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INNOVATIONS IN THE FIELD OF COPPER PROCESSING[1]

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Abstract

SMS Meer GmbH with its division Schumag & Copper produces a full line of systems and machines for the processing of copper. The product range includes: shaft melting furnaces, anode casting lines, horizontal and vertical casting lines, casting and rolling lines for copper wire rod, cold pilger mills, planetary rolling mills as well as tube drawing equipment. Innovations for some of these processes will be highlighted. The new designed shaft furnace is the most economic way of copper melting. The Contilanod® system with hydraulic shear represents a breakthrough into higher production capacities and improved geometrical accuracy of anodes. A comparison with the conventional cast wheel process will be done. The new generation of Contirod® lines with individual drives of rolling stands guarantees cost effective production of highest rod quality. These innovative technologies increase product quality, reduce process costs and help for a wide use of copper in all sectors of life.
Key words: Processing costs; Energy/ gas consumption; Copper processing.

INOVAÇÕES NO SETOR DE PROCESSAMENTO DE COBRE

Resumo

A SMS Meer GmbH produz, em sua divisão Schumag & Copper, uma linha completa de sistemas e máquinas para o processamento de cobre. Este leque de equipamentos inclui: fornos de cuba, linhas de lingotamento de anodos, linhas de lingotamento horizontais e verticais, linhas de lingotamento e laminação de fio-máquina de cobre, trens de laminação a frio de passo peregrino, laminadores planetários e equipamentos de trefilação de tubos. Destacam-se as inovações para alguns destes processos. O novo forno de cuba desenvolvido é o modo mais econômico para a fusão do cobre. O sistema Contilanod® com tesoura hidráulica representa um grande avanço para aumentar a capacidade de produção e melhorar a precisão geométrica de anodos. Será apresentada uma comparação com o processo convencional de fundição de rodas. A nova geração de linhas Contirod® com acionamentos individuais nas cadeiras de laminação garante a produção eficiente e econômica de barras de alta qualidade. Estas tecnologias inovadoras incrementam a qualidade do produto, reduzem os custos do processo e ajudam na expansão do uso de cobre em todas as áreas da vida.
Palavras-chave: Custos de processamento; Consumo energia/gás; Processamento de cobre.

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1 INTRODUCTION

The Contirod® process is today state-of-the-art in the field of copper rod production. During the almost 40 years of Contirod® history, a great many innovations have been made along the whole process line, such as new charging devices, more efficient shaft furnace combustion control systems, variable-frequency drives for the combustion air blowers and individually driven, variable-frequency drives for the rolling stands.
Design work today focuses not only on reliable and state-of-the-art technologies, but also on reducing process costs by using efficient techniques, such as the newly designed shaft furnace as the most economic method of copper melting. Along with improved product quality, higher plant availability and reduced processing costs, improvements in energy efficiency are among the targets to be achieved. In this context, the Contirod® process offers energy-effective production of wire rod of a supreme quality.
This paper discusses some important new developments and the resulting influence on energy efficiency.
The Contilanod® system with hydraulic shear represents a breakthrough into higher capacities and improved geometrical accuracy in anode production, thereby improving the process parameters. The paper conducts a technical comparison with the conventional casting wheel process.

2 SHAFT FURNACE

The use of shaft melting furnace is the most economic way of copper melting. SMS Meer is supplying melting furnaces as part of our continuous and semi-continuous vertical casting plants as well as continuous casting and rolling plants of copper rod (Contirod®) since many years.

2.1 Shaft Furnace Plant

An essential part of copper wire continuous casting and rolling lines is the melting plant, comprising the melting furnace and the casting furnace.
Most operators prefer using the well known and reliable shaft furnace as melting furnace, as this features a whole range of advantages of technical nature and regarding fuel consumption – and therefore commercial advantages.

2.2 Charging Equipment – Skip Hoist

A flexible charge system for cathodes and copper scrap consisting of a free standing pylon construction, a charging car, a winch assembly on floor level and control equipment ensure improved cathode dispersion for better heat transfer and easy scrap handling for in-house scrap boxes (Figure 1).

