

# Flexibility, quality and tolerances: results after four years of activity in the Caleotto rolling mill

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In recent years the steel market has substantially changed, becoming highly variable in the short term, regarding both demand and quantity produced. Despite the manufacturers' willingness to reduce the ever-increasing production costs, there has been a certain interest as well as a revival in the demand for steel in almost all sectors, from reinforced concrete to the automotive steel.

The market demands flexibility and ability to adapt to everyday conditions while preserving marginality. Obviously, the Feralpi Group, which is increasingly engaged in the field of sustainable steel, i.e. "Green Steel", has certainly not been waiting to see what happens next either: it has taken action and aimed, also with the Caleotto plant, at developing the production of wire rod from special steel to the best of their ability, and also to ensure the highest standards to the end customers in terms of products, processes, services and technical assistance.

After the first excellent results that were already obtained back in 2019 with the use of the four-stand MEERdrive<sup>®</sup>PLUS sizing block, along with the latest technologies developed by SMS group S.p.A., several steel grades were rolled in 4.5 mm and 5.0 mm wire rod products at the beginning of 2023, achieving surprising results, which were also confirmed by the end users. How were they produced? What has been achieved after four years of work? Let us take a closer look in this article.

**KEYWORDS:** MEERDRIVE<sup>®</sup>PLUS; SIZING BLOCK, ORRR (SIZING OVAL ROUND ROUND ROUND); SIZING WITH SINGLE FAMILY PASS DESIGN; 4.5 MM WIRE ROD

## INTRODUCTION

From a technical point of view, the term quality means *"a set of characteristics that determine a product's compliance with the function for which it is intended"; the certification, intended as a guarantee of quality, is an acknowledgement of the accurate manufacturing of a product".*

Under these premises, Caleotto, active in the rolling field since 1896, is one of the front-runners and among the leaders in the Italian market for the production of high-quality wire rod. Since 2020 Caleotto has been part of the Feralpi Group founded in 1968, and one of the leading steel producers in Europe, specializing in the production of construction steel and steel for special applications.

As Caleotto has been demonstrating for many years now, the company has been aiming at producing wire rod from high-quality steels to the best of their ability, while ensuring end customers the highest standards in terms of products, processes, services and technical assistance.

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The way to enter new, previously unexplored market niches and to further improve the quality of wire rod products had already been mapped out since the four-stand MEERdrive®PLUS sizing/finishing block, capable of meeting 100 percent of Caleotto's market requirements, went into operation.

By adopting the single drive technology for each stand, the MEERdrive®PLUS sizing block is the best technology on the market for the production of high-quality wire rod, and contributes to significantly reduce operating

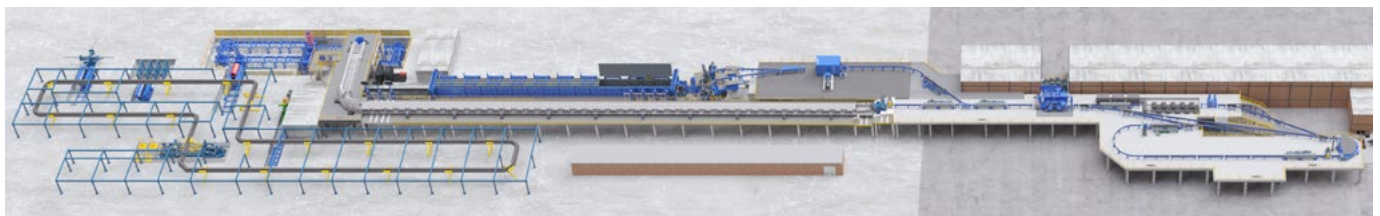
costs in terms of roll rings inventory, changing times and maintenance. MEERdrive®PLUS offers a sound opportunity to produce an excellent wire rod in terms of dimensional tolerances and surface quality - but it is not only this single machine that does the "right job". It is a combination of technologies, allowing a constant control of dimensions and temperatures before and after the sizing block, which provides Caleotto with new opportunities, including consolidating its position on the market.



**EQUIPMENT AND PROCESSES – THE PLANT LAYOUT**

The Caleotto rolling mill has been heavily upgraded by SMS group with the introduction of the latest technologies, namely the MEERdrive®PLUS finishing/sizing block that

ensures the best dimensional tolerances and the cooling and equalizing line (with multi-loop technology) for thermo-mechanical rolling.



