

The successful establishment of DIAMOLD and DYNAFLEX Technology in Billet Casting Plants worldwide (1)

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INTRODUCTION

DIAMOLD, a revolutionary development in the field of High Speed Billet Casting Technology, has been developed and implemented by VAI POMINI - the long products company of the VAI-group - in 1995 to the market.

Two years later the DYNAFLEX Hydraulic Oscillation Technology, which enables highest precision in Mold Oscillation, was put in industrial operation in a Billet Casting Machine, the first time.

Since the initial steps in both technologies, VAI Pomini has equipped and/or upgraded meanwhile 50 Billet Casters respectively more than 200 Strands with DIAMOLD technology and close to 40 Billet / Bloom Casters respectively more than 160 Strands with DYNAFLEX technology. About 60 Strands were installed in Slab Casters.

Especially in the recent years the number of references grew up progressively and several companies or groups of companies not only equipped just one machine, but have equipped subsequently two or more casters with VAI Pomini's technological packages, after they realized the overall benefits of these technologies.

Both technologies are nowadays installed in open stream operated casters for Plain Carbon Steel grades as well as in High Quality Steel, Special Steel and Stainless Steel Casters which of course are operated in fully shrouded casting mode.

The current paper will show the benefits of both technologies in single and combined application on behalf of some successful references and will illustrate the development of references with particular view on satisfied clients in selected markets.

Key words: continuous casting, high speed, hydraulic oscillation

(1) Paper presentation at ABM Steelmaking Seminar, Salvador, BA / Brazil, 2004.

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THE DIAMOLD HIGH SPEED CASTING TECHNOLOGY

Technological Features and Advantages

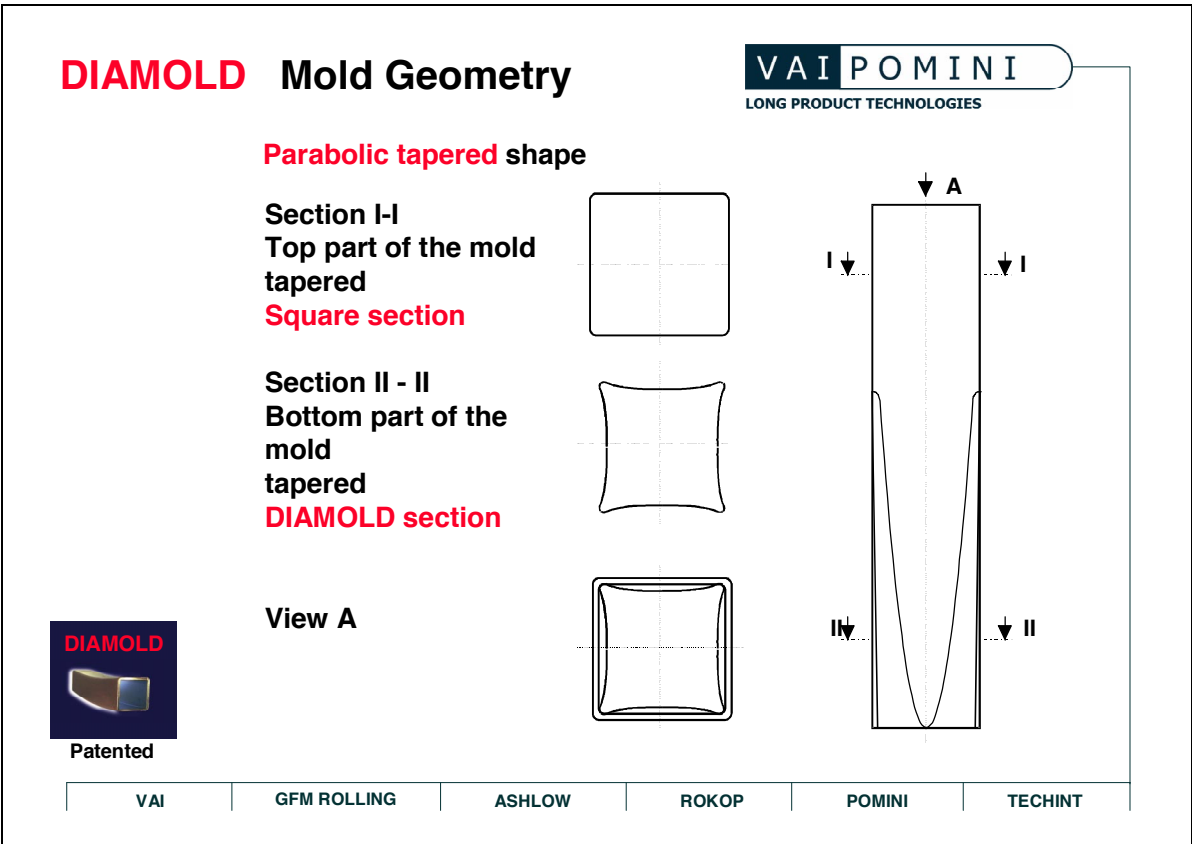
In order to provide a better understanding of the benefits achievable with DIAMOLD technology, a brief presentation of the mold's unique design features is outlined in this section. During casting steel shrinkage is greater in the upper zone of the mold than in the lower zone. In order to ensure optimum contact behavior between the strand shell and the mold along the entire length of the mold, a design characterized by a parabolic concavity of the mold taper represents a major improvement over conventional mold geometry.