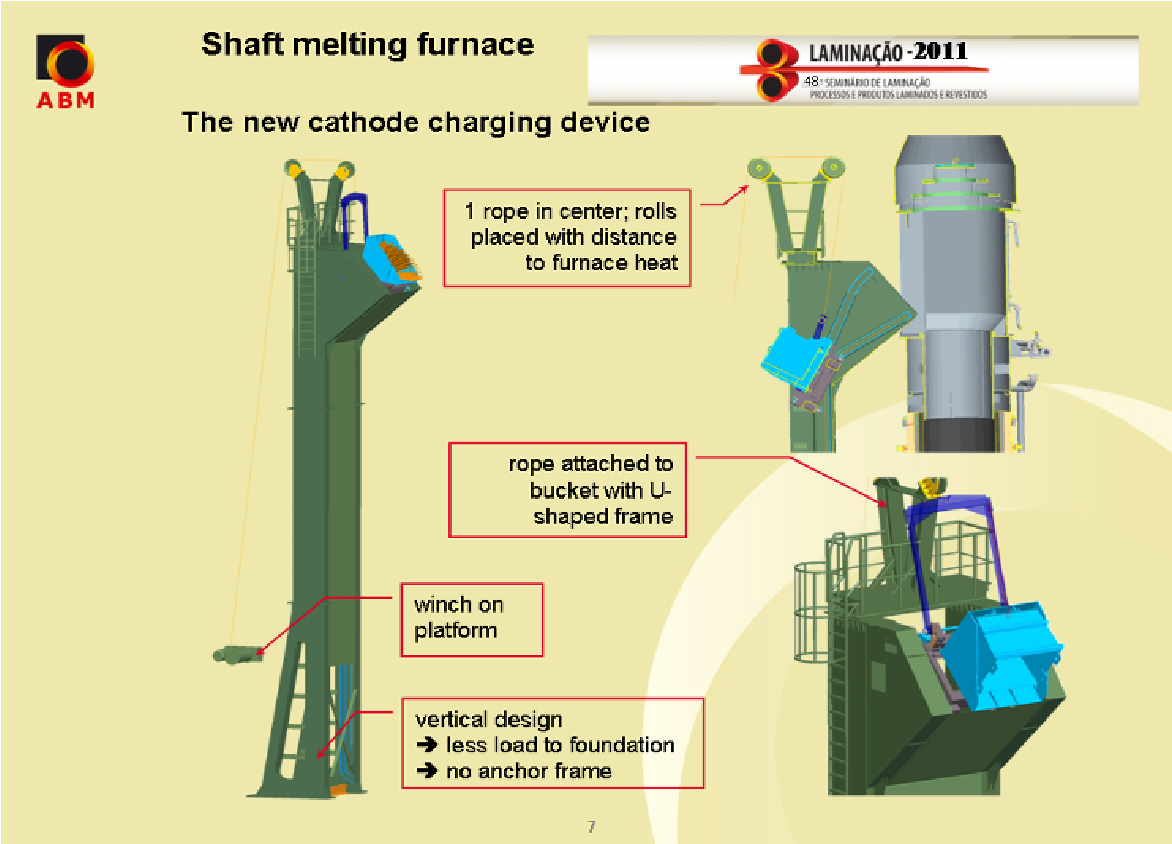

Figure 1. New design of charging equipment.

2.3 Scrap Melting in a Shaft Melting Furnace

A shaft furnace is purely a melting furnace and is not a metallurgical furnace able to refine the material in use. Due to this cathodes and clean copper scrap (in-house scrap from edge scalping, cast bars, scrap rod as well as clean scrap from wire drawing shops) are used as raw material. Individual companies melt up to 70% pure cable scrap in the shaft melting furnace.

2.4 Nozzle Mix System

A feature of the SMS furnace is the nozzle mix system for mixing the fuel gas with the combustion air in the burner. This nozzle mix system is the pre-requisite for the control of each individual burner through which the air and gas ratio can be controlled for each burner to obtain optimum combustion by means of an automatic combustion control system based on Lambda control as shown in Figure 2.

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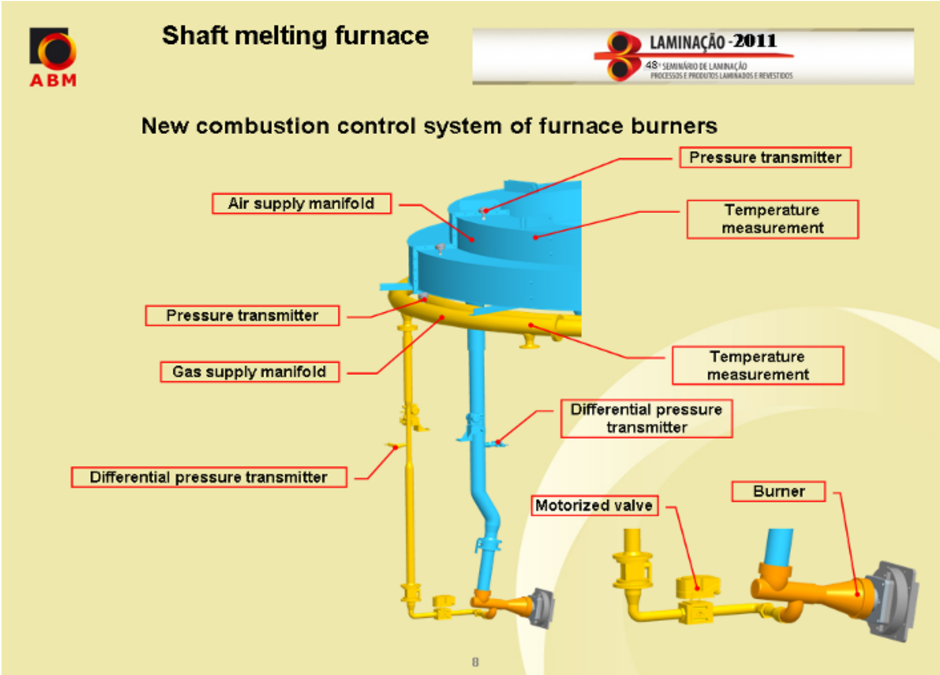

Figure 2. New Lambda combustion control system of furnace burners.

Together with the high effective degree of combustion heat of approx. 65% during melting and pre-heating of the copper supply materials the raw material dispersion in the furnace shaft are of special energy significance to the shaft furnace.

2.5 Process Control and Automation – a Basic Concept

The individual burner control and regulation described above as well as melting rate control is part of the complex control system for the entire furnace plant (Figure 3).