**Fig.1** - Wire rod rolling plant layout including also the bar-in-coil production line.

The multi-loop technology, with several possible cooling paths, depending on steel type and finished product dimensions, increases production flexibility and improves the rolling mill utilization factor. In the Caleotto plant the thermo-mechanical rolling, with final temperatures

below 800°C, can be used for rounds exceeding a 13.0 mm diameter, while the low temperature rolling can be used for smaller diameters. The high cooling impact allows obtaining very fine microstructures, offering considerable advantages to end users. Specifically, the "multi-loop"

concept has a number of operational advantages. All the planned maintenance of the pre-finishing block can be performed while the block is bypassed, using an alternative path, thereby reducing the scheduled machine downtimes. The pre-finishing block is only used when strictly necessary, and is bypassed for several diameters. This allows product changes to be made with fewer time constraints and ensures that settings can be precision controlled, minimizing any problems arising from product changes.

By using the MEERdrive<sup>®PLUS</sup> sizing block alone, for products exceeding 13.0 mm, the energy costs are reduced, as the pre-finishing block is switched off. The efficiency of the lubrication system is also extended, as there is less chance of contamination with cooling water. The use of the single family rolling in the intermediate mill allows a drastic savings in terms of changing times and costs for rolls and guides.

The ability of the Caleotto rolling mill to roll at lower temperatures with fully equalized rod temperature generates further cost savings by reducing the incidence of downstream heat treatments. During the rolling of cold heading steels, for example, the improvement of the microstructure resulting from thermo-mechanical rolling makes it possible to eliminate soft-annealing for some types of boron manganese steels and to substantially reduce soft-annealing (up to 50 percent less) for chromium, chromium boron and chromium molybdenum steels. Thanks to its unique multi-drive technology (one motor per each rolling stand) the MEERdrive<sup>®PLUS</sup> sizing block allows absolute control of speeds between the

different pass sequences, minimizing bar tension and ensuring the best tolerances achievable nowadays on a wire rod mill.

#### MEERdrive<sup>®PLUS</sup>: PASS DESIGN OPTIMIZATION

At the time of the MEERdrive<sup>®PLUS</sup> installation, the pass scheme had already been designed for wire rod products with a diameter of less than 5.5 mm. Indeed, the plant layout is the optimal solution for producing small-diameter products with limited productivity, thanks to the first four roughing stands being separated from the rest of the mill and the different billet sizes available.

The first trials were performed in June 2022, and focused on the production of 5.0 mm wire rod, rolled at a speed of 100 m/s. The excellent results obtained in terms of dimensional tolerances and mechanical characteristics of the finished product encouraged us to continue trials using the 4.5 mm diameter wire rod, which took place in January 2023, with a test speed of 90 m/s. In the future, we envisage reaching and exceeding 100 m/s for both diameters with dedicated conveyors. Currently, the maximum operating speed of the wire rod line is 120 m/s for 5.5 mm rounds.

Different steel grades that are usually produced by Caleotto were tested in both campaigns. The 4.5 mm trial confirmed the excellent results that had already been obtained with the 5.0 mm diameter.

**Tab.1** - Some of the steels and rolled product designations used for the wire rod trials.

Caleotto STD	Steel grade	Standard	Description	
CAL07B	C7D	1.0313	EN 16120-2	Low carbon
CAL055	C56D2	1.1220	EN 16120-4	Medium carbon
CAL072	C72D2	1.1242		High carbon for drawing
CAL082	C82D2	1.1262		
CAL04F	C4C	1.0303	EN 10263-2	Low carbon
CALSG2	3Si1	1.4341	En 14331-21	Welding wire

The undeniable advantages of the MEERdrive®PLUS technology are summarized below:

- Perfect adaptability to different dimensional ranges of the entry side passes from the upstream pre-finishing mill (single family pass design);
- Possibility of rolling at low temperature (750°C) on all steel grades for which this type of process is applicable, in the Ø 4.5 to 28 mm dimensional range;
- Possibility of optimal use and adjustment of reductions for each single product;
- Maximum flexibility in managing inter-stand tensions and roll ring speeds;
- Possibility of using roll rings with different diameters

on the single stands (multi-drive technology);

As a result of the above advantages it has been easy to achieve the tight dimensional tolerances required by Caleotto ( $\pm 0.05$  mm – 60 % ovality), exploiting the existing single family pass design of the pre-finishing block with 10 stands positioned upstream, also thanks to the accurate sizing study performed with the new SMS-LPPS simulation and calculation program



**Fig.2** - MEERdrive®PLUS at CALEOTTO S.p.A.

The classical MEERdrive®PLUS oval-round-true-round sequence has been used, where the first two stands work at higher reductions, preparing an entry feeder pass for the next two stands to obtain a precise finished product with low reductions. The stability of the process and the achievement of the best dimensional tolerances are

ensured by the extremely small distance between the last two stands and the optimal management of inter-stand tensions.



