DANIELI COLD PROCESSING TECHNOLOGY: INNOVATIVE APPROACHES FOR NEW LINES AND UPGRADES *

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Abstract
Optimized CAPEX, OPEX, new products, yield and product quality in new process equipment as well as by upgrading of existing facilities are the key factors for success and profitable operation. For this, innovation in processes and design is crucial. Danieli can support their clients by offering innovative and well-thought-out process equipment and upgrade solutions. In 2018, Danieli has put into operation a complete cold processing complex in Turkey, which includes a new continuous pickling tandem mill featuring latest generation of market oriented technologies. In this line, dedicated to run a broad range of size and grades (IF to AHSS as DP1000), the highly efficient Turboflow® pickling process was selected. This technology already proved its efficiency and ability in former applications handling ultra-thin gauges at speeds even exceeding 400 m/min in the pickling tanks. The 5-stand 6-high OSRT tandem mill features important developments, like actuators to improve significantly strip flatness and a special air knife arrangement on the tandem mill exit side to generate perfect strip surface cleanliness. In galvanizing lines, the zinc pot is the most effective area to reduce costs in operation and consumables and increase the product quality. Danieli has spent significant efforts in developing most advanced technology for the wiping process. A fully integrated system solution has been designed to perform a wiping process with high quality, economy, accuracy and productivity. Center part is the newly developed X-Jet / Compact X-Jet air knife, added by new generation electromagnetic stabilizer as well as robotic systems to reduce human intervention and health risks in this area. This technological package is ideal also for upgrade of existing lines, typically generating a return of investment less than 1 year. On top, Danieli has developed advanced automation systems including L2 and L1 controls to achieve outstanding product performances.
Keywords: Pickling Line, Tandem Cold Mill, Turboflow, AHSS, PLTCM, X-Jet Air knife, Galvanizing.

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1 INTRODUCTION

Danieli's experience in flat products has deep roots as Wean and United, two former American companies that were known worldwide and undisputed pioneers of rolling and strip processing technology and which are now belonging to our organization. Our commitment to this field has been to invest day-by-day in innovation, not only to preserve and confirm the extraordinary work done by Wean and United in earlier days, but also to improve the already reliable design concepts by putting strong emphasis on process technology and automation.
In-depth study of the steel markets, new design solutions for ease of operation and maintenance, implementation of new technology via live measurements, automation algorithms and new actuators make Danieli the answer to customer needs for highest product quality and newest technology in cold mills and processing line.
Our primary mission is to supply to our customers, our partners, the most up to date and cutting edge technology for Cold Mill Complexes, fully optimized for CapEx and OpEx, and ready to produce high-quality steel coils.

Within the Danieli Globe a number of companies and product lines are working together in team up for the cold flat industry, sharing the ideas and knowledge to each other and with our customers.
Our product portfolio ranges today from cold mills and processing lines with Danieli Wean United and Danieli Fata Hunter, via specialty mills and finishing lines with Danieli Fröhling, heat treatment by Danieli Centro Combustion and batch annealing furnaces by Danieli Olivotto Ferrè.
All of these being fed by the overall system integrator and mathematical models developer of Danieli Automation, ensuring that all Cold Mill Complex equipment technology and process know-how is fully in Danieli control.
At Danieli we are aware that know-how reflects not only in technological process and design, but manufacturing capability as well. The fact that we have overall control of our projects from in-house design and manufacturing to on-site start-up and commissioning creates an ideal virtual loop that consistently feeds Danieli's technological knowledge base, resulting in guaranteed quality and reliability.

2 YILDIZ ENTEGRE COLD MILL COMPLEX

Today, it can be said without hesitation that Danieli Wean United, through several years of research, consolidated engineering, and experienced specialists and highly skilled teams in our workshops, can offer excellent and complete packages, in terms of process optimization and state-of-the-art equipment supply. The latest results in pursuing such targets, with special reference as far as complete complexes, can be summarized with figures: 12 Cold Mill complexes in the last decade, with eight of these started in the last five years.
The latest Cold Complex entered into operation is Yildiz Entegre in Turkey, part of Yildizlar Holding with more than 100-year experience in the field of in forestry products, fertilizers, chemistry, port operations, energy generation, and insurance sector, decided to enter the steel business, selected Danieli as the supplier of the cold mill complex to be built in Kocaeli.
The new facility produces up to 1.5 Mtpy of pickled / cold-rolled / galvanized and annealed / skin-passed coils for high quality application, starting from incoming hot-rolled coils.

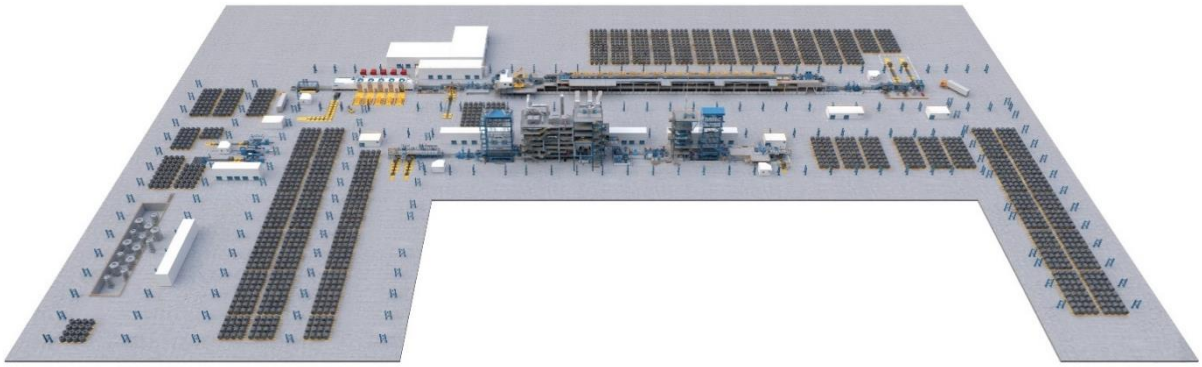

Figure 1. Yildiz Entegre Cold Mill Complex Layout.

