

A closer look at the aluminium welding wire industry

The combination of Properzi hot-rolling and cold-rolling technology revolutionises the production of aluminium welding wire alloys. By **Giuseppe E. Marcantoni***

Revolutionary technology and innovation are no stranger to Continuus-Properzi, S.p.A. In the late 1940s Continuus-Properzi pioneered the continuous casting and rolling of nonferrous wire rod. This disruptive technology totally altered the industrial process of wire rod production throughout the world. Since that time numerous patents and innovative technologies within the nonferrous industry have been brought to the market by Continuus-Properzi. This article will focus on the aluminium welding wire industry and how the Properzi (hot and cold) rolling technology has changed and improved the manner in which aluminium welding wire alloys are produced.

Various industries, especially automotive and transportation, require more aluminium sheet, rod, and other aluminium parts to reduce the weight of anything that moves on roads, rails, rivers, etc. As these industries increase their usage of the light metal, this also drives the demand for aluminium welding wire alloys.

Continuus-Properzi has been providing equipment for the continuous casting and rolling of aluminium wire rod for more than 70 years and the highest quality 4000 and 5000 series welding wire alloys (see table below) have been produced using Properzi technology and equipment for many decades. The Properzi methodology processes molten aluminium through a wheel & belt casting machine yielding a cast bar which is fed directly into an in-line hot-rolling process in order to produce wire rod. The most widely produced aluminium wire rod diameter is 9.5 mm, equivalent to 3/8".

The traditional production process for aluminium welding wire alloys consists of several independent operations. It starts from the procurement or production of 9.5 mm rod, followed by subsequent wire drawing to smaller diameters, to other intermediate operations such as

ALLOYS USED FOR Mig WIRES & Tig FILLER ROD

| Alloy Rod designation | Applications field | Purposes | Typical composition |
|-----------------------|--|----------------------------|--|
| 4003 | Automotive/Aerospace Recreation/Containers | Melting temp & fluidity | Si 4.5-6.0 |
| 4047 | Automotive | Melting temp & fluidity | Si 11.0-13.0 |
| 5183 | Shipbuilding/Recreation Transportation/Containers | Work hardening | Mg 4.3 - 5.2 Mn 0.5 - 1.0/Fe 0.4/Si 0.4 |
| 5356 | Automotive/Aerospace Shipbuilding/Defense Recreation/Transportation/Containers | Work hardening | Mg 4.5-5.5/Fe 0.4/Si 0.35 |
| 5554 | Automotive/Shipbuilding/Transportation | Work hardening | Mg 5.0-5.5 |
| 5556 | Containers | Work hardening | Mg 5.0-5.5 Mn 0.6-1/Fe 0.4/Si 0.25 |
| 5654 | Containers | Work hardening | Mg 5.0-5.5 Mn 0.6 - 1/Fe 0.4/Si 0.25 |

normalization, drawing, intermediate annealing, shaving, and additional drawing, in varying order depending upon the different alloys and producers, and then on to finishing operations such as cutting and packaging.

Since Properzi's founding, their rolling technology was based on a three-roll concept in order to contain the spread of the metal under the rolling forces much better than a two-roll concept and this is especially important when temperature, type of alloy and/or roll surfaces change. Based on their vast experience in the continuous casting and hot-rolling arena, in 1980 Properzi finalized and introduced their Microrolling® technology. This concept made possible the replacement of conventional wire drawing operations for 'hard-to-draw' alloys. This greatly reduced, and in some cases even eliminated, the need for intermediate annealing steps. This allowed the aluminium welding wire producers to cold-roll from a 9.5mm diameter wire rod