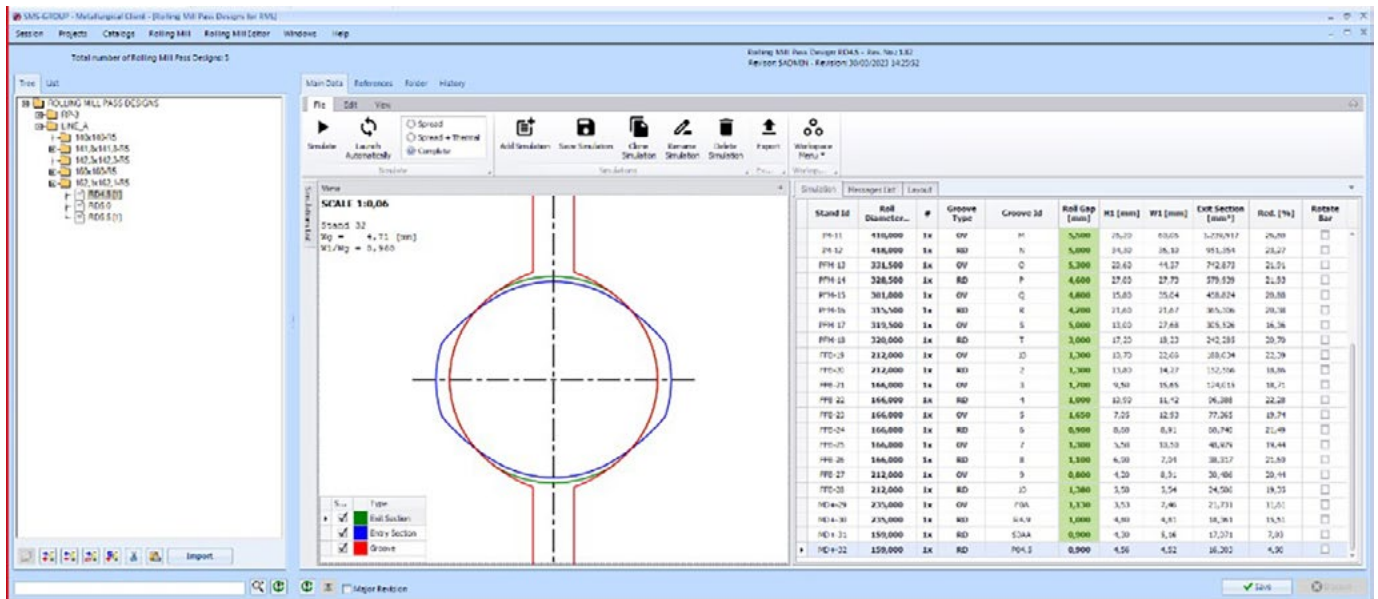


Fig.3 - SMS-SIM PRO 4.0 software for round sizes for 4.5 mm and 5.0 mm wire rod.

### THE PROCESS

Caleotto produces low, medium and high carbon steel for all applications, for cold heading, steel for the production of ropes, chains, springs, boron steel, welding wire and others, also using a thermo-mechanical rolling process. The latest plant upgrade was designed to achieve higher quality products in terms of dimensional tolerances and improved fine microstructures, thanks to low-temperature finish rolling, with all the related benefits on final grain size and microstructure homogeneity. The recent 5.0 and 4.5 mm diameters produced are, in fact, the smallest wire rod diameters ever produced on an SMS group finishing/sizing block and allow Caleotto to produce the thinnest wire rod in Europe. This product can be used for many applications, both when high ductility is required for deep

drawing, which is typical of rope production, and when high plasticity is required, for the production of cold heading components. The 4.5 mm wire rod is 33 percent smaller than the standard 5.5 mm diameter round and allows a drastic reduction in many processes that follow, such as drawing and annealing. The resulting advantages for end-users are particularly clear in the production of small-diameter drawn wire for high-performance ropes and for medium-sized wire used for cold heading and cold rolling. As an example, the following diagram illustrates the standard process for producing thin wires, starting with the standard product diameter of 5.5 mm.