Main plant areas:

- 1,500,000 tpy Continuous Pickling Line coupled with five-stand 6-high OSRT Tandem Mill;
- 400,000 tpy Hot Dip Galvanizing Line;
- 300,000 tpy Batch Annealing Furnaces;
- 450,000 tpy Temper Mill.

The success of this project was a significant milestone for Danieli in Europe, allowing Yildiz to expand its business to high-quality steel market, covering a wide range of products and granting a quick flexibility needed to satisfy end users needs serving automotive, white goods and construction markets.

3 REDUCED OPEX AND INCREASED PRODUCT QUALITY OF PLTCM PROCESS

The new PLTCM is an essential step of the strategic expansion project, with a capacity of 1.5 million tons per year to produce high-quality sheets including inner and outer panels for the automotive market.

3.1 Pickling Process Efficiency

The pickling section based on Danieli patented Turboflo® technology, is preceded by powerful scale breaker, operated at up to 500 kN of tension, to improve the shape of incoming strip and to increase the effectiveness of the further pickling process.

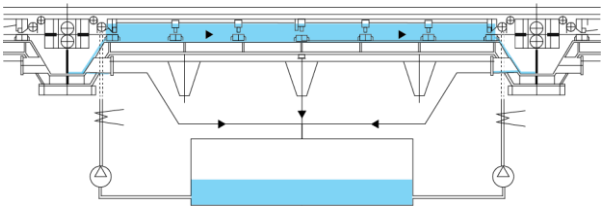

Figure 2. Schematic of the pickling tank.

The unique features of the Danieli Turboflo® Pickling process are:

- Advanced hydraulic sealing with minimal pump pressure;
- Special tank channel design;
- High turbulence on both strip surfaces;
- Level of turbulence is easily adjustable for control of the process;
- Optimization of the strip tension level along the line;
- No need for catenary control;
- The possibility of processing light-gauge strip at speeds up to 450 mpm, meaning 15 s of dwell for light gauge low carbon steel hot band.

The main variables influencing the process efficiency are the acid solution concentration, temperature, its recirculation flow rate, and strip speed.
Danieli Turboflo® doubles the process control capability by means of one more degree of freedom. The reaction can be controlled by either temperature or turbulence or a combination of the two.
The degree of turbulence can be changed quickly, as required by the new coil pickling time, while reaching the ideal reaction temperature.

This leads to less risk of under or over-pickling during temperature change.

Turboflo's advanced turbulent channel concept achieves the highest energy savings and pickling condition flexibility regardless of the strip grade and speed situation.

- 5 - 10% decrease in acid and energy consumption compared with pump-generated turbulence
- 10 - 15% increase in production compared to non-turbulent bath.

Actual ongoing further developments are targeting to even more increase the process efficiency.

3.2 Tandem Mill

The tandem mill section includes five 6-high mill stands with 25,000 kN separating force to produce high-strength quality grades with superior flatness correction capabilities through advanced mechanical equipment and new, accurate and sophisticated models.
The operational flexibility is ensured by the installation on each stand of positive/negative work roll and intermediate roll bending and intermediate roll shifting system with the possibility of using tapered or shaped rolls.
Additionally, final strip shape is controlled by an in-line shapemeter, providing feedback on bending, tilting and selective cooling headers on Mill Stand No. 5.
Ultra-low hysteresis HAGC with a 45% faster response time ensure a precise control of strip thickness.
As a result, strip thickness tolerance will decrease down to ± 0.6%, head/tail off-gauge length will be lower than four meters, and strip flatness less than 6IU.
Accurately control of the roll bite lubrication
Additive direct oil lubrication systems are used to influence the roll bite friction. This supporting function keeps under control roll force variations, e.g. when rolling in low speed range or during weld passage at high strength steel production.

3.3 OSRT (Optimized Shaped Roll Technology)

The tandem mill is designed to cover all the possible product mix for automotive market from ultra-soft material (IF, ULC steel) to ultra-hard material (DP1000-DP1200).
For the above reason, mainly to keep a large shape control area also with the mill at highest rolling force the mill stand can use special shaped rolls named OSR to obtain an equivalent crown that is related to the shifting stroke of the intermediate roll.
The OSR is a special roll barrel contour and based on a combined polynomial and trigonometrical function.
The OSR for the Yildiz mill can be applied to the IR roll keeping the taper zone in place thus to minimize the disturbance to the roll shop and at the same time the Intermediate roll can be utilized with straight or with and with shaped roll contour.
OSR formula with polynomial and trigonometric component for top and bottom IR:

$$Top\ y_1(x) = D + C \cdot sin\left(\frac{\propto}{b} \cdot (x)\right) - A_1 \cdot x - A_3 \cdot x^3$$

$$Bottom\ y_1(x) = D - C \cdot sin\left(\frac{\propto}{b} \cdot (x)\right) + A_1 \cdot x + A_3 \cdot x^3$$

