Yıldız Demir Çelik Cold Mill Complex, Turkey

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Turkish steel market

Turkey experienced robust economic expansion in recent years and it is expected to show continuous growth in the near future. The iron and steel industry grew in parallel to the growing economy, in a climate where much of Europe will see slight increases or no growth at all in the industry.
Turkey's success in the iron and steel industry is evident as it is among the top 10 crude-steel producing countries in the world. Steel production is expected to continue and reach 47 Mt, which is an increase of approximately 5.5% by 2017.
Domestic and international investors are ramping up their investments for qualified steel and finished steel products to capitalize on Turkey's economically attractive iron and steel industry.
These favourable market conditions led Yıldız Entegre Holding to start a new business, entering the cold strip processing sector.

Yıldız Demir Çelik project

Yıldız Entegre Holding has more than 100 years' experience in the forestry products, fertilizers, chemistry, port operations, energy generation, and insurance sectors.
In 2015 it decided to enter the steel business through its subsidiary company, Yıldız Demir Çelik.
Danieli was selected as technology partner and supplier of its first steel processing plant: a new, complete cold-mill complex to transform black coils from the market into added-value cold-rolled, tempered and coated coils.

The cold mill complex

The location selected for the cold-mill complex was Kocaeli, an industrial area in northern Turkey. The installation is comprised of a pickling line coupled to a six-high tandem col mill, a galvanizing line, a temper mill and annealing line.
At the beginning of 2018 it started operating in sequence, and now is producing in excess of the contractual rate, up to 1.5 Mtpy.
The applied innovative technological solutions and process know-how developed by Danieli through continuous in-field experience and continuous R&D improvements, along with the trustful relationship between Danieli and Yıldız Demir Çelik, led to a very successful start-up. In this way, Yıldız Demir Çelik entered the steel business at the highest level of quality and productivity in the Turkish and European markets.

> Main technologies

> 1.5-Mtpy Continuous Pickling Line coupled with five-stand six-high Tandem Mill

One of the strong points of this section is the entry area, designed for high reliability and with an "any-coil-feed" concept to avoid production losses due to coil preparation and joining.
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. Turboflo's advanced turbulent channel concept achieves the highest energy savings and pickling condition flexibility regardless of the strip grade and speed situation.
The tandem mill section includes five six-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 installing positive/negative work-roll and intermediate-roll bending and intermediate-roll shifting system on each stand, 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 ensures 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 will be less than 6IU.
A new system has been developed by Danieli to accurately control roll-bite lubrication, thus changing its effect if and when required to stabilize the friction coefficient of the roll bite in any mill conditions.
To ensure high product quality and surface appearance, an innovative 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. This effectively removes any droplets from the strip surface thanks to a 20% larger shearing effect than standard solutions.
The heavy-duty exit flying shear that, together with the carousel reel, ensures flying gauge change and an endless rolling process can cut all material grades and sizes at a speed of up to 300 mpm, minimizing mill slowdowns that could cause poorer strip quality in terms of shape, thickness, and surface.
The commercial production of the tandem mill started within 22 months from order placement, and the throughput capacity hit more than 50% of nominal quality within 30 days.

OSRT (Optimized Shaped Roll Technology)
The tandem mill is designed to cover the whole potential product mix for automotive markets, from ultra-soft material (IF, ULC steel) to ultra-hard material (DP1000-DP1200).
For the above reason, mainly to maintain a wide area for shape control while operating the mill at highest rolling force the mill stand can use, specially shaped rolls called OSR have been selected in order to obtain an equivalent crown in relation 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 Yıldız mill can be applied to the IR roll, keeping the taper zone in place, thus minimizing the disturbance to the roll shop and at the same time allowing the Intermediate roll to be utilized with straight or with shaped roll contour.
The OSR formula with polynomial and trigonometric component for top and bottom IR is:

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

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

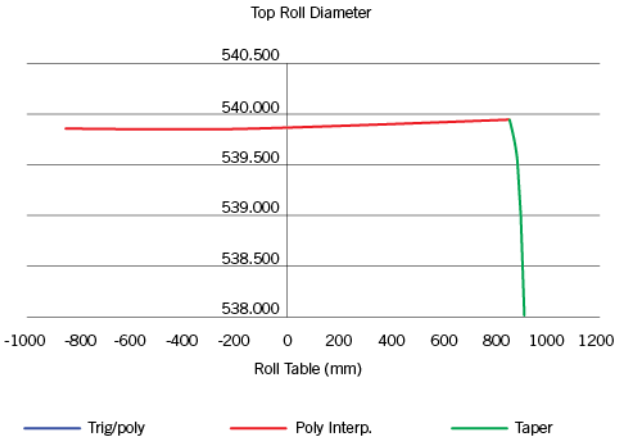


Figure x: Top roll diameter

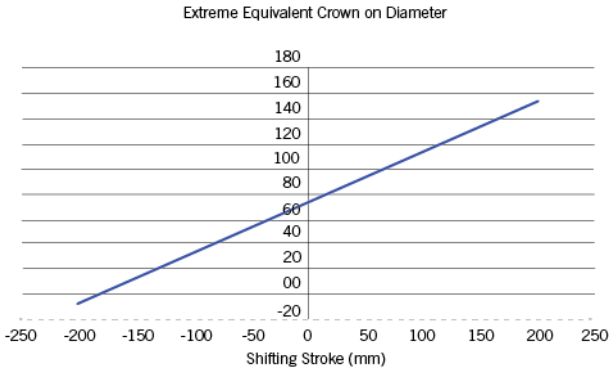


Figure x: Extreme equivalent crown on diameter

> 0.4 Mtpy Hot Dip Galvanizing Line.
The line will process LC, MC, and HSS grades. Strip thickness and width will range from 0.2 to 3.0 mm and from 700 to 1,300 mm, respectively.
The line will run at speeds of up to 200 mpm processing incoming coils of over 30 t. The finishing section has the flexibility to produce coils down to a minimum size of 5 t, suitable for steel service centres.
The vertical annealing furnace from Danieli Centro Combustion includes a recuperative room to heat the strip up temperature; a direct-fired section with multi-burner doors zone to completely clean the strip surface (avoiding the installation of the cleaning section); radiant tubes zone equipped with 2P gas-fired tubes for superior temperature uniformity along the strip width (less than 30 °C on central leg); jet cooling section; and an equalizing zone for HSS grades production.
The Danieli Kohler X-Jet wiping system allows extremely accurate control of final zinc coating thickness down to 40 g/m^2 on each side (at 180 mpm), giving excellent coating uniformity along the strip and consequent line OpEx reduction by 5% per year.
Since the beginning of operations, the HDG Line has been running at the nominal productivity rate, with high quality standards that allowed Yıldız to enter the market at a very high level.

> 0.3 Mtpy Batch Annealing Furnaces
The annealing facility, with a nominal production capacity of 0.3 Mtpy, includes twelve (12) working bases, six (6) heating furnaces and six (6) cooling bells.
The equipment, fully supplied by Danieli Olivotto Ferrè, is the state-of-the-art technology for high-convection coil annealing in 100% hydrogen atmosphere, to ensure optimal heat transfer along coil width and perfect strip surface cleanliness.
The high convection provided by the base high-flow fan guarantees the absence of spot overheating on coil turns and uniform heating for the whole mass of the coil. Consequently, the structure and the mechanical properties of the annealed product will be the same on all the parts of the coil, especially regarding tensile strength and elongation. During the subsequent cooling cycle, finally, the coil turns will not stick to each other, even with thin product.
The all-metal working chamber ensures a dew point around -50/55 °C during the whole heat-treatment cycle, thus absolutely avoiding decarburization.
Danieli Olivotto Ferrè also will supply an innovative set of nine (9) Double Final Cooling Units (DFCUs), which perform an additional cooling (from 160° to approximately 60°C) of the charge after the “standard” annealing cycle. This shortens the waiting time between annealing treatment and Temper Mill rolling, reducing intermediate stocking areas.

> 0.45 Mtpy Temper finishing mill
The four-high mill stand processes annealed coils with a 1,000-ton separating force and at a speed of up to 630 mpm.
The mill stand can operate with double work rolls diameter to broaden the range of steel grades processed (from HSS to EDDQ).
The mill can operate in dry and wet mode and is equipped with a dedicated dust and fume exhaust system to guarantee safe operation conditions.
The mill is designed with an entry bridle for perfect rolling of thin material, an in-line inspection section to check surface appearance, and electrostatic oiling machine to serve market requirements.

> Electrics and automation
Danieli Automation supplied all the electrical equipment and control systems for the entire complex, providing an integrated and optimized system configuration up to Level 3. The single-source automation system and the experience of Danieli Automation, which has been developing innovative solutions in the steel industry for the past 40 years, is a guarantee for a smoother project execution, a quicker start-up, and an easier know-how transfer that will result in high plant efficiency and yield.

