example

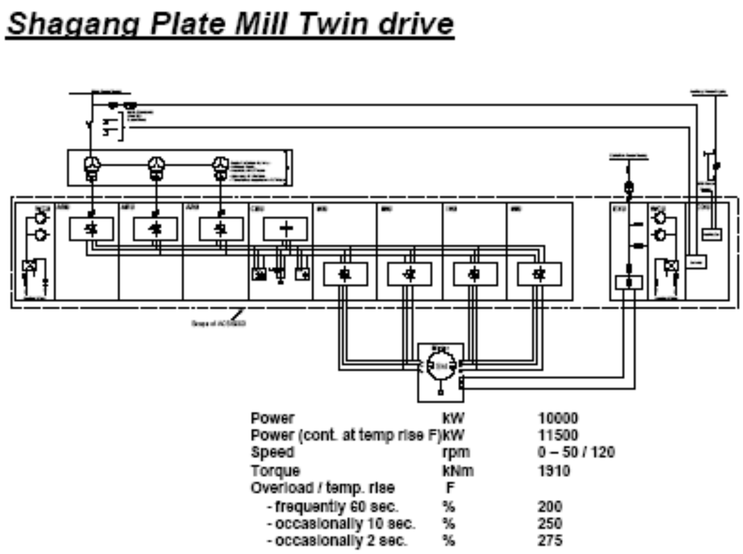


Fig. 11

ACS 6000SD control

Control system

The control structure is similar to the structure that is used for the ABB low voltage AC drives ACS 800. This means that some control boards, like the pulse encoder interface, are used in both products.

The S800 standard I/O, which comes from the Control System 800xA, is used to handle the drive auxiliary functions like cooling, space heating, door locking system, start prevention switches, etc.

Drive HSI

The panel and the PC-tools (DriveWindow and Drive Debug) is exactly the same type that is used for ABB low voltage AC-drives type ACS 800, and this represents an advantage for maintenance, as there are also many low voltage speed controlled drives in the same plant.

Torque Control

The inverters are using 3-level DTC switching to control the torque of the motors and to control the harmonics of the motor torque such as it is not causing any mechanical resonance's. Here the randomness of the DTC is beneficial since it is smoothening the harmonic spectra of the airgap torque.

DTC is a modulator free AC-motor control scheme, which has an extremely low dead time in the torque control loop. DTC is updating the switch positions every 25 μs based on a new evaluation of the motor airgap torque that is based on new voltage and current measurements. This means that the dead time of DTC is extremely small and this means that DTC is behaving like a deadbeat controller.

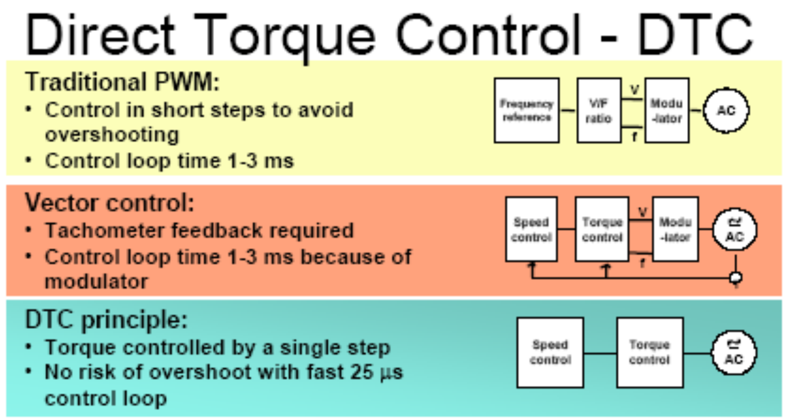


Fig. 12

DTC has enabled a much faster speed control compared to what is possible with cycloconverters, which was the competing drive technology. The "small signal" behavior of DTC, meaning the response time to 25 – 30 % of nominal motor torque, is about 1 ms which shall be compared to 10 ms with a cycloconverter fed synchronous motor drive CC_SM (with a considerable overshoot). For a CC-SM is the dead time 3.3 ms at 50 Hz supply.

Rolling Mill Drive Functions

Introduction

Rolling mill drive systems are especially demanding. The requirements are typically expressed in ms and MNm, reflecting the combination of the large size of rolling mills, and the high tolerance requirements on the final rolled product. Due to the high torque and powers needed, it is very expensive to buy an ideal mechanical construction, e.g. preloaded gearboxes or special couplings. Increasing quality requirements makes it necessary to utilize the drive system, i.e. the combination of converter, motor and drive train optimally. The dynamic properties of the drive train require advanced control solutions in the drive system to be fully optimized. The Rolling Mill Drive functions are located in the fixed part SW of the inverter control for optimal processing speed and synchronization with the torque control.

Control solutions for optimal utilization

RFE – Resonance Frequency Eliminator

Backlash compensation

LSE – Load Shock Elimination

AIC – Adaptive Impact Compensation

Content

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DRIVES E SISTEMAS DE CONTROLE DA ABB PARA LAMINADORES A QUENTE AUMENTAM A LUCRATIVIDADE E QUALIDADE[1]

Lars Mjörning[2]

Resumo

ABB através de anos de fornecimento de uma grande quantidade de drives e sistemas de controle para Laminadores na indústria de siderúrgica, ajudaram as equipes de operação a produzir materiais com alta eficiência, aumentando a lucratividade e qualidade. ABB desenvolveu programas aplicativos cobrindo as mais avançadas aplicações em laminação, suportando toda a equipe de operação para otimizar a qualidade e utilização do Laminador. Estas aplicações são implementadas na nova plataforma de controle 800xA. A nova geração de controle da ABB é um sistema aberto que permite a completa integração de controles avançados, supervisão de equipamentos, planejamento e acompanhamento da produção. Drives para Laminadores devem satisfazer altos requisitos de demanda. Para atender isto, ABB desenvolveu um novo tipo de conversor para controlar motores AC síncronos ou de indução. O novo DTC (controle direto de torque) melhora a performance dinâmica em várias vezes comparadas com as soluções convencionais. O conversor possui fator de potência unitário, não necessitando de SVC.

Palavra-chave: Controle de laminadores; Drives principais.

1 *Contribuição Técnica ao 42º Seminário de Laminação Processos e Produtos Laminados e Revestidos; 25 a28 de Outubro de 2005, Santos, SP, Brasil.*

2 *Rolling Mills, ABB Automation Technologies, Västerås, Sweden.*