TRIMBOT MECHATRONICS STATION FOR TRIMMING AND SAMPLING WIRE RODS IN THE COIL HANDLING AREA

Marco Capitanio – CEO AIC Group, Automazioni Industriali Capitanio, Brescia (Italy)

Jens P. Nylander – Engineering Supervisor, Automazioni Industriali Capitanio, Lycksele (Sweden)

Trimming & Sampling

- ✔ The activity of Trimming is a corrective measure to remove poor quality wire from the coil. Trimming is almost always a manual activity.
- ✔ The activity of Sampling exist to collect a piece of the wire to be measured and analyzed. Sampling is almost always a manual activity.
- ✔ Humans can only perform trimming by counting rings. This “Ring Counting Process” is extremely inefficient and wasteful.
- ✔ The activity of manual trimming is very labour-intense and a frequent source if injury.
- ✔ A new solution must eliminate humans from the process and become more resource efficient.
- ✔ This requires a new energy-efficient process, without humans, able to increase yield and reduce scrap.

Manual Trimming & Sampling

- ✔ Hazardous work
- ✔ Frequent injuries such as:
  - Cuts & lacerations (fingers, hands, arms, legs)
  - Crushing (fingers, hands, arms)
  - Vibration injuries (fingers, hands)
  - Hearing loss
  - Eye injury
  - Burns (fingers, hands, arms)
  - Heat radiation
  - Heavy lifts (tools & removal of scrap)
- ✔ Unlikely career-choice
- ✔ Inconsistent performance
- ✔ Ring Counting – a fundamentally flawed process

High Speed Trimming Shear

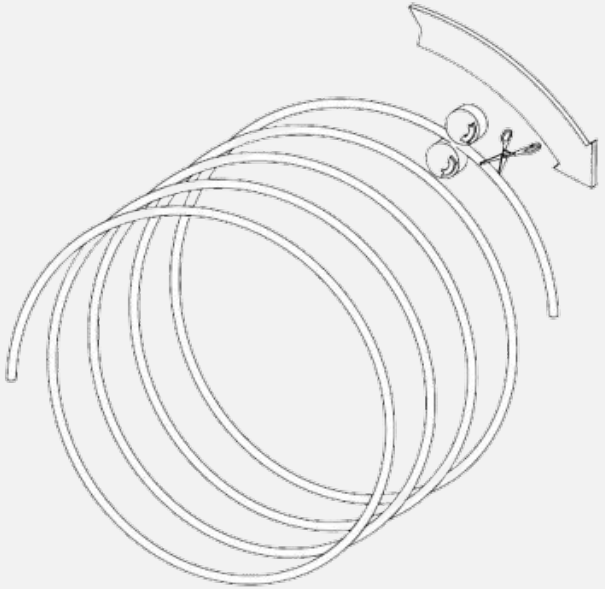
- ✔ Tail-trimming vs. head trimming
- ✔ Worst possible location, speed > 100 m/s
- ✔ Sampling is not possible
- ✔ Need a manual trimming station to finish the job

What's required of a new process

- Exact location of the absolute end of the ring
- Exact measurement to the trimming position
- Exact cut-position

Introducing a process of accuracy

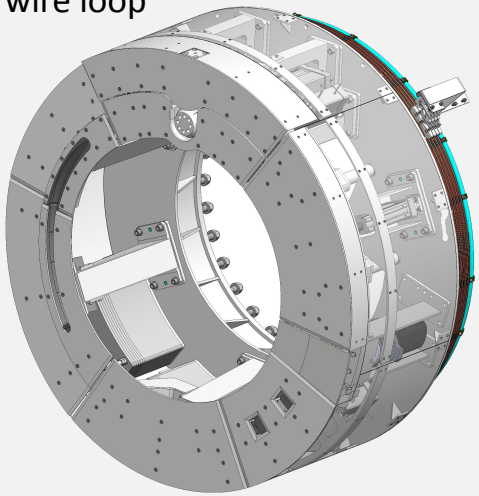
- Follow the natural circular shape of the coiled wire
- Find the end of the coiled wire
- Active measurement along the length to the coiled wire
- Find the exact position along the coiled wire loop to make the cut
- Make an accurate cut at the exact position



The new process requires a new machine to perform the different process-steps.

The Ring Processing Turret is a circular guide with:

- ✔ Ability to rotate the entire machine around the axial center of the coiled wire loop
- ✔ Capability to receive a wire loop into pinch-roll assembly
- ✔ Capacity to move in a circular motion without damaging the wire loop
- ✔ Sensor capacity to detect & identify the end of the wire
- ✔ Sensor capacity to measure distance along the wire loop
- ✔ Sensor capacity to measure wire surface, diameter & ovality
- ✔ Shear capacity to cut a wide range of wire diameters
- ✔ Capability to isolate the trimmed scrap from the rest of the coil
- ✔ Capacity to collect a sample
- ✔ Ability to discard the scrap rings & unload the sample

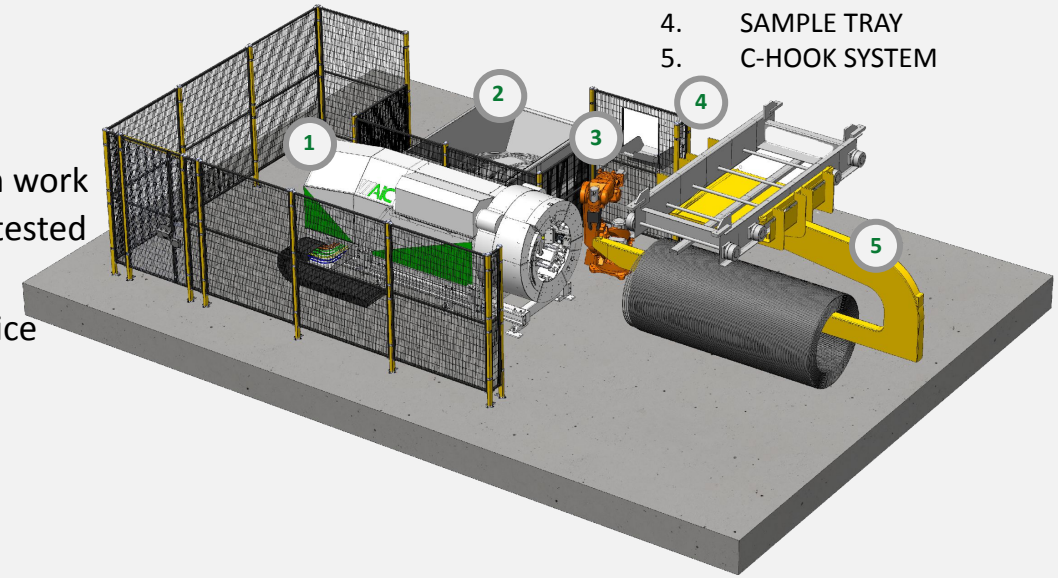


The new system must be attractive to the market.

The TRIMBOT system must be:

- ✔ SAFE !
- ✔ Easy to install
- ✔ Quick to commission & start-up
- ✔ 100% electrical
- ✔ Easy to ship and handle on site
- ✔ Not require any excavation or foundation work
- ✔ Arriving to site pre-assembled and shop tested
- ✔ Able to fit in a relatively small area
- ✔ Easy to trouble-shoot, maintain and service

1. TRIMBOT MACHINE
2. SCRAP BIN
3. ROBOTIC ARM
4. SAMPLE TRAY
5. C-HOOK SYSTEM



The new solution must be inexpensive to purchase, install & operate, and increase yield

(numbers below based on annual 500k ton production, 2 t coil, Ø10 mm & average trim accuracy)*)

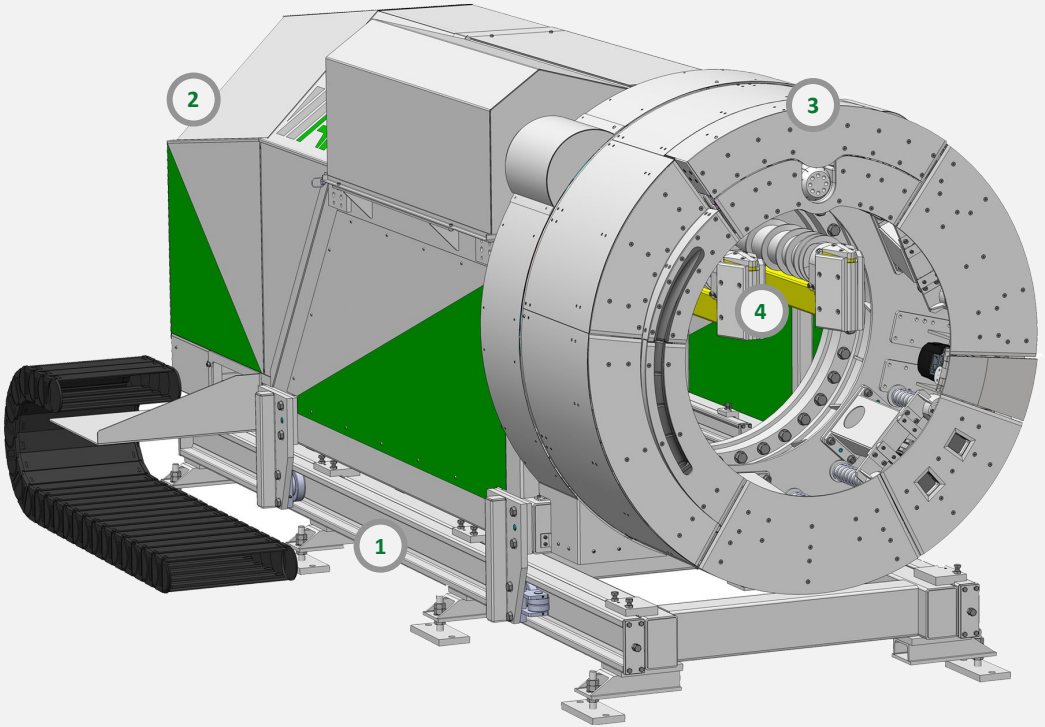
TRIMMING METHOD	TRIMMING LOCATION	TRIM ACCURACY		EXCESS TRIMMING YIELD LOSS	EXCESS TRIMMING SCRAP
		Head trim [mm]	Tail trim [mm]		
High Speed Trim Shear (HSS)	After finishing mill, before loop forming device	+/- 100 - 500	+/- 100 - 500	0.01482%	74.1 ton
Manual trimming on cooling conveyor	After loop forming device - before coil collection tub	+/- 6750	+/- 6750	0.16756%	837.8 ton
Manual ring-counting trimming on Vertical Pallet	In pallet system, after coil collection, before compactor	N/A	N/A	N/A	N/A
Manual ring-counting trimming on C-hook system	In hook system, after coil collection, before compactor	+/- 6750	+/- 6750	0.16756%	837.8 ton
TrimBot trimming on Vertical Pallet	In pallet system, after coil collection, before compactor	+/- 5	+/- 5	0.00025%	1.2 ton
TrimBot trimming on C-hook system	In hook system, after coil collection, before compactor	+/- 5	+/- 5	0.00025%	1.2 ton

