

COMPACT STECKEL / PLATE MILLS UTILIZING DANIELI FTSC TECHNOLOGY ¹

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Abstract

A new generation of 100-150 mm (4"-6") Thin / Medium Slab Caster combined with a 3300 mm (130") Steckel Plate Mill has come into operation between the end of year 2000 and the beginning of year 2005. Danieli Wean United applies its reliable flexible Thin Slab Casting (fTSC) technology and its hot rolling and plate finishing technology to satisfy the final product and grade requirements of two of the most important steel producers in USA and CHINA: Ipsco Steel (USA); Nucor Steel (USA); Shaoguan Iron & Steel (P.R. of China); Anyang Iron & Steel (P.R. of China). The facilities are designed to produce both coiled and discrete plates having high mechanical characteristics and tight geometrical tolerances at a very competitive production cost on the new millennium plate market.

Key words: Slab caster; Steckel plate mill; "fTSC"; Production cost.

LAMINADORES COMPACTOS STECKEL / CHAPAS GROSSAS UTILIZANDO TECNOLOGIA DANIELI FTSC

Resumo

Uma nova geração de Lingotamento de Placas Finas/Médias (100-150 mm) combinado com um Laminador Steckel entrou em operação entre o fim do ano 2000 e o começo do ano de 2005. A Danieli Wean United aplica as suas tecnologias confiáveis para Lingotamento de Placas Finas (fTSC), laminação a quente e acabamento de chapas para atender o produto final e graus requeridos de dois dos mais importantes produtores de aço no EUA e China: Ipsco Steel (USA); Nucor Steel (USA); Shaoguan Iron & Steel (P.R. of China); Anyang Iron & Steel (P.R. of China). As instalações são projetadas para produzir tanto chapas grossas quanto tiras bobinadas, tendo altas características mecânicas e tolerâncias geométricas estreitas num custo de produção muito competitivo no novo milênio de mercado de chapas grossas.

Palavras-chave: Lingotamento de placa; Laminador Steckel de chapas grossas; "fTSC"; Custo de produção

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PRODUCTS AND MARKETS

The new plate mill plants have a production capacity of about 1,000,000 tons per year.

A large variety of steel grades can be produced: carbon, structural, vessel, pipe and HSLA up to X80 grades in both coiled and discrete plates.

The product size covers a wide thickness range (2.3 to 51 mm) with a 40% of the product mix between 2.3 mm and 12.7 mm (Table 1).

Table 1 – Product size				
Steel grades	API: X42, X52, X60, X65, X70, X80, H40, J55, I70, IK55 ASTM: A513, A252, A36, A282, A569, A572, A607, A588 AISI: Gr1070, Gr4130 HSLA: Gr70, Gr80			
	Thickness mm (in.)	Width mm (in.)	Length m (ft.)	Spec. weight kg/mm (PIW)
Slab output	101-152 (4.0"-6.0")	1,524-3,200 (60"-126")	6.1-19.3 (20'-63.5')	22.9 (1,283)
Coiled plate	2.3-19.0 (0.09"-0.75")	1,524-2,515 (60"-99")	-	22.3 (1,250)
Discrete plate	4.8-51 (0.188"-2.0")	1,524-3,124 (60"-123")	2.4-24 (8'-80')	

Such a wide product mix can be economically turned out only by minimizing the equipment and operational costs. Owning the knowledge of the proper thin slab casting technology and matching the production capacity of the mill equipment with the caster, Danieli has reached these goals.

Furthermore, the use of a compact layout assures higher process temperature and thus it permits rolling down to 2.0 mm in thickness with wide products. Since the overall production time from EAF to final product is approximately 3 hrs, it is possible to carry out small but urgent orders with a delivery time less than one day.

The man-hours per ton are less than 0.5 and, on two-shift basis, the total manpower required is less than 100 employees.

The reliability of the equipment is underlined by the guaranteed 7,200 operating hours per year.

PROCESS AND NEW TECHNOLOGY

Danieli equipment includes a single-strand caster, slab quenching box, walking beam reheating furnace, highly automated Steckel Mill, laminar flow cooling and downcoiler, together with in-line plate finishing facilities such as cooling bed,

stationary and flying shears, and hot-cold levelers, to obtain a final product within 1/4 ASTM tolerances.

The use of the Danieli Thin Slab Caster technology allows to produce both coiled and discrete plate in one Compact Mill Plant, introducing some unquestionable advantages compared with the conventional plate process, such as:

- Outcoming slabs with a fine grain structure can be obtained, as those that could be produced only after several roughing passes in a conventional plate mill.
- It permits to enter the reheating furnace at higher temperatures, thus ensuring a “continuous process”, decreasing by two-three times the reheating length, reheating time and fuel consumption.
- It reduces the roughing passes twice, and eliminates the need of a Roughing Stand that in a conventional plate mill has a much higher output capacity in comparison with the overall plant capacity and requires a high installed motor power. This decreases by 30% or more the specific rolling power consumption of the plant.
- It increases the finishing entry temperature, as it is possible to thread the first coiling furnace at a 50-75°C higher temperature than in the conventional plate mill and therefore a lower rolling power and a thinner final gauge are made possible. Moreover it improves both the mechanical and geometrical properties of the final product.

