

Highlights of VAI Continuous Casting Technology

G. Holleis, G. Kuttner, W. Scheurecker

Long-term competitive steelmaking can only be assured by continuously adapting to the market demands and by the application of advanced, cost-saving technologies. This is particularly true in the field of continuous casting where recent developments now enable major improvements to be achieved with respect to production output, quality, reliability of operations and maintenance. This paper discusses the latest technological and automation advances by VAI which contribute to improved performance and cost-savings in the field of continuous casting technology.

Parole chiave: acciaio, colata continua, impianti e attrezzature

PROLOGUE

Investment decisions in today's competitive steel industry are governed by an ever-growing list of determining factors which include quality requirements, productivity, production costs, market requirements, resources, capital market, environmental protection and globalization. Thus the task of making decisions is becoming increasingly complex and greater demands are placed on the development of new processes to collectively meet a wide variety of conditions and demands. Figure 1 illustrates the complexity in selecting the ideal process chain and the individual production facilities based on the available raw materials and the desired hot-rolled products. The investor must decide whether to install conventional or new technologies to meet production targets, whereas there are inherent risks and advantages in each of these approaches. An investment in new technology to meet new market challenges may be riskier, however, the potential to succeed and excel in the market is far greater. Because of the costs and time involved, the development of new technologies should ideally be carried out on a partnership basis between the plant builder and the operator. The synergy of engineering and operational expertise is the best combination to create a win-win situation for both partners. Thus the probability is high that the shared risks could be more than compensated for by the shared rewards. This will hopefully be one of the important trends to witness in the implementation of new technologies in the future.

DEVELOPMENT TRENDS IN CONTINUOUS CASTING

In the economy of the total steel production chain the conversion of liquid steel into solid material via the continuous casting process is of decisive importance. How will the future of steelmaking be influenced by developments in continuous casting? Significant economic advantages are currently being implemented by the direct linking or elimination of production steps, by near-net-shape casting and by the application of high-speed casting technology.

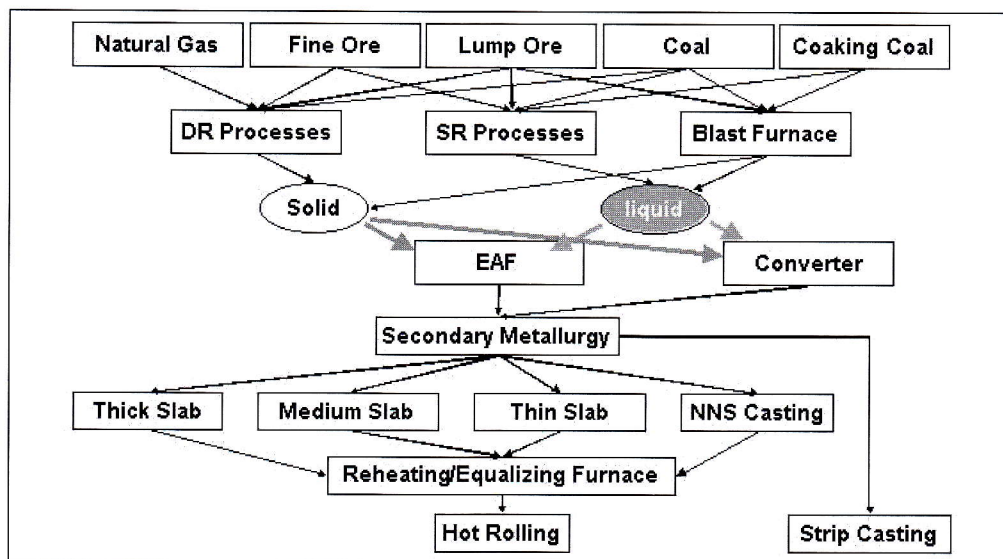
Linking/Elimination of Process Steps

Experience has shown that most of the major reductions in investment and production costs are achieved when fundamental changes in the technology occurs. This was the case with the introduction of the LD steelmaking process beginning in the 1950s and this was also true with the replacement of ingot casting by continuous casting. The linking of process steps as in thin-slab-casting and direct-rolling technology as well as the elimination of process steps as in strip casting technology are other such examples where costs can be slashed and production efficiency increased (Figures 2 and 3).

