ITA
technology & software

Inter Stand Cooling in Hot Strip Mill

ISC Motivation

Reach the desired (target) Exit Rolling Temperature for the whole product mix

Keeping the constant temperature lengthwise (Elimination of skid marks and other temperature inhomogenities)

Increase of the productivity of the mill

Conditions for proper function of ISC

Hardware – Efficient cooling headers, water system

Software – Control system of ISC working either within Level 2 or separately

Demands on Cooling Headers

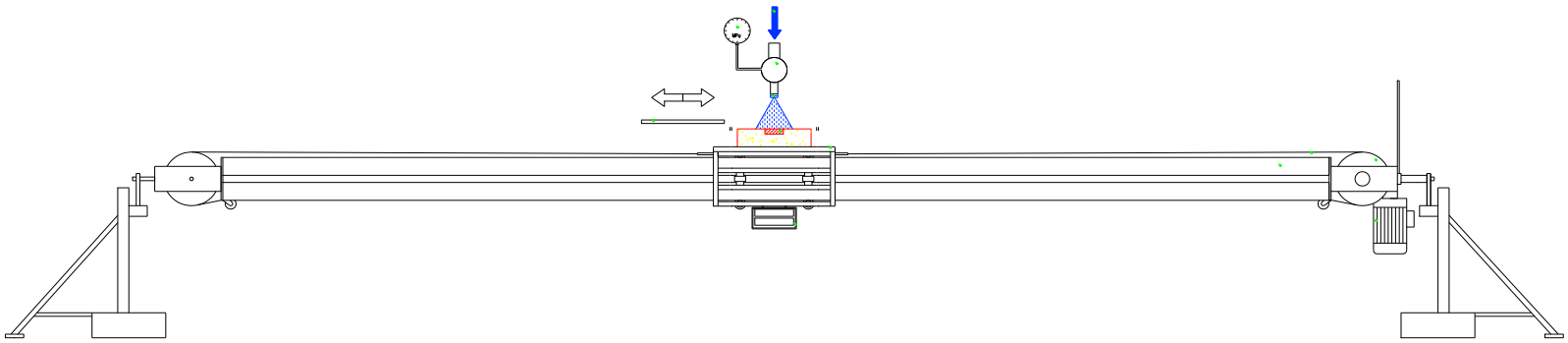
Sufficient Cooling Power (HTC)

Easy flow rate control

Long service life time

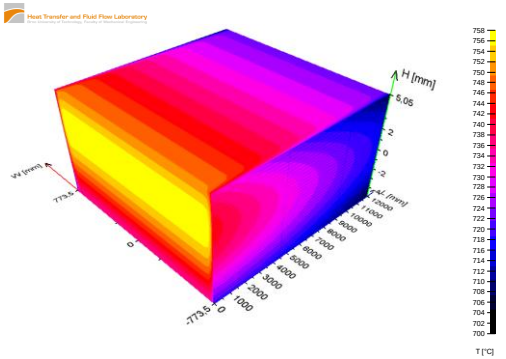
Easy maitanance

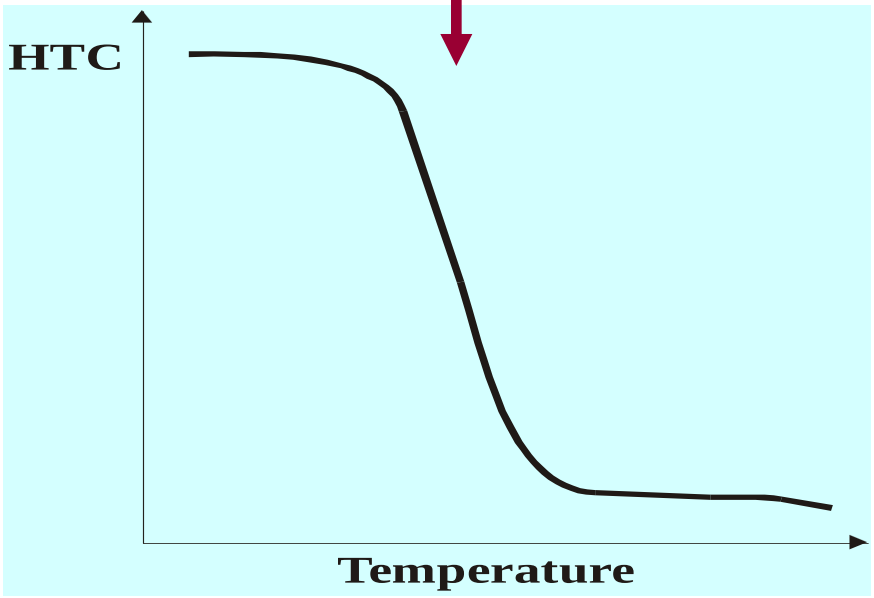
Investigation of cooling headers
Laboratory stand