> Final products and their application
The Cold Complex is designed to produce high-quality steel products to enter the local and international markets at the highest level, satisfying most demanding end users. The product range includes white goods applications, commercial, structural and construction grades, IF, HSS, HSLA and DP material.

> Good teamwork leads to excellent results

In close coordination with the customer, who had extensive and very active participation in preparing the schedule, was closely followed in all details and through the project execution.
This mutual effort was obviously extremely resource consuming but has delivered successful results with a remarkable Tandem Mill start-up, which has delivered zero waste from day one, and followed by a daily increase in throughput and quality, looking forward to completing all performance guarantees, with the customer's full satisfaction.

Flatness Results

From the beginning the tandem cold mill has achieved astonished results for the strip shape. It can impart flat, positive bow or negative bow shape profile in an easy and repetitive way, depending on the downstream processing requirements.
The shape is verified as the quadratic deviation from the target shape as per following formula:

$\sigma = SQRT(\Sigma (fmi-fti)^2/Nzones)$ I –Units

where

> fmi = Flatness reference for i-th zone of the shapemeter;
> ft i= 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 shifting in case of shape asymmetry localized at the strip edges;
> HAGC tilting;
> Selective cooling to control the WR thermal crown

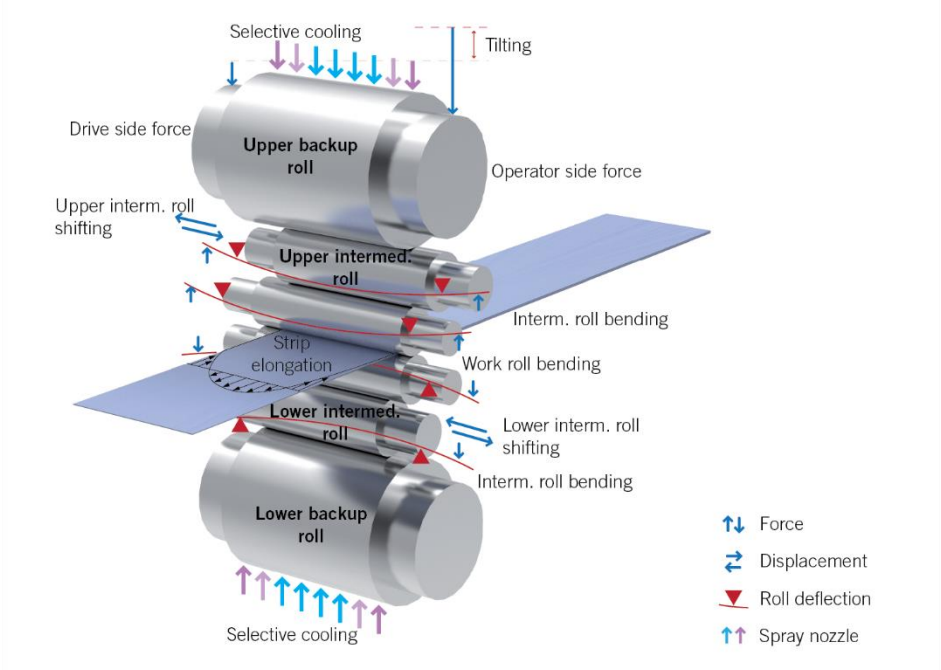


Figure x: Technological ACTUATORs of the stand for thickness and shape control

Flatness results in the first three months of operation:

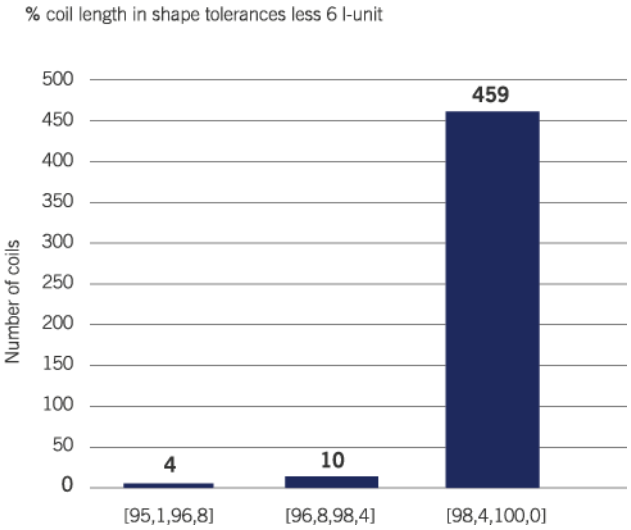
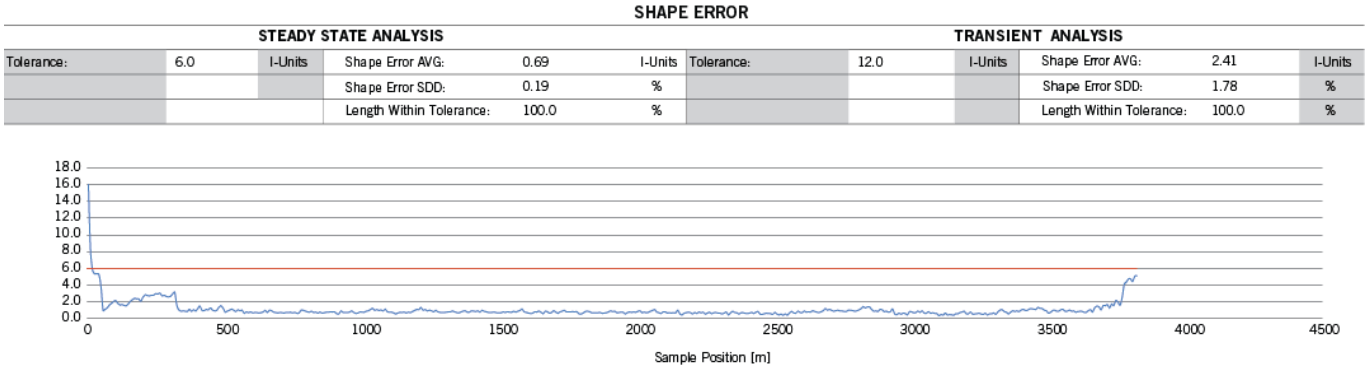


Figure x: % of coils within flatness tolerance



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 x: Example of shape flatness result for one coil

Out of gauge results

The great benefit of endless rolling to a PLTCM is the saving on material yield due to the minimal scrap at the head and tail ends 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 two subsequent strips);

> without flying set-up in case the coil main data does not change 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 for one week of operation during commissioning and optimization period:

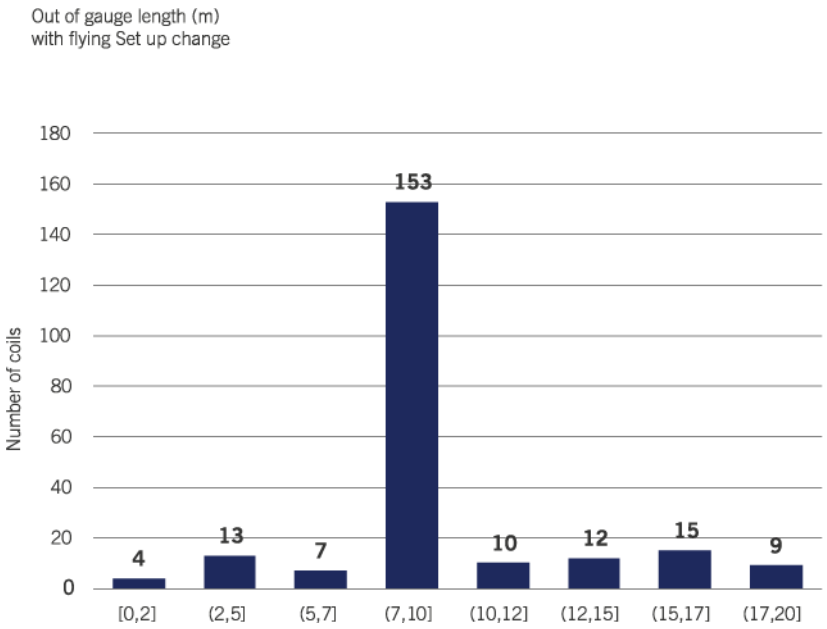


Figure x: Example of out-of-gauge length with flying set-up change.