Excessive taper, however, leads to pressure peaks in the strand-edge areas—especially in the lower zone of the mold—resulting in unacceptably high frictional forces during strand withdrawal. Because of the two-dimensional nature of heat removal at the strand edges, the edge thickness of the shell in the lower part of the mold is already sufficiently thick at about 300–400 mm from the top of the mold. Therefore, at this position it is no longer necessary for the strand edges to be in direct contact with the mold.



The solution was to design a mold with a highly pronounced taper and with open corner areas in the lower mold zone. This unique mold design thus defines the basis of DIAMOLD technology. The key features are illustrated in below figure and can be summarized as follows:

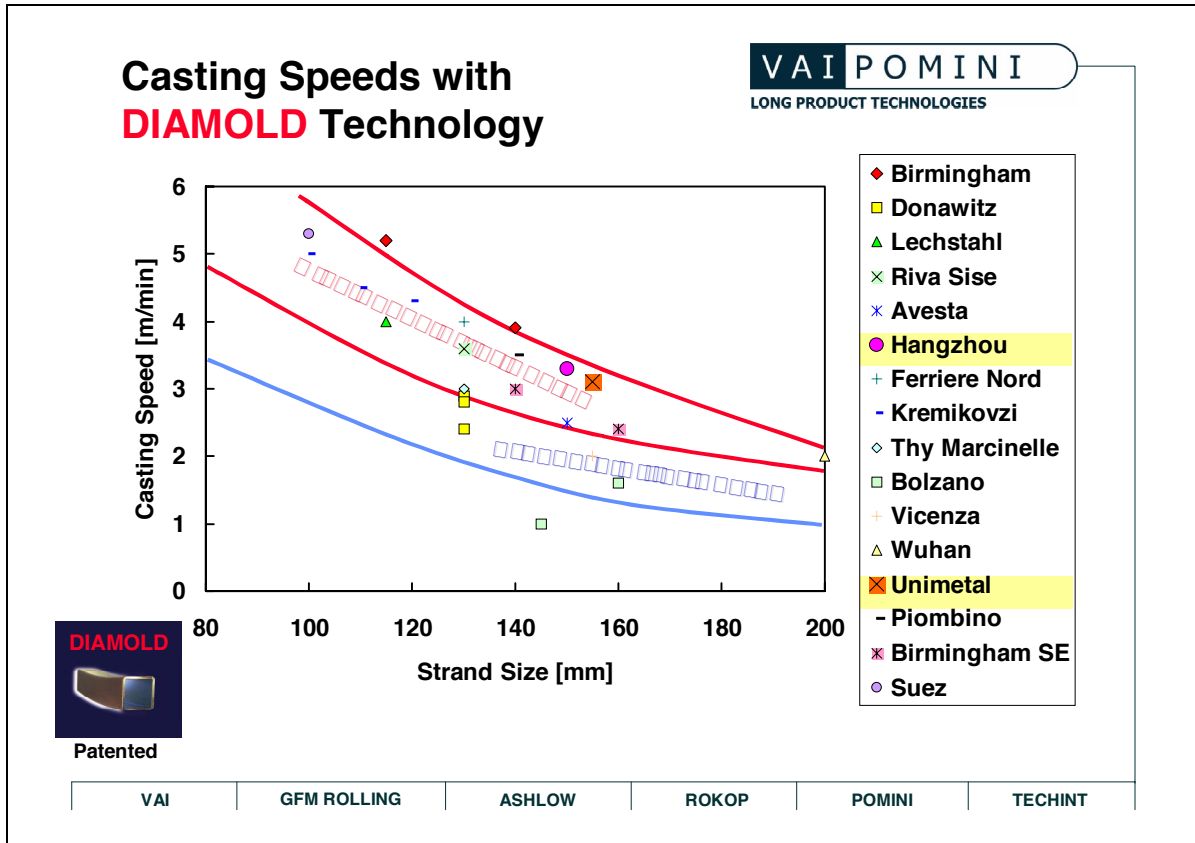
- ◆ Appropriate selection of the mold-tube length to assure sufficient residence time of steel in the mold for the foreseen steel grades and casting speeds
- ◆ Mold design with pronounced parabolic taper at the strand mid-face along the entire mold- tube length to assure rapid and homogeneous strand-shell growth
- ◆ Open corner areas in the lower part of the mold in order to prevent excessive frictional forces during strand withdrawal.
- ◆ Therefore, longer mold lifetimes



