THE VAI COMPACT CASTER - A NEW CASTER CONCEPT FOR INCREASED CAPACITY AND FLEXIBILITY IN SLAB PRODUCTION[1]

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Abstract
Since the introduction of steelmaking, the numbers of continuous casting machines have been increasing steadily across the whole world. For many steel companies, a further capacity increase is only possible by extensive revamping of the existing machines or new investments. However, because of limited area conditions, expanding is difficult or sometimes impossible and the installation of additional casters in different locations comes along with the disadvantage of long steel transportation distances from the existing steel plant to the new continuous casting machines. This paper describes a new slab caster technology with which twin casting of a slab width up to 2 x 1600 mm and a single casting width with a maximum width of 3500 mm are possible with one strand guidance system. Each slab is controlled separately in twin casting mode. Mold oscillation and casting speed are controlled independently. In single casting mode the two drive lines are synchronized.
Key words: Continuous casting; Compact caster.

A MÁQUINA DE LINGOTAMENTO CONTÍNUO COMPACTA VAI UM NOVO CONCEITO DE LINGOTAMENTO CONTÍNUO PARA MAIOR CAPACIDADE E FLEXIBILIDADE NA PRODUÇÃO DE PLACAS

Resumo
Desde sua introdução na produção de aço, o número de máquinas de lingotamento contínuo tem crescido consistentemente em todo o mundo. Para muitas siderúrgicas, um aumento adicional de capacidade de produção só é possível mediante uma ampla reforma das máquinas existentes ou novos investimentos. Entretanto, devido às limitações de espaço, a expansão é difícil ou, às vezes, impossível e a instalação de máquinas de lingotamento continuo adicionais em diferentes locais envolve a desvantagem do transporte do aço por longas distâncias desde a aciaria existente até as novas máquinas de lingotamento contínuo. Este artigo descreve uma nova tecnologia de lingotamento contínuo de placas com a qual é possível o lingotamento duplo de placas com largura de até 2 x 1600 mm e uma largura de lingotamento simples de no máximo 3500 mm utilizando um único sistema de guia do veio. Cada placa é controlada separadamente no molde de lingotamento duplo. A oscilação do molde e a velocidade de lingotamento são controladas de forma independente. No modo de lingotamento simples as duas linhas de acionamento são sincronizadas.
Palavras-chave: Lingotamento continuo; Máquina de lingotamento contínuo compacta.

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INTRODUCTION

Since the introduction of steelmaking, the numbers of continuous casting machines have been increasing steadily across the whole world (Figure 1).
Because many companies already have a 100% CC-ratio, a further capacity increase is only possible by extensive revamping of the existing machines or new investments. However, because of limited area conditions, expanding is difficult or sometimes impossible.

Because of space limitations, it is not easy to install additional casters without having the disadvantage of long steel transportation distances from the existing steel plant to the new continuous casting machines.

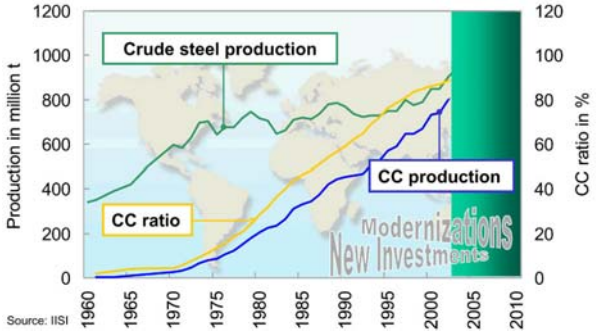

Figure 1. Development of Steel Production Worldwide

The new concept of VAI's Compact Caster enables steel producers to increase their steel production without this disadvantage.