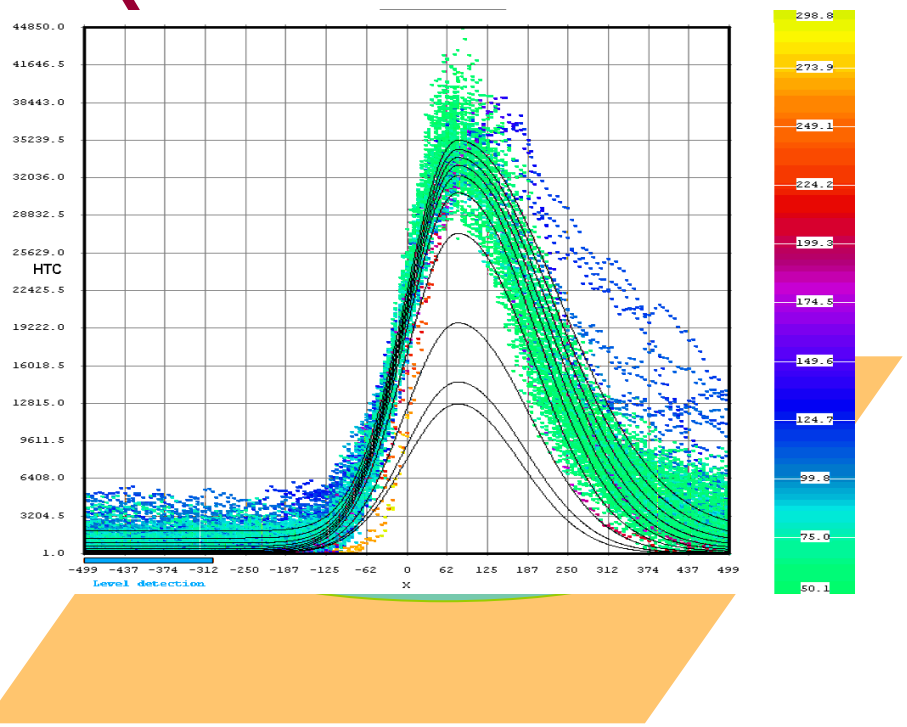


Heat transfer coefficient

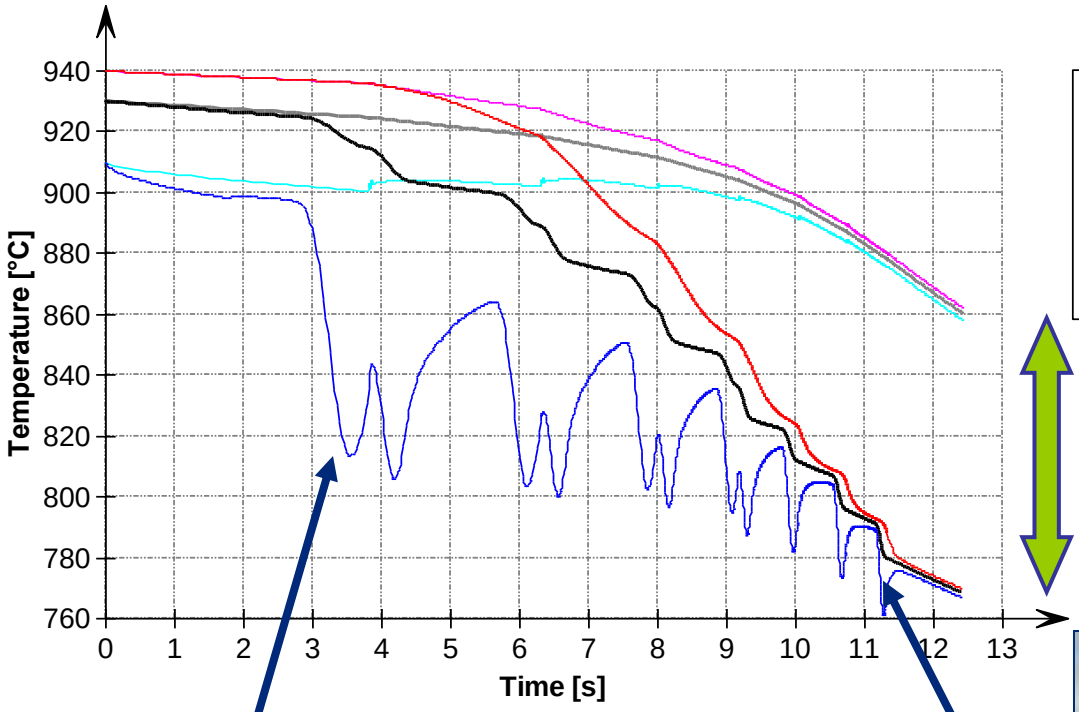
$$HTC = f(T, x, y)$$

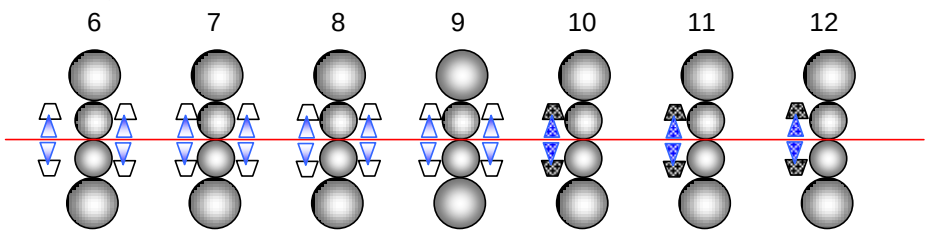






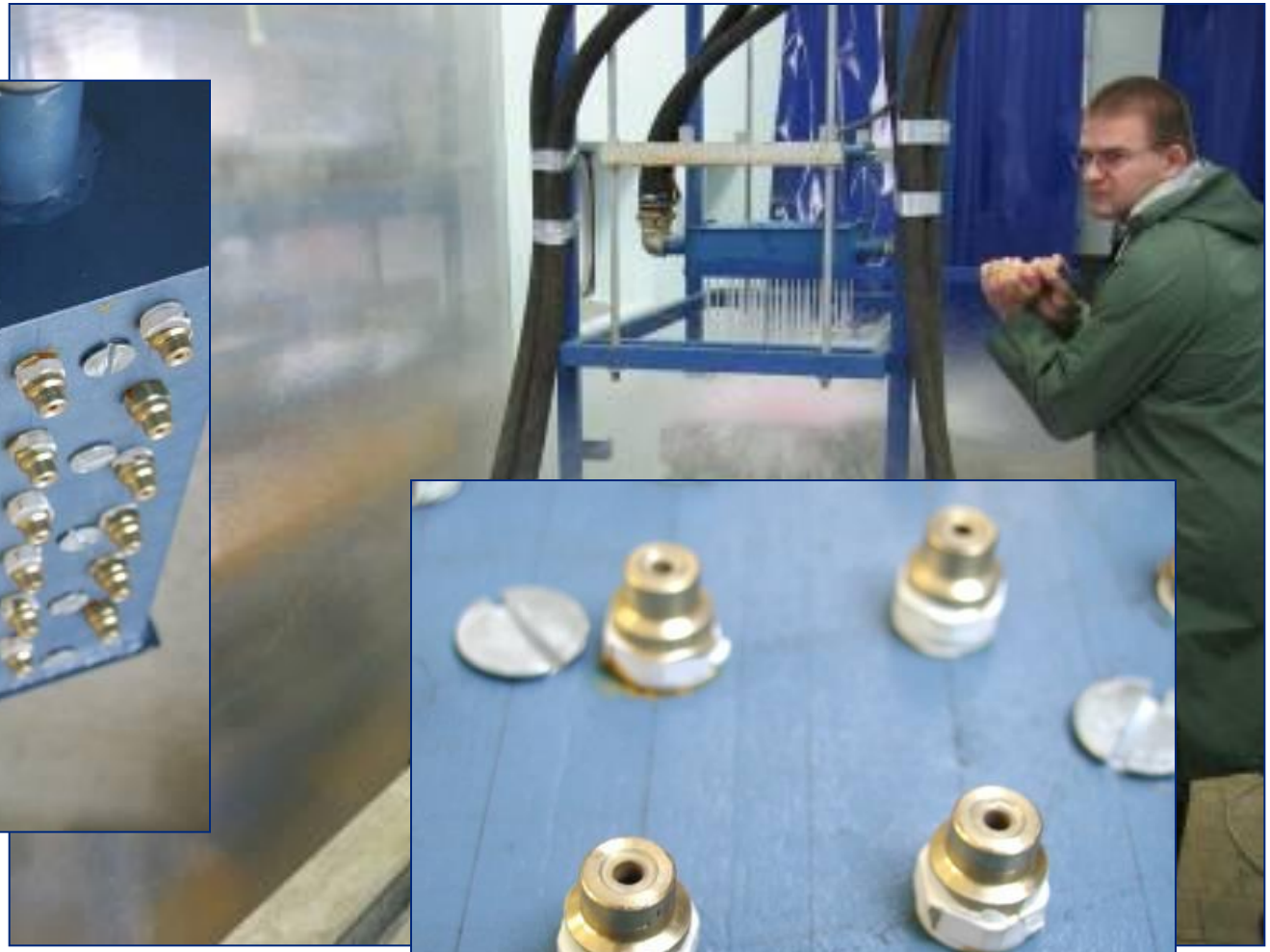
Computer simulation of cooling abilities