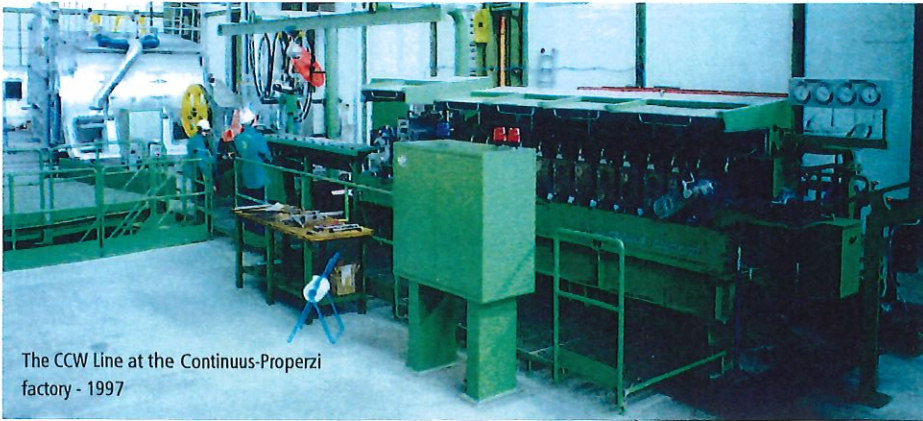
inlet size down to wires in the 2mm range while avoiding the intermediate annealing steps! The aluminium welding wire alloy manufactures around the world quickly recognized the potential benefits of the Properzi Microrolling® technology and began to adopt it. Today, all of the major aluminium welding wire manufacturers utilize the Properzi Microrolling® cold-rolling mill in their production scheme.

In the late 1990s, Giulio Properzi (President and CEO of Continuus-Properzi) proposed yet another innovative concept to the aluminium industry for the production of difficult aluminium mechanical alloys. This concept was driven by four major considerations:

1. Mechanical alloys are required in relatively small quantities when compared to electrical alloys

2. A small dedicated system to produce continuously cast wire instead of rod will facilitate savings in both CAPEX (Capital Expenditures) and OPEX (Operational Expenditures)

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The CCW Line at the Continuous-Properzi factory - 1997

