The autonomous trimming and sampling system of wire rod coils

AIC Group has developed an ambitious mechanical system, AIC TrimBot, using both vision technology and industrial robotics, including mechanical parts, 3D vision systems, a high level of automation and artificial intelligence. It will be able to perform automatically, both trimming and sampling in wire rod rolling mills worldwide, without any human intervention, except for monitoring and supervision activities.

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INTRODUCTION

When rolling wire in a long product rolling mill, the head and tail are normally of inferior quality. There are several production related reasons for this, such as lack of cooling at the front ends, or uneven cooling on the loop cooling conveyor. Regardless, these parts of the wire must be removed in a process called coil trimming.

Conventional trimming and sampling stations are typically located within the confines of the coil handling system. The most common coil handling method is to use a horizontal C-hook system where the coil rests on a horizontal load-carrying member of a C-hook, supported by an overhead conveyor structure. Very often, when the coil arrives at the manual trimming station, the front and the back of the coil can be quite disordered, with the first several rings tangled or intertwined with each other. This necessitates manual intervention, where the operator must untangle the first rings and create order from the disorder. Once this is accomplished, the operator identifies, separates, cuts and removes pieces of the wire, ranging from a short sample of a loop to several loops from the exposed end of a wire rod coil. This manual activity takes place in a very poor working environment and is a frequent source of different types of injury to the operator. There is also a negative impact on both yield and product quality, as individual operators may interpret and implement the static trimming instruction differently from their colleagues.

To address this issue, AIC Group is proud to introduce a new, patent-pending robotic system to the market intended to completely eliminate the above-mentioned manual trimming activity, based on counting rings. The new process is able to cut the wire with extreme accuracy and repeatability, which reduces the amount of waste and increases the overall yield of the rolling mill. The autonomous system is also able to communicate with the rolling mill in real time, making it possible to adjust the trimming and sampling process for each individual coil, depending on the actual rolling parameters for each billet.

THE TRIMBOT MACHINE – A NATURAL PROGRESSION FOR THE MARKET

In recent years, AIC introduced the automatic tagging robot to the market which has been exceptionally well received (*see Millennium Steel International 2021, p107*). It was therefore a natural progression of the company's ambition to develop an automatic trimming and sampling robot. The most obvious approach is to simply replace the human operators with robotic arms supported by a vision system designed to count loops. However, this approach would not add any value to the process as it would carry forward the obvious flaws and limitations of the manual process. Therefore, rather than develop a robotic solution that mimics the manual ring counting and trimming activity, a decision was made to develop a completely new process more suited to the task.

The development work that ensued was inspired initially by the process of forming the wire loop in the laying head.

In the rolling mill, after being rolled into a straight round wire at a very high axial velocity in the rolling process, the straight wire enters the straight section of the laying head pipe and when the wire exits the curved section on the other side of the pipe, it has the shape of a continuous helical loop. This brought about an idea of a novel process where the looped wire could be made to pass through a guide of a similar shape. By using a loop shaped guide the wire would be properly contained without risk of causing damage to the surface, or shape of the valuable finished wire. To attain relative movement between the guide and the wire, a wire feeding pinch roll is placed within the guide, acting on the wire. Along with the guide, at a specific distance from the pinch roll, a cutting device is added to perform the actual cutting of the wire. To enter the wire into the guide, a system that is able to find the end of the looped wire is required and once the end is located, it is pushed into the looped guide by the pinch roll. All these movements require the wire moves relative ▷