CONCEPT OF A VAI COMPACT CASTER

To start with further explanations, the following example is taken:
Imagine that most of the time in the year a steel plant produces slabs with a maximum width of 1300 mm and that the annual production should be much more than this plant is able to produce on 3 strands.
Additionally, there is sometimes a demand for wide plates with widths of up to 3000 mm, which could be sold on the market with good profits.
Example of required annual production:

- Slab width 800-1300mm: 2.500.000 t/y
  Steel grades: peritectic grades
  low carbon grades
  ultra low carbon grades
  medium carbon grades
  HSLA grades
- Slab width 2000-3000 mm: 500.000 t/y
  Steel grades: peritectic grades
  low carbon grades
  medium carbon grades
  high carbon grades

To meet both demands, the steel producer would need three strands with a casting width of 1300 mm and one wide slab caster. This would be possible by installing two double strand casters, whereby one strand of a two-strand caster would be wider for the production of wide plates.
The casting machines would include:

- two ladle turrets
- tundishes (min. 14)
- four tundish cars
- molds for small and wide slabs
- three-strand guides for small slabs
- one-strand guide for wide slabs
- corresponding runout facilities
- corresponding peripheral facilities

The required space for all those strands would be at least 75 m across the casting direction. With the new concept of a VAI Compact Caster, the space requirement and the amount of equipment can be reduced, and as a result the investment costs can be cut whilst still achieving the same production.
This paper describes the new VAI concept for a continuous casting machine, which is designed to cast single wide slabs or two independent small slabs per strand with the same equipment, maintaining maximum flexibility.

THE VAI COMPACT CASTER

Layout of a VAI Compact Caster

First let's compare the required space across the casting direction:
A typical 2-strand caster has a strand center distance of approx. 6 m. The minimum distance to the centerline of a second 2-strand caster is approximately 36m, resulting in a minimum width of 55 to 60 m needed for two 2-strand casters. The casting floor width would require at least approx. 75 m (Figure 2).
Compared to that, the VAI Compact Caster (as shown in Figure 3) requires a maximum width of approx. 25m at the strand guide area if the outside drives are located in a common steel structure, or less than 20m if they are supported by the steel structure. In the area of the casting floor, this space requirement is less than 50 m.
Therefore, with a VAI Compact Caster more than
30 % required space at the casting floor and 50 to 60 % at the strand guide area can be saved. The space requirement for 4 strands is quite similar to one traditional 2-strand caster. At the same time, the client would have the additional advantage of casting wide slabs to a width of up to 3000 mm using the same casting equipment.

Capacity Comparison

Table 1 shows the relation between the annual output of a VAI Compact Caster and two traditional 2-strand casters. The result is that for the same caster area the productivity is around 40 % higher with the VAI Compact Caster.

Table 1. **Relation of Output to Required Area**

	Two 2-Strand Casters	**VAI Compact Caster**
Caster area [m^2]	75m x 117m appr. 8800	48m x 132m appr. 6400
Output/area	340 t / m^2	470 t / m^2
	100 %	138 %