Near-Net-Shape Casting (NNSC)

Because of the obvious cost-saving potential, intensive efforts have been made since the early 1990s to optimize NNSC. A typical example is the beam-blank caster which

Figure 1: Process Selection Alternatives.



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Paper presented at the Continuous Casting
Conference, Linz, 5-7 June 2000

Memorie

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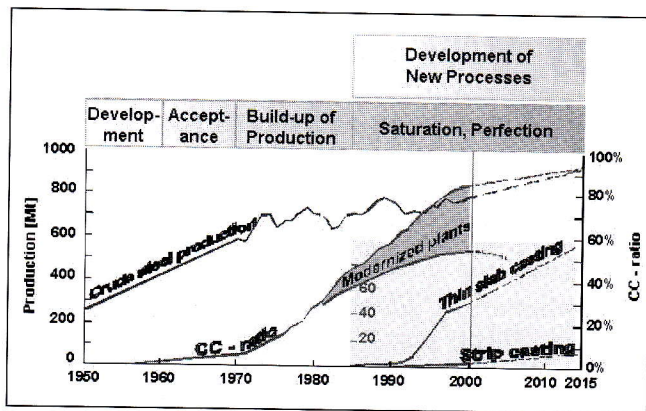


Figure 2: Market Share of New Casting Technologies.

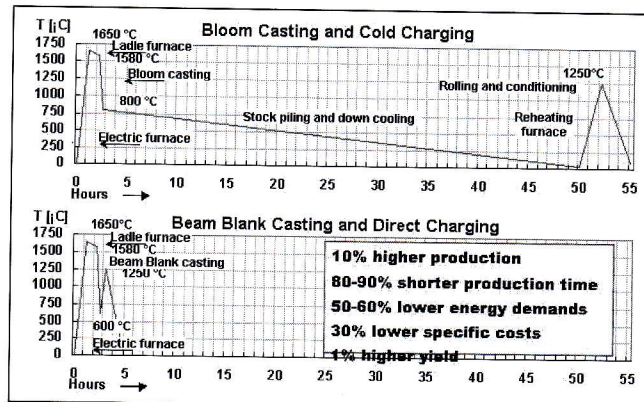


Figure 5: Benefits of Near-Net Shape Casting and Direct Charging.

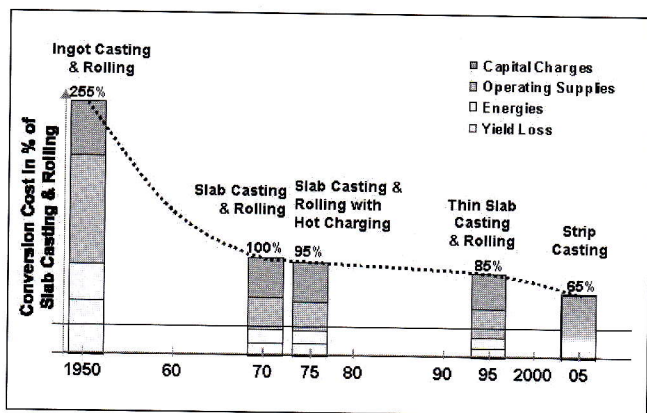


Figure 3: Conversion Cost Comparison of Different Process Routes from Liquid Steel to Hot-Rolled Coils.

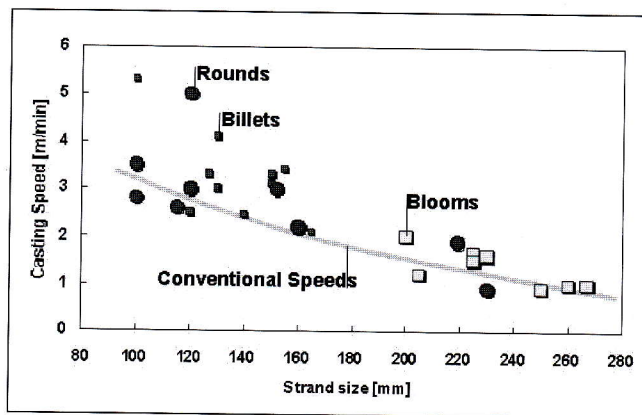


Figure 6: High-Speed Billet and Bloom Casting Technology.