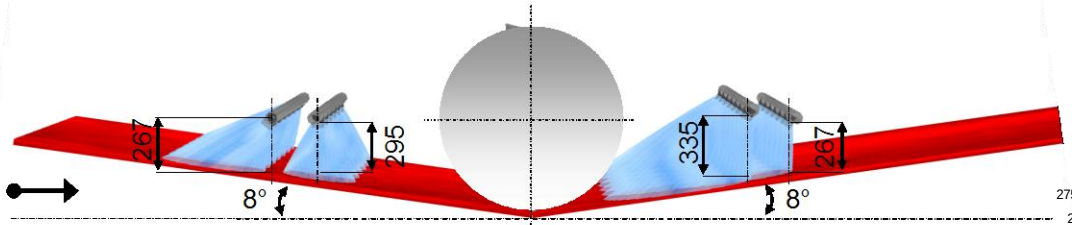


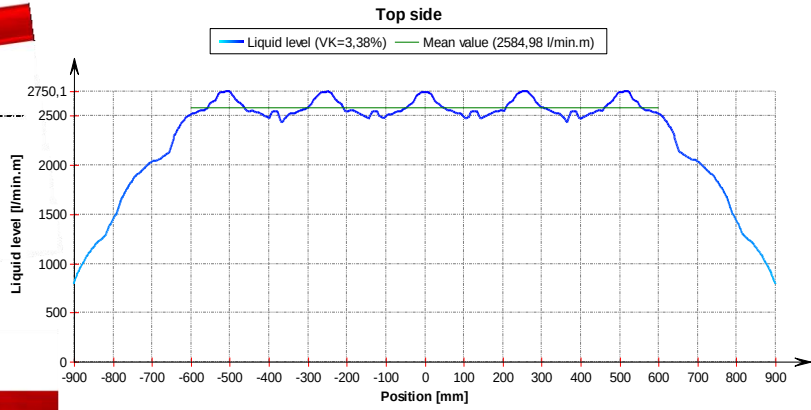
Headers with conical nozzles

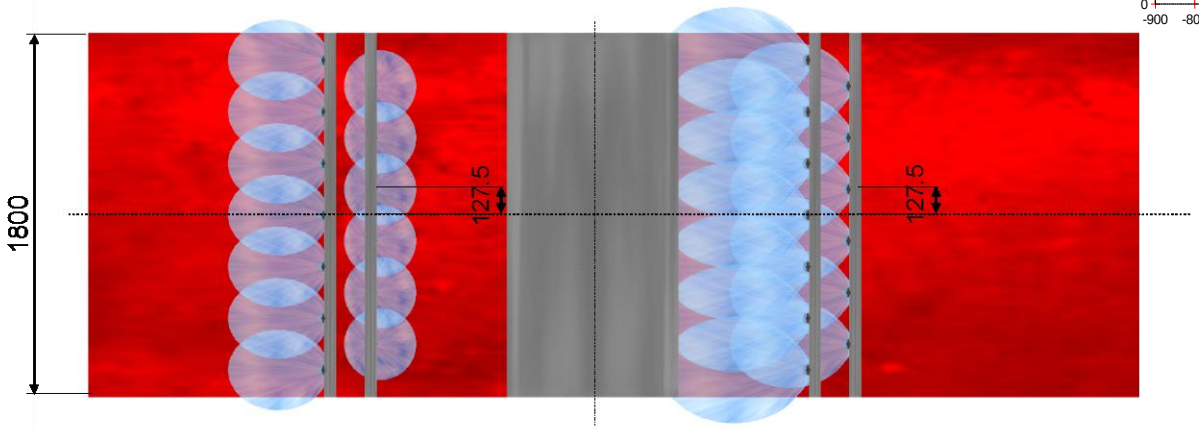
Headers with nozzles (Solid Jet)



Designed upper cooling headers with conical nozzles





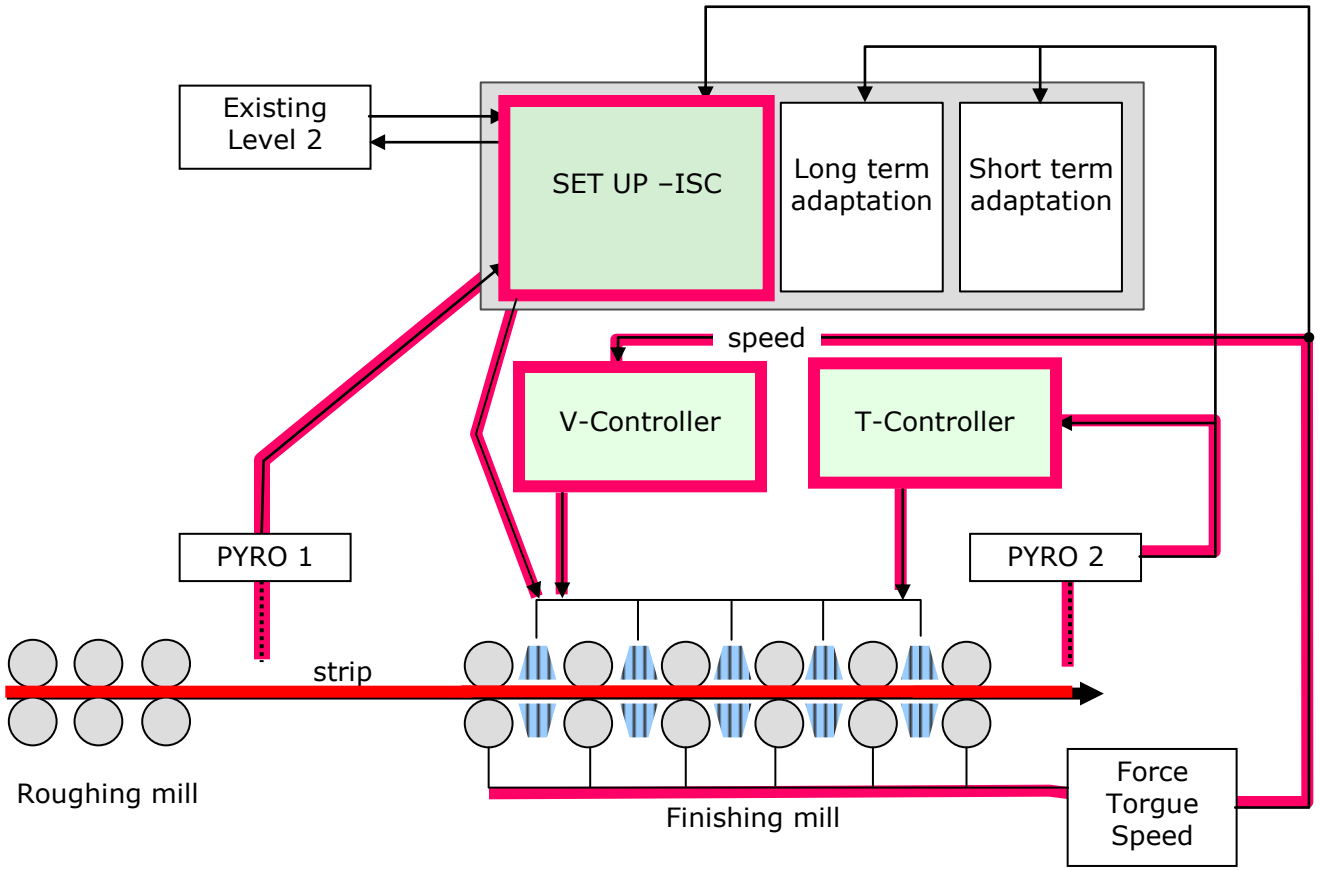


Control system of ISC

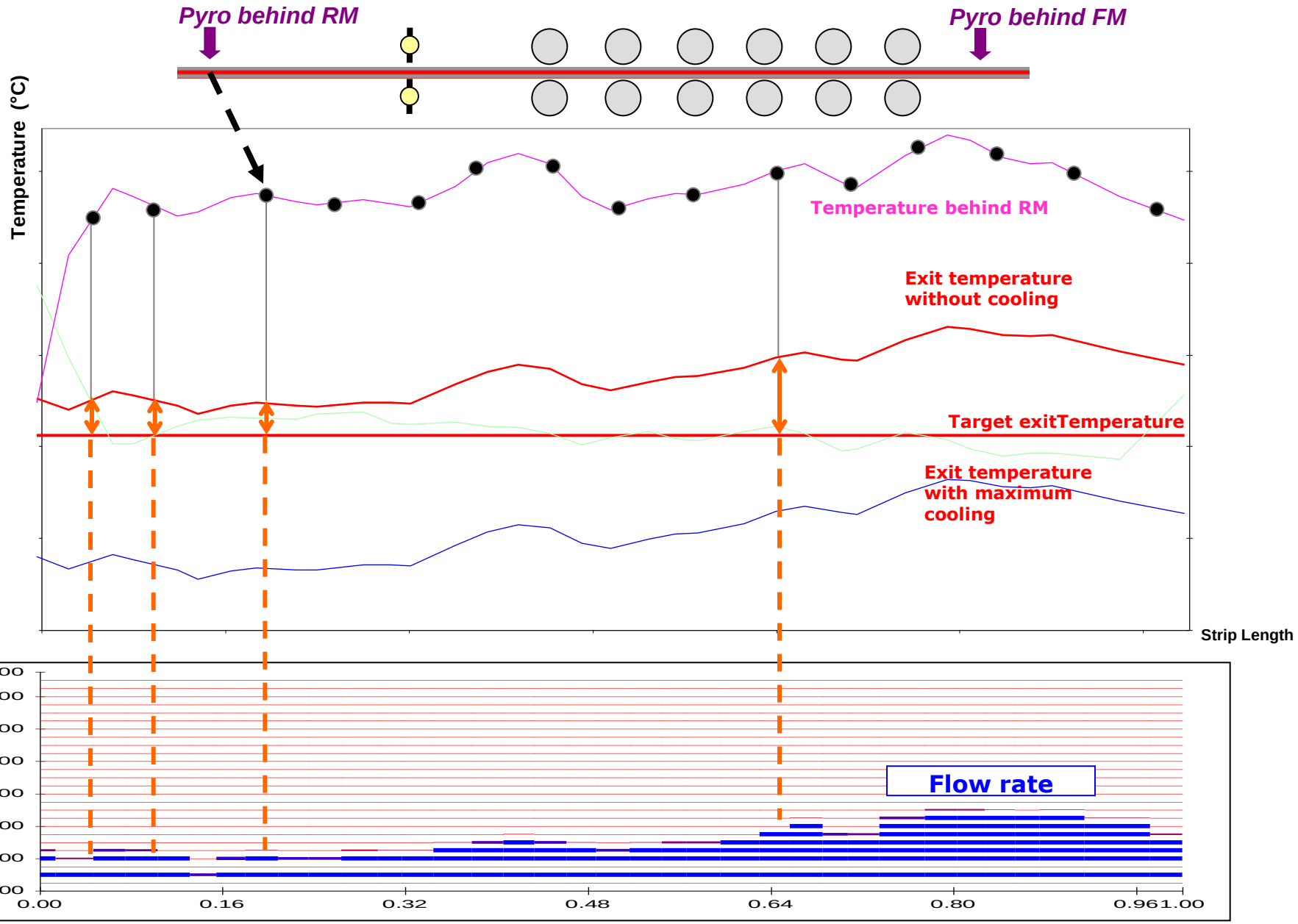
a) In existing Level 2, working on process computer