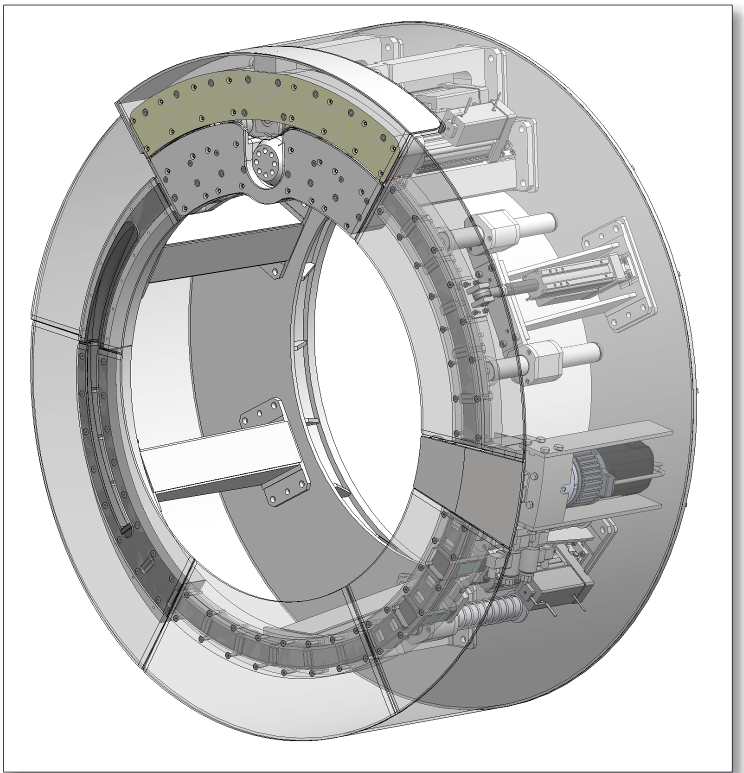

Fig 1 **Visualisation of the ring processing turret**

to the guide in a circular manner, both clockwise and counter-clockwise. However, rather than rotating the entire coil while keeping the guide stationary, the novel process rotates the guide and keeps the coil stationary to achieve the desired relative movement.

Such a process allows order to be imparted to the often tangled and unruly first few rings of the coil. Once this perfect order is established, the process that follows is very simple and, thanks to its simplicity, guarantees that the trim cut will always occur at the exact intended location. The process is also extremely repeatable thanks to the controlled environment created by the novel system.

This ultimately led to the development of the TRIMBOT with its unique and patent-pending ring processing turret (*Figure 1*). The turret is inspired by the laying head and parts of the laying head process, but the similarities end at the helically shaped guide.

The Ring Processing Turret is essentially a circular guide with a shape that follows the natural circular shape of the coiled wire (*Figure 2*). Distributed along the circular guide is an advanced pinch roll assembly, a number of sensors, several guide segments and a cutting device. The ring processing turret is mounted on to a large diameter slewing ring which is bolted to the main trolley. The actual rotation of the ring processing turret is performed by a gear motor mounted on the main trolley.

The features as described give the ring processing turret the ability to:

- Receive a ring from the coil and bring it into the pinch roll assembly.
- Rotate CW (clockwise when facing the ring processing turret) towards the end of the coiled wire.
- Locate the end of the coiled wire and stop.
- Rotate CCW (counter-clockwise away from the located end) while measuring the exact position of where to make the trim cut.
- Locate the trim cut position and stop, followed by making the trim cut.
- Rotate CCW (counter-clockwise away from the located end) while measuring the exact position of where to make the sample cut.
- Locate the sample cut position and stop, followed by making the sample cut.
- Eject the trimmed rings to be discarded.
- Eject the sample wire for testing.

As an added benefit of the novel process behind the ring processing turret, the unique process works regardless of how the coil is oriented.

ROBOTIC ARM AND VISION SYSTEM

To support the interaction between the coil and the ring processing turret, AIC has designed a ring transfer and separation system (*Figure 3*) which pulls the forwardmost rings from the exposed end of the C-hook towards the turret while also spreading them to create additional separation. An advanced vision system (*Figure 4*) takes a snap shot of the wire loops and selects a particular wire, based on an advanced image analysis algorithm.