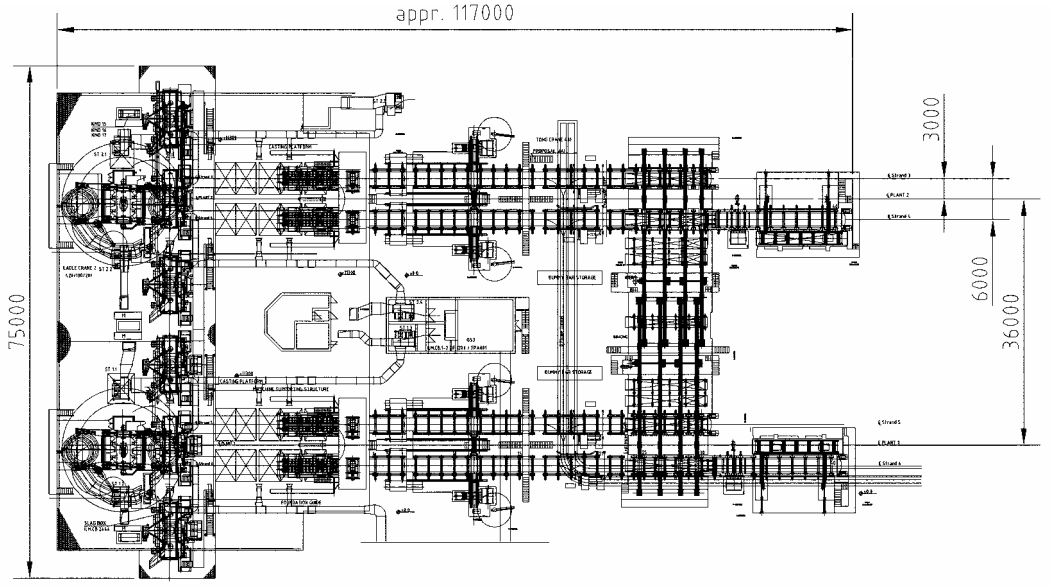

Figure 2. Layout of 2 x 2-Strand Slab Casters

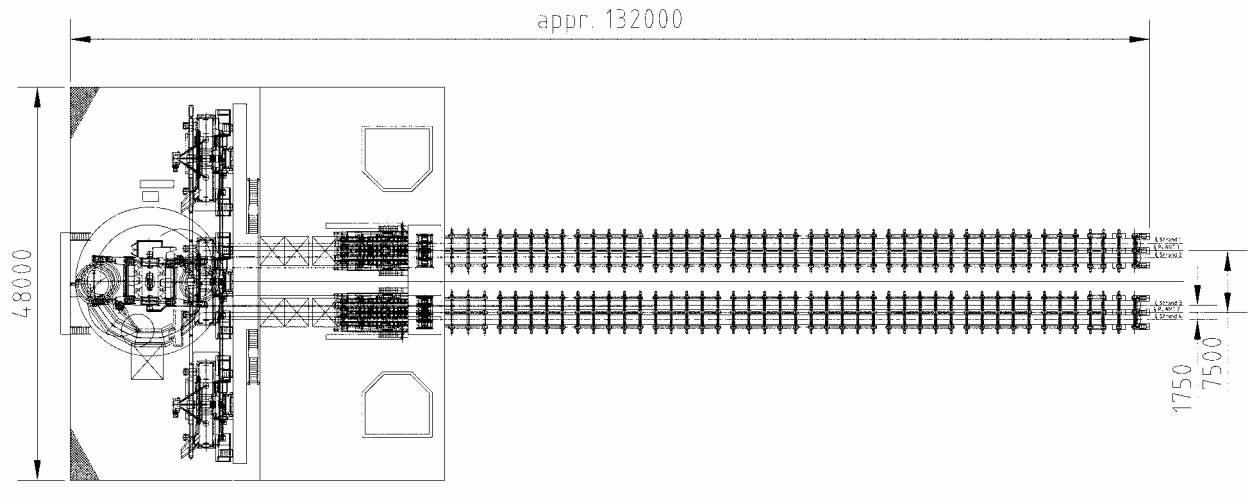

Figure 3. Layout of New 2 (4) Strand VAI Compact Caster

Main features of the VAI Compact Caster

Arrangement of segments and drives:

The key feature is a twin caster with a centerline distance of 1750 mm between the twin slabs. An identical caster will be arranged close to this twin caster a second time. Between these two casters there is only a walkway (Figure 4).

At a common twin caster a wide slab is divided in two small slabs with a divider arranged in the center of the mold. Both slabs are operated with the same oscillating device and therefore have to be cast at the same casting speed. In case of a casting irregularity, the casting condition for both strands has to be changed according to the failed one. Furthermore, independent dynamic adjustment of slab cooling for each strand is not possible.

With the VAI Compact Caster as proposed, each strand is operated totally separately. There are independent molds, independent oscillating devices and a roller guidance that allows different casting speeds and that has individually driven and adjustable rollers for each strand.