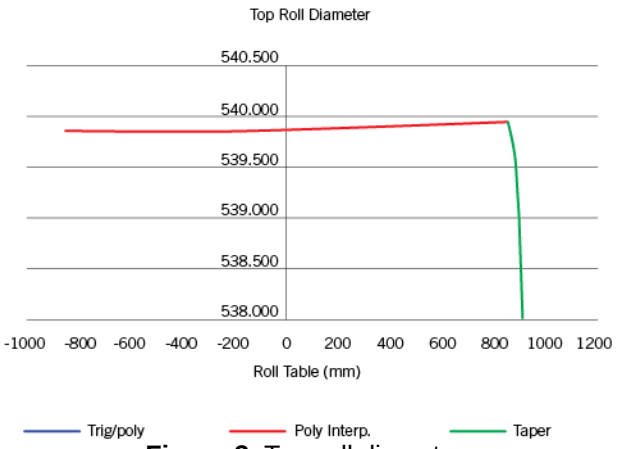

Figure 3. Top roll diameter.

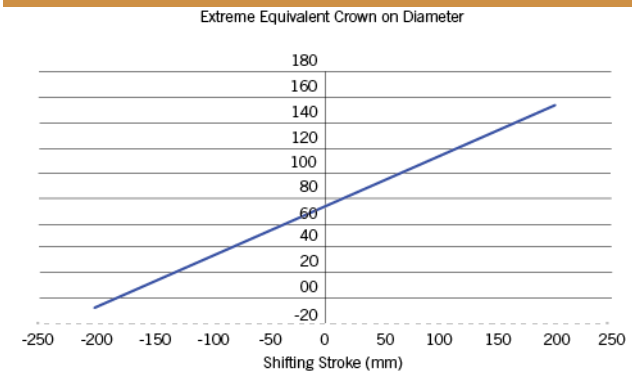

Figure 4. Extreme equivalent crown on diameter.

3.4 Flatness

The tandem cold mill achieved since the beginning astonished results for the strip shape. The mill can obtain flat, positive bow or negative bow shape profile in an easy and repetitive way depending from the post stream process request.
The shape is verified as the quadratic deviation from the target shape as per following formula.

σ = SQRT(Σ (fmi-fti)^2/Nzones) I –Units

where

> fmi = Flatness reference for i-th zone of the shapemeter
> fti= Measured flatness for i-th zone of the shapemeter
> Nzones= total number of the measuring zones (zones of the shapemeter completely covered by the strip). The measuring zones at the strip edges are excluded.

The main actuators for shape control are:

> Positive and negative WR bending
> Positive and negative IR bending
> IR shifting with flat tapered roll or with shaped (OSR) tapered roll;
> Differential IR shiting in case of shape asymmetry localized at the strip edges;
> HAGC tilting;
> Selective cooling to control the WR thermal crown

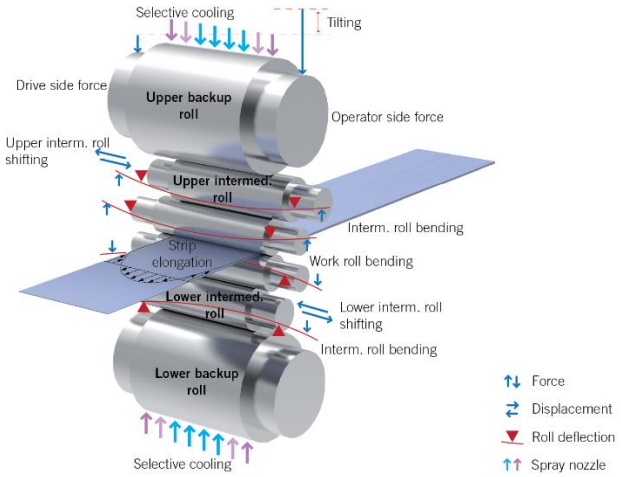

Figure 5. Technological ACTUATORs of the stand for thickness and shape control.

Flatness results after start of commissioning:

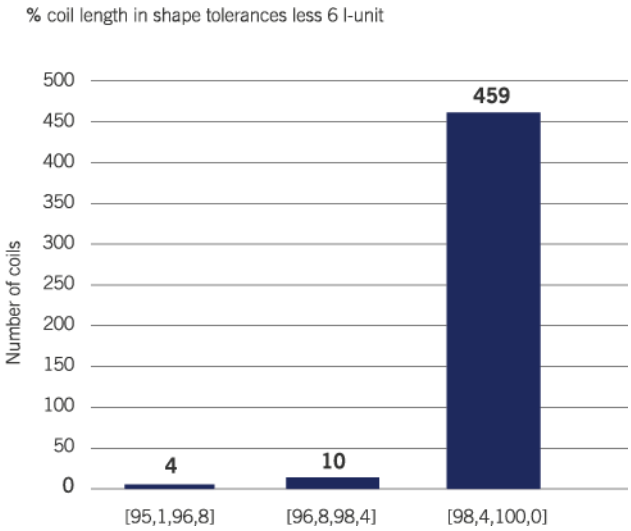

Figure 6. % of coils within flatness tolerance.