Once the selection is made, a robotic arm moves to collect the selected wire and to place the loop segment into the pinch roll of the ring processing turret. After the ring processing turret has performed its trimming and sampling sequence, the robotic arm moves into position to collect and discharge the trimmed rings. If a sample is required, it is collected in a separate sample guide which extends and exposes the sample to the robotic arm, collects the sample and places it in the sample tray (*Figure 5*).

BENEFITS HIGHLIGHTS

The TRIMBOT is intentionally designed to be reasonably priced and inexpensive to install and operate. The ambition of AIC is to make the machine suitable for every existing and future wire rod rolling mill in the world and also to make the machine affordable to every potential customer. To make this possible, the TRIMBOT is designed to be installed directly in front of an existing C-hook on any existing mill floor, without excavation or pouring of new foundations. The system is very compact and while the actual TRIMBOT equipment only requires approximately $10m^2$ of floor space, a safe work area with both sample and scrap collection will require 25-30m^2 of space, depending on final configuration. It is also completely electrical, which eliminates any risk of hydraulic oil contamination from leaking hoses, pipes or connections.

The design is also such that parts subject to wear are easy to access and simple to replace. The entire system is also designed to fit into a standard 20-foot covered shipping container and the weight is less than 5 tons which makes it easy to handle on most sites with existing cranes. The system is meticulously tested under realistic conditions in the AIC assembly and test facility prior to being prepared for shipping to its final destination. Upon arrival at site, it can be installed and commissioned within hours and reach full capacity in a few days.

The ambition has been to create a system that can finance itself in 12 to 24 months depending on production rate and product mix. Immediate cost savings to the rolling mill operation would obviously originate from the elimination of salaries and benefits to operators. Almost as important is the gain in yield and cost reduction associated with the handling and processing of smaller quantities of scrap, which is becoming increasingly important as the industry strives towards a reduced carbon footprint.

For example, a normal manual ring counting trimming process can be assumed to regularly trim one extra ring ▷

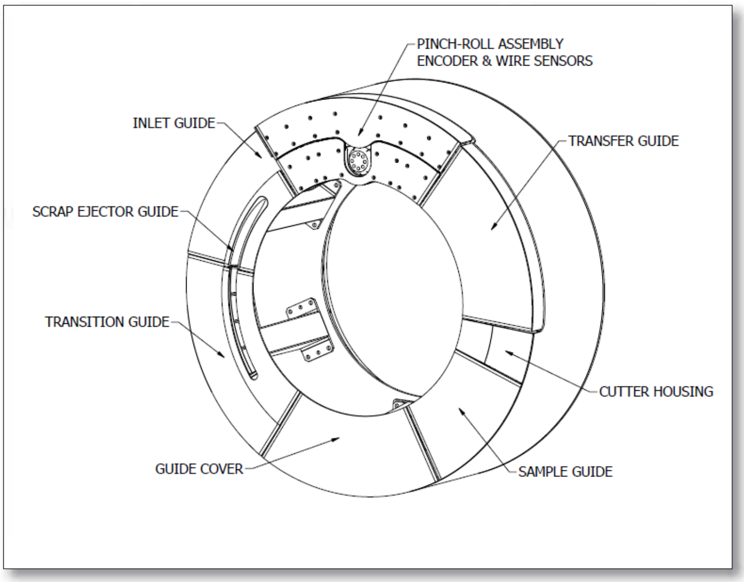

Fig 2 **Schematic of the ring processing turret**

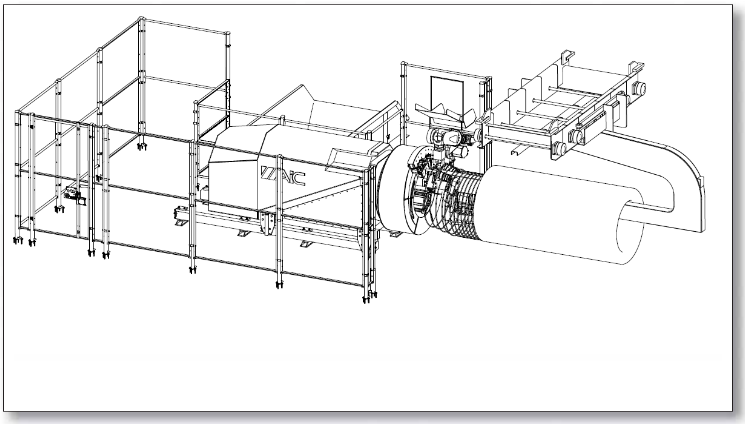

Fig 3 **Illustration of rings being transferred from the C-hook towards the turret**