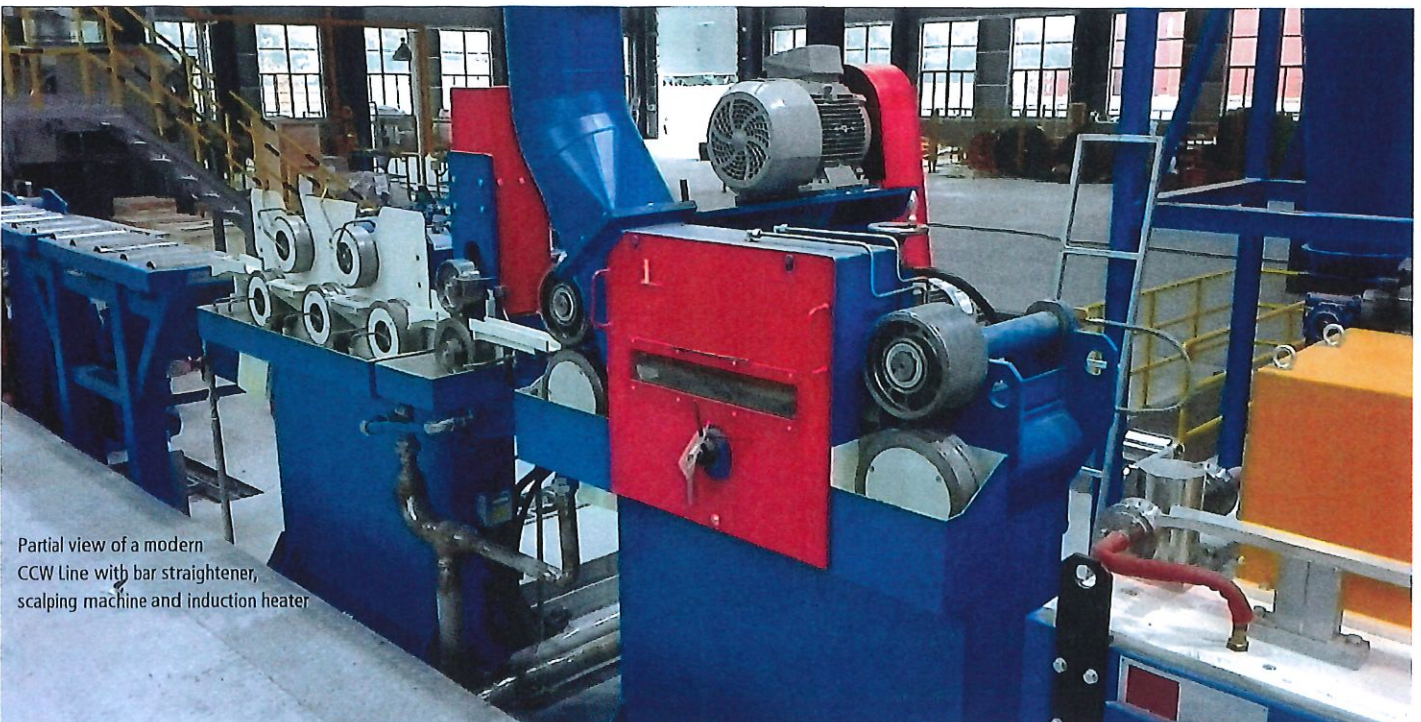
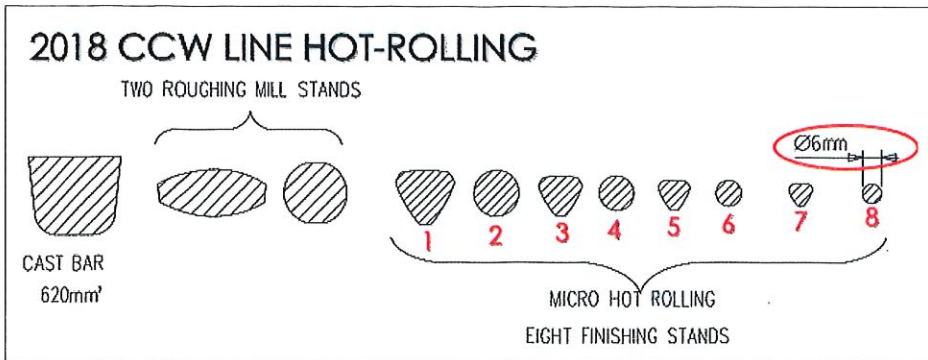
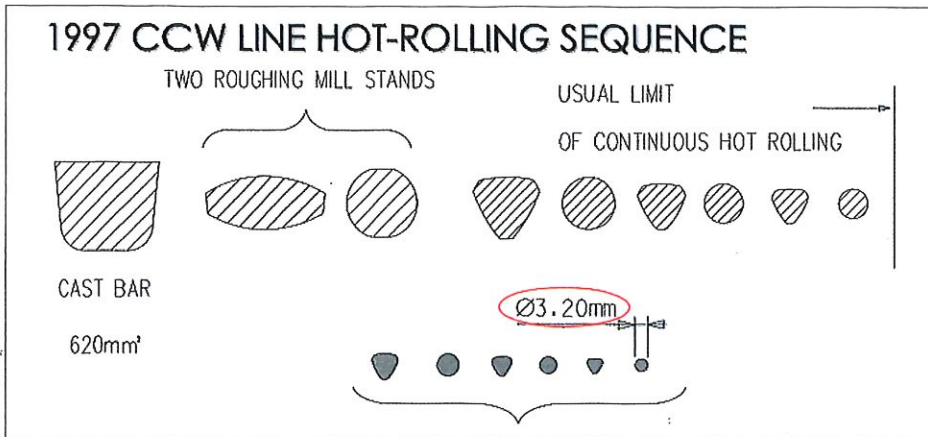
3. A cast bar having a smaller cross section will render the production of mechanical alloys much easier

4. The alloy producer's expense for intermediate annealing can be significantly reduced

A key point of this idea for a Continuous Rolling Wire (CCW) Line was the Microrolling[®] machine's ability to roll down to a diameter of 3.2mm directly from molten aluminium. Knowing that the market would be reluctant to leap into this new revolutionary concept, Properzi decided to invest in a prototype CCW Line in order to demonstrate it to the market. This prototype CCW Line was installed at the Continuous-Properzi factory in 1997 during the Wire Association's International Technical Conference (ITC) that was held in Stresa, Italy. The operation of the CCW line was demonstrated to more than 110 of the conference attendees, mainly American and European, that opted to make the journey from Lake Maggiore to the Properzi factory located on the outskirts of Milan in Sordio, Italy.