SHAPE ERROR

STEADY STATE ANALYSIS						TRANSIENT ANALYSIS					
Tolerance:	6.0	I-Units	Shape Error AVG:	0.69	I-Units	Tolerance:	12.0	I-Units	Shape Error AVG:	2.41	I-Units
			Shape Error SDD:	0.19	%				Shape Error SDD:	1.78	%
			Length Within Tolerance:	100.0	%				Length Within Tolerance:	100.0	%

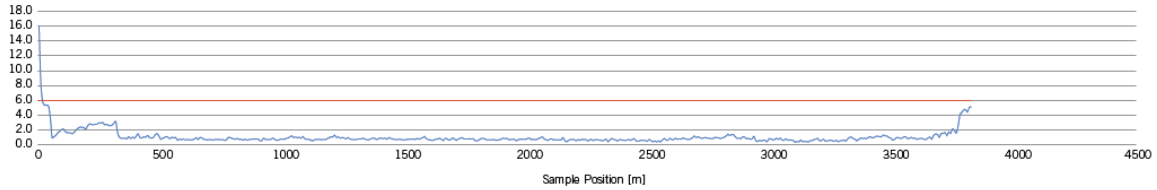

Figure 7. Example of shape flatness result for one coil.

3.5 Weld seam passage

The huge benefit of endless rolling of a PLTCM is the saving on material yield due to the minimal scrap at the head and tail end of the coil due to weld rolling at the TCM.

Out of Gauge length around the weld seam is defined by strip thickness deviation exceeding ± 2% of its nominal value.

The tandem mill operates in two possible modes:

> With flying set up change at the weld passage (in case of different thickness or width for 2 subsequent strips);

> Without flying set up in case the coil main data are not changing at the weld passage.

The mill technological sensors used for weld passage control and for proper mill stand exit speed detection are X-Ray thickness gauges and laser speed meters at the entry and exit side of stand #1, as well as the encoders to measure the strip speeds for stands #2, #3 and #4.

Out of gauge results in 1 week of operation during commissioning and optimization period:

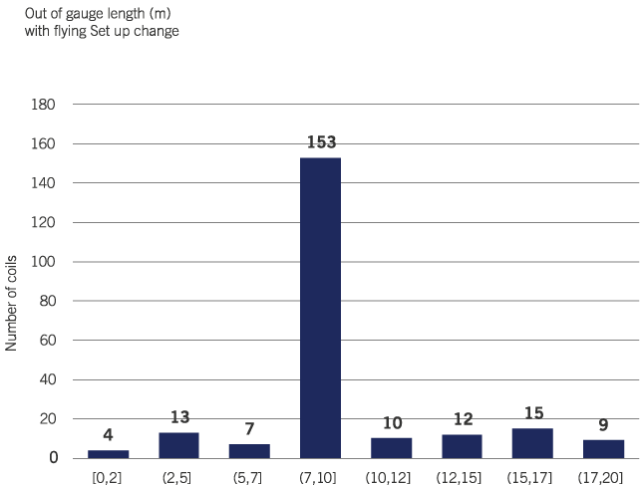

Figure 8. Example of out of gauge length with flying set-up change.

DANIELI AUTOMATION

TCM
QUALITY REPORT

YILDIZ DEMIR CELIK

PRODUCED COIL ID:	19120064TN	INPUT COIL ID:	19100012LP	SCHEDULE ID:	10407	ROLL TYPE:	0: BRIGHT

PRODUCED COIL DATA

Steel Grade ID:	ST22-NLMK	Exit Thickness:	0,590	mm	Calculated Weight:	14108,1	kg	Production Start:	18-03-2019 22:08:12		
Grade Group:	7: LOW_ST22	Width:	1210,0	mm	Measured Weight:	20250,0	kg	Production Stop:	18-03-2019 22:18:44		
Destination Process:	4: GALVANIZ	Length:	3626,6	m	External Diameter:	1728,8	mm	Shift:	3: NIGHT		
		Head Out Of Gauge:	5,0	m	Internal Diameter:	508,0	mm	Crew:	CREW1		
		Tail Out Of Gauge:	6,3	m	S5 Roll Roughness:	0,4	um	S5 Rolling Mode Setup:	1: SHEET		

INPUT COIL DATA

Last Annealing Thickness:	2,000	mm	Entry Thickness:	2,000	mm	Weight:	21100,0	kg	Trg Thickness:	0,590	mm
						External Diameter:	1875,9	mm	Trg Red. from Last Ann Thk:	70,5	%
Previous Process:	1: UNDEFINED / DEFAULT		Length:	1098,2	m	Internal Diameter:	850,0	mm	Trg Red. from Entry Thk:	70,5	%

THICKNESS

STEADY STATE ANALYSIS						TRANSIENT ANALYSIS					
Positive Tolerance:	0,8	%	Thickness AVG:	0,590	mm	Positive Tolerance:	1,6	%	Thickness AVG:	0,590	mm
Negative Tolerance:	0,8	%	Thickness SDD:	0,0014	%	Negative Tolerance:	1,6	%	Thickness SDD:	0,0038	%
Positive Tolerance:	0,006	mm	Length Within Tolerance:	100,0	%	Positive Tolerance:	0,013	mm	Length Within Tolerance:	98,6	%
Negative Tolerance:	0,006	mm				Negative Tolerance:	0,013	mm			

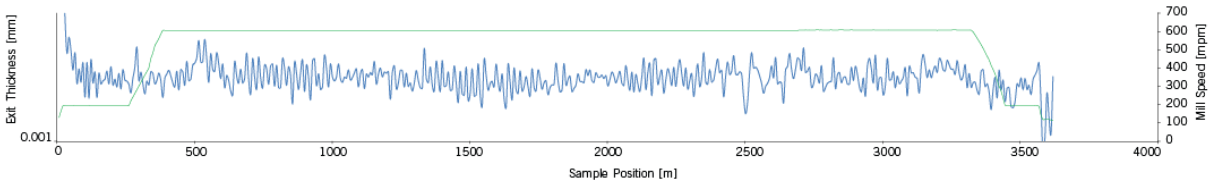

Figure 9. Example of out of gauge length with flying set-up change result for one coil.