At a common double strand caster the distance to a second double strand caster is defined mainly by the space requirement of the tundish and tundish cars (four units are usual). Considering a VAI Compact Caster, only two tundish units are necessary. Therefore the space requirement of the withdrawal drives defines the distance to the neighboring machine. There are two possibilities of arranging the drives of the VAI Compact Caster. They could be located on both sides in the steel structure used for the segment removal rails as shown in Figure 4 or only inside in the steel structure and traditionally on the outside as shown in Figure 5.

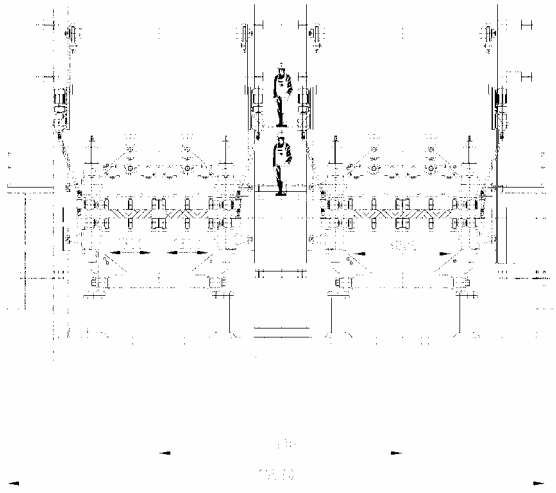

Figure 4. Cross-Section through a VAI Compact Caster with Minimum Space Requirement

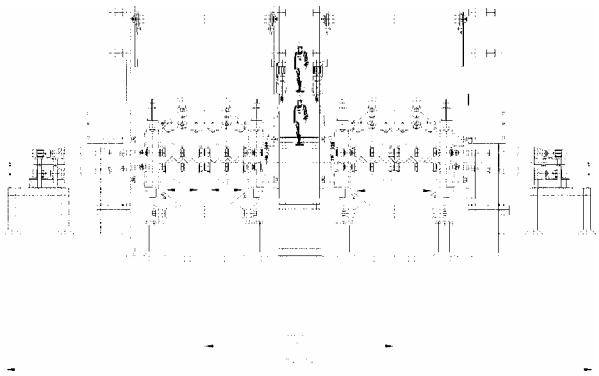

Figure 5. Cross-Section through a VAI Compact Caster with Traditional Drives Arrangement at the Outside

Flexible torch cutting machine arrangement:

After the strand leaves the caster, there is also a separate roller table for each strand as well as independent torch cutting machines. The cutting machines are able to cut two small slabs at different withdrawal speeds, as well as one wide slab (Figure 6).

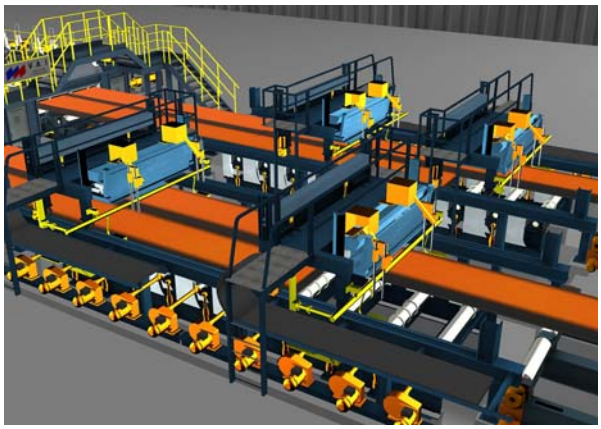

Figure 6. Solution of Torch Cutting Machine for a VAI Compact Caster

Mold and oscillator

At a common twin caster there is a wide mold with a divider, which is clamped between the wide side copper plates. This twin mold is supported on one oscillating device.
At the VAI Compact Caster, separate molds are foreseen for casting small slabs and other separate molds are foreseen for casting wide slabs. With this design solution, it is possible to cast two small slabs or one wide slab on one strand.
When casting small slabs, a separate oscillating device is assigned to each of the two molds. When casting wide slabs, the mold is supported on both oscillating devices, which operate in a synchronized manner. The oscillators are hydraulic DynaFlex units.