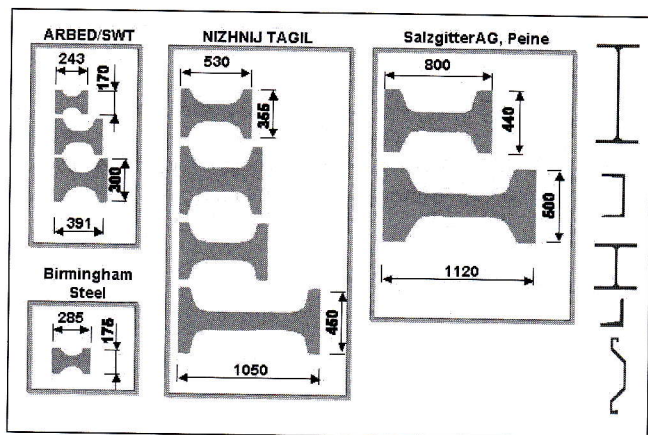


Figure 4: Overview of Sections Produced with VAI Beam-Blank Casters.

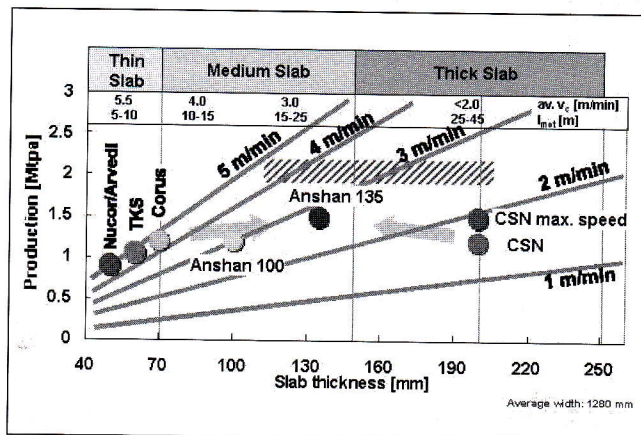


Figure 7: Comparison of Slab-Casting Speeds and Production Output.

produces a wide range of final sections (Figure 4). The various benefits of NNSC in connection with direct charging is seen in Figure 5. The other examples of NNSC are thin-slab casting—in combination with ultra-thin hot rolling—and strip casting which are bringing the thickness of the intermediate products ever closer to their final product gauges. When considering the benefits of NNSC the impact on the entire production system must be considered as well. A change in an individual process step usually affects the upstream and downstream facilities to a certain extent which means that automation, logistics and other operational services must be integrated and optimized. Therefore, process and logistical simulations are of great importance in minimizing risks as well as for ensuring ideal plant and process design and utilization.

High-Speed Casting

Application of high-speed casting in billet/bloom installations enables the caster output to be increased by more than 50%—depending on the strand formats and steel grades (Figure 6). As of December 2000 orders for VAI's DIAMOLD high-speed billet-casting technology have been received from a total of 15 steel producers on four continents. High-speed casting of a single-strand medium-thick slab at 4 m/min allows for a caster production of approximately 2 million t/a.

The risk of internal quality defects can be minimized through the application of soft reduction. Double width (3200 mm) casting would again double the caster output. Figure 7 shows the relationship between slab thickness, casting speeds and productivity.

OTHER TECHNOLOGICAL HIGHLIGHTS

The implementation of new technologies requires continuous development in the fields of sensors, automation and equipment, etc. Simultaneously, operational results of casters and market requirements must be permanently analyzed, which necessitates a close cooperation between producers and suppliers. On the basis of this approach, a number of new caster solutions could be implemented, several of which are outlined in the following sections.

Conversion of Curved to Straight Molds in Slab Casting

Use of a straight mold has been shown to be the best solution for satisfying the highest internal-cleanliness demands for slabs. The conversion from a curved to a straight mold can be accomplished with minimum modifications to existing equipment, with only a short caster downtime and at low investment costs. Again, close cooperation with the client results in the best technical solution.