b) Independent control system working on separate computer

Scheme of the control system ISC



Setup of ISC


Pyro behind RM
Pyro behind FM
Temperature (°C)
Temperature behind RM
Exit temperature without cooling
Target exitTemperature
Exit temperature with maximum cooling
Strip Length
Cooling heads
Flow rate
0.00
0.16
0.32
0.48
0.64
0.80
0.961.00

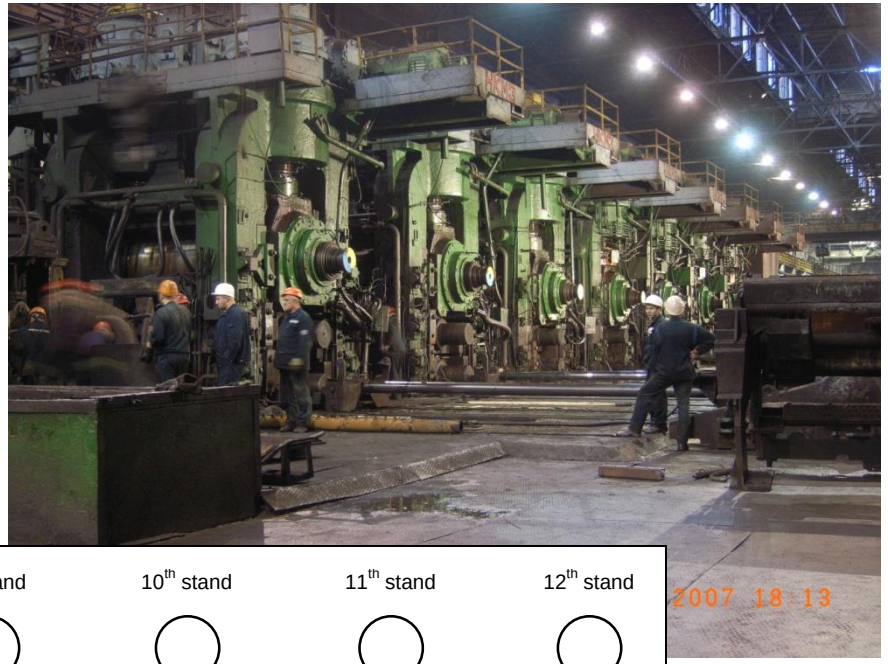
Practical Experience

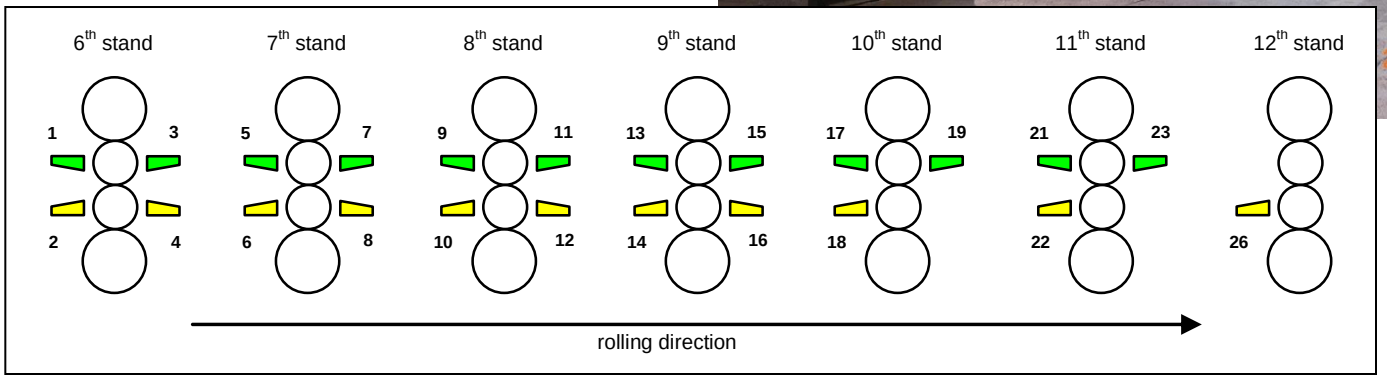
(2000 mm hot strip mill)