Before mentioned design criteria result in Casting Speed which are up to 50% higher than with standard conicities, it allows for a very wide operating window, covering a wide range of different steel grades with different shrinking behavior and casting speed.

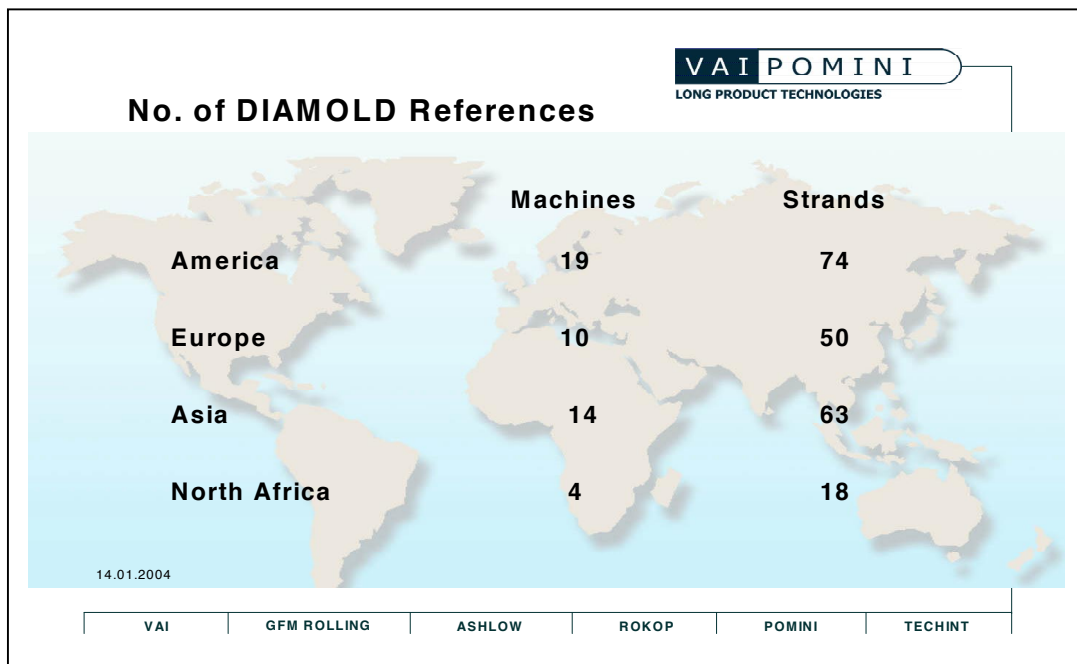
The particular shape also allows for very long lifetime of the copper tube.

In all the reference plants a significant speed increase could be achieved maintaining and improving the quality - and operational-parameters.