TRIMMING METHOD	ASSOCIATED COST [$]				
	CORE EQUIPMENT	SITE PREPARATION	INSTALLATON	OPERATIONAL TRIMMING COST	OPERATIONAL SAMPLING COST
High Speed Trim Shear (HSS)	400k	200k - 1M	100k - 200k	N/A	N/A
Manual trimming on cooling conveyor	< 50k	< 50k	N/A	50k - 200k	included in trimming
Manual ring-counting trimming on Vertical Pallet	N/A	N/A	N/A	N/A	N/A
Manual ring-counting trimming on C-hook system	< 50k	< 50k	N/A	50k - 200k	included in trimming
TrimBot trimming on Vertical Pallet	500k	< 50k	< 50k	< 30k	included in trimming
TrimBot trimming on C-hook system	500k	< 50k	< 50k	< 30k	included in trimming

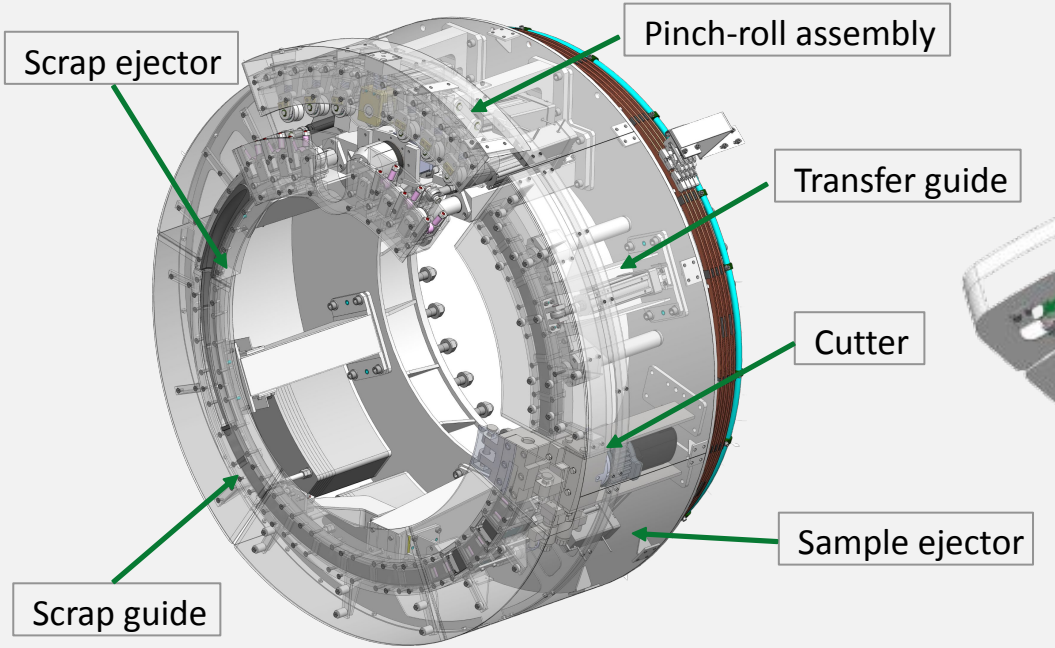
*) Strictly theoretical and not based on actual empirical data

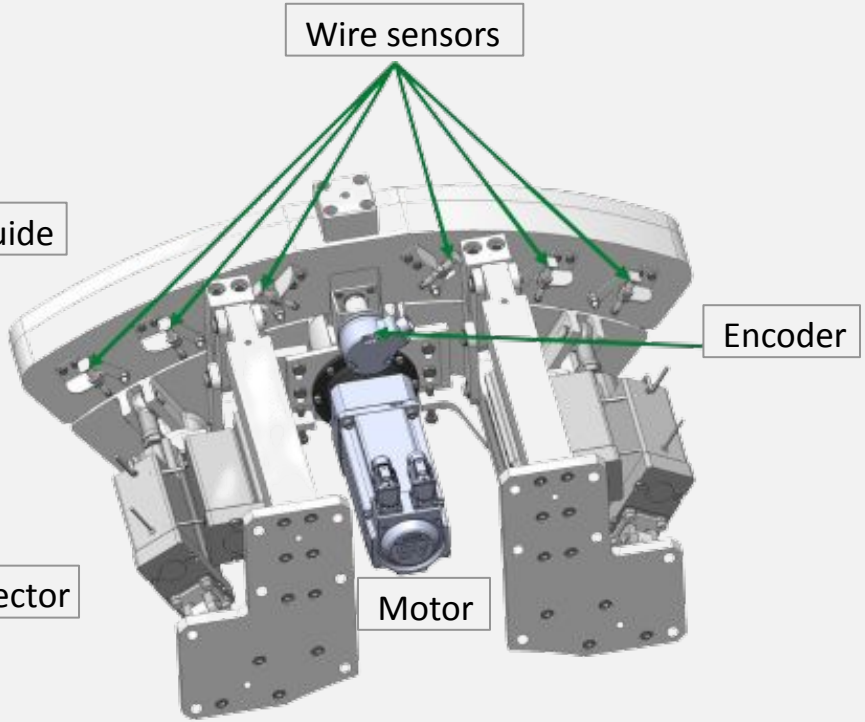
The new machine consists of the following main assemblies:

1. Rigid base frame
2. Main trolley
3. Ring processing turret
4. Internal ring-transfer trolley

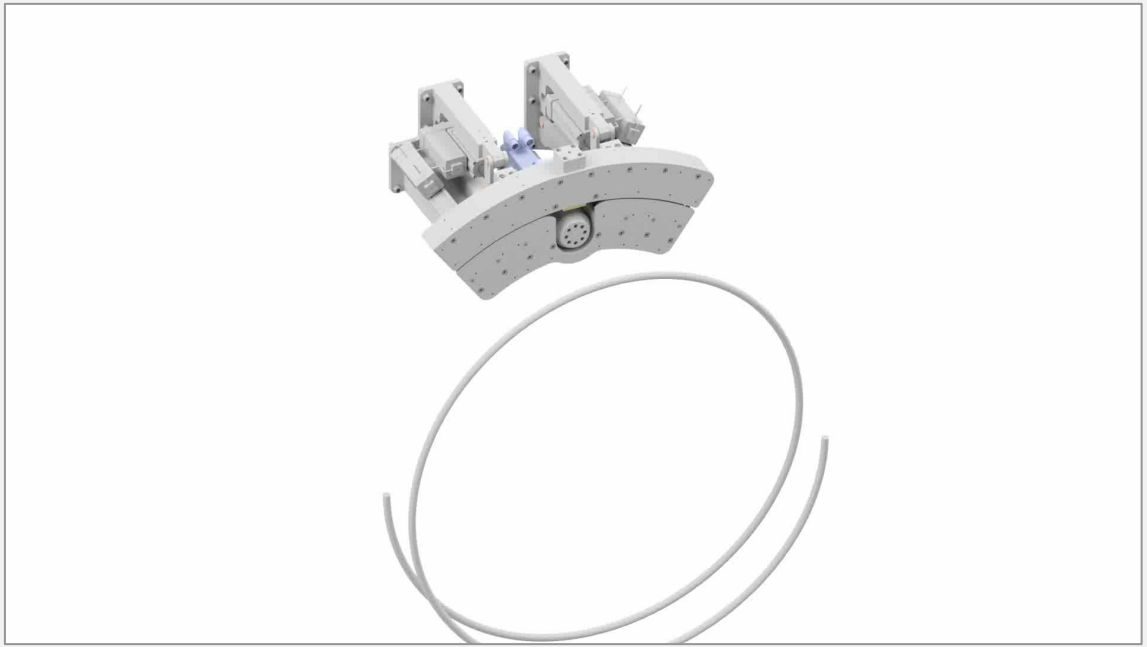


The **Ring Processing Turret**:



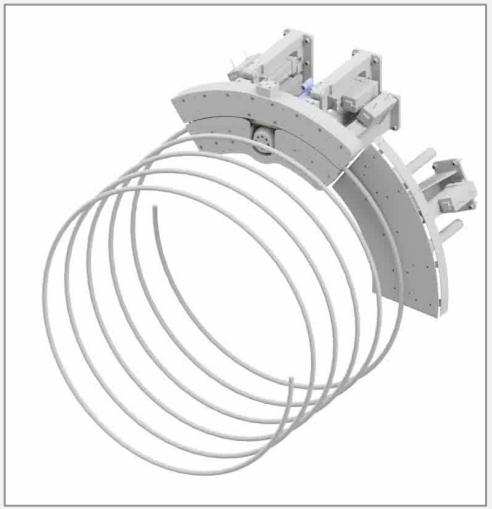


The **Ring Processing Turret Sequence**: Loading wire into Pinch-Roll Assembly

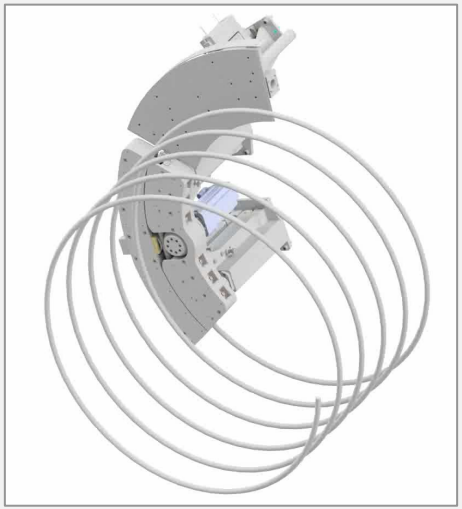


The **Ring Processing Turret Sequence**:

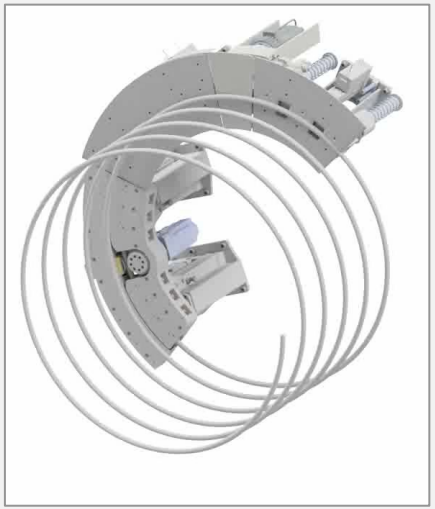
Find End

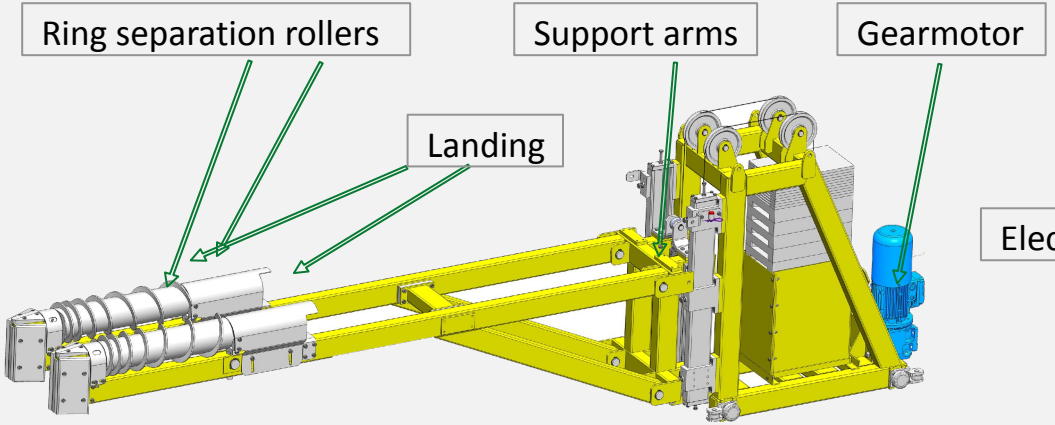


Extend Transfer Guide

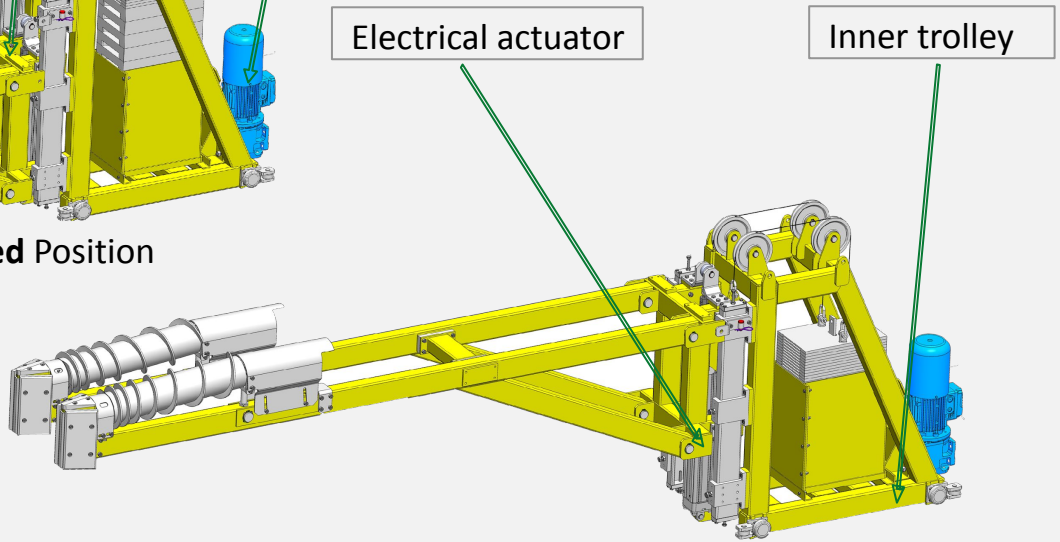


Measure to Cut Position





Internal ring transfer trolley – **Lowered** Position

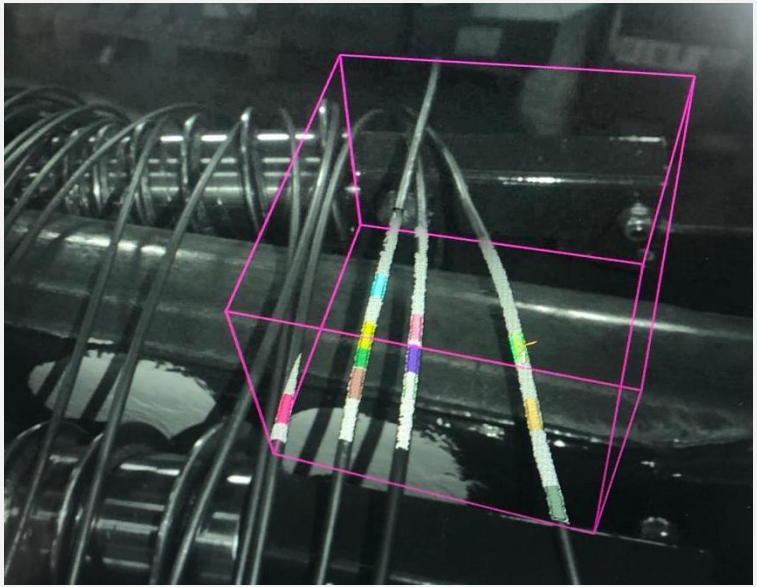


Internal ring transfer trolley – **Raised** Position

INTERNAL RING TRANSFER TROLLEY

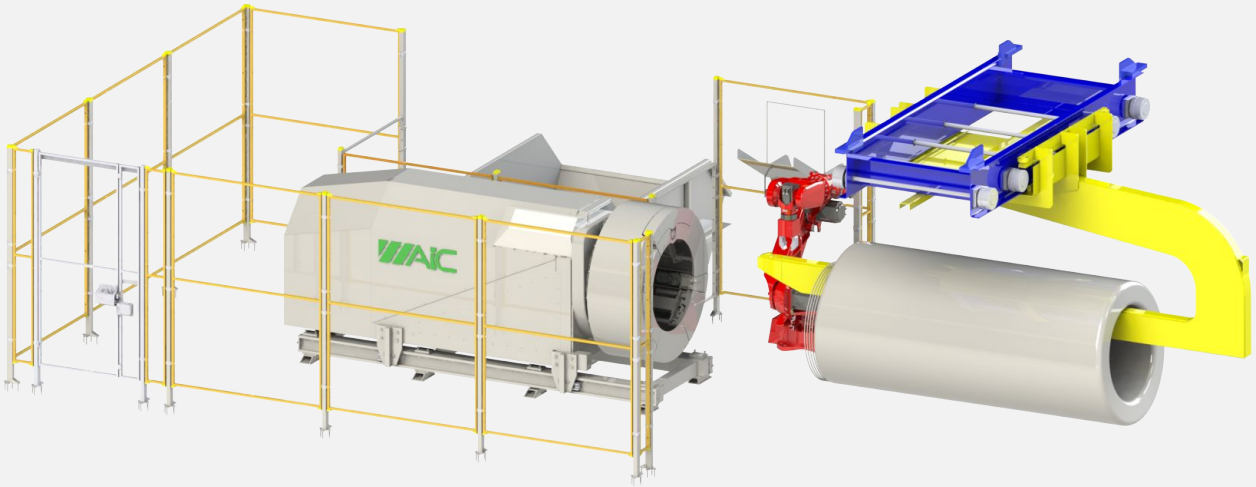
VISION SYSTEM

Rings distributed on separating rollers

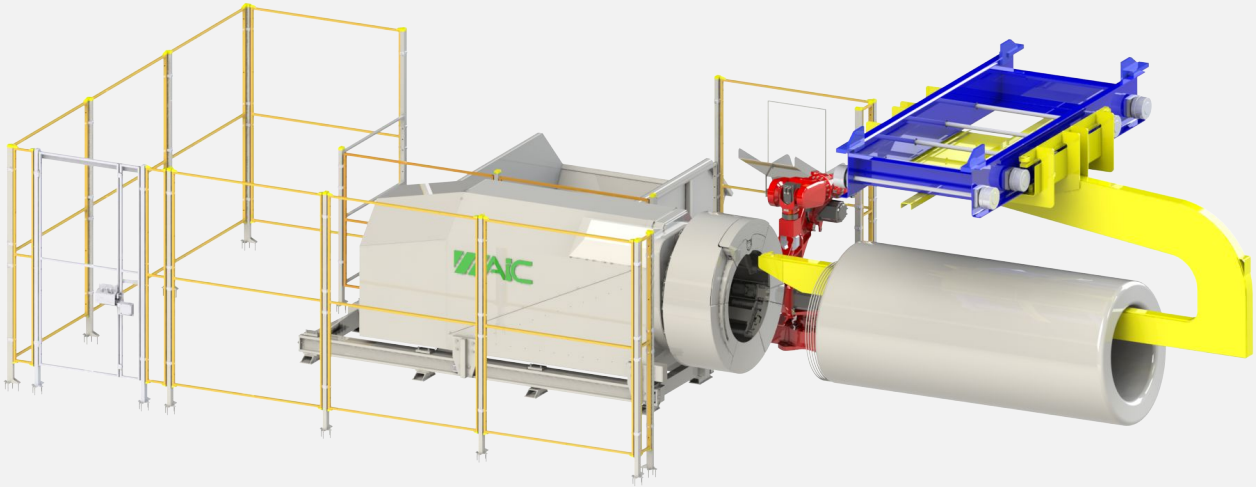


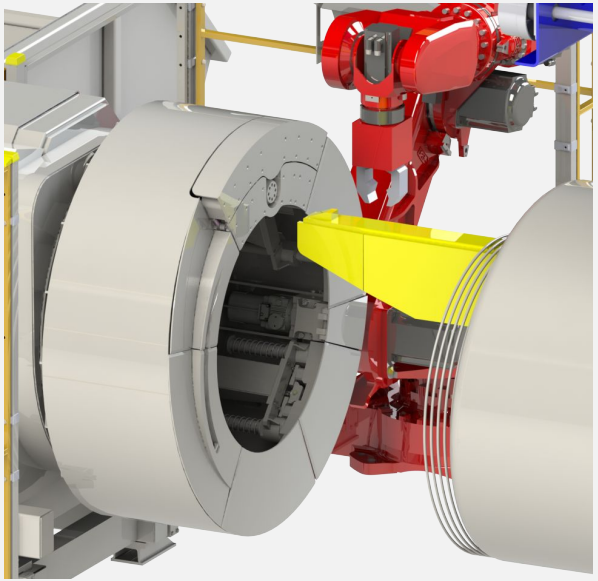
Same rings through the vision system

Step 1 – Hook with coil arrives at trimming station, hook centered & locked in position



Step 2 – TRIMBOT Move forward

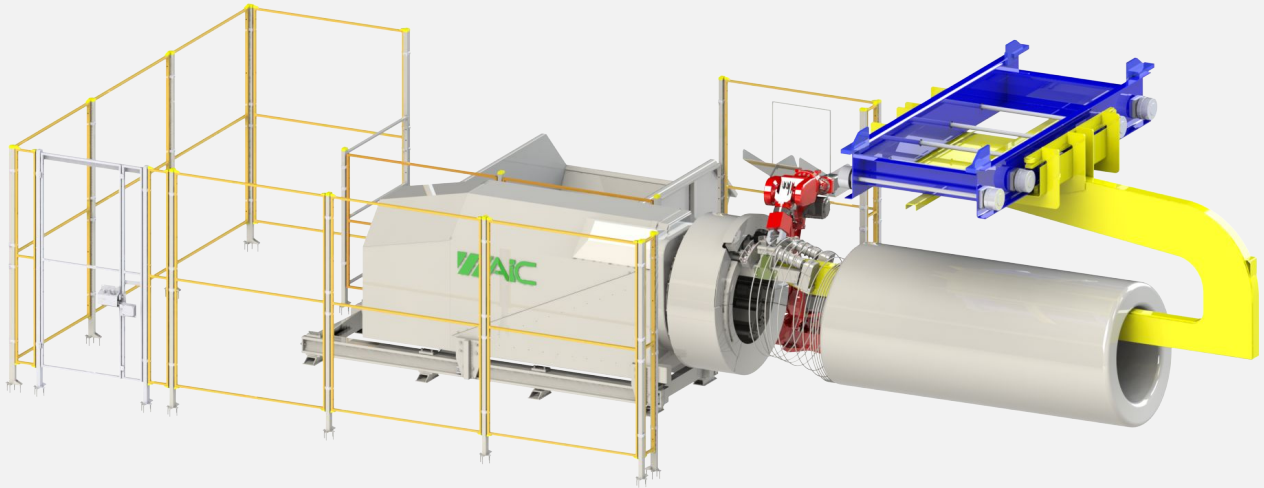




Step 3 – Separating arms extend, lift and pull forwardmost rings towards RPT.