A fully operational CCW Line was presented to the attendees. The 1997 CCW version was equipped with: a 6 ton reverberatory furnace; a 1.5 tph casting machine; and a Microrolling[®] Mill that converted the 620mm² cast bar into 3.20 mm wire with a maximum exit speed of 20 m/sec. It was evident from the first cast that having a smaller cast bar cross section was extremely beneficial in controlling the solidification parameters especially with alloys containing Mg in the range of 5% or Si in the range of 6 to 12%.

In hindsight it is evident that the attendees, and therefore the market in general, did not realise the full potential



Partial view of a modern CCW Line with bar straightener, scalping machine and induction heater



Tight coil of 6 mm diameter wire continuously cast on the CCW Line

of this innovative concept targeted for the production of mechanical alloys. After the inauguration, the Properzi team operated the CCW Line from time to time for more than two years conducting numerous tests on different mechanical and welding alloys. Despite its promotion through several technical papers and advertisements, as well as endorsements from the Italian Welding Association, the reaction of the market was virtually zero and the line remained idle for some years.

This prompted Giulio Properzi to simply state, "Sometimes if you are too far ahead, you stand alone." Bringing innovative technology to the market, before the market can understand and appreciate its advantages, is an occurrence that has repeated itself throughout Continuus-Properzi's history.

Never resting on their laurels, and firmly believing in the merits of the CCW concept, the Properzi organization decided to combine these two methods. In 2018 Properzi married the Microrolling® process conceived in the early 1980s with the CCW process that was developed in the late 1990s in order to significantly streamline the production of aluminium welding wire alloys and provide an advantageous alternative production method for these specialty alloys.

As mentioned previously, the major aluminium welding wire producers throughout the world have already opted to replace the traditional rod breakdown process with Properzi Microrolling® in order to avoid the intermediate annealing steps. Now they have the ability to utilize the latest technology to even further optimize the aluminium welding wire production process.

This revolutionary Properzi process utilises both the CCW technology and the Microrolling® technology. It starts by

melting ingots and preparing the alloy in a continuous or batch mode. The molten aluminium is fed to the modern CCW Line where it is continuously cast with a wheel & belt machine and the cast bar is directly hot-rolled through a special 2-stand roughing mill and an 8-stand finishing Microrolling® mill to produce 6mm wire/rod.

Between the casting machine and the rolling train, the modern CCW Lines are equipped with a rotary bar shear, a bar straightener, a bar scalping (milling) machine and a bar induction heater, items that were not present on the 1997 CCW Line prototype.

Partial view of a modern CCW Line with bar straightener, scalping machine and induction heater

The CCW Line exit diameter of 6 mm was selected for two reasons. First, the larger exit diameter reduces the exit speed thereby simplifying the continuous automatic coiling operation. Second, it facilitates the use of an almost identical 8-stand Microrolling® mill in the cold-rolling operation. The 6mm diameter produced by the modern CCW Line is coiled with a double automatic take-up into standard 2-ton tight coils.

Tight coil of 6mm diameter wire continuously cast on the CCW Line

The first Microrolling® mill is an 8-stand hot-rolling mill that is the finishing mill within the CCW Line. The second Microrolling® mill is an almost identical 8-stand cold-rolling mill that replaces the traditional breakdown drawing machine. In this manner the two rolling mills enjoy commonality of parts with the only exception being the work rolls.

The 6mm wire enters the Properzi cold-rolling mill with about 20% elongation and exits at 25 m/sec with approximately 3% elongation and a diameter of 2.15mm. 2.15mm Wire being spooled at 25 m/sec

After this, the only annealing operation of the entire process, if necessary, takes place before the final draw and any other required operations such as shaving, cutting, packaging, etc. This modern CCW integrated process is flexible, appropriately sized, energy efficient, and controllable from molten metal to the final product. It has been supplied to three different welding wire producers in China that are manufacturing technologically advanced products from raw metal to top quality aluminium welding wire alloys with full control of the process while obtaining consistent energy and process savings. Utilisation of the Properzi CCW Line in conjunction with the Microrolling® machine is the optimal process for highly specialised production plants making aluminium welding wires and mechanical alloys. ■