Market Acceptance

The overall positive development in modern casting machines and processes can also be observed by the successful introduction of DIAMOLD to the market. A high amount of installations of DIAMOLDS (and DYNAFLEX) in several plants of well reputed steel producers proves the advantages and thus many major steel producers have already installed DIAMOLD tubes either in new machines or in upgraded / revamped casters (Riva, Nucor, Arcelor, Gerdau, etc).

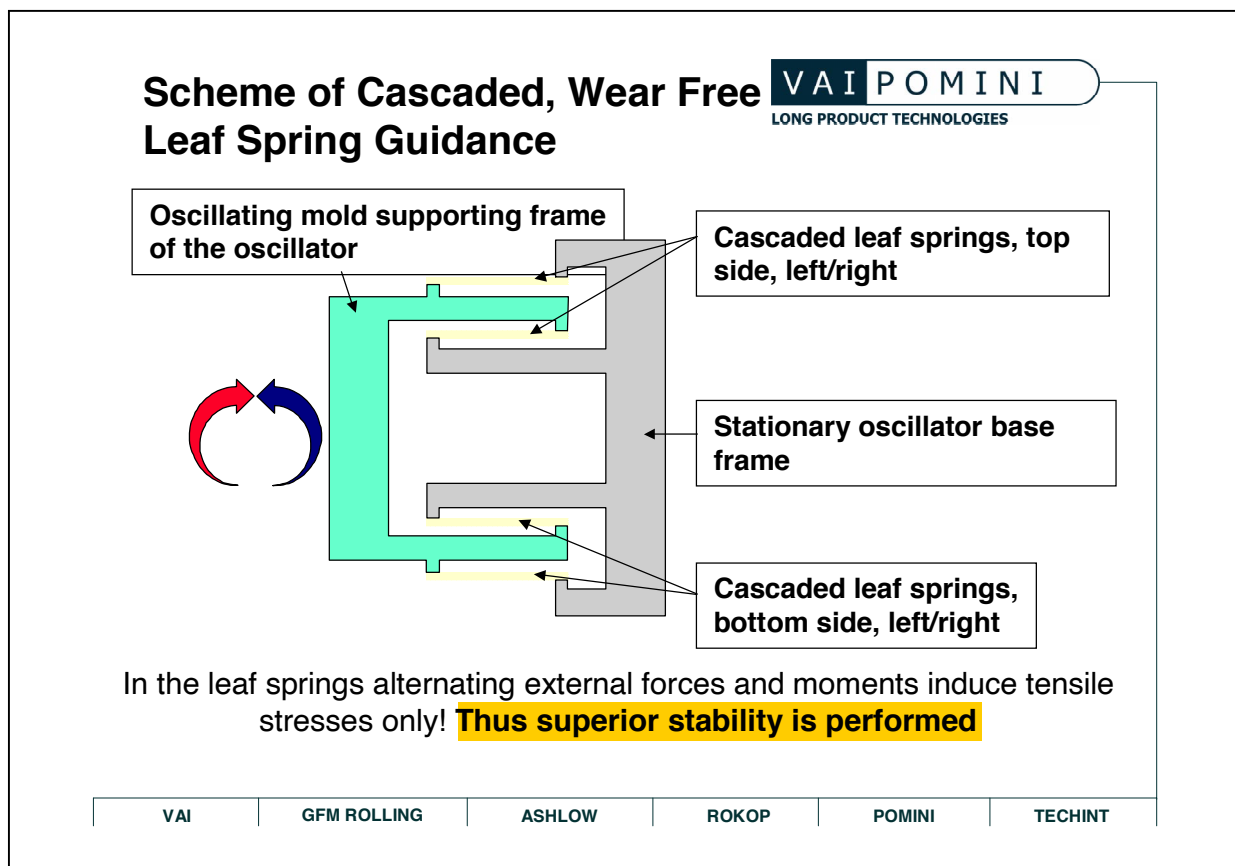


THE DYNAFLEX SYSTEM FOR BILLET CASTERS

Technological Features and Advantages

In view of the disadvantages of using conventional oscillation equipment in billet casting, such as wear on the guidance system, mechanical backlash, and the need for complicated procedures of stroke adjustment, VAI decided to develop a new type of hydraulic oscillator. The basic design derives from the DYNAFLEX oscillators used in slab casting because of favourable operational experiences in using the wear-free system of leaf-spring guidance and the hydraulic drive.