1. Thin Strips

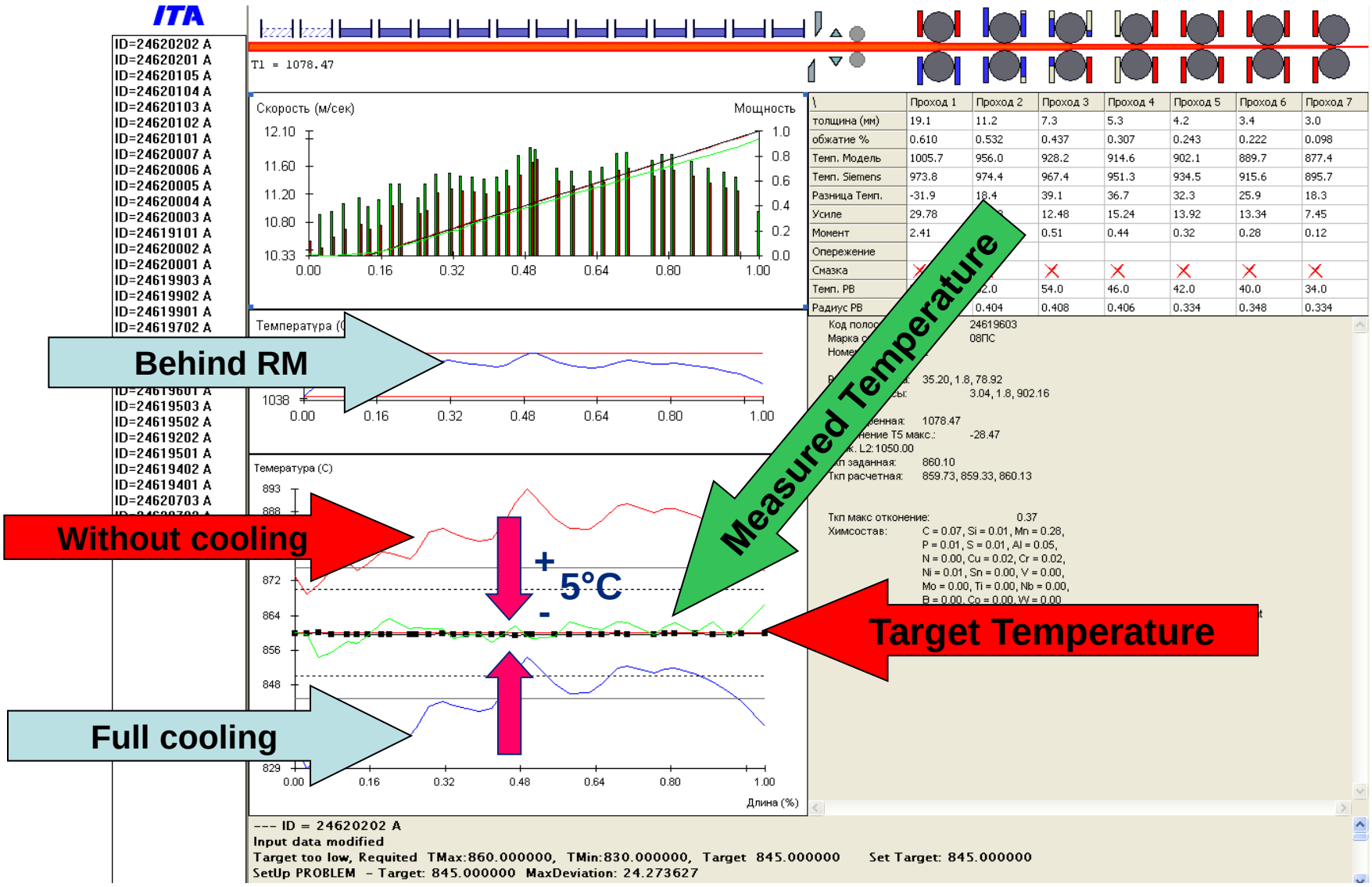
2. Thick Strips

3. Productivity





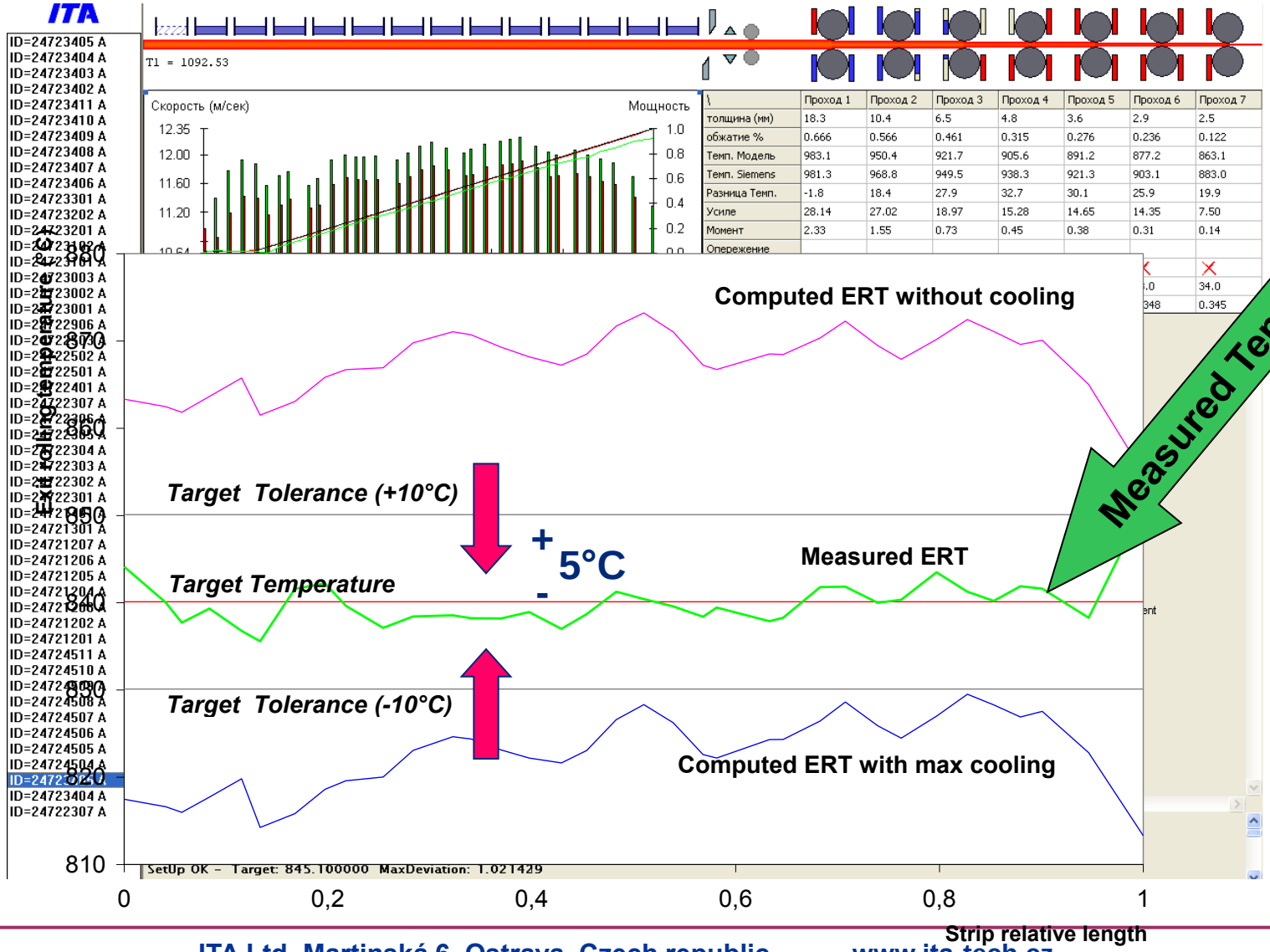
Thin strips (thickness 3 mm)



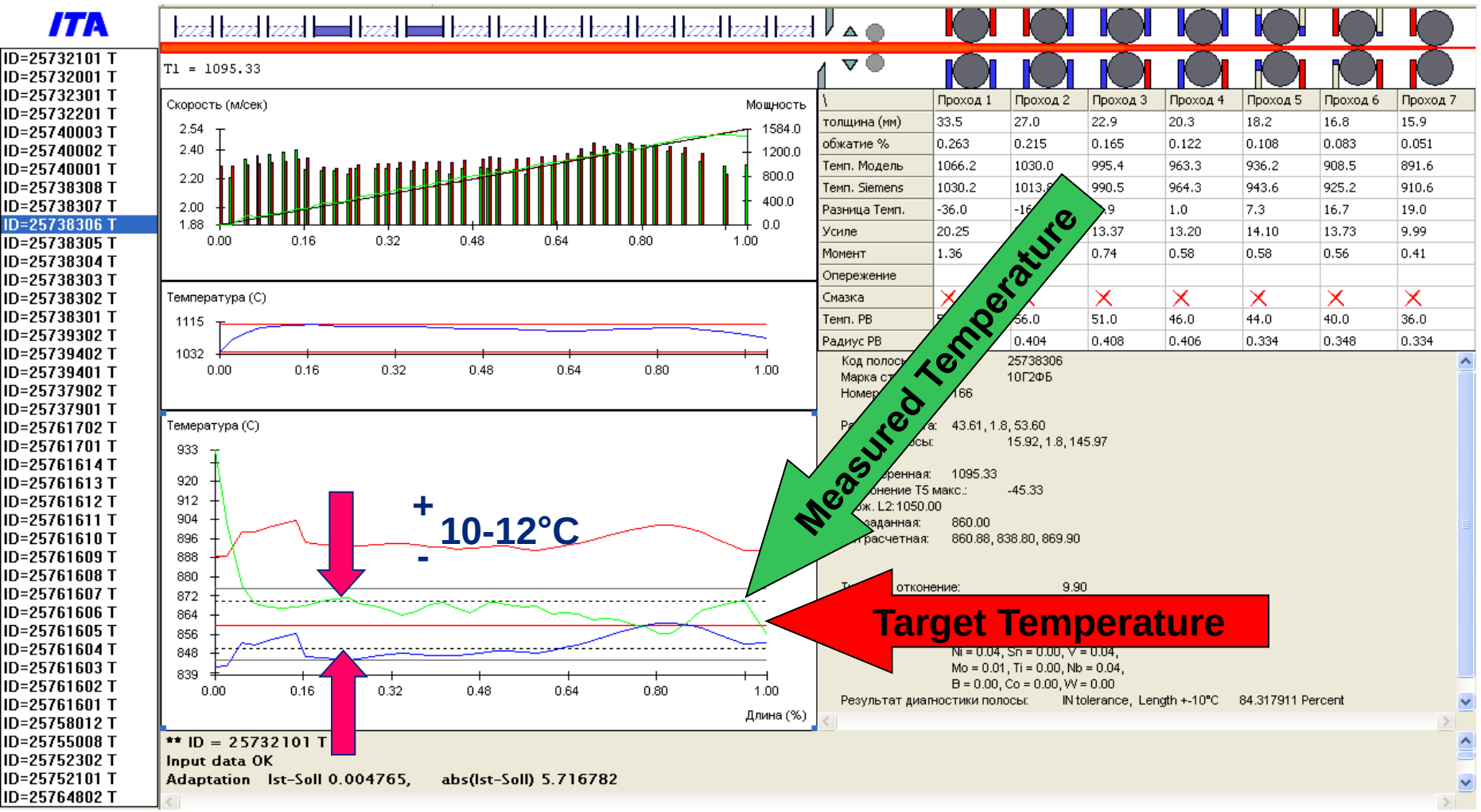
\	Проход 1	Проход 2	Проход 3	Проход 4	Проход 5	Проход 6	Проход 7
толщина (мм)	19.1	11.2	7.3	5.3	4.2	3.4	3.0
обжатие %	0.610	0.532	0.437	0.307	0.243	0.222	0.098
Темп. Модель	1005.7	956.0	928.2	914.6	902.1	889.7	877.4
Темп. Siemens	973.8	974.4	967.4	951.3	934.5	915.6	895.7
Разница Темп.	-31.9	18.4	39.1	36.7	32.3	25.9	18.3
Усилие	29.78		12.48	15.24	13.92	13.34	7.45
Момент	2.41		0.51	0.44	0.32	0.28	0.12
Опережение							
Смазка	X		X	X	X	X	X
Темп. РВ		2.0	54.0	46.0	42.0	40.0	34.0
Радиус РВ		0.404	0.408	0.406	0.334	0.348	0.334