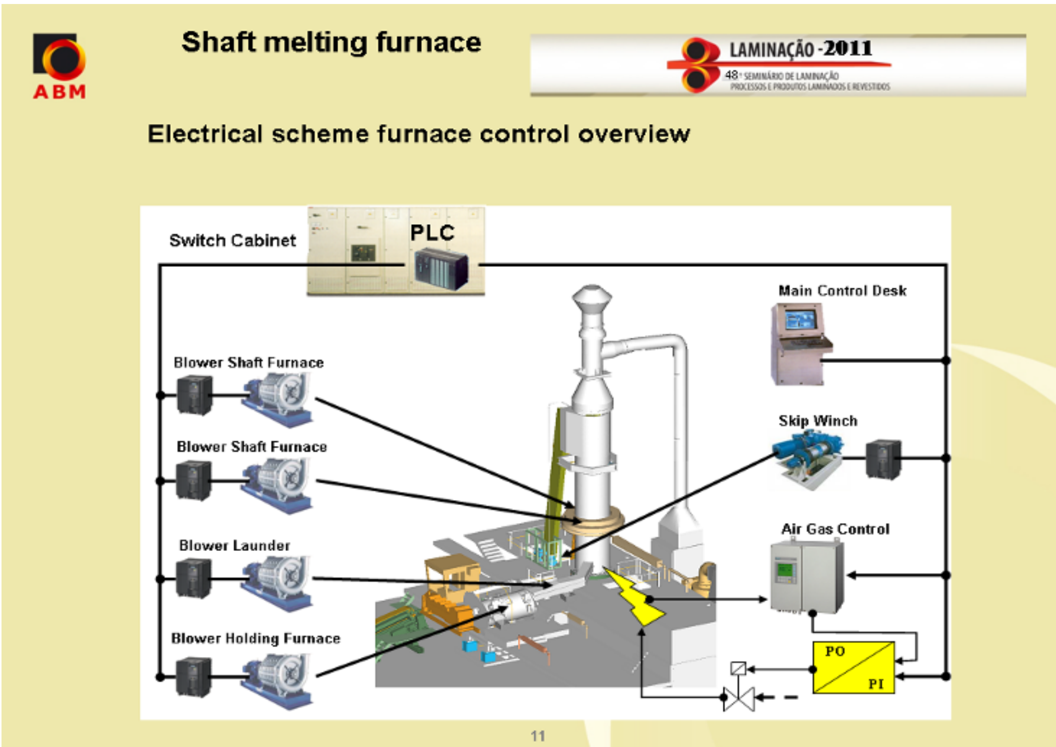

Figure 3. Furnace control system.

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Use of individual blowers with frequency controlled drives optimize combustion air regulating and reduced energy consumption.
In order to meet the requirements of large-scale producers such as copper refineries and also of the smaller cable factories for melting capacities between 5 t/h and 70 t/h or 20,000 tons to 400,000 tons per annum the shaft furnace is the only furnace, which may be used economically, in accordance with its melting capacity and the low fuel consumption data (Figure 4).

2. Process costs

2.2 Fuel consumption

Line Type		Capacity t/h	Fuel Consumption [kcal/t]	Reduction to Old design [%]
Average Small Line	Old design	9	475,000	
Small line	New design *		351,000	-26.1%
Average Small Medium	Old design	15	468,000	
Small medium line	New design**		344,000	-26.5%
Average Medium	Old design	28	458,000	
Medium line	New design**		335,000	-26.9%
Average Medium Large	Old design	42	415,000	
Medium Large line	New design**		289,000	-30.4%
Average Large	Old design	53	394,000	
Large line	New design*		285,000	-27.7%

* data calculated **data proven during acceptance tests at new design plants

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Figure 4. Fuel consumption of conventional (old fashioned) and new design shaft furnace plants.

3 AUTOMATIC COPPER ANODE CASTING SYSTEM

Currently two different technologies for casting of copper anodes are existing:

- casting Wheel - the most popular process for casting of anodes, with proven technique and lower investment costs;
- Contilanod® a state of the art continuous casting process with at present best results regarding casting structure and geometry of anodes.

SMS Meer GmbH is worldwide the only supplier of copper processing machines and plants which is able to offer both anode casting technologies.

3.1 Anode Casting Wheel

Depending on customers technical requirements (anode weight, production capacity, space requirements etc.) single casting wheels as well as twin casting wheels with single and double pouring system can be used. SMS Meer offers several layouts for anode take-off and anode stacking, which makes casting of different anode shapes on one wheel possible.