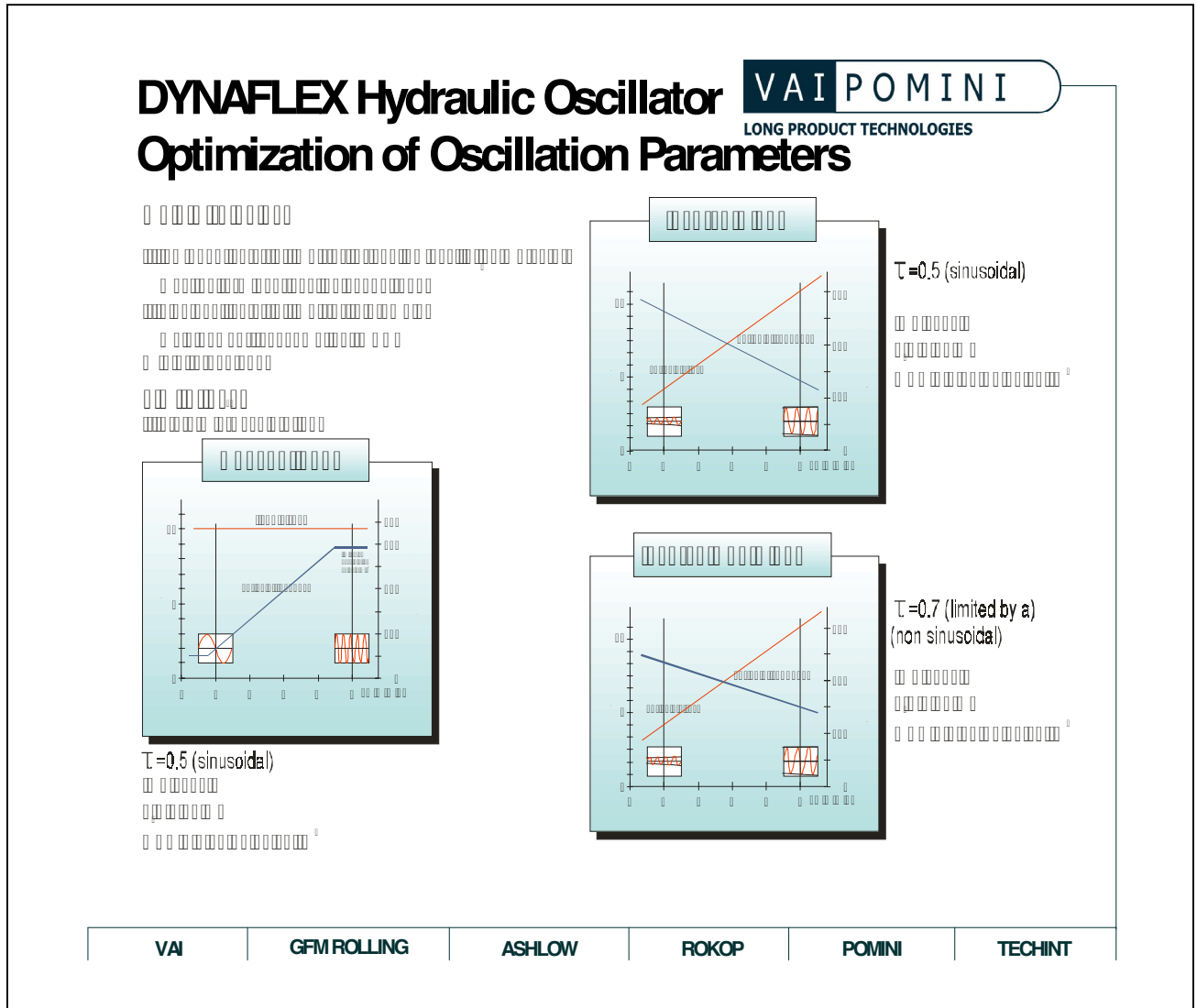
Typical space restrictions in billet casters, compared with slab casters, for the integration of the guidance system was overcome by using a patented, cascaded leaf-spring guidance system (International Patent Application WO99/122676). The system is illustrated in Figure below.



For economical reasons (low operational and maintenance costs) the drive system was designed with only one cylinder and without any servo-hydraulic components. Proportional – hydraulic components are applied as a standard.