– Vision system identify ring to be collected by robotic arm

– Selected loop placed in extended receiving guide



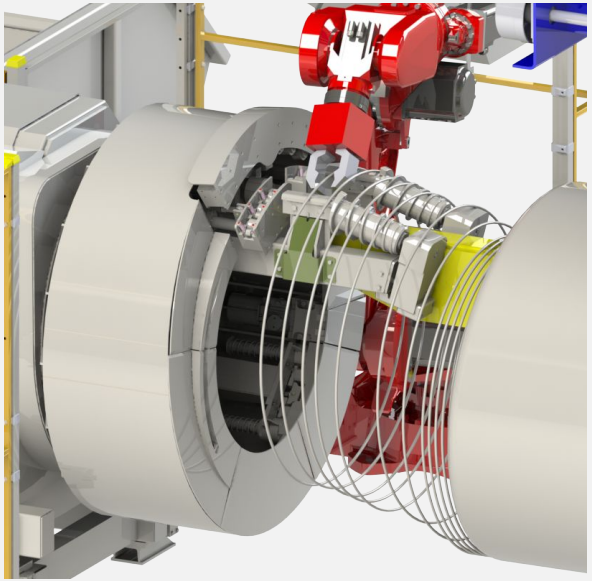
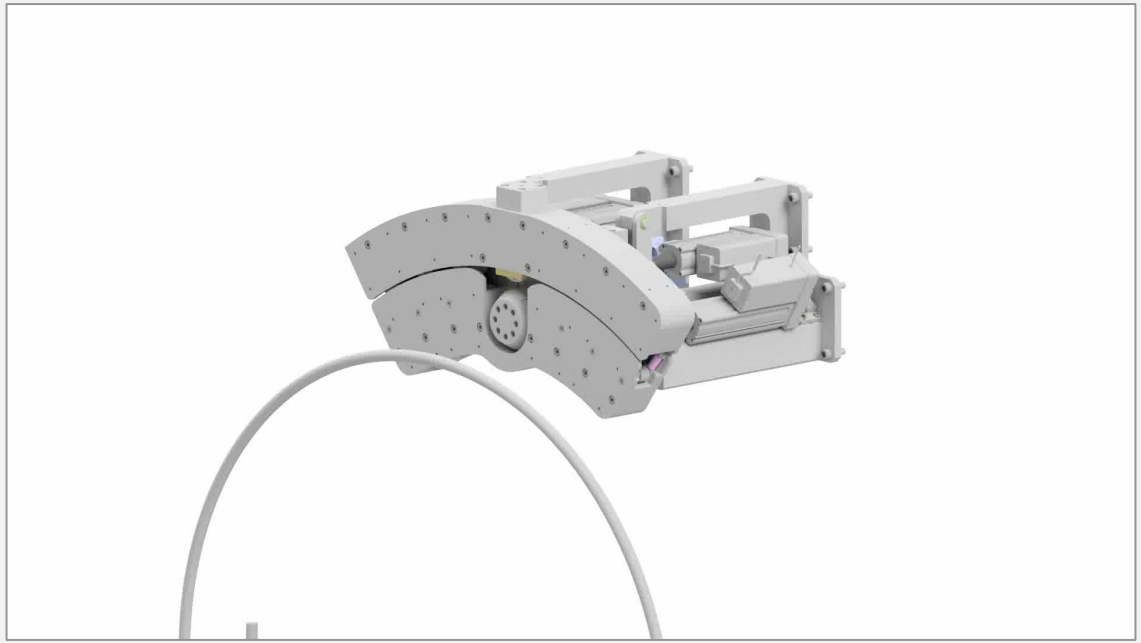
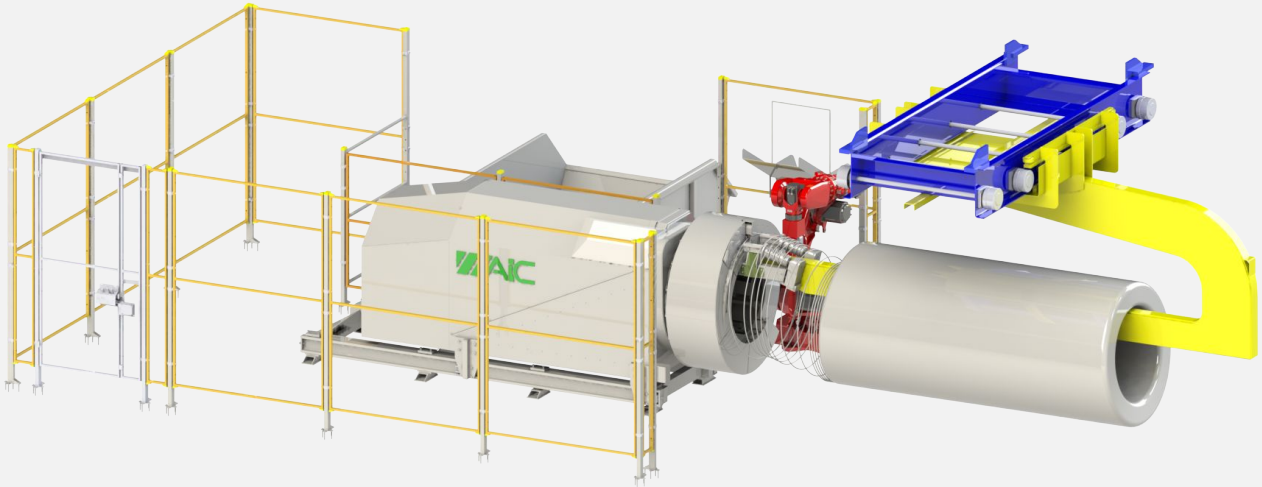


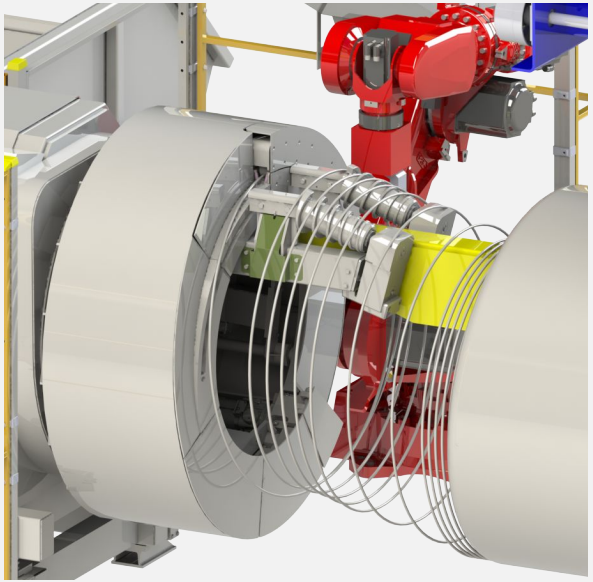
Illustration of pinch-roll open, wire being placed into receiving guide & pinch-roll closing



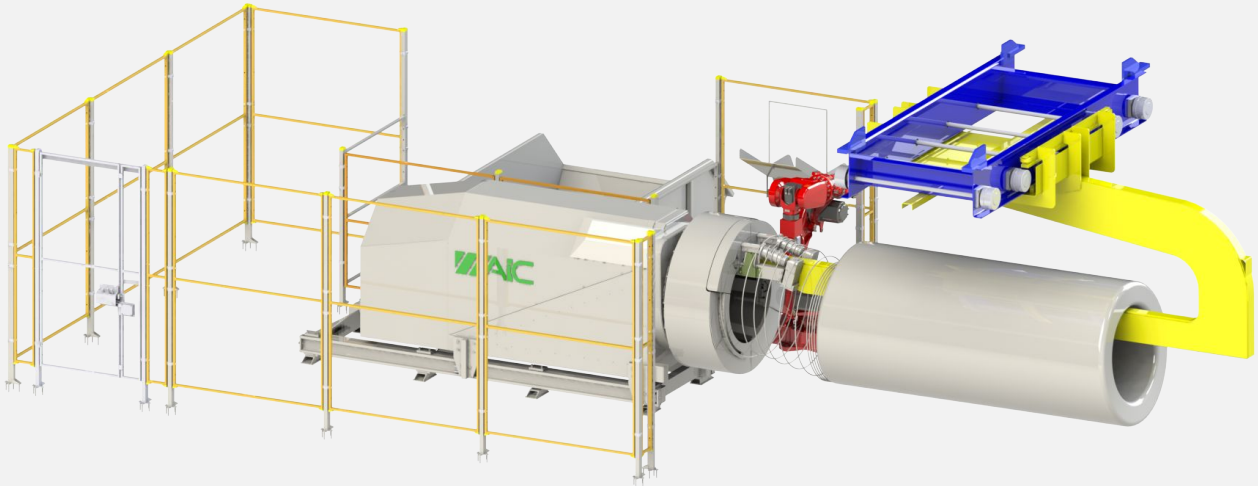
Step 4 – Ring Processing Turret begin rotating CCW until sensor #1 loose contact

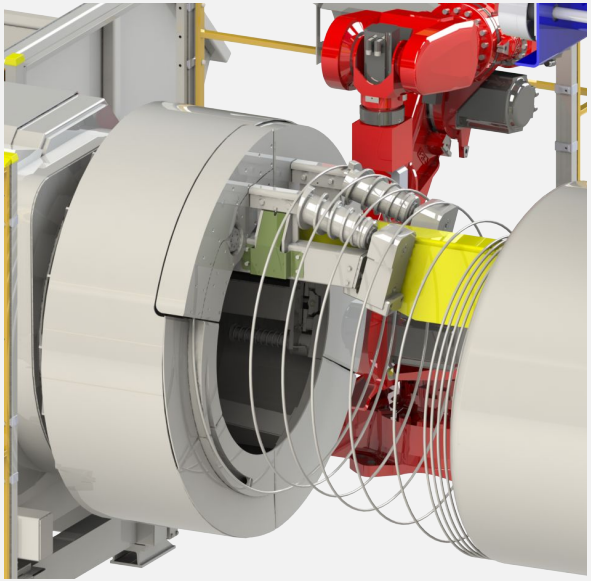
– RPT slows down until sensor #2 loose contact