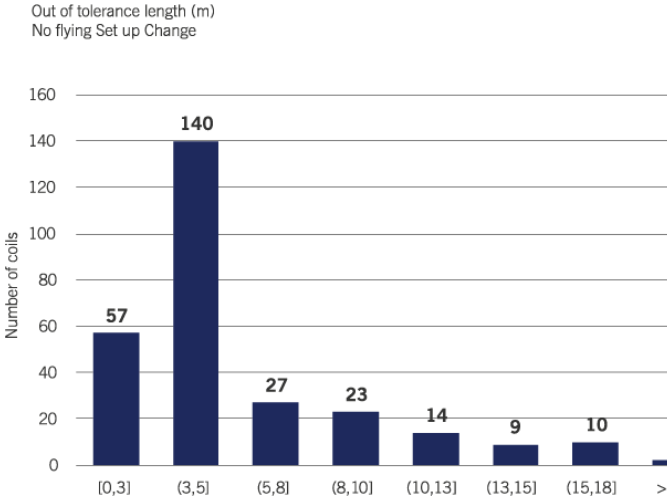

Figure 10. Example of out of gauge length without flying set-up change.

DANIELI AUTOMATION

TCM
QUALITY REPORT

YILDIZ DEMİR ÇELİK

PRODUCED COIL ID:	19130085TN	INPUT COIL ID:	19120016LP	SCHEDULE ID:	10871	ROLL TYPE:	0: BRIGHT

PRODUCED COIL DATA

Steel Grade ID:	ST22-NLMK	Exit Thickness:	0,330	mm	Calculated Weight:	20703,8	kg	Production Start:	26-03-2019 01:31:57		
Grade Group:	7: LOW_ST22	Width:	1255,0	mm	Measured Weight:	20740,0	kg	Production Stop:	26-03-2019 01:44:21		
Destination Process:	4: GALVANIZ	Length:	6346,9	m	External Diameter:	1720,6	mm	Shift:	1: MORNING		
		Head Out Of Gauge:	0,3	m	Internal Diameter:	508,0	mm	Crew:	CREW3		
		Tail Out Of Gauge:	3,1	m	S5 Roll Roughness:	0,4	um	S5 Rolling Mode Setup:	1: SHEET		

INPUT COIL DATA

Last Annealing Thickness:	2,000	mm	Entry Thickness:	2,000	mm	Weight:	21380,0	kg	Trg Thickness:	0,330	mm
						External Diameter:	1858,9	mm	Trg Red. from Last Ann Thk:	83,5	%
Previous Process:	1: UNDEFINED / DEFAULT		Length:	1073,2	m	Internal Diameter:	850,0	mm	Trg Red. from Entry Thk:	83,5	%

THICKNESS

STEADY STATE ANALYSIS						TRANSIENT ANALYSIS					
Positive Tolerance:	1,0	%	Thickness AVG:	0,330	mm	Positive Tolerance:	2,0	%	Thickness AVG:	0,329	mm
Negative Tolerance:	1,0	%	Thickness SDD:	0,0009	%	Negative Tolerance:	2,0	%	Thickness SDD:	0,0017	%
Positive Tolerance:	0,005	mm	Length Within Tolerance:	99,9	%	Positive Tolerance:	0,010	mm	Length Within Tolerance:	100,0	%
Negative Tolerance:	0,005	mm				Negative Tolerance:	0,010	mm			

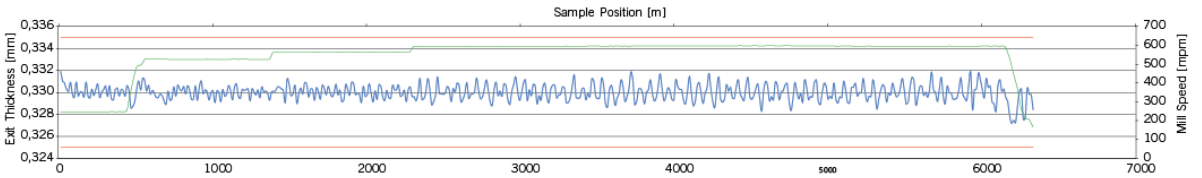

Figure 11. Example of out of gauge length without flying set-up change result for one coil.

3.6 Confined Jet Dryer (X-DRY)

To ensure a high product quality and surface appearance, an innovative and patented strip drying system called Confined Jet Dryer is installed in addition to the equipment used to seal the exit strip gap of a rolling stand.