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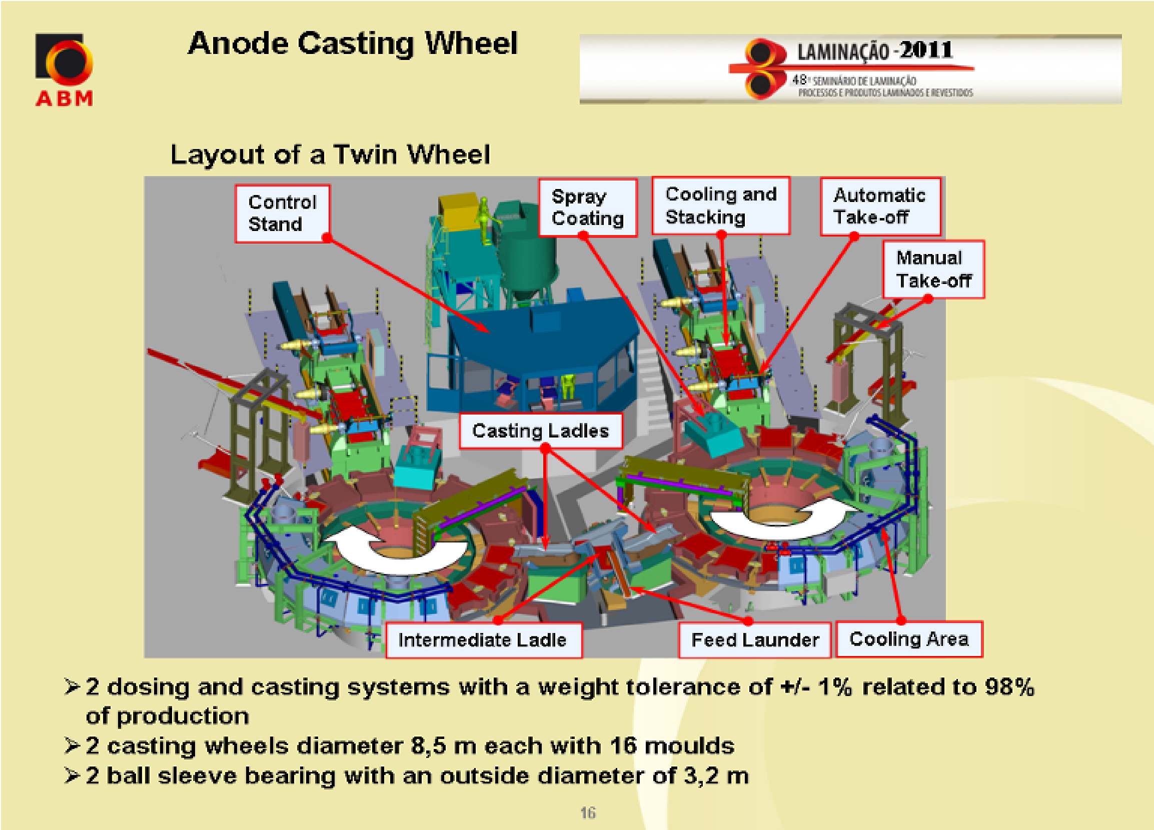

Figure 5. Anode twin wheel.

4 THE CONTILANOD® PROCESS – CONTINOUS CASTING AND SHEARING OF COPPER ANODES

The new Contilanod® system with hydraulic shear represents a breakthrough into higher production capacities and improved geometrical dimensions of the anodes. Greater efficiency and a higher degree of utilization in the copper tank house process is thus made possible.

4.1 Contilanod® - The New Design

The newly designed Contilanod® plant (Figure 6) includes all technologically necessary equipment, starting with the casting furnace (1), tundish (2), Hazelett casting machine (3), pinch roll (4), curved guide, hydraulic shear (5), cooling tunnel (6), stacking device (7), the transport equipment (8) as well as the hydraulic supply system and the electrical equipment including the control equipment, for automatic operation of the plant.

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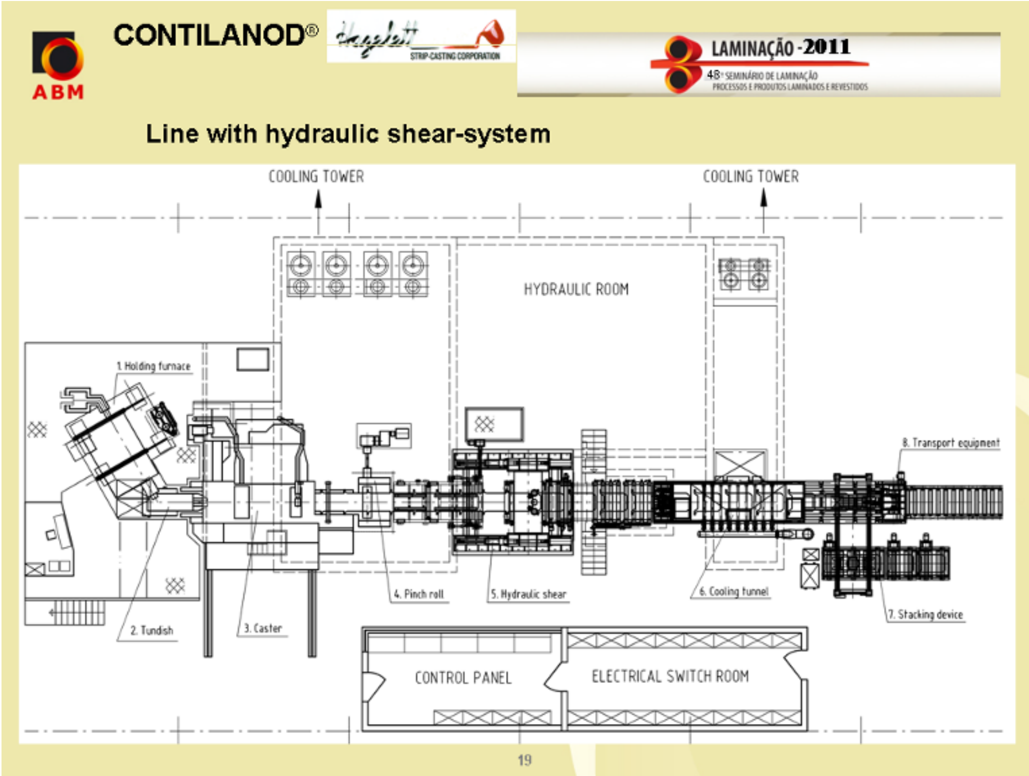

Figure 6. Layout of Contilanod® line at Gresik Smelter.