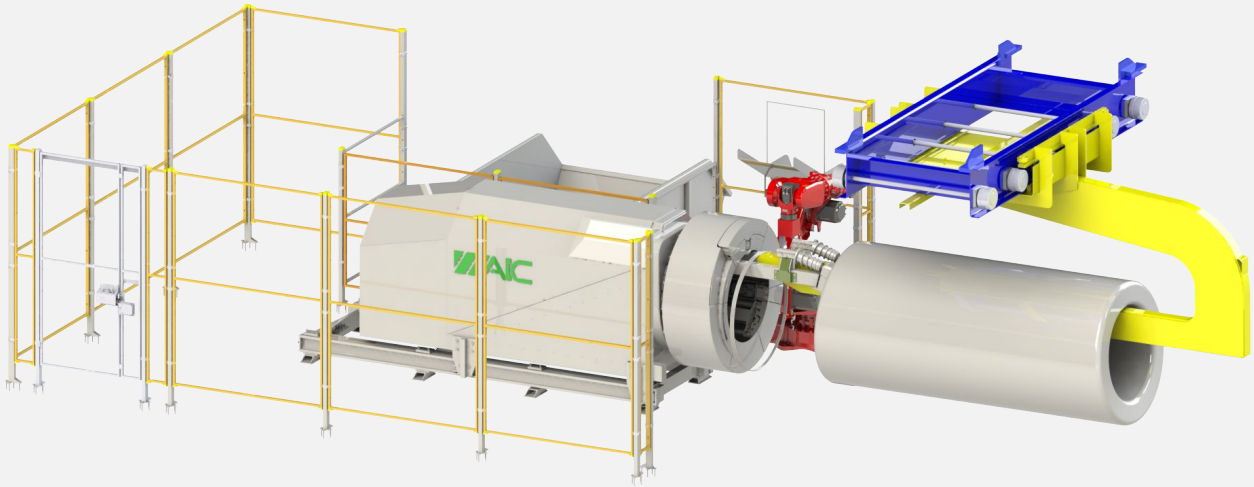


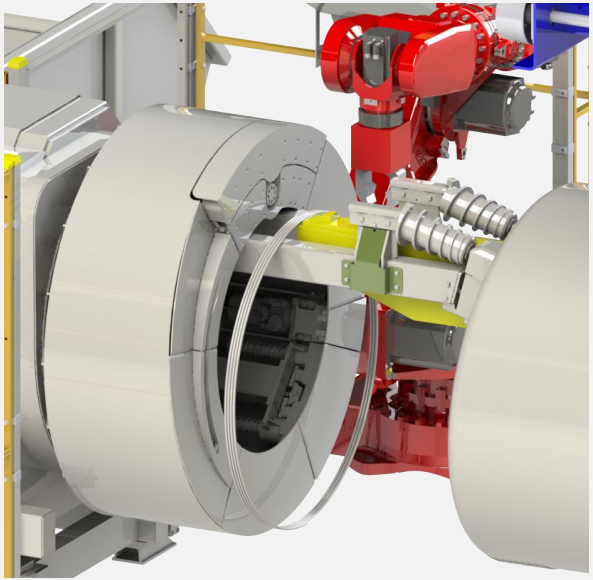
Step 5 – RPT stops, encoder reset, transfer guide extend
– RPT begin rotating CW until sensor #1 is engaged
– Encoder begin to measure distance
– RPT speed-up, scrap-wire exits onto extended arms



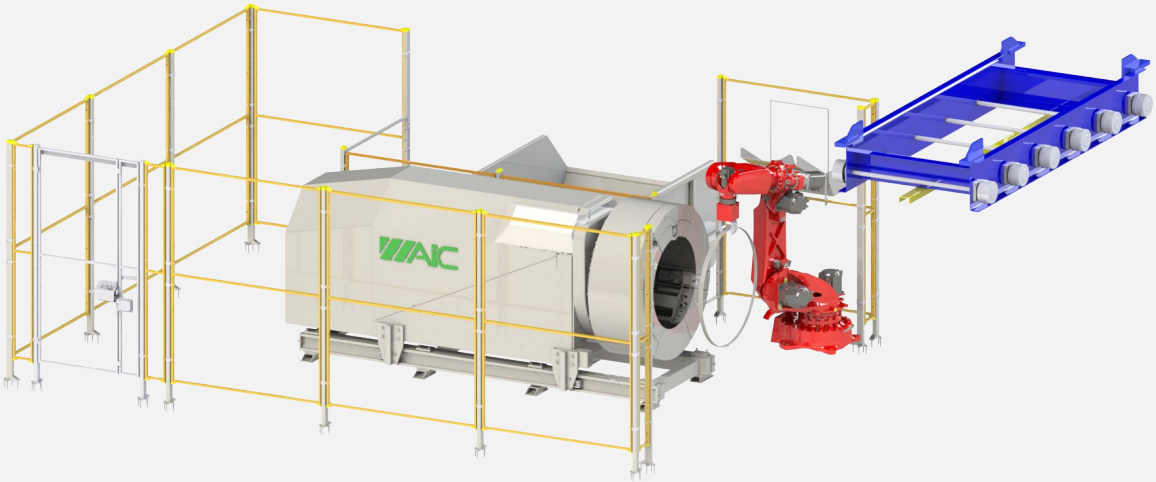


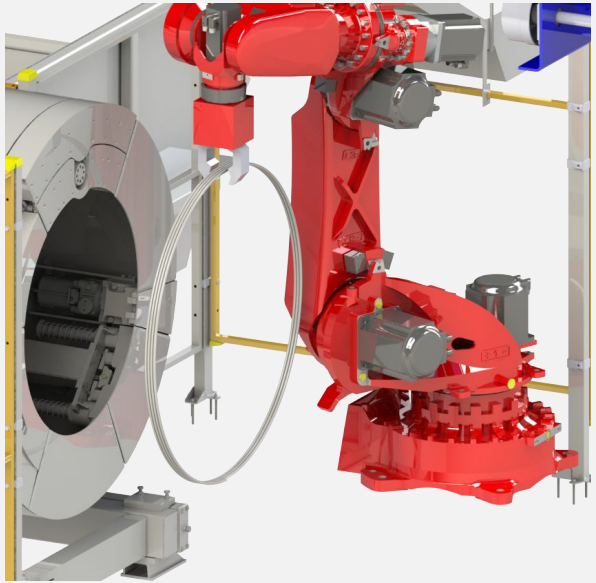
Step 6 – Upon reaching the cut-location, the RPT stops
– Cutting tool engage, wire is cut
– Separating rollers reverse & separating arms move trimmed wire end back to C-Hook



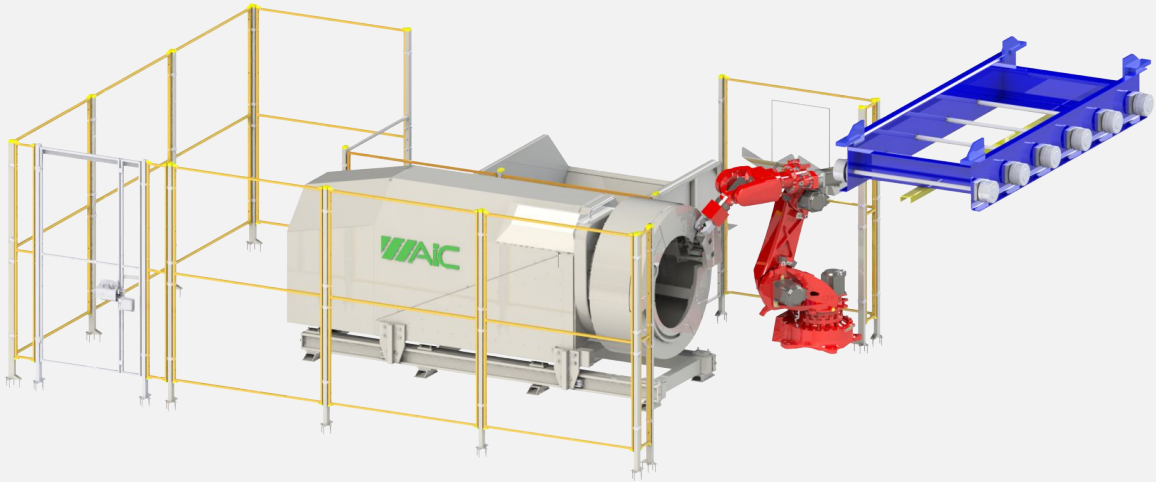


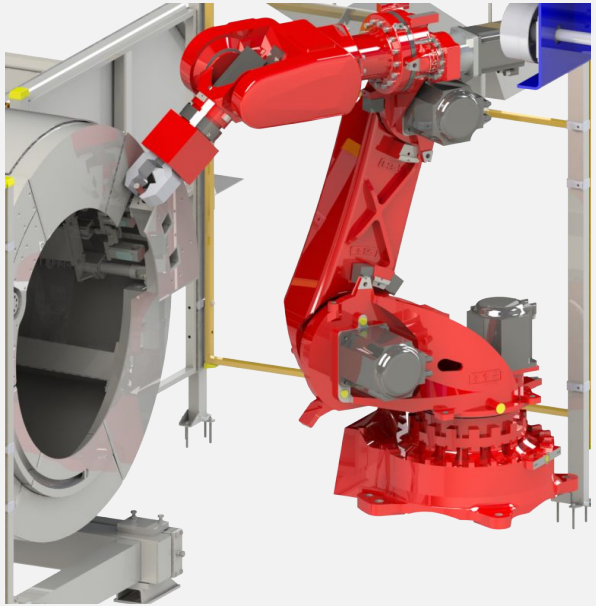
Step 7 – TRIMBOT reverse to unload position, C-hook is released
– Robotic arm grab, lift and remove scrap rings & place them in discard container



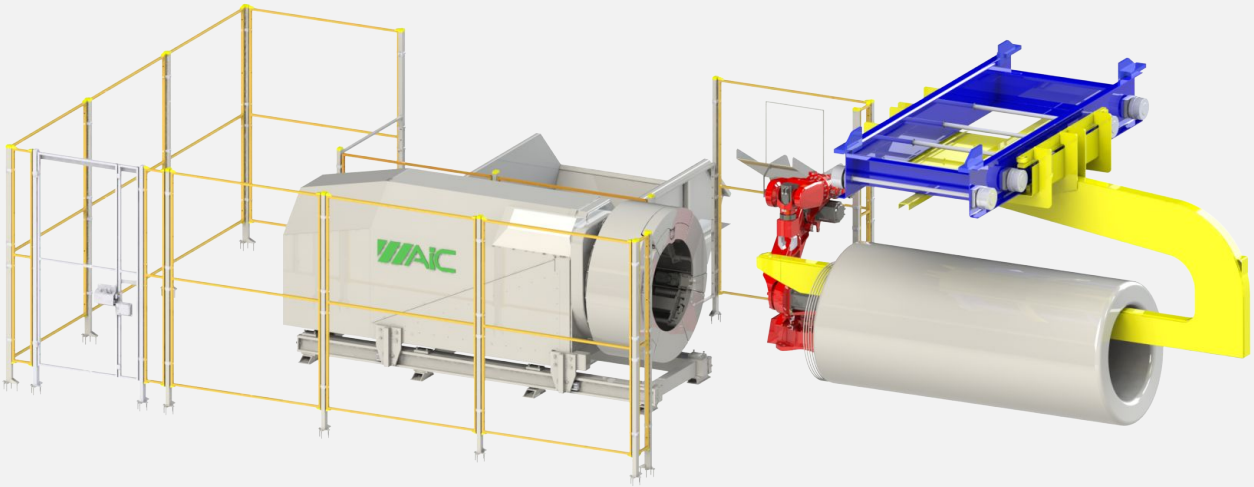


Step 8 – Sample guide extends. Exposed sample is collected by Robotic arm & placed in sample tray