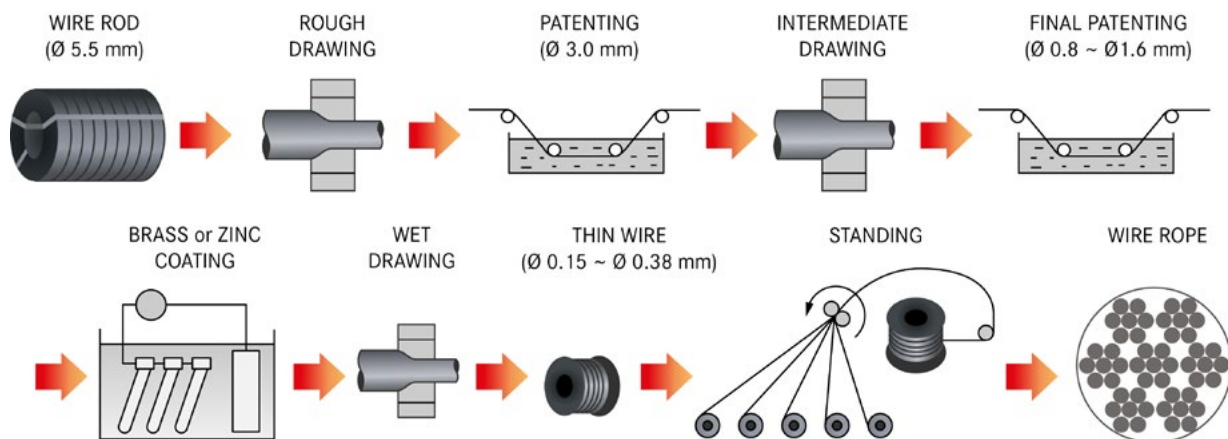
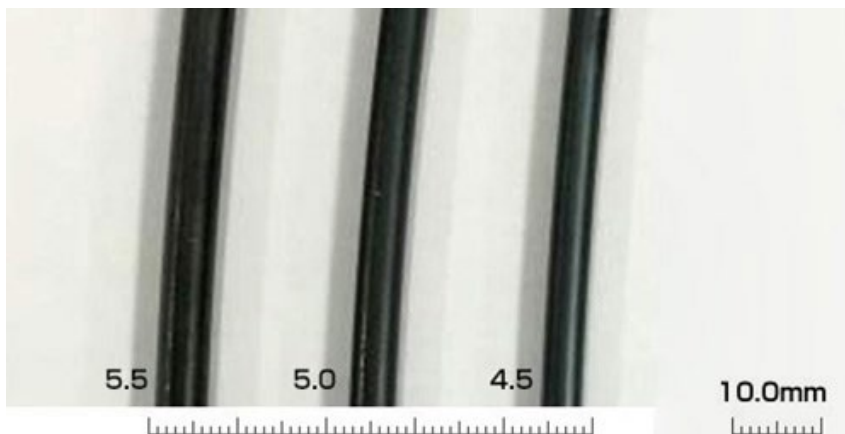


Fig.4 - Production diagram for wire rod and subsequent drawing.

The use of a smaller initial diameter produces significant advantages, such as the elimination of one of the patenting process steps, or of one or more drawing steps. Another resulting advantage is the final microstructure, which is finer and more homogenous, due to the improved cooling effect of the coils on the cooling conveyor, leading to a reduction in pearlitic lamellar spacing. The subsequent drawing becomes more reliable and smooth; the frequency of wire breakage and consequent process

interruptions are reduced.

Caleotto plans to carry out an in-depth analysis, together with end users, to precisely assess the economic benefits of this product, depending on the final application, which includes not only ropes and tyre bead wire, but also welding wires, automotive springs as well as other mechanical springs, wires used for cold rolling of small flats and other shaped products.