DANIELI AUTOMATION — **TCM QUALITY REPORT** — YILDIZ DEMİR ÇELİK

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			

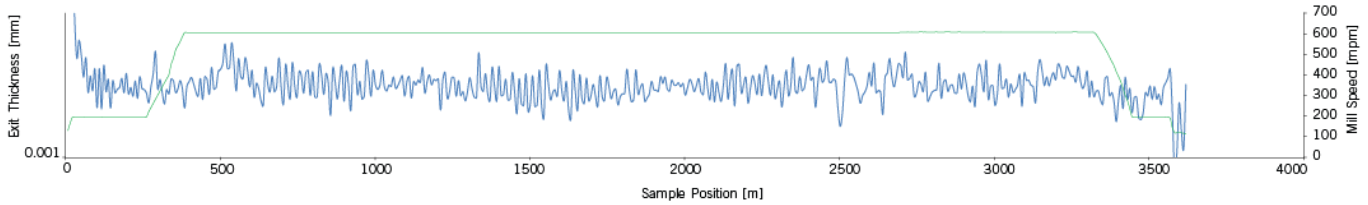


Figure x: Example of out-of-gauge length with flying set-up change result for one coil.

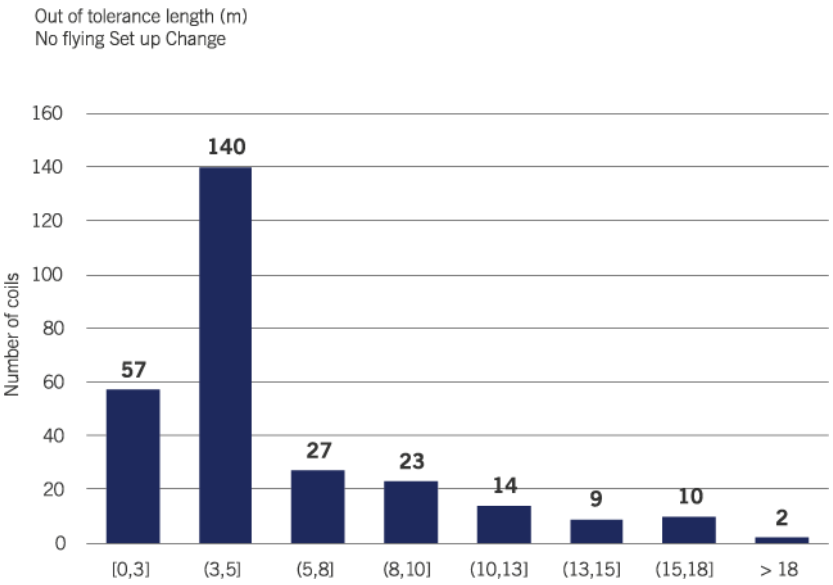
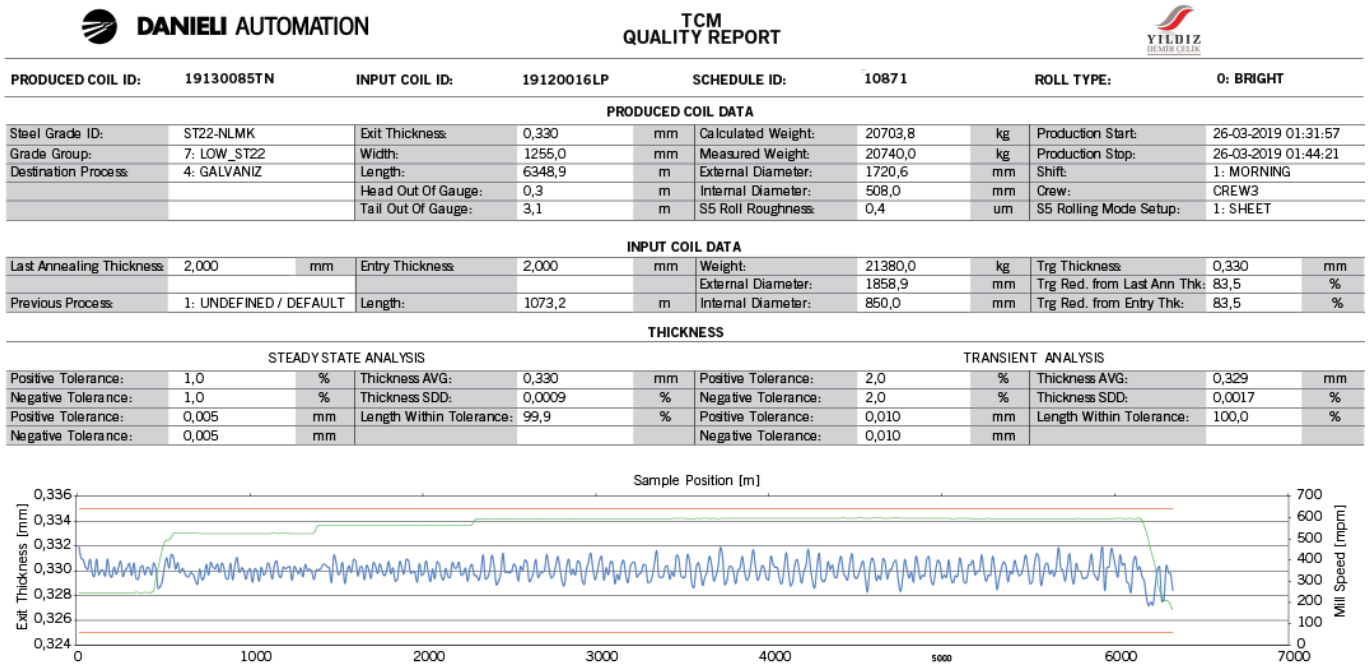