Step 9 = Step 1 – Next Sequence

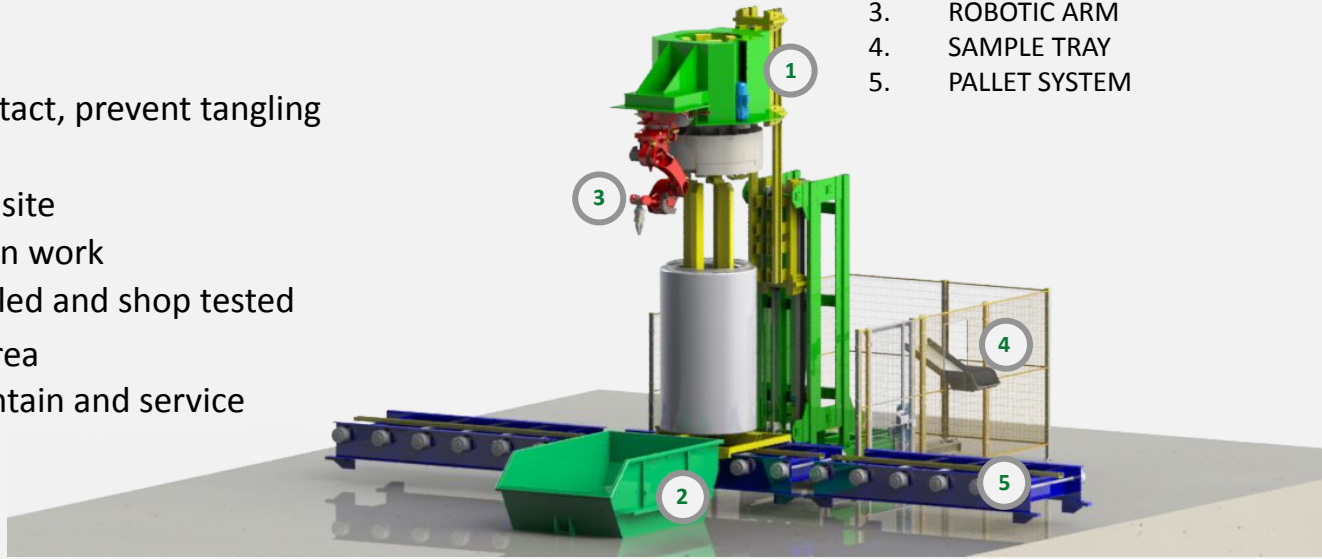


Vertical trimming & sampling

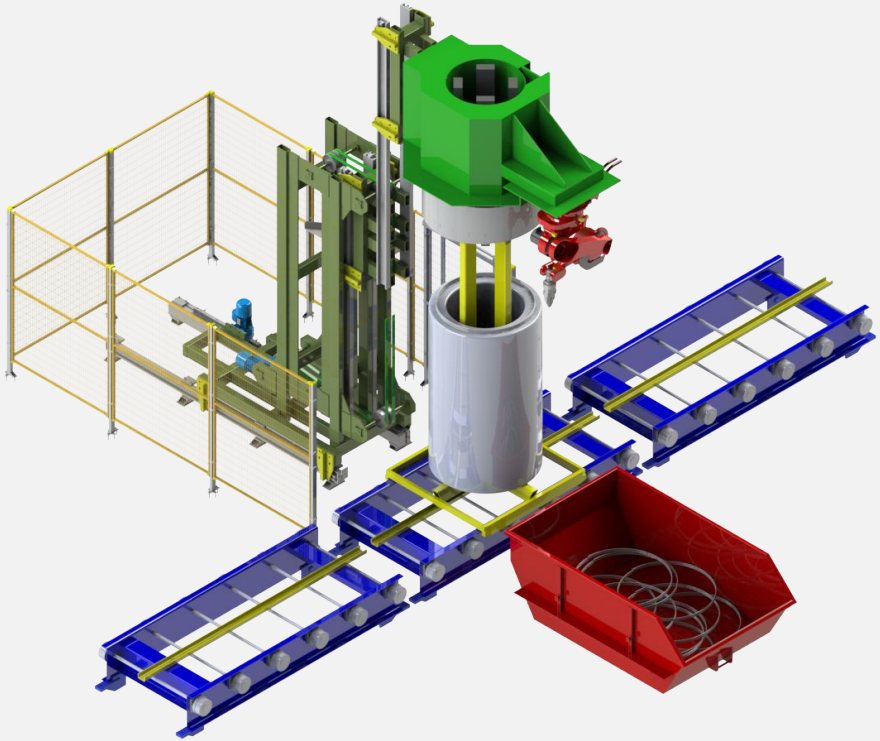
The vertical TRIMBOT configuration introduce new possibilities:

- ✔ Immediate trimming & sample after exiting from reform station
- ✔ Rapid Upset Test
- ✔ Short cycle-time
- ✔ Coil loop-pattern remain intact, prevent tangling
- ✔ 100% electrical
- ✔ Easy to ship and handle on site
- ✔ No excavation or foundation work
- ✔ Arriving to site pre-assembled and shop tested
- ✔ Able to fit in a very small area
- ✔ Easy to trouble-shoot, maintain and service

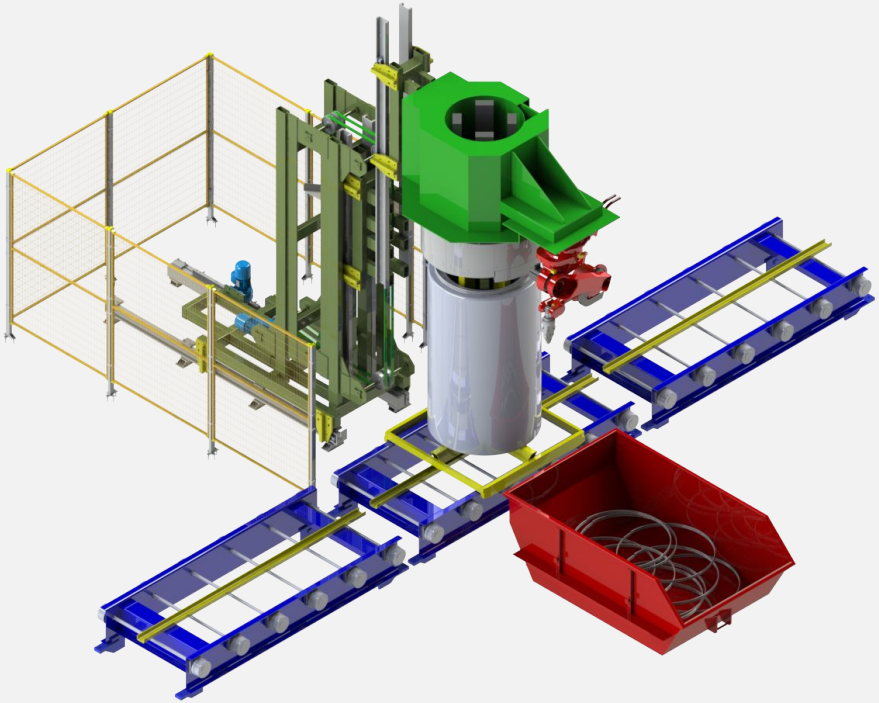
1. TRIMBOT MACHINE
2. SCRAP BIN
3. ROBOTIC ARM
4. SAMPLE TRAY
5. PALLET SYSTEM

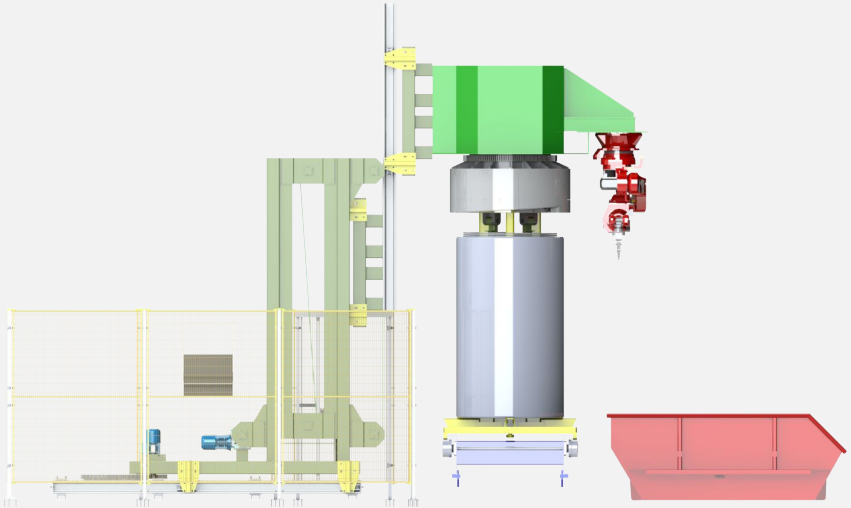


Step 1 – Pallet with coil arrives at trimming station, pallet centered & locked in position