After intensive testing and optimization procedure in the workshop with a full scale model, VAI Pomini installed the first Dynaflex Oscillator for Billet Casters in Lechstuhlwerke / Germany in 1997.

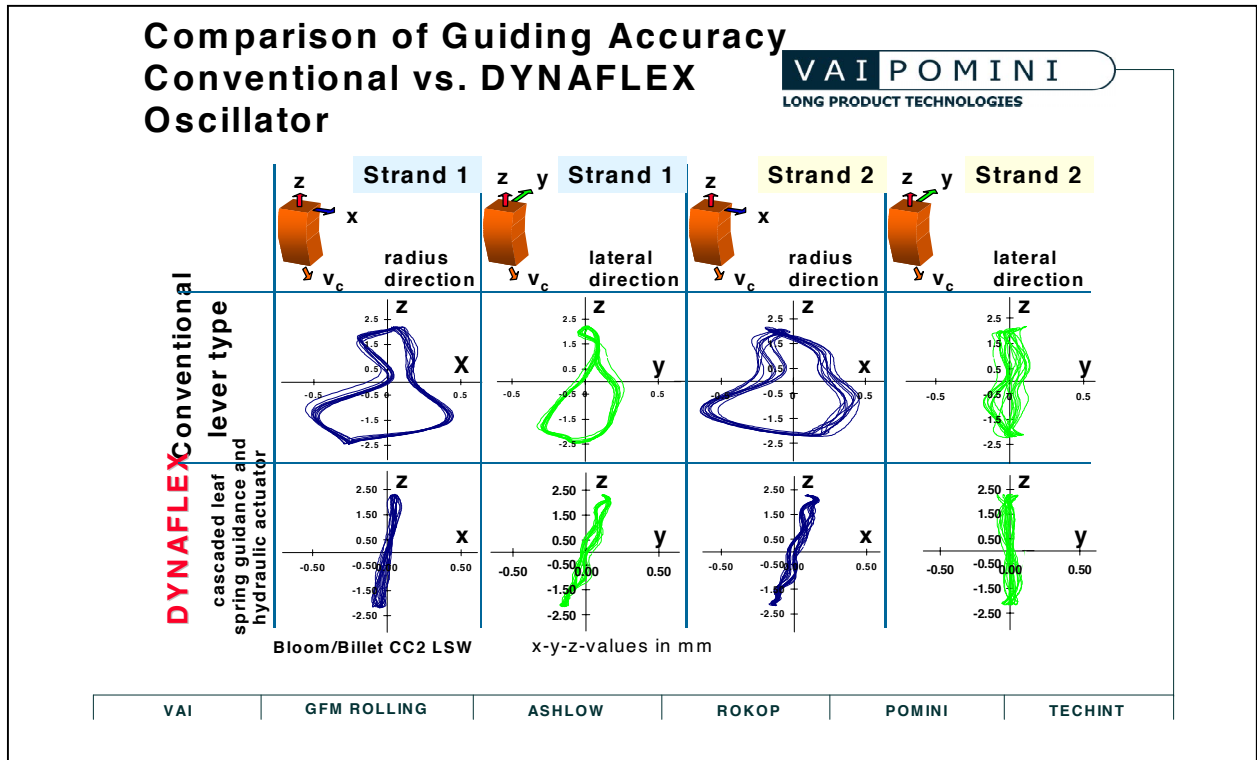
In Lechstuhlwerke the high movement precision of the system could be proven, comparing the old electromechanical oscillators with the new Dynaflex Oscillators.



The advantages of the modern actuator mechanism permit the achievement of ideal oscillation characteristics (figure above), as the waveform (sinusoidal, non-sinusoidal, saw-curve, etc.), stroke (amplitude) and frequency (strokes per minute) can be varied in order to optimize the positive and negative strip time as desired:

- low negative strip time for shallow oscillation marks
- high positive strip time to promote mold powder consumption
- inverse oscillation algorithm to adapt frequency and stroke to the casting speed in order to maintain the negative strip time constant