Код полос 24619603
Марка с 08ПС
Номе
35.20, 1.8, 78.92
3.04, 1.8, 902.16
1078.47
-28.47
L2:1050.00
860.10
Ткп расчетная: 859.73, 859.33, 860.13
Ткп макс отконение: 0.37
Химсостав: C = 0.07, Si = 0.01, Mn = 0.28, P = 0.01, S = 0.01, Al = 0.05, N = 0.00, Cu = 0.02, Cr = 0.02, Ni = 0.01, Sn = 0.00, V = 0.00, Mo = 0.00, Ti = 0.00, Nb = 0.00, B = 0.00, Co = 0.00, W = 0.00

Thin strips (thickness 2.5 mm)



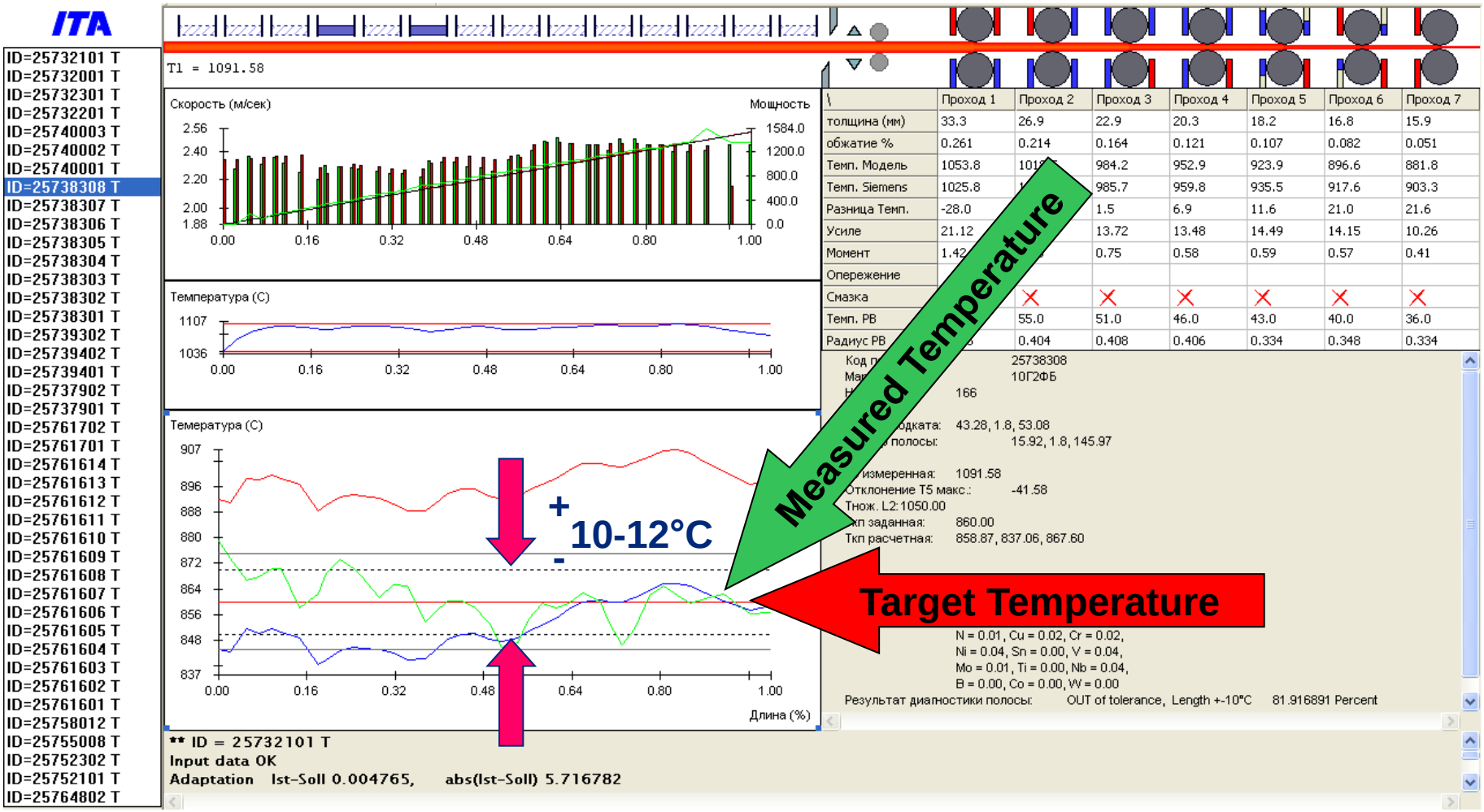
Thick strips (thickness 16 mm)