For example, USINOR and VAI jointly developed and patented a new casting transition curve from the vertical into the existing constant radius. Figure 8 shows the principle of the modification at SOLLAC Fos Sur Mer (France), where the caster was started up in November of 1998. The predicted improvements in quality were fully met or exceeded.

Mold and Oscillator Developments

The demand for zero maintenance and an excellent equipment state throughout its operational lifetime has also been a

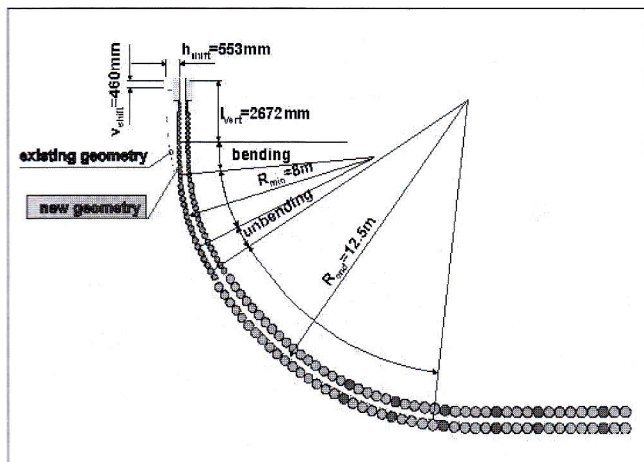


Figure 8: Conversion from Curved to Straight Mold.

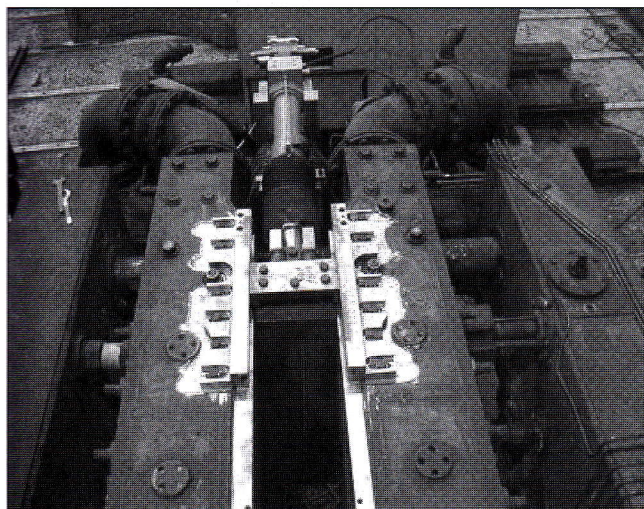


Figure 9: The Hydraulic Mold-Width Adjustment System (HYDROWAM), SSAB Tunplåt, (Lulea, Sweden).

driving force for caster improvements.

One such example was the introduction of a hydraulic mold-width adjustment system (HYDROWAM) at SSAB Tunplåt, (Lulea, Sweden) as seen in Figure 9. Modification costs are relatively small and the reduced maintenance costs shorten the return on investment.

Another important improvement was the development of DIAFACE technology which is characterized by

- Parabolic mold taper
- Chamfered edges in the lower part of the mold.

This solution ensures direct contact between the strand shell and the copper plate along the entire mold length, promoting a rapid and homogeneous strand-shell growth. The chamfered edges reduce the mold friction, thus minimizing wear of the copper plate. The internal structure of the cast slab is of higher quality and internal defects at the strand corners are eliminated. Lateral strand bulging is also reduced. Figure 10 shows the difference in shell growth between the conventional linear mold and DIAFACE.

Ideal oscillation is an absolute prerequisite to utilize the advantages of optimized mold design. The recently developed hydro-actuated oscillator with leaf spring guidance improves product quality, increases operational safety and reduces maintenance requirements.

With the installation of the MoldEXPERT, a quality-improvement tool for operational and maintenance supervisors, total control of the casting process is possible (Figure 11). Important additional information is also provided for precise diagnosis and quick solutions to operational problems.