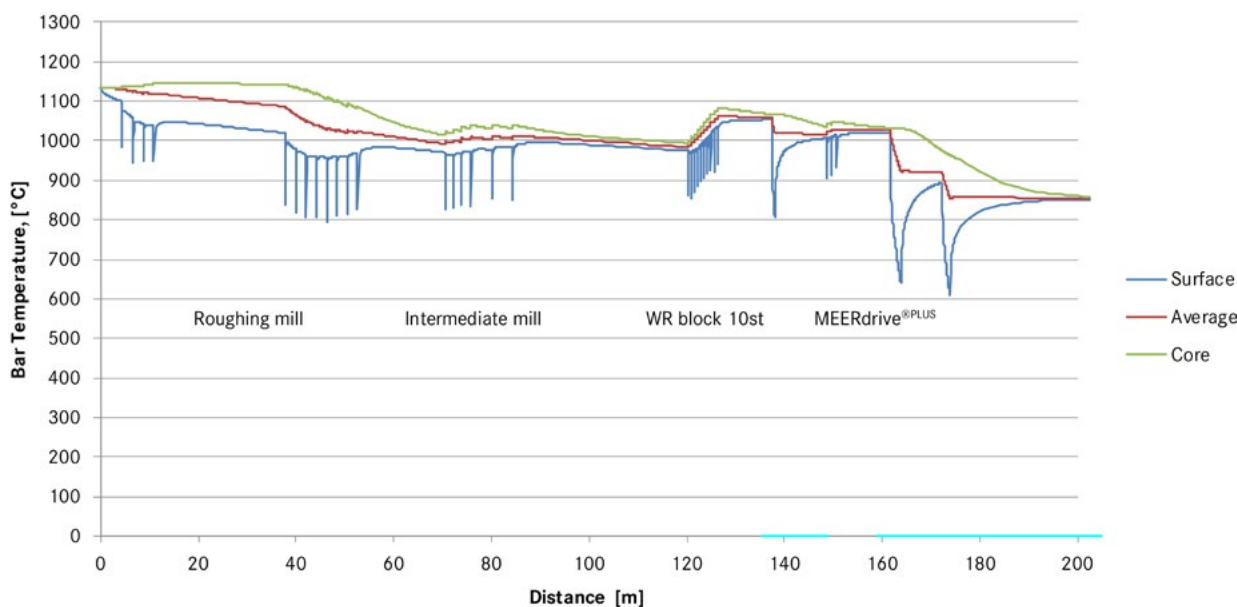


**Fig.5** - 5.5 mm, 5.0 mm and 4.5 mm wire rod produced on the MEERdrive®PLUS sizing block.

**COOLING LINE CONTROL AND MANAGEMENT**

In the first rolling trials, the cooling line was adapted to the different steel grades, especially as regards the temperature at which the coils are formed on the cooling conveyor. The following chart shows the temperature curve

for a high-carbon steel grade with a final temperature between 800°C and 900°C.



**Fig.6** - Temperature and cooling chart for high-carbon steel.

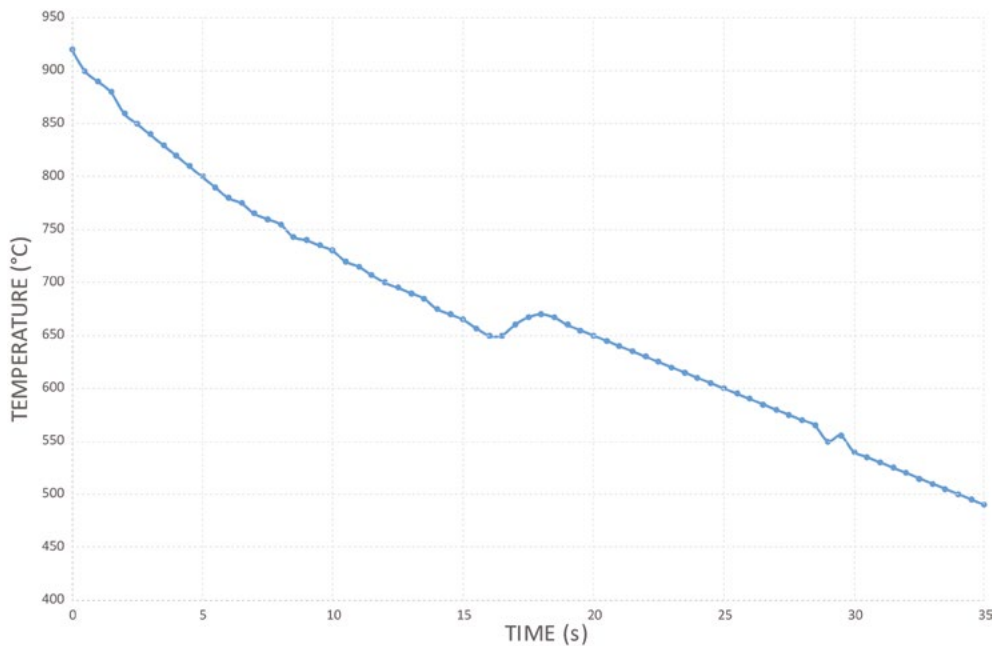
Downstream, of the pre-finishing block the material is slightly cooled to feed the MEERdrive<sup>®</sup>PLUS finishing/sizing block at the correct temperature, and is finally cooled for optimal coil formation.