Figure x: Example of out-of-gauge length without flying set-up change.



DANIELI AUTOMATION

TCM
QUALITY REPORT

YILDIZ DEMIR CELIK

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:	6348,9	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 x: Example of out-of-gauge length without flying set-up change result for one coil.

> Danieli market share

In the last 10 years, six out of the seven large Cold Mill Complexes in the Mediterranean region (four of which are in Turkey) have been supplied by Danieli.
The orders received from MMK Metalurji and Atakaş confirm the Danieli leadership in cold-mill complex integrated technology, and as a point of reference for customers looking for the “single-source responsibility”, ensuring high-quality steel production and the best CapEx and OpEx.

Claims and statements from Yıldız Demir Çelik and Danieli

Yıldız Demir Çelik: Why steel and why a cold mill complex in Turkey?

“Our main aim in making an investment in a cold rolling plant with a 1.5 million tons production capacity is to contribute 1 billion dollars to Turkey’s struggle against its current deficit. Yıldız Demir Çelik is one of the largest industrial investors in Turkey that has been implemented by Yıldızlar Yatırım Holding.

“With this investment, our company will meet the need for high-quality flat-sheet metal products, to be served to the white goods and automotive industry. We aim to offer our products to the market as Yıldız Demir Çelik, which will be a replacement for imports in such industries.

“We completed the first phase of our Yıldız Demir Çelik investment, and in 2020 we will complete our second phase investment, which will be an investment at the amount of 350 million USD. Turkey today is importing 9 million tons of flat steel products. The gap between exports and imports reaches 4.7 million tons. The Yıldız Demir Çelik factory, where 450 people are employed, will reach 750 people with the completion of second phase investment.”

Yıldız Demir Çelik: Danieli as a reliable partner
“Danieli, the leading steel-industry engineering company in Italy, puts innovation at the forefront and believes in continuous improvement. From planning to design, from manufacturing to production and service, it is possible to see the passion for innovation in every stage of business processes.

“We, as Yıldız Demir Çelik, are a company that gives importance to innovation and continuous improvements. We played an important role in the economic development of our country. In this respect, we matched Danieli at many points. The main reason we chose Danieli was the successful implementation of their company in many countries around the world. Danieli being a company that closely follows and applies technological developments in the sector, that monitors the sustainability of its business were crucial elements, for our choice.

“Our cooperation with Danieli also takes part in strengthening the relations between Turkey and Italy.

“The technical teams of Danieli and Yıldız Demir Çelik have signed a very impressive cooperation in Kocaeli. The results are extremely impressive in terms of quality and efficiency.”

Danieli division manager / Tommaso Settimo
“Despite the market difficulties, Yıldız had the courage and vision to build the most complete cold-rolling complex in the region. The Danieli and Yıldız Lar teams related closely, working as one flexible, dynamic, lean team to create a plant designed and constructed for easy and flexible operations and maintenance; on-time and with consistent performance.
“In such a spirit of partnership, we can find together with our customers the optimal solutions for long-lasting success, which is a powerful driving force that unites us all.”

Danieli project manager / Marco Girardi
“Since the beginning of the feasibility study Yıldız aimed to build the most advanced plant in Turkey in the shortest possible time, and with the highest quality level. Thanks to both teams’ close and useful cooperation we were able to achieve required targets with the full satisfaction of both companies.”

Danieli tech team / Dmitriy Voitekhovskiy
“Our target was to implement the most advanced technological features, allowing a fast start-up of the plant with high quality levels from the beginning. Field results were really surprising and even better than expected. Performance levels were reached just a few days after commercial production.