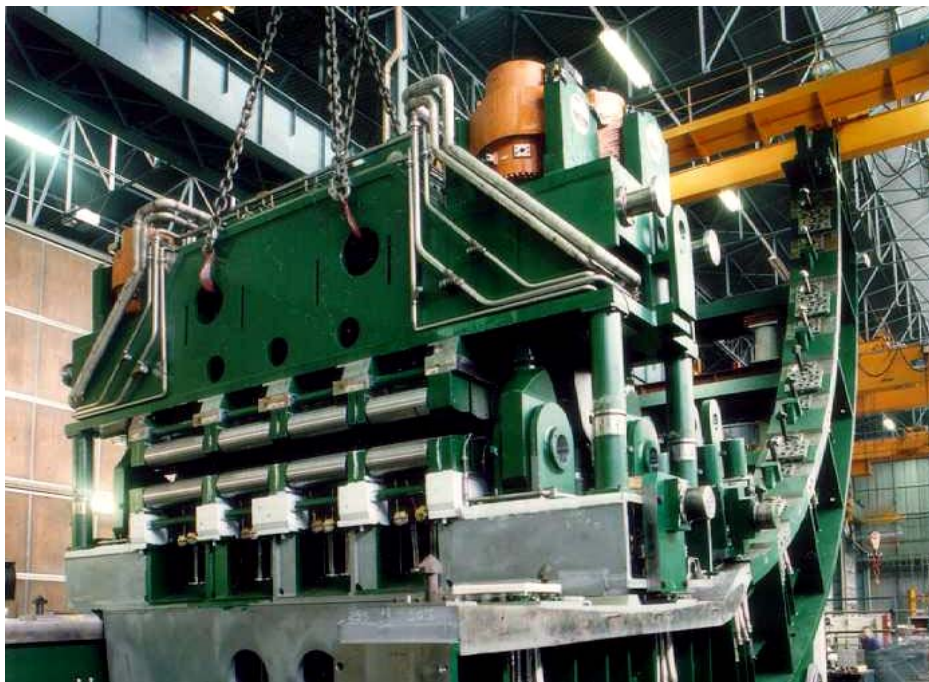


Figure 1 - Casting segments and withdrawal block

Danieli Dynamic Soft Reduction permits a grain refinement of 1 ASTM grade in every casting condition, allowing in the meantime a better fluid dynamics, thanks to the larger volume of the mould. The Danieli patented mould and special submerged entry nozzle design optimize fluid flow pattern in the mould, thus having positive effects on surface quality, which is extremely important for hot charge practice.

The length of the Plate Mill area is reduced by the use of coiling furnaces upstream and downstream the horizontal stand, for plate thicknesses below 25.4 mm: the specific coil weight is not further limited by the roller table length and the temperature losses. The yield losses are reduced because of a lower scale formation and a better

head & tail end shape. The final product properties and geometry are the best achievable.

THIN / MEDIUM SLAB CASTER

The caster area includes the following items of equipment:

- Danieli flexible Thin / Medium Slab Caster equipped with the H² mould (long funnel type) and with the Dynamic Soft Reduction system – both Danieli patents.
- Cut to length machine, which is capable of cutting a 102 x 3,124 mm (4" x 123") slab cast at 4.2 mpm with two torches having a cutting speed of 870 mmpm thanks to the use of high pressure oxygen nozzle. The 200 mm long samples are cut using four (4) torches instead of two.
- Slab quenching system – Danieli patent – automatically controlled, in order to eliminate the detrimental effects of N and C precipitates on the product surface quality.

The thin/medium slab caster has been conceived and designed to satisfy the major requirements of a modern steelmaking plant:

- Wide range of castable steel grades
- High quality slabs with a wide range of operating conditions
- High productivity
- User-friendly and reliable operation
- Advanced and reliable automation packages
- Minimization of storage and slab conditioning.

Thanks to the special features of the caster, the reliability of the mechanical solutions and the flexibility of the technology, the thin/medium slab caster will be able to cast slabs 152 mm to 101 mm (6" to 4") thick and 1,800 mm to 3,200 mm wide (71" to 126"). Casting speed will range from 0.8 m/min to 4.0 m/min. Supported length is 15,327 mm.

The thin/medium slab caster is vertical curved with multi-bending and multi-unbending design. Such solution minimizes stresses in the solidified shell while allowing at the same time significant savings in terms of civil constructions and caster layout.