For high-carbon steels, the cooling time on the coil cooling conveyor is carefully adjusted to achieve a fine pearlitic structure, with as little proeutectoid ferrite and coarse lamellar pearlite as possible, phases that reduce ductility and drawability.

In order to obtain a fine pearlitic structure, the material must be cooled, from the coiling temperature to the

transformation start temperature - a process that must be performed in a short time - while keeping the material at a constant temperature for the period of time required to complete the transformation.

Cooling of 4.5 mm diameter coils on the conveyor is adjusted so that the phase transformation occurs after about 12-15 seconds, as similarly performed for small diameter products (5.5 mm) intended for drawing. The following graph shows the indicative temperature profile, measured along the coil cooling conveyor, for the C82D steel grade.



**Fig.7** - CCT curve for C82D steel

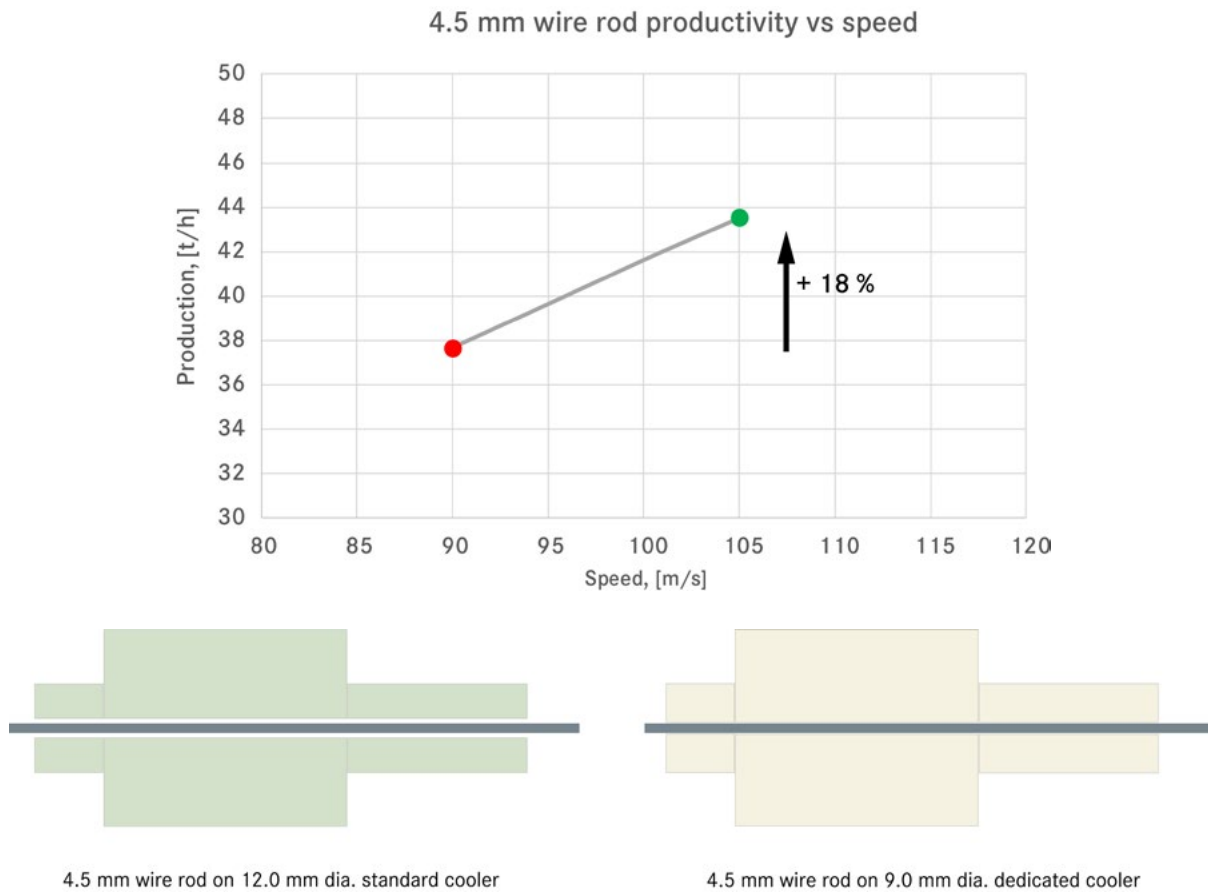
For other grades, such as low carbon or low alloy steels, the cooling gradient on the cooling conveyor is very slow; since the aim is to obtain a low hardness ferritic structure, required for subsequent cold rolling or heading. The same treatment is also applied to welding wire rod production, the aim of which is to obtain a fully ferritic-perlitic structure, without any trace of martensite.