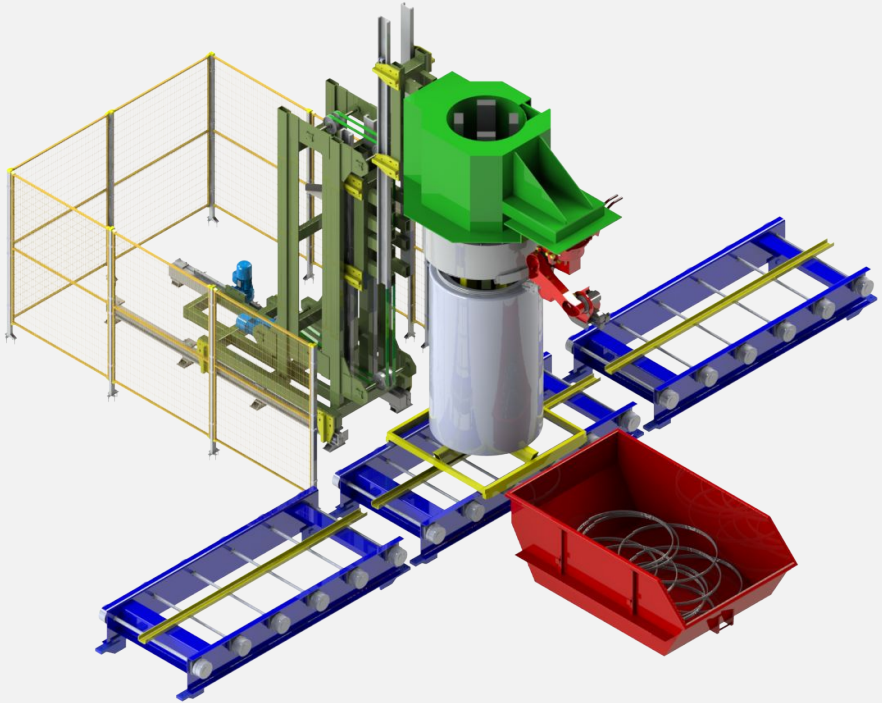


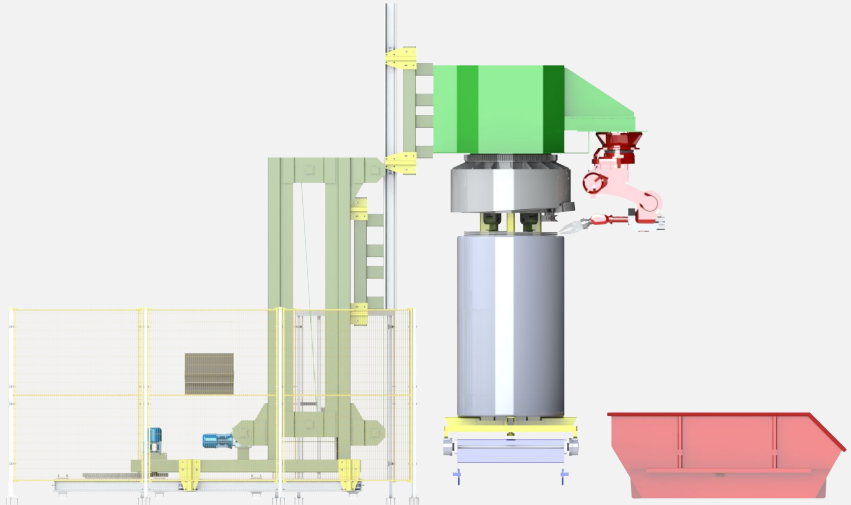
Step 2 – TRIMBOT Move down, toward coil



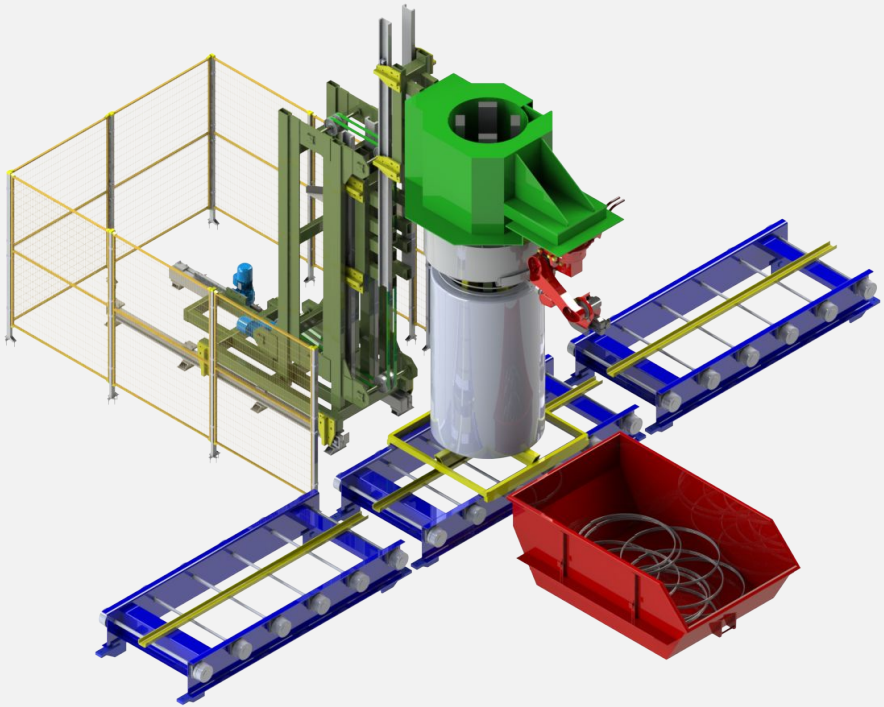


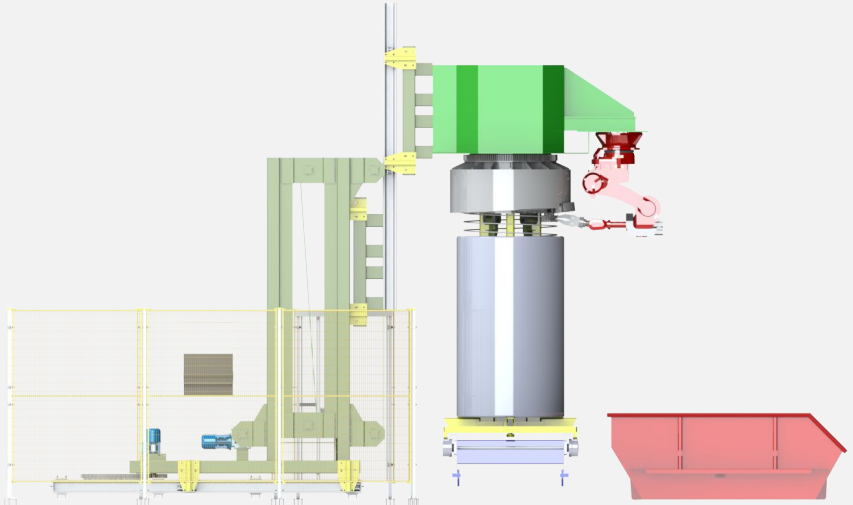
Step 3 – Robotic arm & vision system identify a ring and pinch-roll & receiving guide open



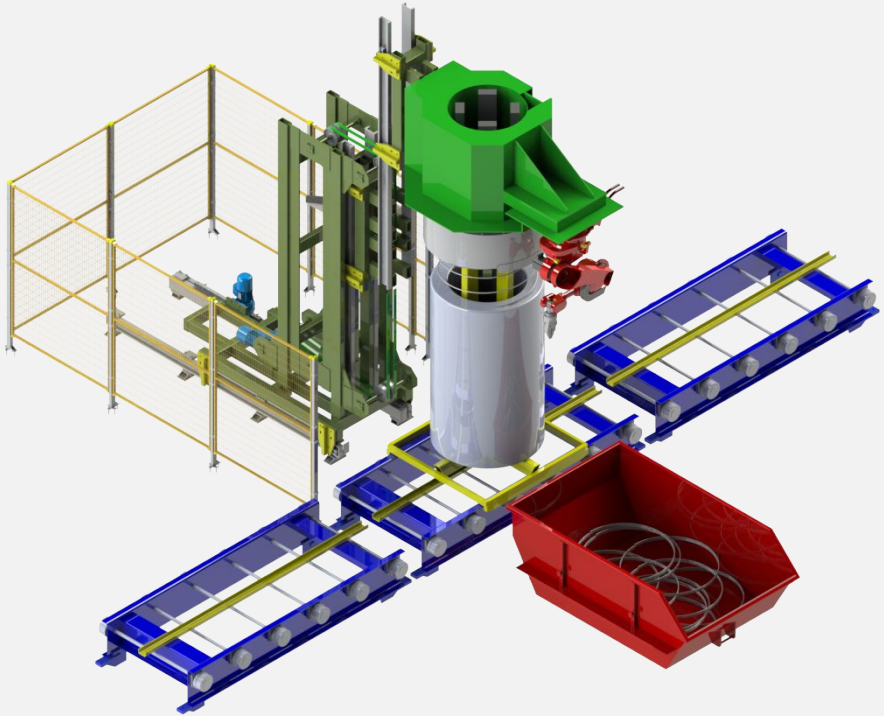


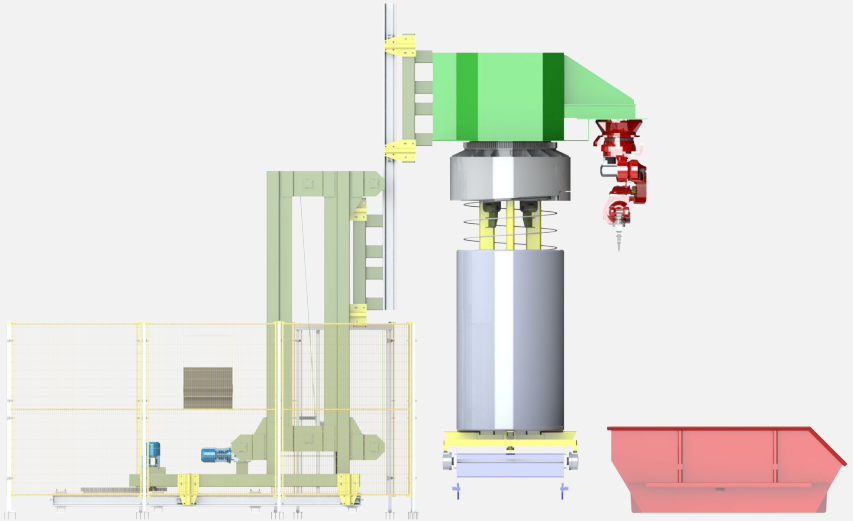
Step 4 – Robotic arm pick the selected ring and places it in extended receiving guide



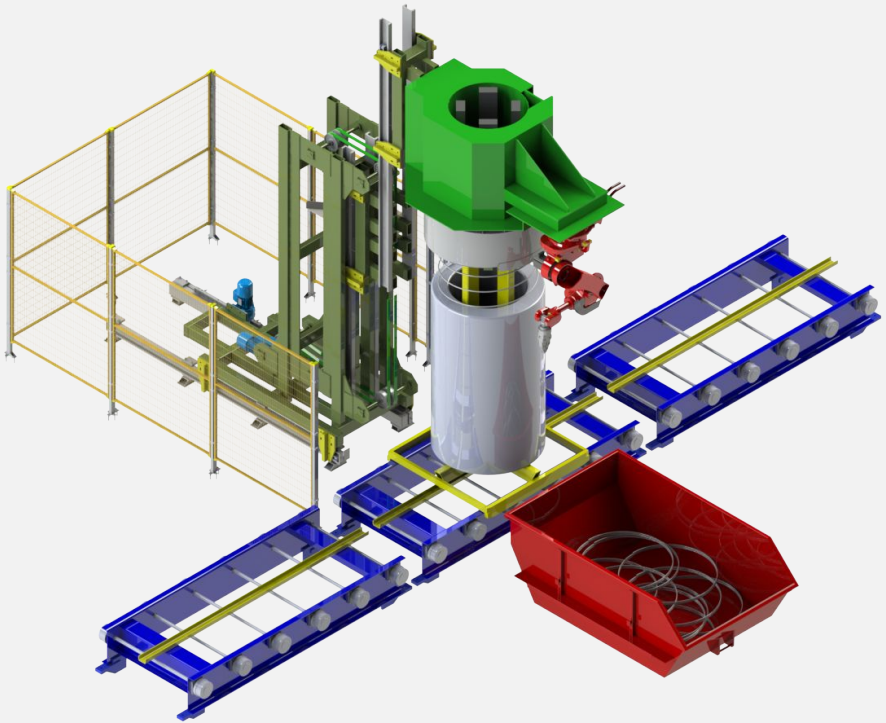


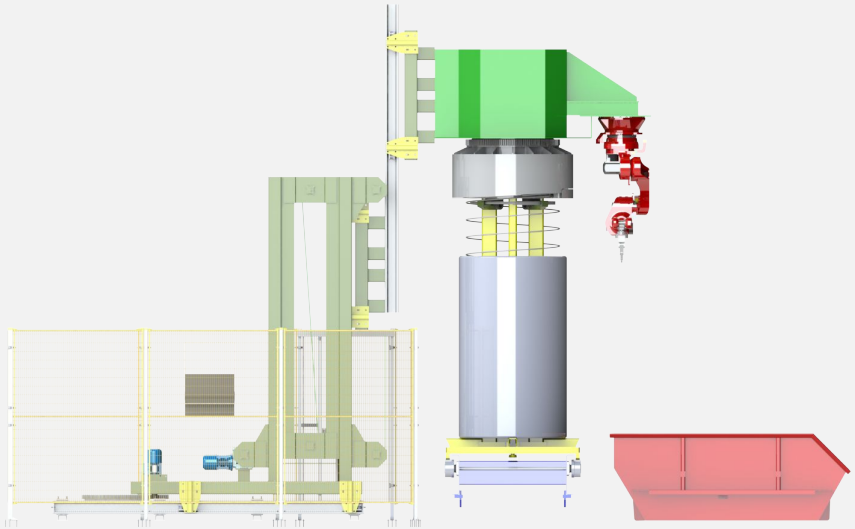
Step 5 – Ring Processing Turret (RPT) begin rotating CCW until wire-end is located