The caster consists of a H² mould and nine (9) segments equipped with hydraulic cylinders for continuous adjustment of the roll gap between segments. Pinch rolls are distributed along the containment length for a smooth distribution of the withdrawal forces.

The state-of-the-art thin/medium slab caster is equipped with:

- H² long funnel mould
- Special submerged entry nozzle
- On-line soft reduction dynamically adjusted by means of the Liquid Pool Control System
- Advanced Breakout and Sticker prevention Systems
- Mathematically controlled air mist secondary cooling system
- Independent machine cooling and scale flushing
- Short lever hydraulic oscillator
- Sophisticated process control
- Quality Control System
- On-line mould width adjustment
- Automatic mould level control.

Furthermore, the plant features a state-of-the-art slab quenching system to allow direct rolling through hot slab charging. The slab quenching system will be automatically controlled to guarantee optimum results regardless of the casting conditions.

The H^2 mould minimizes the stresses within the shell, while enhancing mould fluid dynamic performances. There is no need for expensive electromagnetic devices to avoid turbulence and meniscus waving. The long funnel mould also promotes a better fluid dynamic pattern while casting thicker slabs permitting, at the same time, better conditions for mould powders performances.

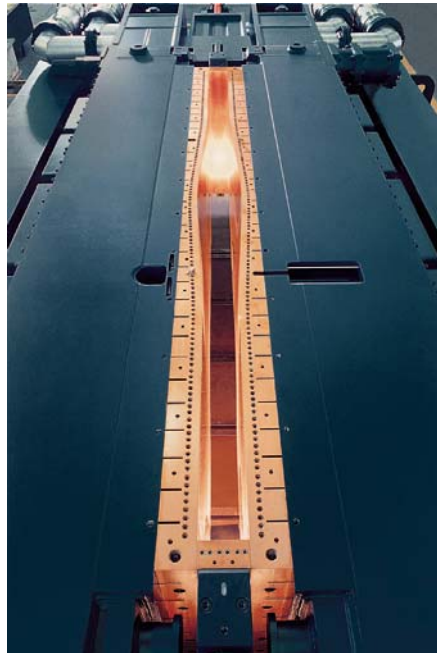


Figure 2 - H^2 long funnel mould

Dramatic benefits are achieved from the long funnel mould, especially for the thinnest slabs. The mould is equipped with a double mould level control: one system is radioactive type, the second one is electromagnetic type.

Danieli developed the quenching system to improve the product surface quality for hot charging and to improve the mechanical properties of the final product when utilizing the thin/medium slab casting technology for plates.

Typically, in hot charge practice the precipitation of nitrides or carbides creates embrittlement of the surface, which may cause cracks during rolling. The quenching system consists of a special spray box positioned after the slab deburrer. Through the quenching box the slab surface is cooled down to 300°C , promoting a phase transformation from austenite to ferrite within a given thickness. The transformation and consequent nucleation of a new phase spreads the precipitates within the new phase, while originally they were concentrated at the grain boundary, where they embrittle the structure.

The slab quenching is precisely controlled on the bottom and top surface of the slab by a mathematical model. Sprayed width and length are also precisely controlled to allow an even heat removal and therefore to avoid deviations in the geometry of the slabs.

STECKEL / PLATE MILL

The mill plant layout consists of:

- Scale breaker, where the 200 bar jet pressure permits to achieve an impact pressure up to 1 N/mm² with only a 10°C temperature drop.
- Vertical Edger, where the 1,600 mm long stroke hydraulic cylinders operate two flat or grooved rolls: in this case the width control capability is of 2" on the final product.
- Steckel Mill stand, where the 4-Hi reversing stand has a nominal separating force of 60,000 kN and it is powered by two 8,000 kW drives at a maximum rolling speed of 10 m/s. It is equipped with bottom HAGC cylinders and top screwdowns and load cells, 2,600 kN positive heavy bending and ±150 mm work roll shifting for thickness, profile and flatness control. The head-body-tail temperature is controlled by a proper cooling header and stand descaling headers. The scale formation is prevented by the use of stand descalers acting on strip and roll star system acting on rolls. The oxide dust is suppressed by special headers. Guaranteed tolerances are within 1/4 ASTM A6 standard on thickness, width, length, camber and flatness.
- Coiling furnace. The furnace can coil a 25.4 x 3,124 mm plate with a max weight of 70 ton at 5.5 m/s. It can maintain the rolling stock at a maximum temperature of 1,100°C.
- Hot drum shear: after 3-7 roughing passes with a max draft of 30 mm the rolling stock is reduced to a thickness of 25-50 mm and the head and tail are cropped at 1 m/s by this shear before being coiled into the furnaces. The cutting capacity is 51 mm x 3,124 mm (2" x 123").