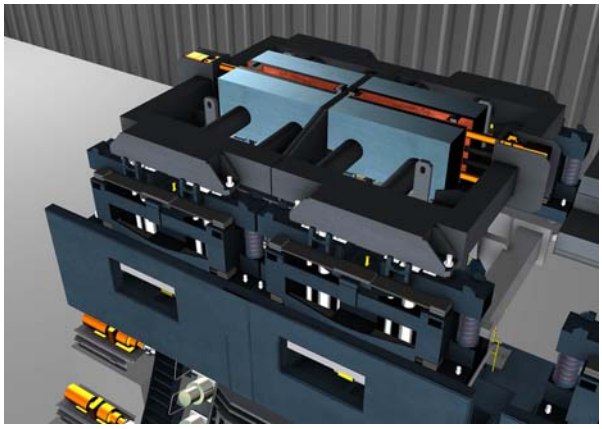

Figure 7. Independent Mold and Oscillating Device of a VAI Compact Caster

The strand guide (Figure 8) operates in the same manner. For the casting of two small slabs, the two strands are operating independently. For the casting of one wide slab, all the drives are synchronized.

Figure 8. General View of the Strand Guide of a VAI Compact Caster (one line)

Dummy bars:

To start casting small slabs, each strand is equipped with its own dummy bar with separate dummy bar heads (Figure 9). The start of casting of each strand does not have to be at the same time.

When casting a wide slab, the two dummy bars, which are used for the small slabs, are connected together with the wide slab dummy bar head (Figure 10).

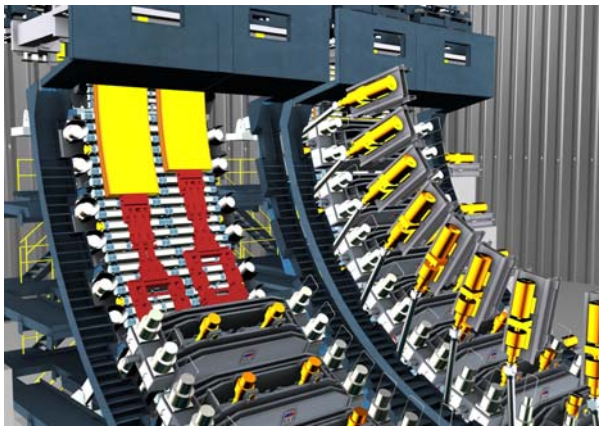

Figure 9. Dummy Bars for two Small Slabs after the Start of Casting

The distance between the centerline of one separately controlled twin caster with two slabs of 1300 mm to the next is also extraordinarily small.

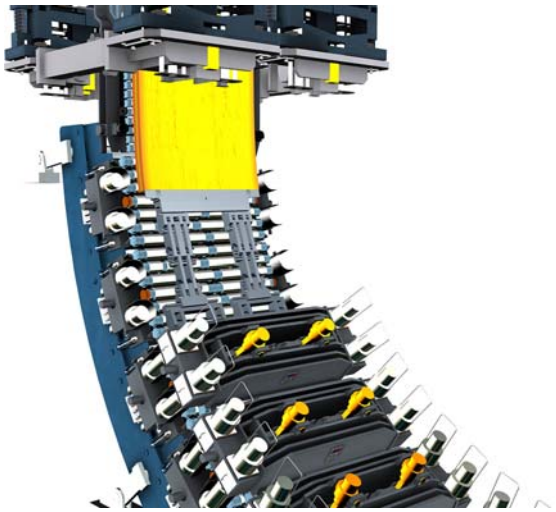

Figure 10. Dummy Bars for two Small Slabs Equipped with Wide Slab Head

This distance is only 7.5 m if there is a 1 m wide walkway between them (see Figure 3 and Figure 4 and 5). At a common twin caster, this distance would be 36 meters at a minimum.

Equipment comparison:

Table 2 lists the number of main components to be used at a 2-strand VAI Compact Caster for the production of small and wide slabs in comparison to conventional 2 x 2-strand standard casters. The comparison does not consider spare parts.