The top and bottom of the mold are formed by two endless steel casting belts, which are tension controlled and supported accurately throughout the mold region. The belts are supported by accurate roller shafts, which ensure a perfectly flat anode. The backsides of the belts are continuously cooled by high-speed water flow (Figure 7).

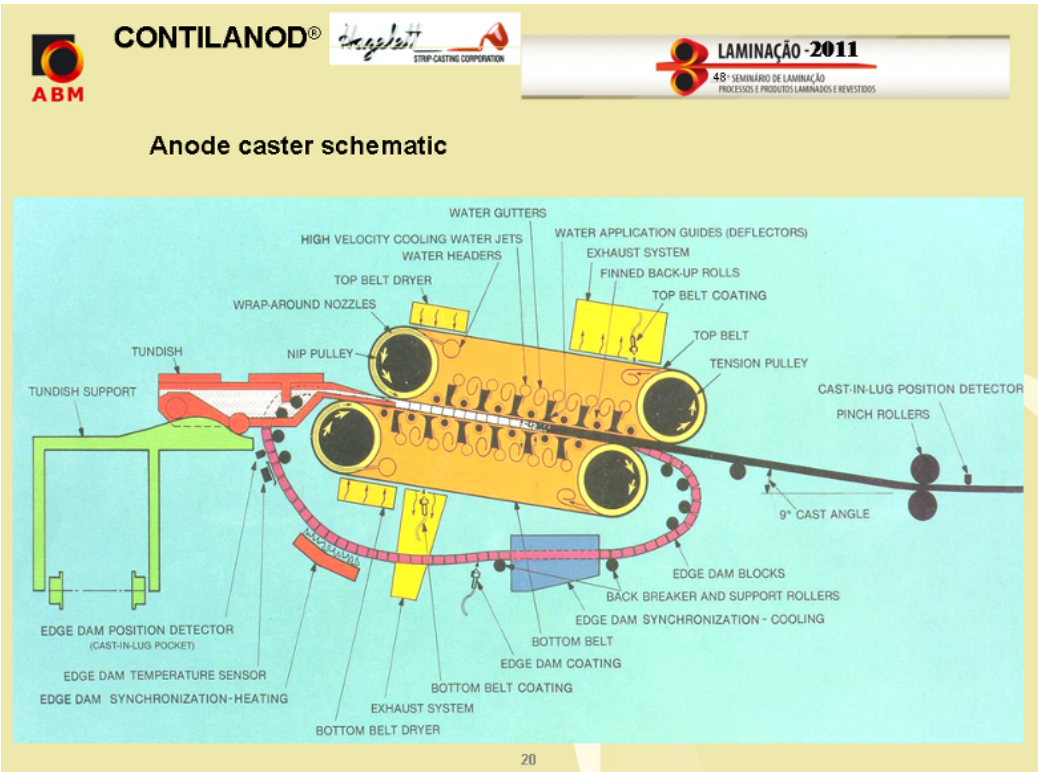

Figure 7. Hazelett twin belt caster.

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Two endless chains of metallic dam blocks, which are sized according to the anode dimensions, form the sides of the mould. The location of the anode lugs on the emerging casting slab and the position of the lug pockets are continuously controlled and monitored. The opposing lug pocket blocks on both sides of the caster are synchronized by heating or cooling the dam blocks to thermally contract or expand the distance between succeeding pocket blocks.

Figure 8. Hazelett anode caster at MKM line.

The hydraulic shear is arranged to move together with the anode slab to carry out the cut without any difference in speed between anode slab and shear knives. Special attention is made to the lug area to avoid any buckling during cutting.

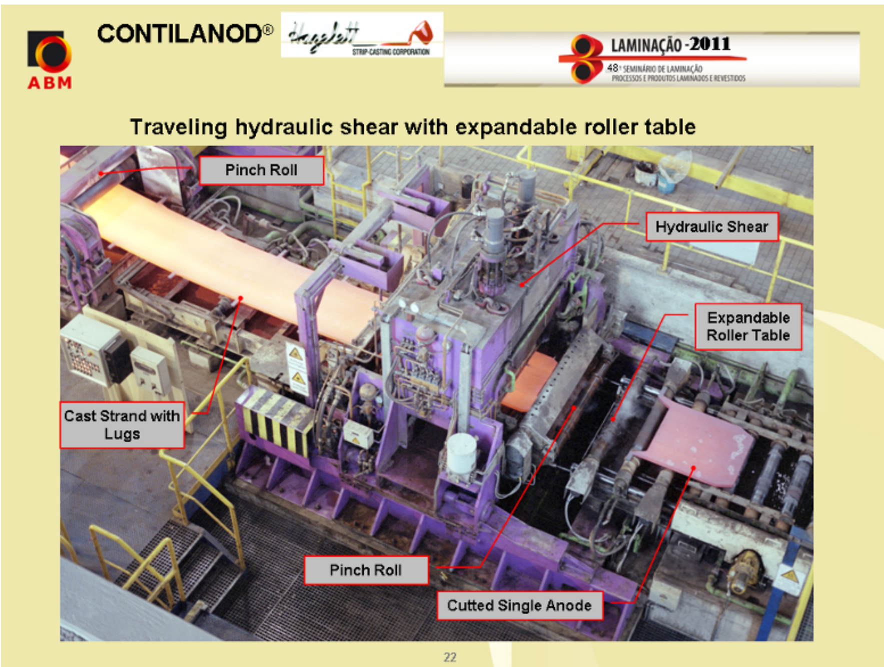

Figure 9. Traveling anode shear at MKM line.