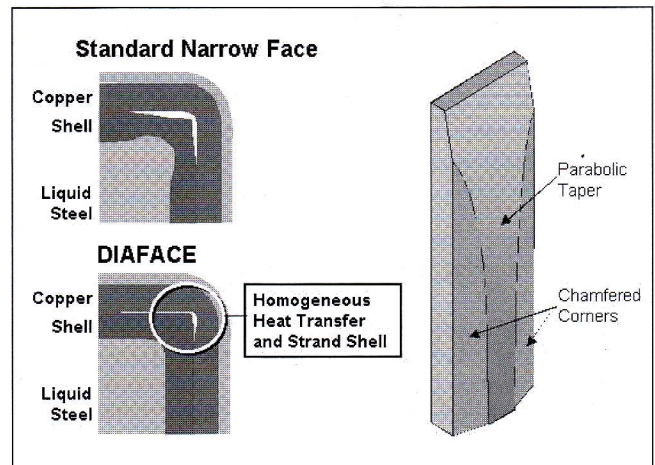


Figure 10: DIAFACE Mold Design.

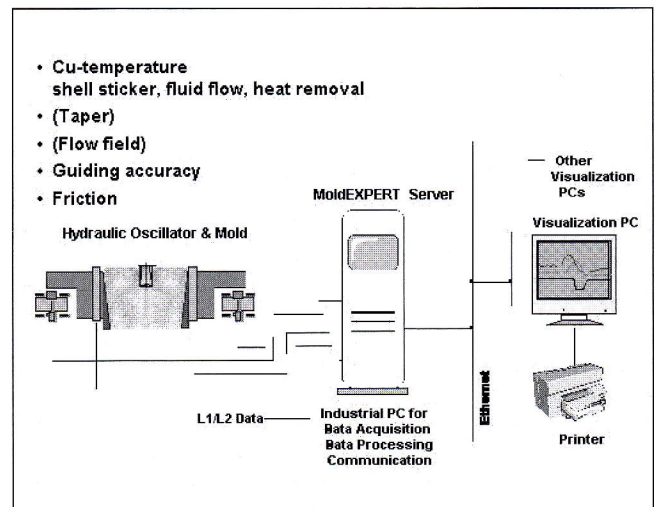


Figure 11: MoldEXPERT Technological Package for the Mold Area.

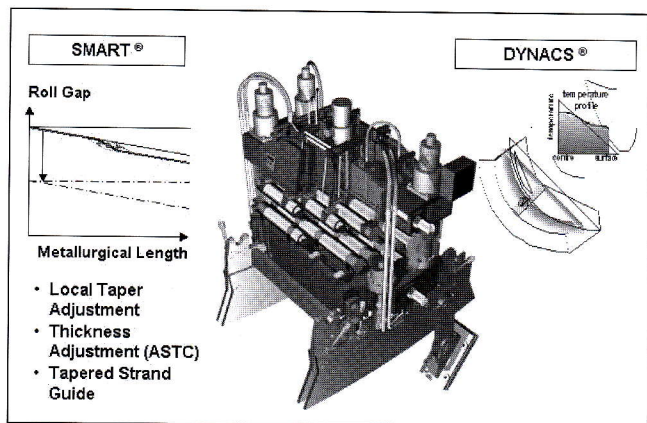


Figure 12: SMART®/DYNACS® Technological Package.

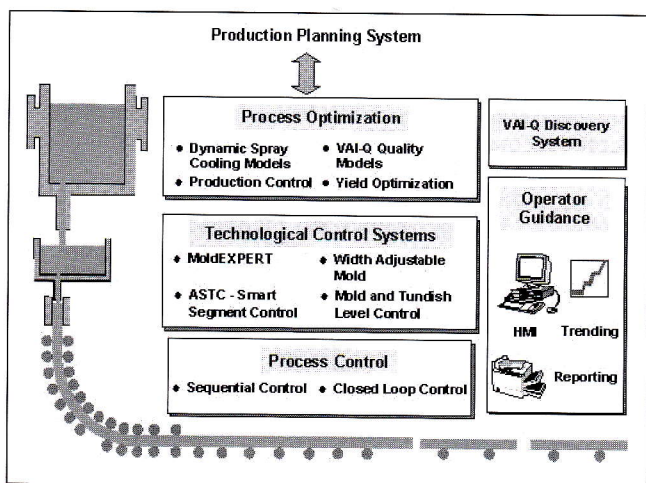


Figure 13: Caster Automation Configuration.