Fig 4 **Photo of separated rings and the vision system interpretation of the same**

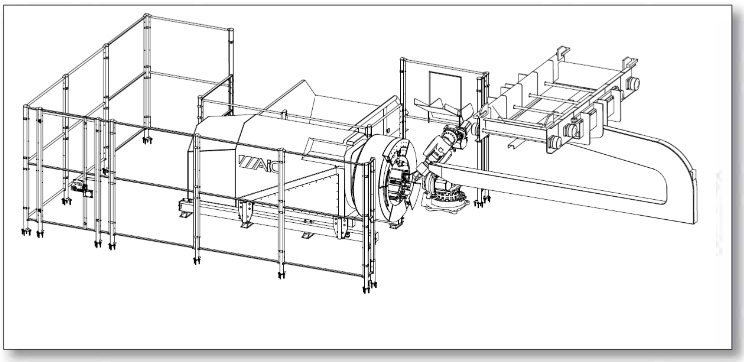

Fig 5 **Illustration of the robotic arm collecting a sample**

from both the head and the tail to be certain that enough of the inferior quality wire is removed. If it is assumed that 2t coil has a wire diameter of 10mm, from a plant with an annual production of 200,000t, then removing two extra rings on every coil amounts to 1.3kg of the excess prime product being removed. For the hypothetical annual production mentioned above, this is equal to discarding 260t of prime product each year, every year. To add insult to injury, the 260t of prime product are recycled, re-melted and cast into new billets before being rolled into a new coil.

The TRIMBOT introduces completely new dynamic functionalities. For instance, the actual length of wire that should be trimmed is calculated based on a 'nominal' rolling speed for each diameter and steel quality. This is translated into printed trimming instructions for manual operation as 'X' or 'Y' number of rings, etc. However, the actual rolling speed can change from billet to billet throughout a rolling campaign and this change in speed directly correlates to the length of wire that must be trimmed. The TRIMBOT is able to compensate for the actual length of wire that should be trimmed and removed from one coil to the next, as long as the necessary production data and proper product tracking data are made available by the rolling mill control system to the local TRIMBOT control system.

CONCLUSIONS

The completely electrical TRIMBOT is designed to fit and operate in almost any existing coil handling system with minimum disturbance to the existing site. It is primarily designed to replace any existing manual ring counting trimming activity, but its value to the rolling mill extends beyond just replacing the human operators in this area.

It offers a level of trimming accuracy that isn't possible on a ring counting trimming method. The novel trimming process makes it possible to reach a trimming accuracy of +/- 5mm under certain conditions and with this level of accuracy it becomes relevant to adjust the actual trimming position based on the actual dynamic variations in the rolling process for each individual coil. For this reason, a dynamic trimming feature has been introduced, intended to further reduce waste and yield losses. **MS**