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The lower cutter carries out the cut and at the same time the cut anode is hold parallel by means of the knife holder and clamping device. The cut and released anodes run out by pinch roll located downstream of the shear. In the same time the shear is moved back to "0" position to start the cutting cycle of minimum 12 seconds again.
A driven conveyor chain transfers the anodes through the cooling tunnel to the stacking device. All movements of the shear are controlled by a PLC-System based on the speed signal of the caster pinch roll and laser beams for lug detection. In this way a precise cut without any destruction of anode geometry is carried out.

4.2 Performance

The largest of the new Contilanod® lines in commercial production is located at the Mitsubishi/Freeport smelter (P.T. Smelting) in Gresik, Indonesia.
Tank house performance has accelerated rapidly in the few months of operation. The latest Figures available are shown in Table 1.

Table 1. Contilanod® performance at P.T. smelting

Casting Rate	100 Metric Tons per Hour
Anode weight	380 kg
Tank house Scrap Rate	11%
Tank house current density	314 A/m²
Tank house Current Efficiency	99%
Cathode quality meet with CME grade A from aspect of both physical and chemical analysis	

4.3 Conclusion: Contilanod® Advantages

The money-saving and quality advantages of using the Contilanod® process compared to the conventional wheel casting method become apparent later on in the tank house operation:

- due of the perfect geometrical accuracy of the twin-belt caster mould and the superior knife-edge contact of the lugs, there is no need for additional equipment and labor for anode conditioning.
- the casting scrap rate is significantly lower than that of a conventional casting process (1%).
- a reduced tank house anode scrap rate is achieved (up to 10%).
- a reduced spacing (pitch) in the tank house cells
- increased current density and current efficiency
- cathode quality is improved due to: more uniform current distribution per cell; elimination of the mould coating which reduce slime handling and treatment costs and result in a more effective precious metals winning; the more homogenous structure of the Contilanod® anodes results in a higher quality of the cathodes.

The newly designed Contilanod® system using a traveling hydraulic shear represents a breakthrough into higher production capacities and improved geometrical dimensions of anode production as a basis for greater efficiency and a higher degree of utilization in the tank house operation and copper production at all.

5 CONTIROD® PLANTS

5.1 Introduction

Cast wire rod as the starting product for the electrical and electronics industry accounts for more than half the world's total copper demand. Contirod® plants for production of high-quality copper wire rod with annual production capacities between 40,000 t and 360,000 t are in operation worldwide with the leading copper producers and at major cable factories.

5.2 Layout of Contirod® Line with a capacity of 25 t/h (Type CR 3500)

The casting and rolling plant is laid out in a straight line. From his control room, the caster operator can survey the whole plant through to the laying head.