Figure 3 - 4-Hi Steckel reversing stand

- Cooling devices: after 9-13 rolling passes a Laminar Cooling for discrete and coiled plate drops the temperature by 300-350°C with the desired cooling pattern, thus allowing to obtain the required final tensile properties. Automatically controlled side sweeps eliminate the water transport along the plate and thus undesirable cooling differences across the plate width.

- Hot Plate Leveler: the final mother plate can be leveled by a 25,000 kN leveler with a leveling speed up to 3 m/s. Automatic gap and roll pass adjustment are provided. Danieli supplies also the automation for the roll force and temperature control. The unit consists of 9 leveling work rolls and on-line hydraulic leveler adjustment.
- Upcoiler for a max coil weight of 40 ton and 22.3 kg/mm specific coil weight, which guarantees an optimum coil telescopicity control, thanks to an entry pinch roll with a tilting platform to bend the strip and to wrapper rolls with automatic jumping control.
- Cooling bed, which is designed to cool the mother plate down to 100-150°C and is divided into four zones: the disc type transfer bed has a minimizing function of the empty zones.

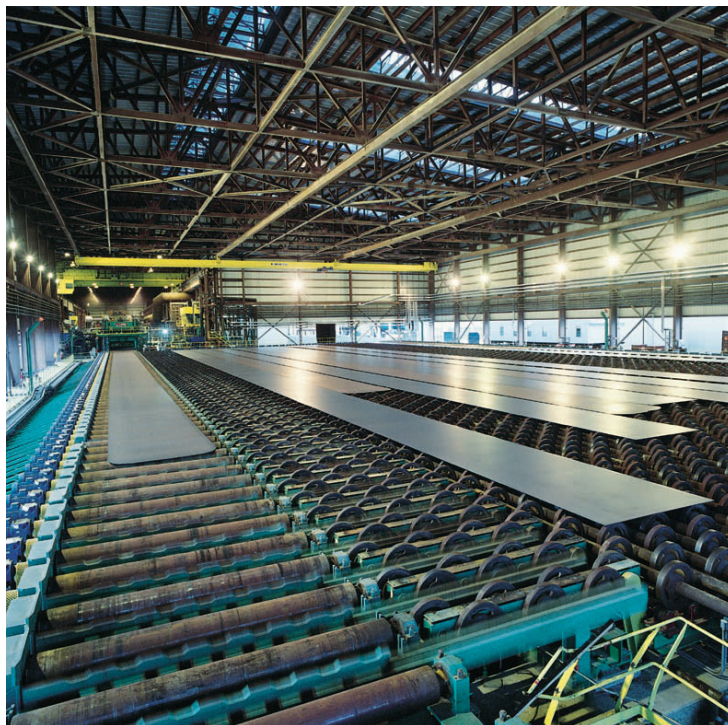


Figure 4 - Cooling Bed

- Cold plate leveler: the cold mother plate passes through a 4-Hi reversing leveler with multiple backup rolls controlled by a Danieli Automation Package at a leveling speed up to 1.5 m/s. The flatness is within 1/4 ASTM tolerance (see ASTM-A6-A20). Four hydraulic cylinders permit to control the edge waves independently.
- Stationary shear: the cold mother plate reaches the desired final discrete plate size using a guillotine shear, capable to perform 4 cuts per minute with a cutting section of 16-51 mm x 3,124 mm.
- Flying shear, which cuts thin plate, 4.8-16 mm thick, operating a maximum of 18 cuts per minute. Both shears are used either for head and tail cuts or for sampling.
- Cold finishing area: the plate finishing area is completed by marking and stamping devices with a plate speed of 40 mpm, an inspection line and two plate pilers, one for each stacking and handling line. The light one piles plates 4.8-16 mm thick and 2.4-12.2 m long with 4.5 ton weight is used together with a post piler having 18 ton capacity. The heavy piler, magnetic type, is composed by two units with a maximum

total capacity of 18 ton/each to stack one-four plates 16-51 mm thick and 2.4-24.4 m long.

CONCLUSION

The new plate mill generation produces both coiled and discrete plate, ranging from 1,524 to 3,124 mm (60" to 123") in width and from 2.3 to 51 mm (0.090" to 2") in thickness, processing pipe, structural, vessel and HSLA steel grades within 1/4 ASTM A6 tolerances.

Danieli Thin Slab Casting technology using a patented H² mould and the Dynamic Soft Reduction System allows the drastic decrease from 10" conventional slab thickness down to 4"-6" depending on the final plate size, maintaining the same grain refinement of a conventional plant.

The plant does not require a roughing stand and a finishing stand but only a single stand thus allowing a lower investment and operational cost, higher rolling temperature and better and uniform final plate characteristics.

This will help Danieli Customers to be competitive in the more and more demanding plate market.