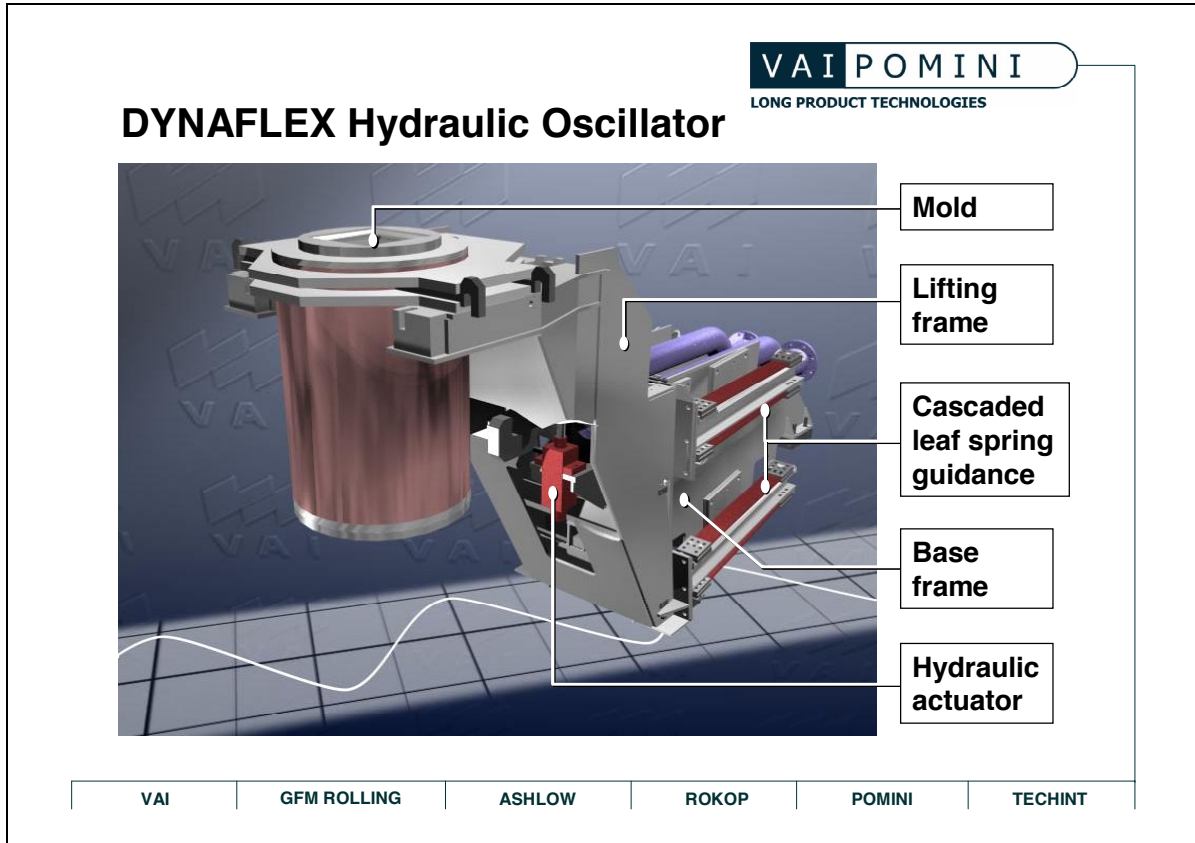
Guidance accuracy was of a high standard as shown in the next figure. At a stroke of 5 mm and frequency of 300 strokes/min the horizontal deviations were only 0.06 mm. This superior standard of accuracy was maintained for a period of more than two years without need for maintenance apart from the exchange of a hydraulic cylinder because of overcasting (i.e. overfilling of mould with steel resulting in steel flooding over the oscillator).



Since that first installation VAI POMINI has successfully equipped more than more than 160 Billet and Bloom strands worldwide with DYNAFLEX Oscillators. All of these oscillators follow the same functional principles as described before, but the design has been individually adopted, especially under the view of modernization projects for casters of different brands, in order to allow minimum modification of steel structure, etc. as well as under the view of reutilizing existing mold housings.