### ROLLING SPEED FOR SMALL DIAMETERS

It is well known that small wire rod, rolled at very high speed, needs to be conveyed and guided very accurately, to avoid vibrations and possible cobbles along the rolling line. The configuration of the process line, in terms of the diameter of the cooling elements and the various conveyors used for the first trials with the 4.5 mm wire rod, was originally the same as that designed for the 5.5 mm round. The 4.5 mm wire rod is indeed much smaller and less rigid and

would require dedicated guides and conveyors. With this configuration, a 90 m/s steady rolling speed was achieved, i.e. the maximum speed for such a small product.

On the other hand, the 4.5 mm wire rod has an inherent production limit due to its small cross-section; hence it is necessary to reach the maximum speed that can combine high productivity with process stability. The chart below shows the output level that can be achieved with a standard line and with a line optimized for 4.5 mm wire rods. By using a conveyor line with a dedicated diameter, therefore a smaller one, the finishing speed can be increased up to 105 m/s, boosting productivity by 18 percent.



**Fig.8** - Potential of the new dedicated cooling elements.

**CALEOTTO 2023 OPERATIVE RESULTS**

The wire rod coils produced during the trials were sent to some of Caleotto's customers to assess the overall quality of the product and the possible benefits resulting from the reduction of diameter. The following table lists the steel grades and the main mechanical and microstructural characteristics obtained during the various trials.

Decarburization values, surface defects and the mechanical properties are in line with the current plant production and in accordance with the main quality standards. The microstructural characteristics were found to be compliant with customer requirements

**Tab.2** -Results on steel grades and designations of the rolled products for the wire rod trials.

Steel grade	Standard	Partial decarburization	Max defects depth [mm] (%)	Rm [MPa]	Z [%]	Microstruttura
C4C	EN 10263-2	*	0.045 (1.0)	357	81	Ferrite + carbides
C7D	EN 16120-2	*	**	377	81	Ferrite + carbides
C56D2	EN 16120-4	0.055 (1-2)	0.035 (0.8)	969	54	Pearlite
C72D2		0.035 (0-08)	0.03 (0.7)	1194	54	Pearlite
C82D2		0.045 (1-0)	0.03 (0.7)	1252	48	Pearlite
C84D2		0.04 (0-9)	0.025 (0.6)	1274	46	Pearlite

Notes:

(\*) The decarburization value is not significant for low-C steel

(\*\*) Free cast billets; surface defects were not measured



### LOW CARBON STEEL - C4C

The C4C low carbon steel is intended for the production of standard components, obtained by cold heading. For this type of processing, the product is first drawn. Compared to the 5.5 mm round, the mechanical strength of the 4.5 mm wire rod is lower, and the required drawing steps have decreased from 10 to 7.

The customer has not reported any irregularity when using this product; the main advantage of which is the 30 percent reduction in drawing steps.

### LOW CARBON STEEL - C7D

The C7D steel is intended for the production of cold rolled shaped flats. For this type of processing, the rolled product undergoes a series of treatments.

1. Acid pickling, to remove scale and achieve a perfectly smooth surface
2. Drawing, to reduce the diameter of the rolled product to the final product size
3. Cold rolling
4. Packaging

For smaller flats, the diameter of the starting wire rod must be less than 5.5 mm, followed by several phases of the drawing process (pass sequences). The use of a smaller diameter allows to obtain a range of finished products without undergoing this pass sequence, or with a lower number of passes, with significant cost savings.