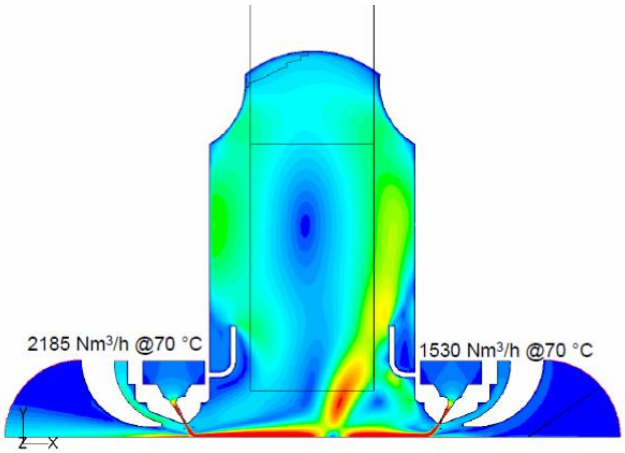

Figure 12. Advanced Fluid Dynamic Simulation of the X-DRY.

The X-DRY consists of a wiping system to remove the rolling solution from top and bottom strip surfaces simultaneously.
The X-DRY consists of an “enclosed” blowing/suction box, where a strong subsonic air jet is blown onto the strip surface. The air jet is highly concentrated and able to detach the solution droplets from the strip surface. In addition, the sealing knife blocks the flow
produced on the strip by the wiping knife and prevents the escape of any solution from the X-DRY chamber. The X-DRY is fed by two dedicated air fans, one blower feeding all four jets and a second blower exhausting both chambers. X-DRY nozzles are characterized by values 10 to 20 times higher shear forces compared to typical nozzles.
The resulting mist is completely contained within the X-DRY and then exhausted from the mill area.
Thanks to the small required space (less than 0.5 m), it can easily be applied to existing rolling mills (reversing or tandem) to produce a spotless and clean rolled strip.

4 HIGH EFFICIENCY OF GALVANIZING PROCESS

Also on Galvanizing lines Danieli has gone through lots of extra steps to further optimize CapEx and OpEx, with special focus on several areas like the Zinc wiping technology, Side trimmer and furnace technology.
In galvanizing lines, the zinc pot is the most effective area to reduce costs in

operation and consumables, and at the same time to increase product quality.
Insufficient wiping capacity often results in a bottleneck for the line productivity and coating uniformity of the final products.
This is why Danieli concentrate its efforts in continuously innovating the wiping process.
In the first years after 2000, Danieli Research made a significant development of KOHLERJET Air Knives design using Fluid Dynamics Modeling
Since the core of the wiping process is defined by the delicate and complex fluid dynamics phenomena that occur when the jet impinges on the coating surface, the study of a numerical modeling of air knife wiping was carried out.

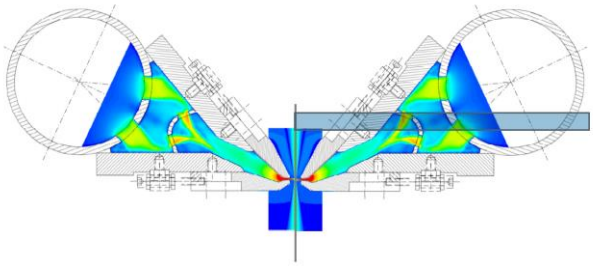

Figure 13. Fluid Dynamics Modeling for former KOHLERJET.

The study clearly indicated the directions for further development of wiping technology.
The target of the simulation campaign was to provide a complete database of cases for a general study of the jet impact dynamics and effect on the coating film.
A comprehensive model has been since then developed, in order to evaluate the evolution of the coating film under the effect of the air knives.
By employing the most modern numerical simulation techniques, a useful and accurate model of the wiping equipment and process has been created.

The model has been used to direct the development of improved wiping equipment with additional advantages in productivity, quality and/or energy input.

The result of this R&D activity resulted in the brand-new design of Danieli Kohler X-JET air knife, featuring a more efficient jet, with sharper pressure profile and extended laminar zone.

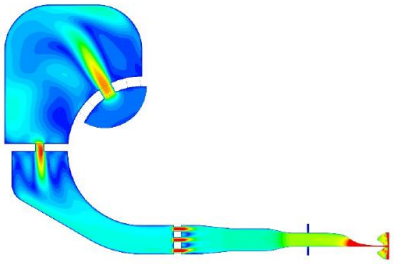

Figure 14. X-JET flow simulation.

Since its operational debut in 2009, the X-JET air knife has lived up to the most optimistic projections from the simulations.

More than 35 X-JET's installations, carried out till the beginning of 2019, have shattered all previous limits on high speed, light coating weight performance while optimizing quality and ease of use through all combinations of line speed and coating weight.

The **X-JET** has these key features:
> Four chambers to optimize uniformity across the width of the jet;
> Extended length and special shape of the last chamber to re-establish laminar flow.

The result is a sharper, more focused jet compared to other designs, with substantially better performance.

Figure 15. X-JET air knife.

The X-JET air knives nozzle design with extended laminar zone length, improves

wiping capability. The immediate benefits are:
> Thinner coating at the same speed;
> Same coating at higher speed;
> Reduced splashing and spitting;
> Reduced edge overcoating.

Previous X.JET features, applied together with cutting edge design of Danieli Kohler Elevator/Positioners, Non-Contact Baffles and Roll Equipment, further improve wiping capability by:
> Allowing flatter nozzle gap profile;
> Improving strip shape and vibration;
> Edge overcoating reduction.