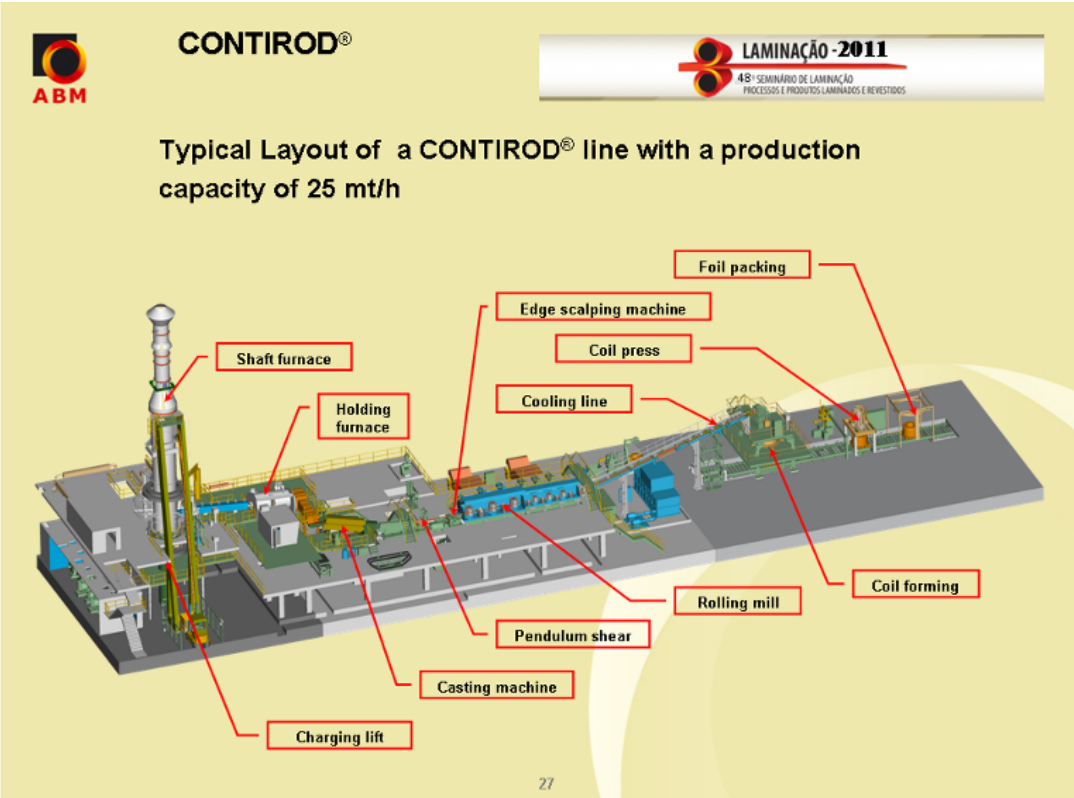

Figure 10. Layout.

The typical layout of all our Contirod® lines is illustrated in Figure 10:

- charging system for cathodes and copper scrap in various shapes and sizes;
- shaft melting furnace with high-efficiency burner system and transfer launder;
- storage and metering furnace with a capacity appropriate to the plant capacity;
- casting launder with automatic metal flow control;
- twin-belt caster with secondary cooling;
- control room for the caster;
- pinch roll unit of the caster;
- hydraulic pendulum shear for cutting the cast strand;
- edge scalping machine to chamfer the 4 edges of the cast strand at an angle of 45°;

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- 12-stand mill with individual drives for all the stands;
- rod cooling and deoxidization section with an alcohol/water mixture;
- laying head with waxing station and laying pipe;
- ring collector for spiral and orbital coils;
- lifting table under the ring collector;
- automatic coil transport line with pallet magazine, transport roller tables, coil press and foil packaging station.

5.3 The Contirod® Process and Its Benefits

A reliable heavy-duty charging system for cathode and scrap ensures a uniform distribution of the charged material.
Automatic burner and melting rate control ensure complete combustion of the gas/air mixture under optimum conditions with high thermal efficiency, low oxygen absorption in the liquid copper.
Uniform, controlled fast cooling in the Hazelett caster with a simultaneous low casting temperature results in a fine-grained, dendrite-free microstructure with a uniform distribution of the oxygen and impurities over the strand cross-section. This ensures a reduced hot shortness even with higher impurities contents in the raw material, so high proportion of inexpensive scrap possible.
Use of individually driven roll stands permits maximum flexibility with respect to the finished product dimensions, allows tension and slip-free rolling in all the stands and hence closer wire rod tolerances, higher roll service lives and higher rod surface quality.
The individually driven roll stands offer a large number of benefits. The individual speed setting per stand simplifies the rolling of different product sizes and the flexible employment of differently remachined rolls. The main advantage, however, lies in the optimum speed settings. Different influences such as temperature, surface quality of the rolls or condition of the emulsion have a significant effect on the friction conditions within the forming zone. An increase in the roll life also boots the availability of the line and reduces the production costs for roll rings (Figure 11).

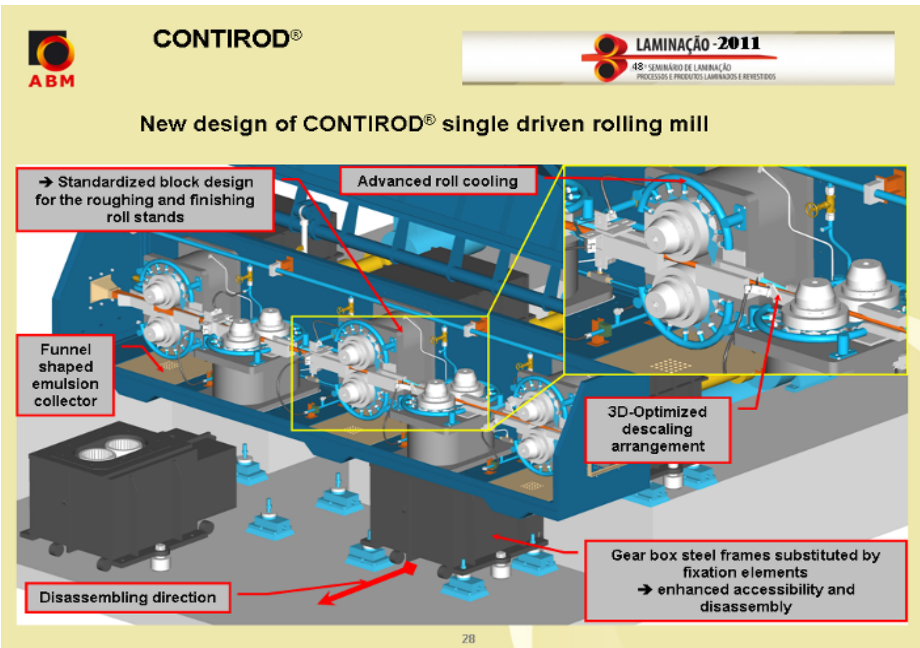

Figure 11. Single driven roll stand design.