Table 2. Equipment Comparison without Spare Parts

Conventional 2 x 2-Strand Casters	**VAI Compact 1 (2) x 2-Strand Casters**
▪ 2 ladle Turrets	▪ 1 ladle turret
▪ 14 tundishes á 60 t	▪ 8 tundishes á 100 t
▪ 4 preheating stations	▪ 2 preheating stations
▪ 4 ladle shroud manipulators	▪ 2 ladle shroud manipulators
▪ 4 tundish cars equipped with 4 stopper rods	▪ 2 tundish cars equipped with 4 stopper rods
▪ 3 molds for small slabs	▪ 4 molds for small slabs
▪ 1 mold for wide slabs	▪ 2 molds for wide slabs
▪ 4 oscillator support frames	▪ 2 oscillator Support Frames
▪ 4 oscillating devices, 3 for small, 1 for wide slabs	▪ 4 oscillating devices for small slabs
▪ 3 benders for small slabs	▪ 2 benders, used for small and wide slabs
▪ 1 bender for wide slabs	---
▪ 39 segments for small slabs	▪ 26 segments, used for small and wide slabs
▪ 13 segments for wide slabs	---
▪ 4 support structures	▪ 2 support structures
▪ 3 drive sets for small slabs	▪ 4 drive sets for small slabs
▪ 3 small dummy bars, 1 wide dummy bar	▪ 4 small dummy bars, also useable for wide slabs
▪ 4 dummy bar ramps	▪ 2 dummy bar ramps
▪ 4 scrap removal systems	▪ 2 scrap removal systems
▪ 4 burr removal systems	▪ 1 burr removal system
▪ 4 fixed stops	▪ 2 fixed stops

Description of the main components of a VAI Compact Caster

- Ladle turret:
  It is a conventional butterfly-type ladle turret. Heat sizes larger than 200 are preferred.
- Steel structure:
  It's comparable with a large two-strand caster. Additionally, it serves as support for the drives of the driven roller (Figure 11).
  A channel-type cooling chamber is integrated info the steel structure, which separates the two strands so that maintenance work can be safely done on one strand during casting operation of the other strand