Another important feature of the X-JET air knife is the possibility to install the Width Adjustment system as modular add-on.
Since the main justification for the width adjust comes from the use of nitrogen as the wiping fluid, it is not usually necessary for the user to include the width adjust in the initial installation.
In case the product line will dictate the use of nitrogen in the future, adding the width adjust will be impactless, simple, quick and inexpensive.

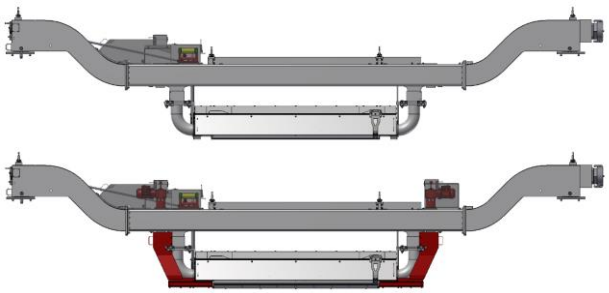

Figure 16. Modular width adjustment add-on system.

X-JET are rated to produce the following low coating weights at high Line speeds (CW are indicated as total both sides):

70 g/m^2 (0.236 oz/ft^2) at 160 mpm (525 ft/min)
78 g/m^2 (0.262 oz/ft^2) at 180 mpm (590 ft/min)
90 g/m^2 (0.302 oz/ft^2) at 200 mpm (656 ft/min)

Our Customers are able to routinely produce the following commercial coating classes.

Z50 at 140 mpm
Z70 at 175 mpm
Z80 at 185 mpm
Z100 at 200 mpm

Recent revamp of a major South American CGL by supplying Danieli Kohler X-Jet technology targeted to change the product mix to thinner strip with light coating weight while increasing the line speed to maintain the overall production rate.
Following goals have been reliably achieved:
> Increase of the speed from 150 m/min to 180 m/min for producing Z80;
> Operation at 9.5 mm from the strip instead of 7 mm;
> Decrease of wiping related defects by almost 70%.

Another X-JET revamp of a major Southeast Asian CGL, that targeted to increase quality to serve the export market, has given following results:
> Decrease of coating consumption by 5%;
> Decrease of wiping related defects by more than 30%;
> Improvement of surface appearance, that is now accepted in all export markets.

Two X-JET revamping projects, on Galvanizing Lines in Turkey, showed that the improved wiping capability allowed a ***payback time of only 4 months***, based just on a production increase of approx. 10%, without considering the reduction in zinc consumption or further benefits (since the wiping equipment revamping in both lines routinely produce Z80 @180 mpm, and the average coating weight of the products produced on both Galvanizing Lines is now less than 100 g/m^2).

Despite the proven advantages of the X-JET design, for revamping projects often crowded pot areas and space constraints are limiting factors.
Lead time and cost is increased by the need to modify or replace existing equipment. In extreme cases, it might be even not practical to fit into an existing pot area at all.
To overcome this limitation, Danieli returned to the same team that was so successful in its initial efforts.
The new goal was to achieve the same performance in a substantially more compact envelope.

The further development of air knives resulted in the Compact X-JET (CXJ) air knife, designed to be even more easily integrated in already operating galvanizing lines.

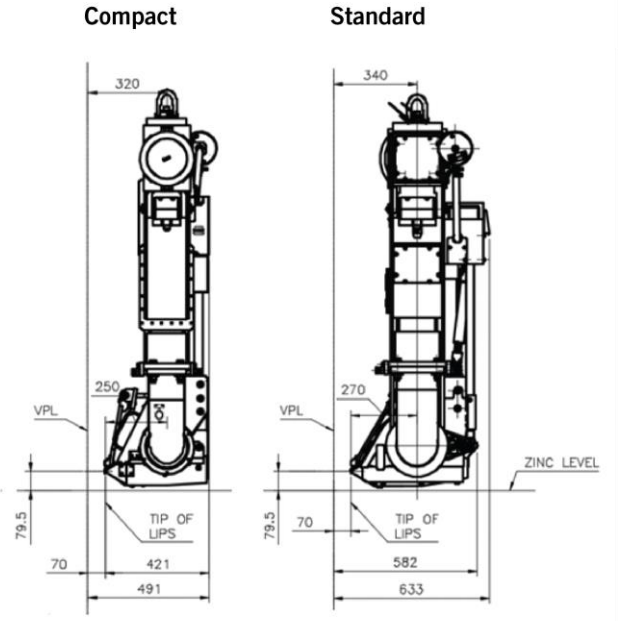

Figure 17. Main dimension comparison between compact and normal X-JET.

The critical dimension perpendicular to the strip is significantly reduced for the Compact X-JET (CXJ). It is now possible to fit into extremely crowded pot areas (with minimum disruption to surrounding equipment).

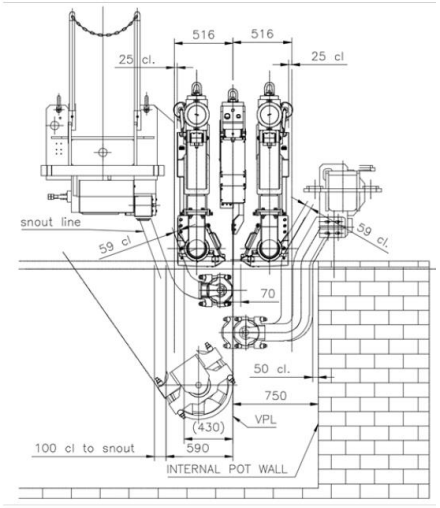

Figure 18. Layout arrangement of compact x-jet on existing pot.