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The designs of roll stand and their arrangement have been optimized with respect to ease the maintenance. This has permitted greater accessibility and quicker replacements of all wear parts. In line with these re-engineering activities we were able to increase the bend and torque stiffness of the roll shafts as well as the lifetime of the main loaded bearings.
The cantilever design of the roll stands and rolling torque transmission via internal gearing permits symmetrical adjustment of the roll rings on both sides while maintaining the mill centerline even when the roll rings have been machined down by up to 10%. The possibility of remachining the roll rings up to 25 times extends the service life of the rings reduces the size of the roll park and reduce the process costs.
The use of separate emulsion systems with dosing pumps for alcohol, emulsion oil and pH neutralization agent allows the chemical composition of the emulsion for roughing and finishing stands to be perfectly adapted to the specific rolling conditions. This, and the use of an additional high-pressure descaling system, enable longer roll service live and better surface quality of the finished product to be achieved.
The rod coils in spiral or orbital form produced by the laying head are very uniform and guarantee optimum drawing conditions in the drawing shop, even at high speeds.
The use of low-maintenance rector controlled 3-phase AC motors, a precisely controlled rolling process, and a powerful process visualization with diagnostic and data logging functions, simplify the operation and increase the availability of the line.
The sum of these mill-specific benefits result on the one hand in cost-effective production of the best possible quality of our Contirod® wire rod, on the other hand in the fact that in addition of cathodes, a large proportion of inexpensive scrap can be processed to produce the wire rod.

5.4 Electric Power Consumption of Contirod® Lines

The electric power consumption per t rod is shown in Figure 12. The data for the average power consumption are in a range of 90 kWh/t to 106 kWh/t, while older lines have even higher consumption rates of up-to 150 kWh/t.

ABM

2. Process costs

2.3 Electrical Power consumption

Line Type	Electrical Consumption [kWh/mt]	Relation to Average [%]
Average Small	90.0	
Maximum Small	102.0	13.3%
Average Small Medium	90.7	
Maximum Small Medium	100.0	10.2%
Average Medium	106.2	
Maximum Medium	150.0	41.3%
Average Medium Large	85.8	
Maximum Medium Large	95.0	10.7%
Average Large	91.2	
Maximum Large	121.0	32.7%

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Figure 12. Electric power consumption of old design Contirod® lines.

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Much better results were reached between others by our modern state of the art plants using frequency controlled AC drives as drives for all blowers and the rolling mill.

Elec. Power Consumption Comparison (16, 25, 35 t/h) from start-up data of New Design CONTIROD® lines

	CONTIROD 16t		CONTIROD 25t		CONTIROD 35t	
Installed Power						
Furnace	210 kW		340 kW		390 kW	
Mill Drive	1190 kW		1350 kW		1800 kW	
Auxiliaries	320 kW		360 kW		380 kW	
Total	**1720 kW**		**2050 kW**		**2570 kW**	
Power consumption per hour (% of installed power)						
Furnace	35 kWh	17%	75 kWh	22%	120 kWh	31%
Mill Drive	380 kWh	32%	642 kWh	48%	735 kWh	41%
Auxiliaries	210 kWh	66%	224 kWh	62%	240 kWh	63%
Total	**625 kWh**	**36%**	**941 kWh**	**46%**	**1095 kWh**	**43%**
Power consumption per ton						
Furnace	2.2 kWh/t		3.0 kWh/t		3.4 kWh/t	
Mill Drive	23.8 kWh/t		25.7 kWh/t		21.0 kWh/t	
Auxiliaries	13.1 kWh/t		9.0 kWh/t		6.9 kWh/t	
Total	**39.1 kWh/t**		**37.6 kWh/t**		**31.3 kWh/t**	

Values (excl. cooling water pump, cooling tower, office and workshop facilities, lights)

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Elec. Power Consumption Comparison per ton

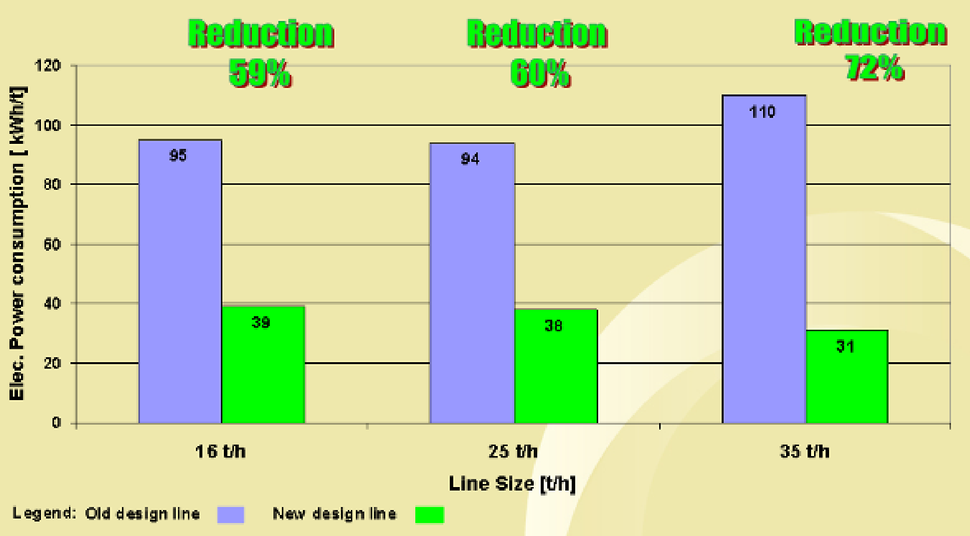

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Figure 13. Electric power consumption of state if the art Contirod® lines.

Savings are based on the use of frequency controlled drives in the area of shaft furnace and rolling mill.