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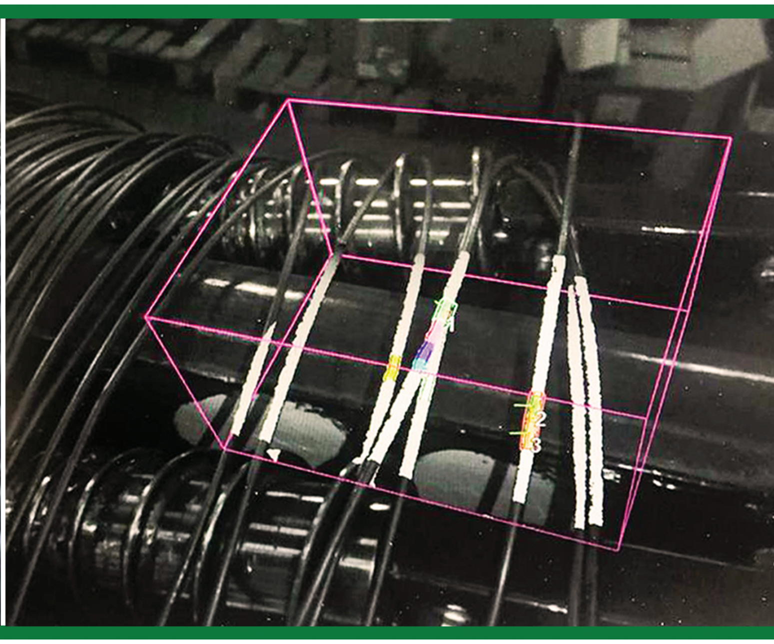
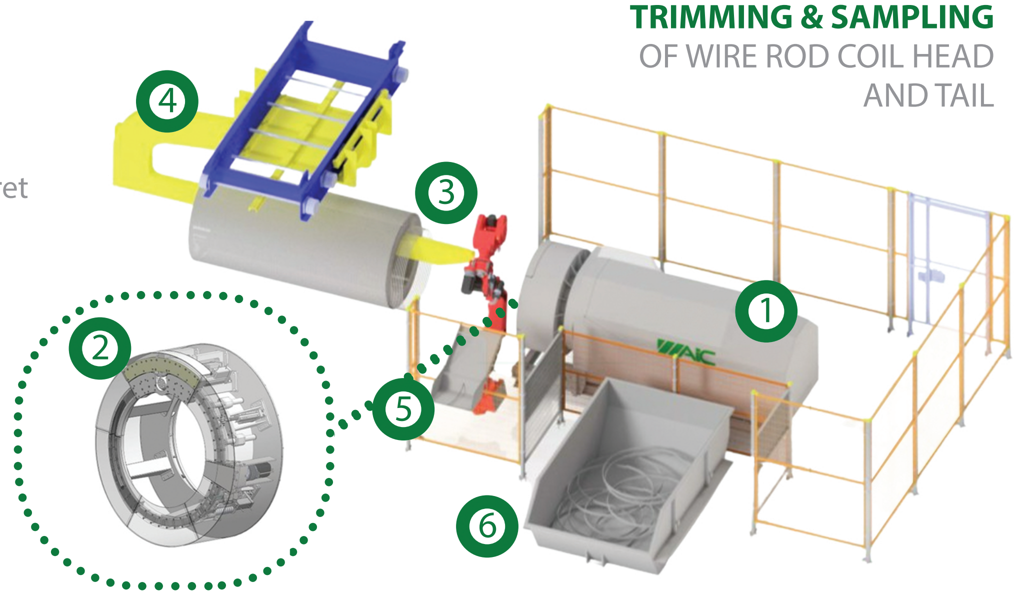


TRIMBOT

TAILORED MECHATRONICS

AUTONOMOUS
TRIMMING & SAMPLING
OF WIRE ROD COIL HEAD
AND TAIL

1. Trimbot machine
2. Ring processing turret
3. Robotic arm
4. C-Hook system
5. Sample tray
6. Scrap bin



Fit in a small floor-space, 100% electrical and easy to handle on-site

AIC has more than 45 years of experience in the steel and metals industry

We offer state-of-the-art technological solutions (specially designed for **long-product rolling mills, meltshops & casters**).

We handle **in detail every step** from Power control, PLC & HMI software up to innovative solutions, Level 2&3, mechatronics applications with robotic and vision technologies, special machines, safety systems, commissioning and after-sales services.

THE LOYALTY OF OUR BEST CLIENTS IS A CONSTANT CONFIRMATION OF OUR RESULTS.

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