A closed-loop control for coating weight, including a sophisticated coating model, long-term adaptation functions, as well as precise controllers for air knives distance and pressure, supports a tight coating weight accuracy and fast adjustment in case of flying product changes.

In a galvanizing line, human operation is most challenging in the zinc pot area. To reduce human intervention and health risks, Danieli developed robotic systems designed to skim the surface of the zinc bath, remove dross and place it in a dross container or to handle the zinc ingot feeding.
The Q-Robot Zinc can be fully integrated to the Level 1 automation system and automatically follows the bath level, optimizing the skimming action.

5 CPXPC PERFORMANCE COORDINATOR

In large production complexes, the quality supervision is a demanding task that involve staff having different roles and working both offline (i.e. after production execution, by a quality supervisor) and online (i.e. while the production is in progress on the single machine, by the machine operator).

The CPXPerfCoordinator (CPXPC) has been realized for a steel cold complex production site and aims at interacting with the users (operators and quality supervisors) to reduce to minimum the possible occurrences of human mistakes that can influence the material quality. More precisely the CPXPC aims at supervising the quality in a cold complex having the following production lines equipped with a Level 2 automation system:

> Continuous Pickling Line + Tandem Mill (PLTCM);
> Hot Dip Galvanizing Line (HDGL);
> Batch Annealing (BA);
> Temper Mill (TM).

In an online environment the CPXPC aims at presenting in real-time the quality of the coil as it comes from the upstream processing line to the operator: in this way the operator of a production line is warned at the right moment when a possible defect is entering his line.

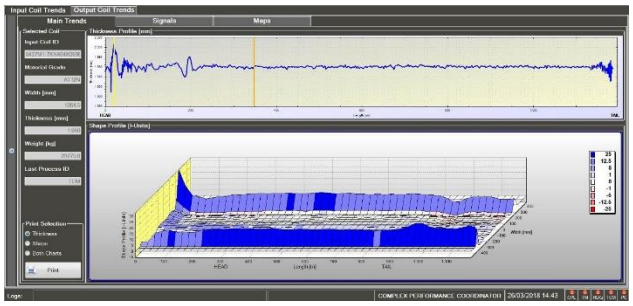

Figure 19. 2d Thickness and 3d shape strip trend.

Voice Alarms are given to the operator to be real-time informed of what is the expected quality of the next meters of material entering the machine. At the same time both 2D and/or 3D diagrams are real-time presented to the operator about the quality of the input material collected from the previous processing lines, with evidence of possible recorded defects.
Furthermore, in an offline environment the CPXPC stores the whole information produced by each production line visualizing the history of each produced coil while the coil proceeds from line to line. Additionally, the efficiency of each production line and of the overall cold complex is recorded and presented to the quality supervisor.

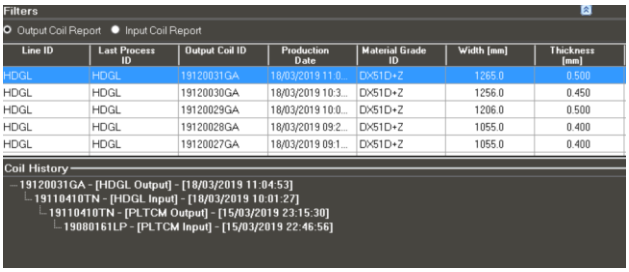

Figure 20. Historical evolution of a coil between areas.

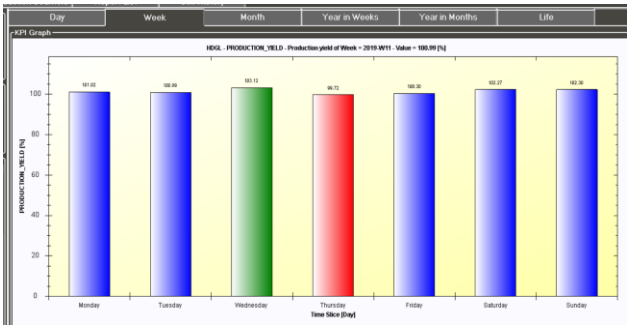

Figure 21. Production efficiency (several KPIs are available like Yield, Average processing speed, etc.).

The intuitive visualization of top performance indices and bottom performance indices allow the quality supervisor to dig in the data to explore possible limiting effects or possible advantageous factors in order to optimize the quality and productivity in a synergic way for the overall complex.

6 CONCLUSIONS

The market for cold rolled and galvanized strip has become highly competitive, forcing producers to establish continuous efforts to reduce costs and improve product quality and productivity.
With the latest rolling mill concepts and technologies, as well as integrated technological packages for wiping process in galvanizing lines, Danieli is providing answers to these ambitious targets.

Installations in both greenfield plants and - as upgrade packages- in existing lines already have proven the superiority of these new technologies.

Today, Danieli Wean United is not only a globally recognized, premium supplier of single processing lines and cold rolling mills, but much more. Danieli Wean United is a unique Cold Mill complex supplier offering the highest degree of integrated solutions, all studied to work in synergy from the very first conceptual sketch to the finished, operating plant, allowing customers to focus on their downstream activities.
We are in the forefront of finding solutions, and passion is what drives us.