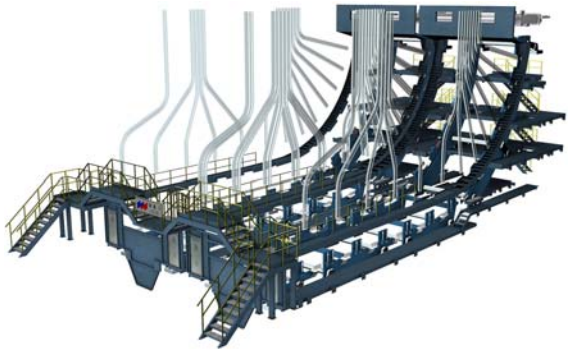

Figure 11. Steel Structure

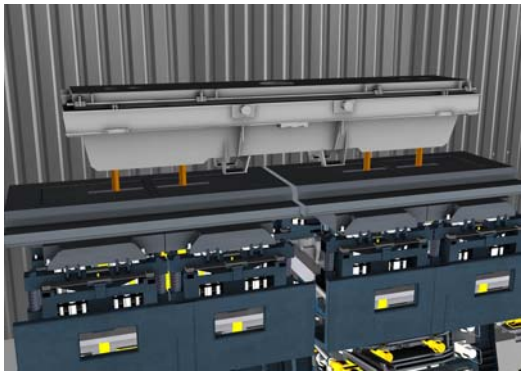

Figure 12. VAI Compact Caster Tundish

- Tundish and tundish cars:
  They are similar to those of a 2-strand caster. They are however, equipped with flow control devices for the additional strands.
  Tundish contents increase to about 100 t because of increased throughput.
- Molds:
  For each small slab (width of 1300 mm), a separate compact mold is mounted on a strand independent oscillator device. The width adjustment for the various section sizes is done by moving the outer narrow side assembly of the compact mold. It can be shifted by means of two hydraulic cylinders. The inner narrow side assembly is mounted to the wide side inserts, so that the slab distance of 400 mm can be achieved.
  On the outer narrow side, a combined clamping and expanding device is installed for expanding the wide sides during width adjustment. On the inner narrow side, a disc springs clamping device is used.
  For casting a wide slab, the two compact molds are changed to one wide slab mold. Two synchronized oscillator devices serve this single mold. The width adjustment is made by moving the narrow side assemblies by means of two hydraulic cylinders on each side.
- Oscillating device:
  The well-proven DynaFlex oscillator serves as basis of the hydraulic oscillator.
  Each strand has its own oscillating device, which acts completely independently from the others. These devices are so close together, that a distance of 400 mm from the neighboring strand can be achieved.
  In wide slab casting, two oscillating device are synchronized and serve as one oscillator for one mold.
  All the connections and fixing devices are designed for a wide slab mold as well as for two smaller molds.
- Strand guide:
  Two small slabs are guided into one segmented strand guide. Beginning from the bender to the last horizontal segment, the rollers are specially arranged, in order to avoid contact between the slab of one side and the roller of the other side.
  Each side has its separate adjustable roller which is controlled independently.
  The driven rollers on the left and right side are individual rollers without any connection. This enables casting the individual strands with different casting speeds, or if necessary only casting on one track.
  For wide slab casting, the same strand guide system used for the small slabs is used. The rollers are arranged in such a way that the wide slabs are supported and guided just as in a common strand guide. All the drives and adjustable rollers are synchronized electronically to ensure uniform withdrawal of the wide slab.
  Modern features like hydraulic thickness adjusting, DynaGap soft reduction or VAI STAR

rollers for hot conditions [2] can be added or retrofitted.

- Dummy bar:
  The dummy bar chains for the small slabs are also used for the wide slab head. For the erecting of the wide head, the chains are positioned in a centering device and a quick coupling serves for the connection to the head.
- Dummy bar ramp:
  One liftable car transports the dummy bar to the left or right position on the roller table. The wide dummy bar is deposited on the outside.
  The dummy bar depositing stand is separated from the strand with heat protection walls.
- Runout roller table:
  Each side/strand has a separate roller that is independently driven. The center bearings are water-cooled.

Operational Aspects:

The main advantage of a VAI Compact Caster compared to a twin caster is that in the case of failure at one strand, it is possible to change the casting parameters specifically for this strand, e.g. casting speed, oscillating stroke or speed. This allows casting each strand according to optimum casting conditions.
At a twin caster, the parameters for both strands have to be changed in case of problems and in some cases the casting of both strands has to be stopped.
Therefore, all these negative influences to the operational process during solidification of the slab, caused due to compromises required during common twin casting, do not occur during the casting of independent slabs in a strand guide system, as at the VAI Compact Caster.

CONCLUSION

With a VAI Compact Caster all the requirements of a modern caster are united in one solution.
Small slabs at high productivity, as well as wide slabs, can be cast with the same casting equipment.
The required space is reduced to a minimum, comparable to that of a common two-strand caster, but at about a 40% higher throughput.
Each strand can be controlled independently and operated with the optimal casting parameters, which increases operational flexibility.

OUTLOOK

VAI, as one of the largest plant builders worldwide, introduced a number of new technological packages and innovations for continuous casting machines, which are already in use and proven by many installations. Based on the principles of modular design and high functional standards, excellent operational features could be achieved [1].
VAI's task is to improve existing technologies and to find new solutions for our customers with a minimum of risks.

REFERENCES

1 K.Mörwald: "From Innovative Ideas to the Successful Implementation of New Technologies", CCC 2000, Paper No. 13, Linz Austria, June 2000.
2 G. Deibl, J. Guttenbrunner, J. Poeppl: "VAI-Rollers for Hot Conditions", CCR 04, Paper No. 7.2, Linz Austria, June 2004