Strand Thickness Control

SMART® technology (for dynamic roll-gap control) in combination with DYNACS® (VAI's dynamic secondary cooling system) (Figure 12) form a unique technological package with the following advantages:

- Strand-thickness reduction
- Remote control of roll-gap taper to improve internal quality (soft reduction)
- Dynamic change of cooling to achieve ideal surface temperature for best surface quality.

NEW AUTOMATION METHODS

Major developments in automation are being made in parallel with the advances in technology. Application of integrated process control solutions has become necessary with consideration to the complexity of decision making and the number of influencing parameters and their interdependency. A number important trends and developments in this field are outlined.

Overall Automation Structure

Ever-increasing demands on cast and finished-product quality as well as for directly linked processes require integrated automation solutions, access to online computer support for optimization, an automatic quality control system and continued know-how development. New developments in technological control systems, process optimization and quality-control functions as well as their integration with effective production scheduling are promising steps towards zero-defect production (Figure 13).

Mathematical Modeling

Casting is one of the most complex processes in steel production. Mathematical models can now be employed to numerically simulate different aspects of continuous casting. Measurements and physical modeling have successfully verified the models. The results can then be used for online process control and optimization. By means of new sensors in the mold, e.g., mold flow sensors, the modeling of slag entrapment in the solidifying shell will be possible. VAI automation is focusing its activities on making commercially available the latest research results of mathematical modeling. Mathematical models for strand temperature (used in the DYNACS® cooling model), precipitation of nitrides and intermix calculation are already implemented.

Further model developments will deal mainly with the modeling of inclusions and crack formation during casting. The models will replace the existing statistics-based defect prediction model. The extensive knowledge about the casting process gained through modeling will also be used to improve the casting practice.

Quality Data Warehouse Solution

In 1998 VOEST-ALPINE Stahl Linz and VAI began working on the joint development of a plant-wide VAI-Q Quality Data Warehouse. The comprehensive functions of this system support process and quality documentation, quality certification and trace-back in the case of claims and process development. New dimensions in product quality control are now available to producers.

The system was recently put into operation on the Inspection Line No. 3 and Tinning Line No. 2 at the VOEST-ALPINE Stahl Linz works (Austria). The quality data warehouse for steelmaking and continuous casting, the so-called VAI-Q Slab Discovery system, is currently being implemented.

Connect and Cast

Experience in the reuse of application software packages as well as the availability of low-cost computer power are the basis for a new system architecture. Individually tested hardware and software components are connected and configured for dedicated applications. This leads to short system development and start-up times, reliable operation, easy integration into the existing environment and easy upgrading.

Figure 14 shows the average reduction in implementation times of VAI automation projects achieved through the application of the above approach.

Online Customer Services

The availability of internet and other global communication facilities provides new methods of customer support and data presentation.

Remote Support

VAI specialists can be connected to their customers during the commissioning and warranty periods for diagnosis and support purposes. Thus the software experts do not have to remain on site for the amount of time that was necessary in the past. The installed data connections can later be used for service and assistance as well as for software upgrades.

Internet Visualization

Quality data and reports will soon be available not only via dedicated display but also by internet or WAP technology. Metallurgists and production managers can access process data at any workstation on a plant network, at home or at any other place around the world. By making use of these technologies, the large amount of available information can be used in a more efficient way.