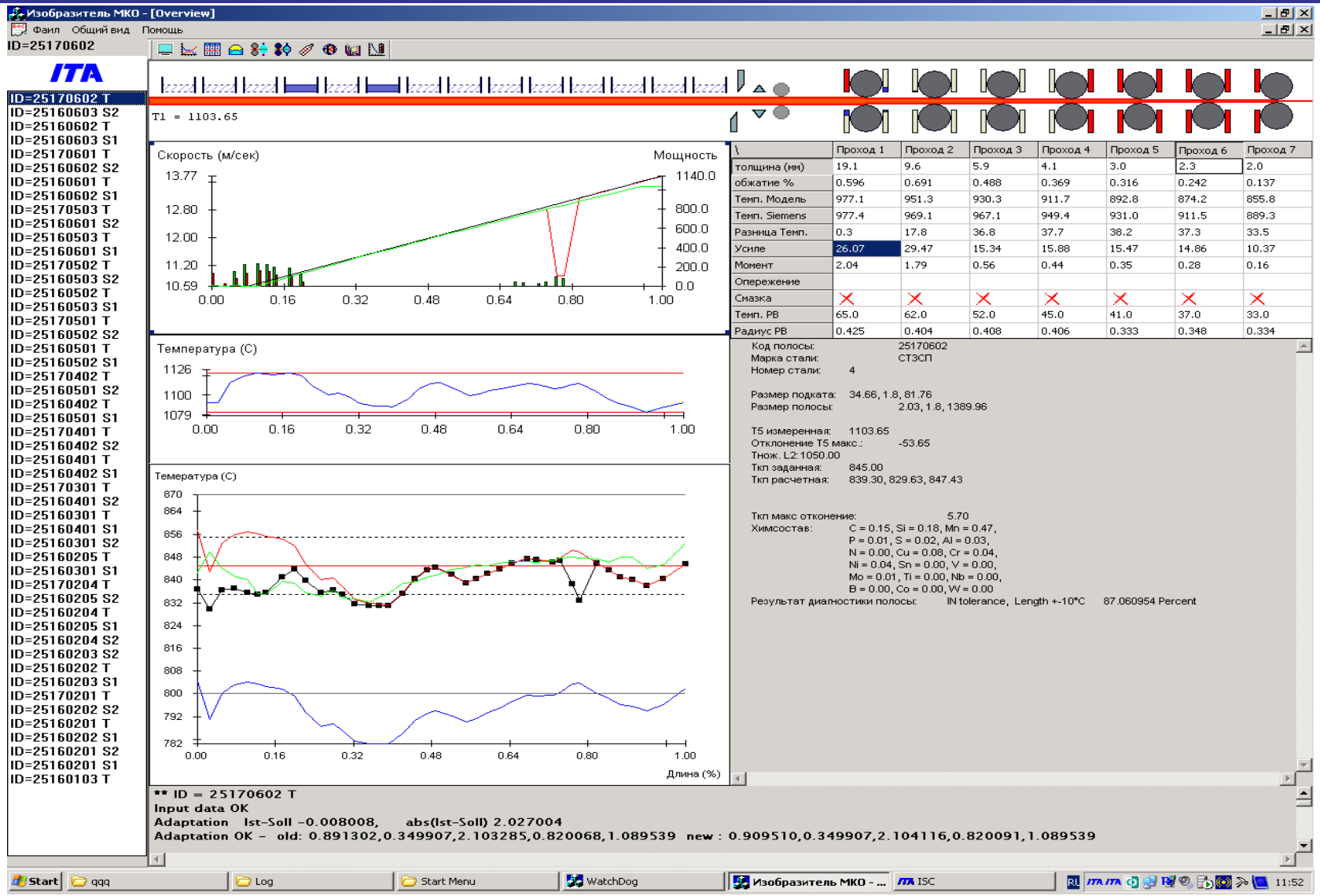
\	Проход 1	Проход 2	Проход 3	Проход 4	Проход 5	Проход 6	Проход 7
толщина (мм)	33.5	27.0	22.9	20.3	18.2	16.8	15.9
обжатие %	0.263	0.215	0.165	0.122	0.108	0.083	0.051
Темп. Модель	1066.2	1030.0	995.4	963.3	936.2	908.5	891.6
Темп. Siemens	1030.2	1013.6	990.5	964.3	943.6	925.2	910.6
Разница Темп.	-36.0	-16	.9	1.0	7.3	16.7	19.0
Усиле	20.25		13.37	13.20	14.10	13.73	9.99
Момент	1.36		0.74	0.58	0.58	0.56	0.41
Опережение							
Смазка	X	X	X	X	X	X	X
Темп. PB	5	56.0	51.0	46.0	44.0	40.0	36.0
Радиус PB		0.404	0.408	0.406	0.334	0.348	0.334

Код полосы: 25738306
Марка ст: 10Г2ФБ
Номер: 166
Ра: 43.61, 1.8, 53.60
сы: 15.92, 1.8, 145.97
еренная: 1095.33
онение T5 макс.: -45.33
ж. L2:1050.00
заданная: 860.00
расчетная: 860.88, 838.80, 869.90
отконение: 9.90
Ni = 0.04, Sn = 0.00, V = 0.04,
Mo = 0.01, Ti = 0.00, Nb = 0.04,
B = 0.00, Co = 0.00, W = 0.00
Результат диагностики полосы: IN tolerance, Length +-10°C 84.317911 Percent

Thick strips (thickness 16 mm)



Increase of productivity
Velocity 14 m/s (2mm strip)



\	Проход 1	Проход 2	Проход 3	Проход 4	Проход 5	Проход 6	Проход 7
толщина (мм)	19.1	9.6	5.9	4.1	3.0	2.3	2.0
обжатие %	0.596	0.691	0.488	0.369	0.316	0.242	0.137
Темп. Модель	977.1	951.3	930.3	911.7	892.8	874.2	855.8
Темп. Siemens	977.4	969.1	967.1	949.4	931.0	911.5	889.3
Разница Темп.	0.3	17.8	36.8	37.7	38.2	37.3	33.5
Усиле	26.07	29.47	15.34	15.88	15.47	14.86	10.37
Момент	2.04	1.79	0.56	0.44	0.35	0.28	0.16
Опережение							
Смазка	X	X	X	X	X	X	X
Темп. РВ	65.0	62.0	52.0	45.0	41.0	37.0	33.0
Радиус РВ	0.425	0.404	0.408	0.406	0.333	0.348	0.334

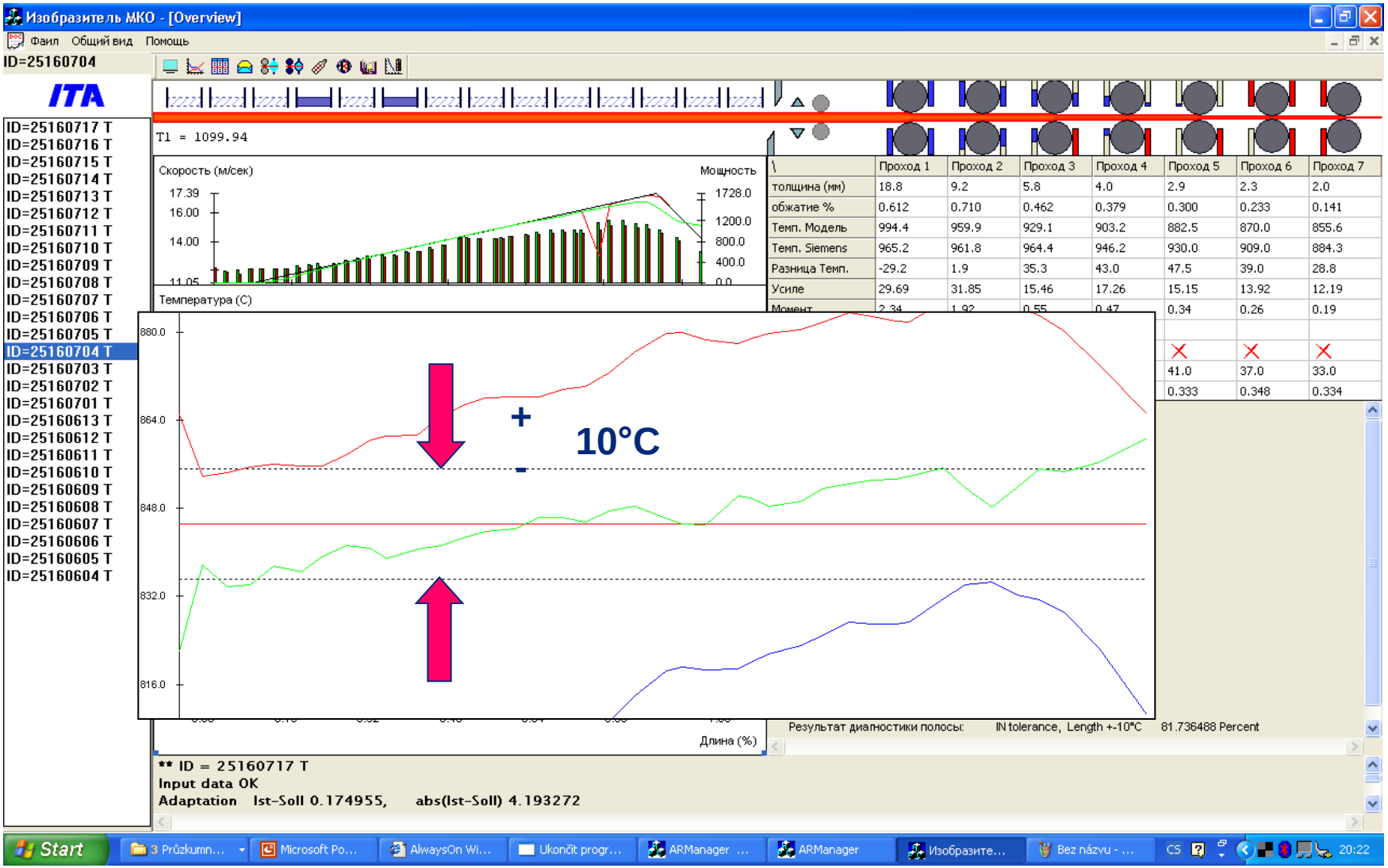
Код полосы: 25170602
Марка стали: СТ3СП
Номер стали: 4