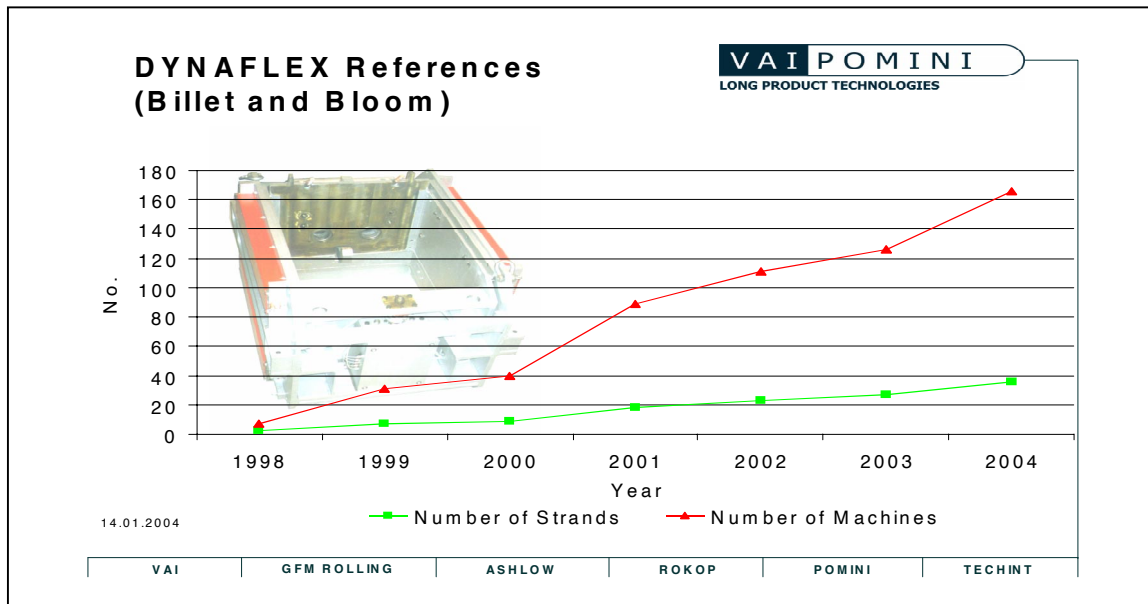
Summarizing the advantages of the DYNAFLEX oscillator represents a unique machine component which was, and still is, revolutionary on one hand for the production of billets with highest surface quality and on the other hand in the ease of maintenance and operation:

- No mechanical backlash of the drive and guidance mechanisms of the oscillator table
- Simplicity of adjustment of stroke, frequency and wave form
- Smooth running over the whole frequency range
- Adjustment of stroke height, frequency and wave form during casting
- No servo-hydraulic components
- Nearly maintenance free



Market Acceptance

The DYNAFLEX Technology has been a breakthrough in oscillation technique. Thus, major customers over the entire world are already using this unique method of mold oscillation. Within the last years a significant numbers in sales approved the industrial conditions for such equipment resulting in perfect operational results, quality increase and reduction of maintenance costs. Benchmark clients of VAI POMINI invested already in this proven technology.



CONCLUSION

Producers must take the latest technology, as DIAMOLD and DYNAFLEX, into consideration in order to be competitive. On the one hand, they must be able to deliver the product quality requested by the customer with tightest tolerances, and on the other hand the production should be fast and as flexible and as cost efficient as possible. Production, high productivity and low maintenance are to be seen as benchmark indicators for new plants and as potentially savings in modernization and upgrades of Continuous Casting Machines, where the following aims have to be achieved:

Minimum investment

- Cost savings as minimum number of strands achieve maximum production
- Main equipment is the DIAMOLD tube which can be inserted in every mold

Maximum production

- Parabolic mold tube shape for optimum heat transfer means high casting speeds
- DIAMOLD shape for increased machine availability due less breakouts
- Lowest / Reduced production costs

Reduced manpower due to minimum number of strands

- DIAMOLD shape for higher casting safety
- DIAMOLD shape means reduced mold tube wear

□

Highest guidance accuracy and minimum maintenance

- DYNAFLEX guarantees highest guiding accuracy and wear free operation
- Minimum space demand due to cascaded leaf springs and backlash free operation

Best operational- and quality-results

- DYNAFLEX permits on-line adjustment of frequency, stroke and wave form (sinus, non-sinusoidal) to achieve optimised casting parameters

Flexible design

- Box-type or cantilever-type design of DYNAFLEX oscillators can easily be installed in new or existing casting machines.
- The modular automation system provides interfaces to all common electrical and automation components and systems.