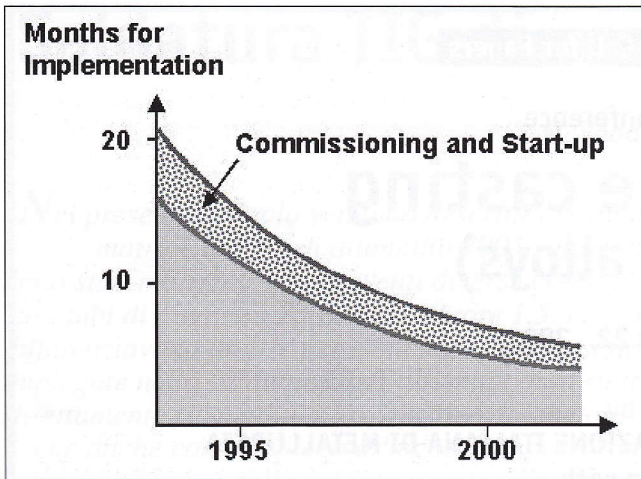


Figure 14: Average Reduction in Implementation Times of Medium-Size VAI Automation Projects.

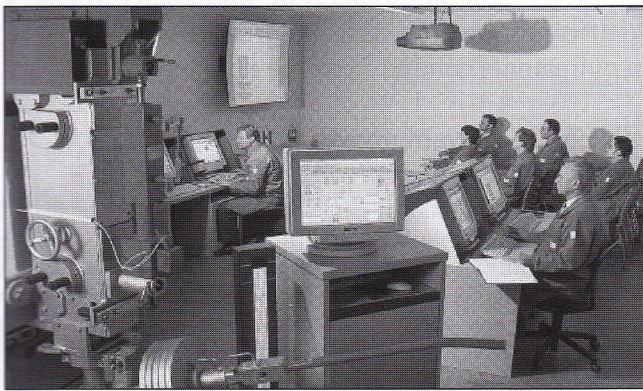


Figure 15: Caster Training Simulator.

SERVICE

The future will belong to those steel companies that are capable of gaining and maintaining an edge over the competition through their capacity to learn and change quickly and systematically. This can be achieved more readily with competent support, backed by optimized methods and a strong sense of commitment.

Metallurgical Services

Through VAI's daughter company VOEST-ALPINE Industrial Service (VAIS) a wide range of services are provided to steel producers, including:

- Consulting and assistance
- Outsourcing and offline maintenance
- Service engineering and materials management.

For example, caster operational personnel can be quickly

and effectively trained with the Caster Simulator. This state-of-the-art unit provides hands-on training in a modern classroom environment (Figure 15). The stopper mechanism, automation and instructor functions ensure training under realistic conditions, meeting the requirements of beginners as well as advanced personnel. Well trained operational personnel means considerably shortened start-up curves.

Outsourcing/Offline Maintenance

According to a study by McKinsey, 40 to 60% of the value-added chain at a steel plant consists of activities that can be outsourced. Examples include maintenance, repairs, logistics and environmental services. VAIS additionally offers offline maintenance for continuous casters to enable producers to concentrate on their core business. Through specialization a continuous enhancement of the caster equipment and a steady reduction of the specific maintenance cost are achieved. Offline maintenance services are already provided for numerous customers, for example in Brazil, South Africa and the USA.

Materials Management

To ensure that the materials required for most repair jobs are always quickly available, VAIS has developed a Material Information System (MAISY). This computer-based system facilitates identification of a specific part or suitable substitutes and also optimizes inventory control. An effective warehouse system provides fastest possible access.

In the future, steel plants will be able to rely on just-in-time delivery of critical and expensive spare parts within a period of less than 24 hours. This will be possible through a worldwide pooling service of interchangeable spares such as the rotary bearings of ladle turrets, complete roller sets, etc. Information on the availability of such spares will be provided through the internet. A company's net current assets will no longer be inflated by holding expensive items on stock just for the unlikely case of failure.

CONCLUDING REMARKS

Progress in materials development, automation, sensors, simulation tools, consumables, etc. has opened the door for the introduction of new solutions such as high-speed casting, near-net-shape casting and total quality control. The application of highly automated solutions and process models is the key for maximizing operational benefits and plant performance.

In spite of these advances, it does well to remember that the operation of a metallurgical plant remains a symbiosis between human capability and state-of-the-art technology. Development and retention of qualified personnel is thus equally vital for successful production operations and for maintaining high standards of excellence in continuous casting.