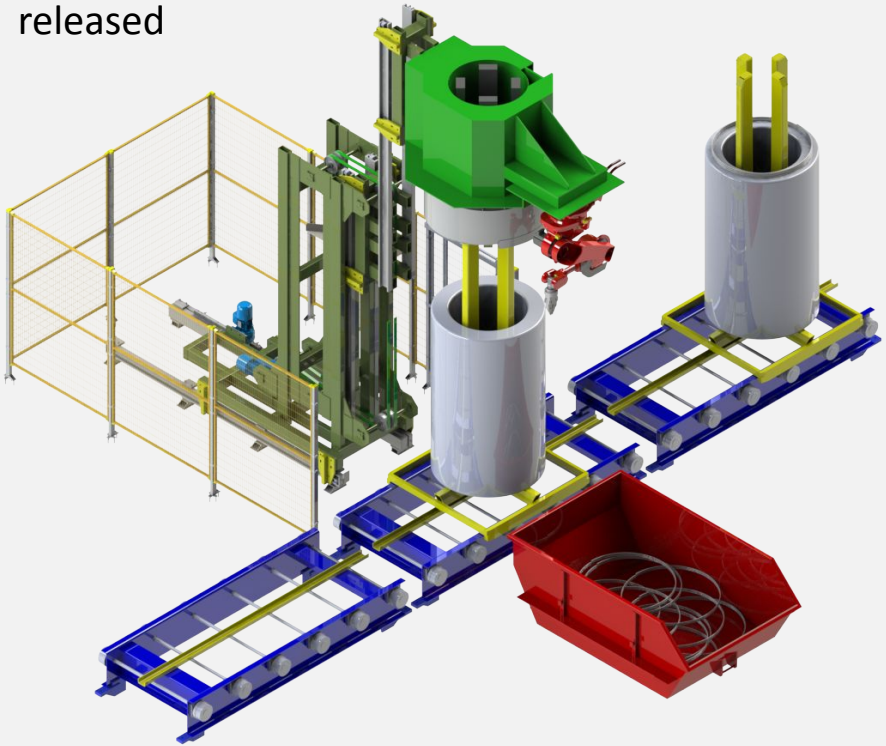


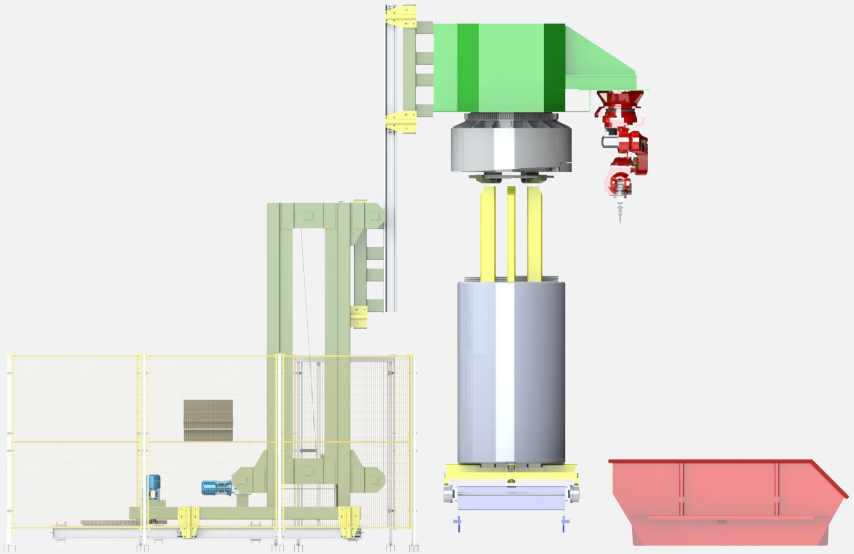
Step 6 – Ring Processing Turret begin rotating CW until the cutter reach the cut-position
– Wire is cut



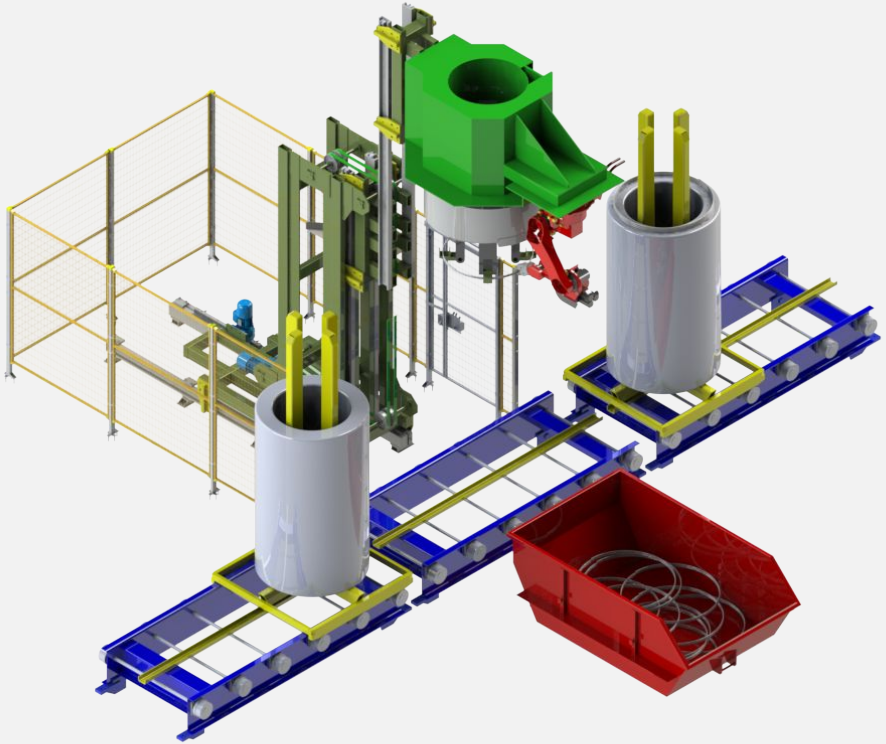


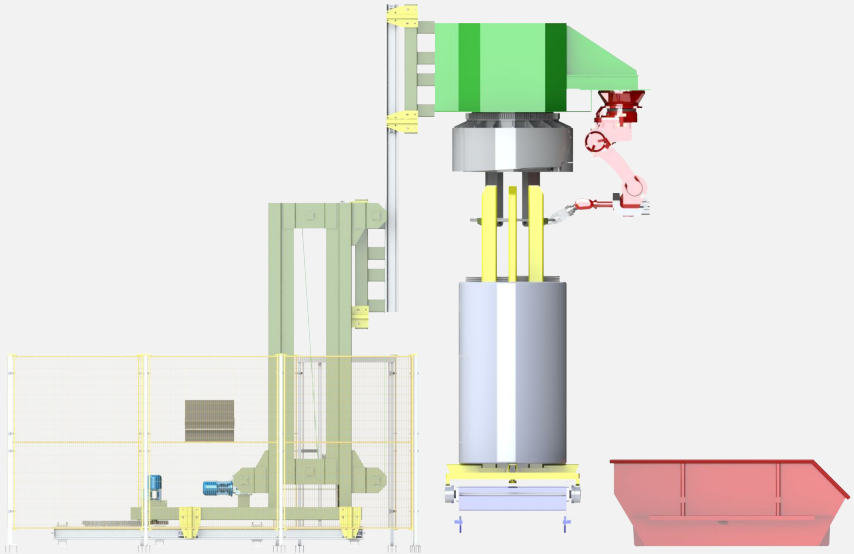
Step 7 – TRIMBOT releases the trimmed coil & move up, away from coil, pallet is released



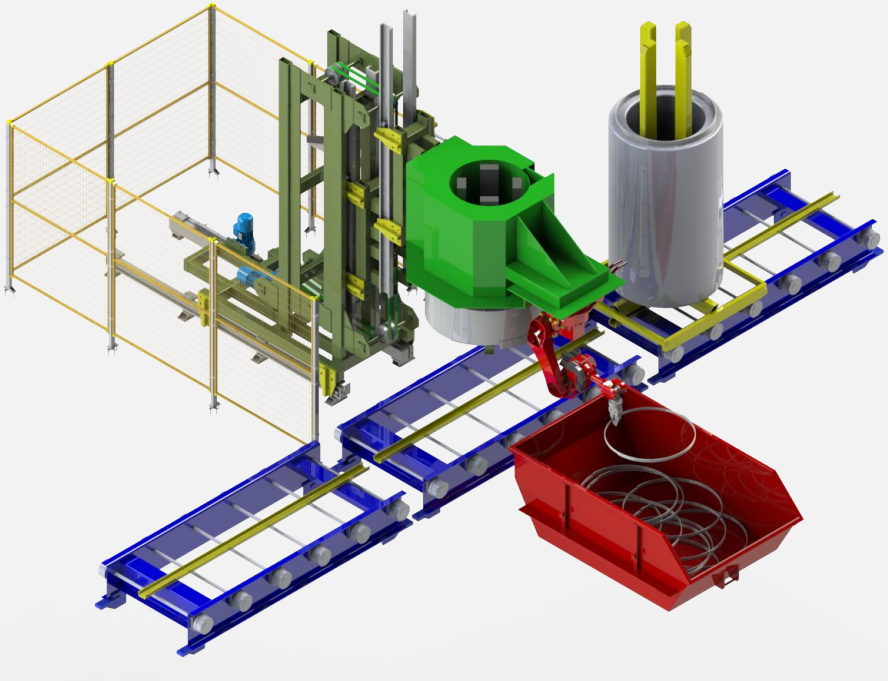


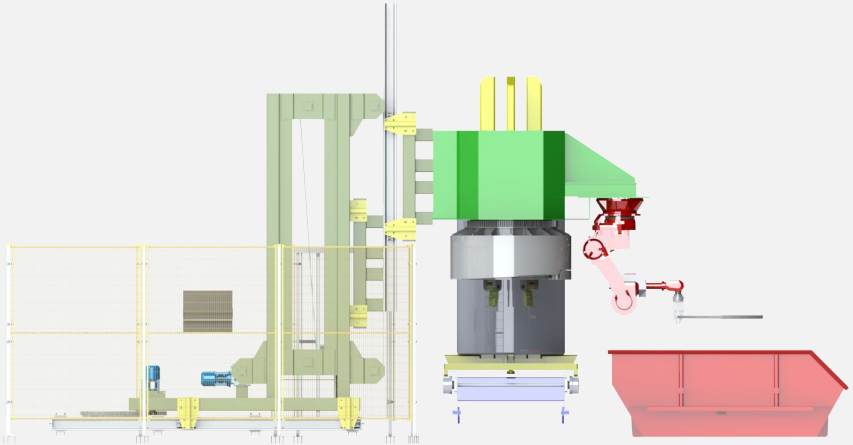
Step 8 – Scrap retaining arms extend, robotic arm picks up the trimmed rings





Step 9 – Scrap retaining arms release rings, TRIMBOT lowers and robotic arm places rings in scrap container





The **TRIMBOT** technology:

- ✔ Eliminates the dependance of human operators at existing trimming & sampling process
- ✔ New coil handling system can be more compact, requiring smaller building-area
- ✔ Reduces scrap & Increases yield
- ✔ Introduces **Dynamic Trimming**, the ability to adjust the length of the trimmed wire based on actual rolling conditions, for each coil.
- ✔ Performs real-time measurements on wire surface & cross section shape
- ✔ Enable trimming & sampling while coil is vertical
- ✔ Creates opportunity to develop new processes without humans

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