No problems in the use of the new product have been

reported by the manufacturer of cold rolled flat bars either. What remains to be evaluated is whether the production of very precise intermediate diameters, between 4.5 and 5.5 mm, can completely eliminate drawing operations for a certain group of finished products.

### MEDIUM-HIGH CARBON STEEL, 0.56 – 0.72 %C

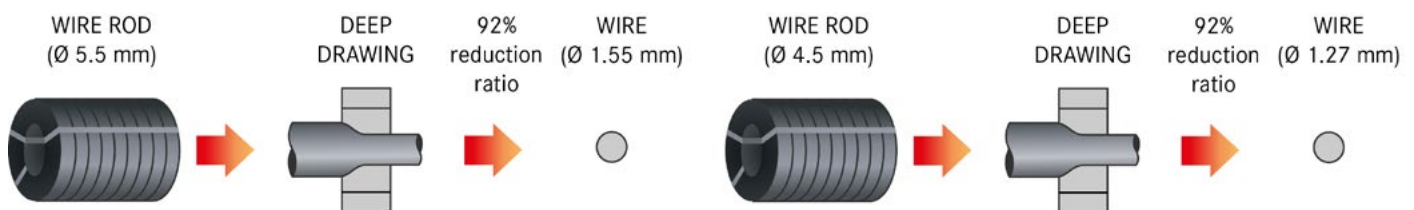
Medium and high carbon steel is mainly used to produce various medium or high-demanding mechanical components, such as springs.

For this application, the wire rod undergoes surface scale removal and is then drawn to the correct diameter for subsequent coiling. This operation can only be carried out if the residual plasticity of the material, measured as number of torsions before breakage, has remained sufficiently high. The advantage of using a semi-finished product with a smaller diameter is, in fact, the greater residual plasticity, due to the fewer drawing steps, and consequently less work hardening.

### HIGH CARBON STEEL, 0.82 – 0.84 %C

This steel is mainly used for the production of high-strength ropes.

For this application, the starting wire rod is drawn to very thin diameters, a process called deep drawing. The maximum area reduction for a drawing stage without intermediate heat treatment is set at 92 percent; therefore the minimum diameter obtainable depends on the starting diameter:



**Fig.9** - Deep drawing diagrams for 5.5 mm and 4.5 mm wire rod.

The advantage of starting from a smaller diameter is the reduced number of intermediate heat treatments required. A further advantage comes from the finer pearlitic structure of the 4.5 mm wire rod compared to that of the 5.5 mm round, due to the greater efficiency of the on-line patenting treatment on the controlled cooling conveyor. On-line patenting is a controlled cooling process of coils carried

out up to a temperature of 550°C, followed by isothermal maintenance until the transformation from austenite to pearlite is completed. The final microstructure consists of very fine pearlite, which is not visible under an optical microscope. The resulting effect is high ductility and drawability for a process without downtimes due to wire breakage.

**CONCLUSIONS**

Caleotto is a steel plant of the Feralpi Group that specialized in the production of high-quality wire rod, obtained from billets produced at the Calvisano steel plant. Thanks to the modernization of the rolling mill by SMS group S.p.A., the plant produces a vast dimensional range, which has recently been expanded to include small diameters, i.e. 5.0 mm and 4.5 mm. The small-diameter wire rod makes it

possible to achieve drastic reductions in many secondary processes, and the resulting advantages for customers are fully acknowledged, especially in the production of thin drawn wire for high-performance ropes, and drawn wire of various diameters for springs, cold heading or rolled components.



**Fig.10** - Wire rod coils used during the trials.

These new products, rolled in a wide range of steel grades, are currently supplied by Caleotto to the many Italian customers traditionally dedicated to wire drawing and cold heading, and potentially to customers throughout Europe. The new diameters allow Caleotto to be ranked among the most innovative producers of high-quality drawing steel. The super thin high-carbon wire rod can eliminate the need for intermediate wire annealing and reduce the number of drawing pass sequences, thereby reducing production costs during final processing. The wire rod for

cold heading components is generally more plastic, less brittle due to fewer drawing steps, and features greater cold formability. Thanks to the technologies provided by SMS group S.p.A., Caleotto is pleased to be able to expand its dimensional range and to offer its customers the thinnest wire rod produced in Europe. In the future, the long-standing collaboration will be consolidated thanks to the commissioning of the new large-diameter bar-in-coil line, scheduled for the third quarter of 2024.

**TORNA ALL'INDICE >**