Размер подката: 34.66, 1.8, 81.76
Размер полосы: 2.03, 1.8, 1389.96

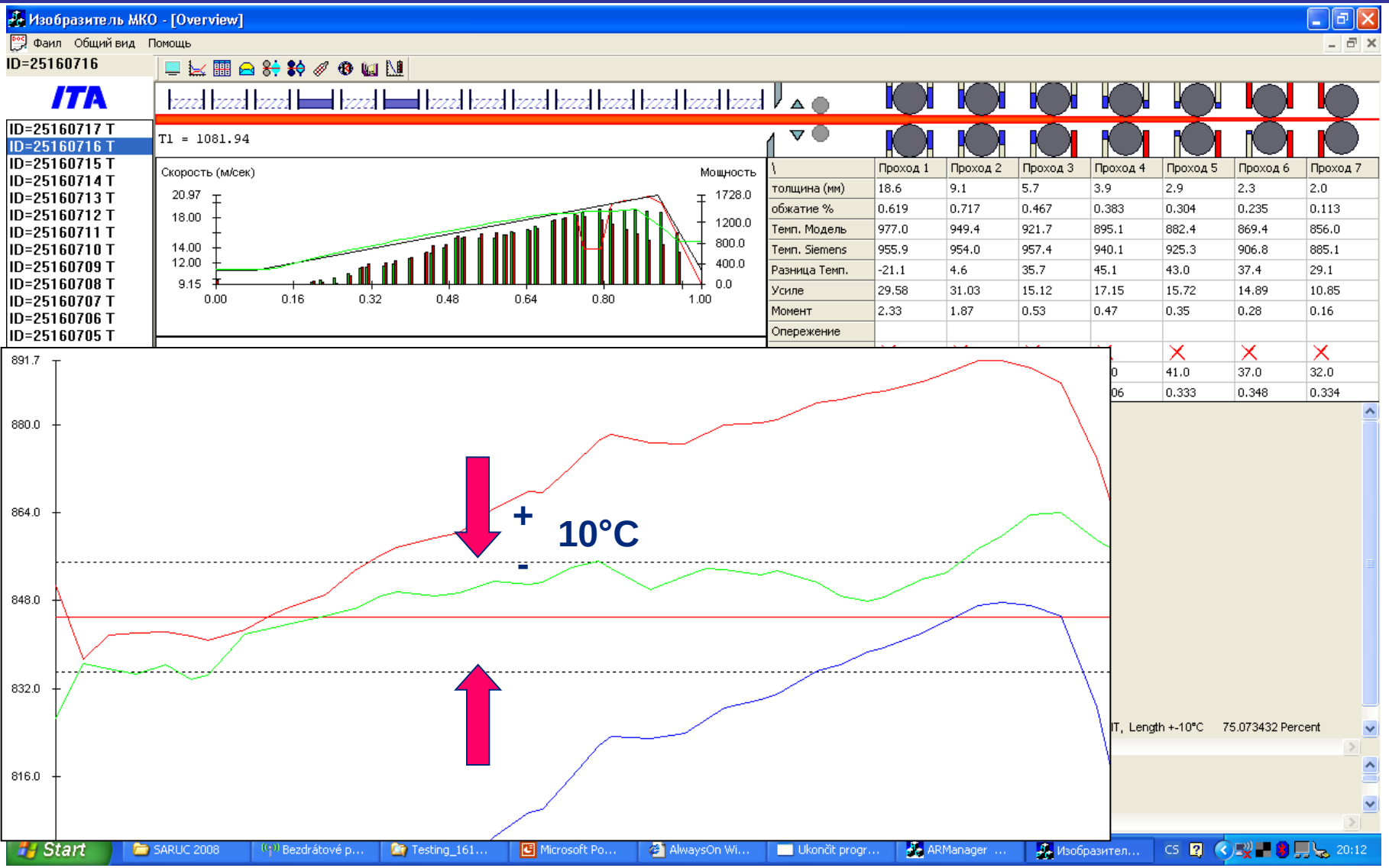
Т5 измеренная: 1103.65
Отклонение Т5 макс.: -53.65
Тнож. L2:1050.00
Ткп заданная: 845.00
Ткп расчетная: 839.30, 829.63, 847.43

Ткп макс отклонение: 5.70
Химсостав: C = 0.15, Si = 0.18, Mn = 0.47,
P = 0.01, S = 0.02, Al = 0.03,
N = 0.00, Cu = 0.08, Cr = 0.04,
Ni = 0.04, Sn = 0.00, V = 0.00,
Mo = 0.01, Ti = 0.00, Nb = 0.00,
B = 0.00, Co = 0.00, W = 0.00
Результат диагностики полосы: IN tolerance, Length +-10°C 87.060954 Percent

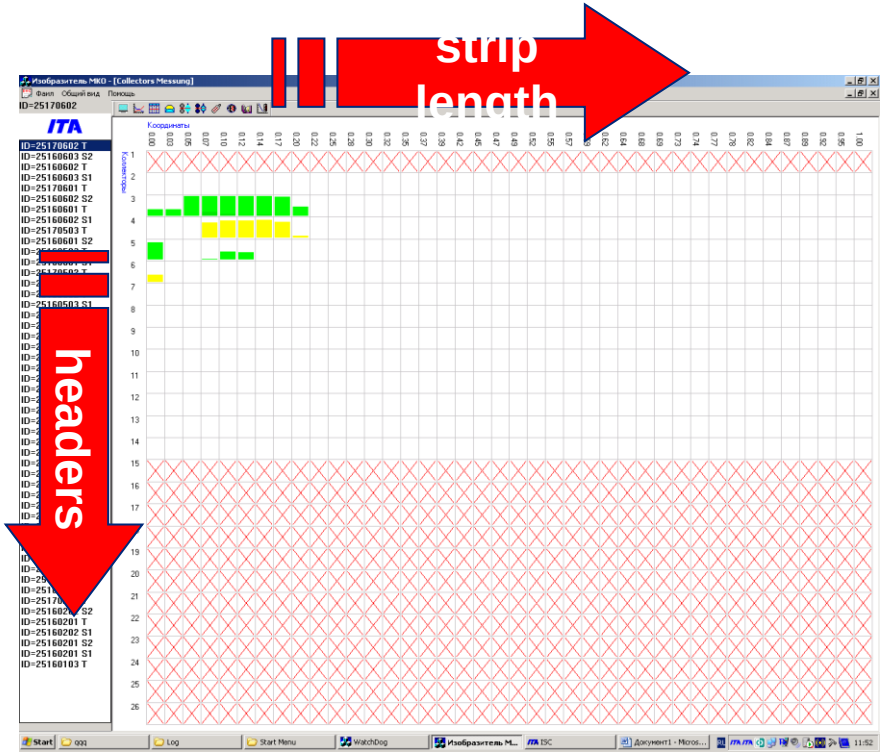
Increase of productivity
Velocity 17,4 m/s (2mm strip)



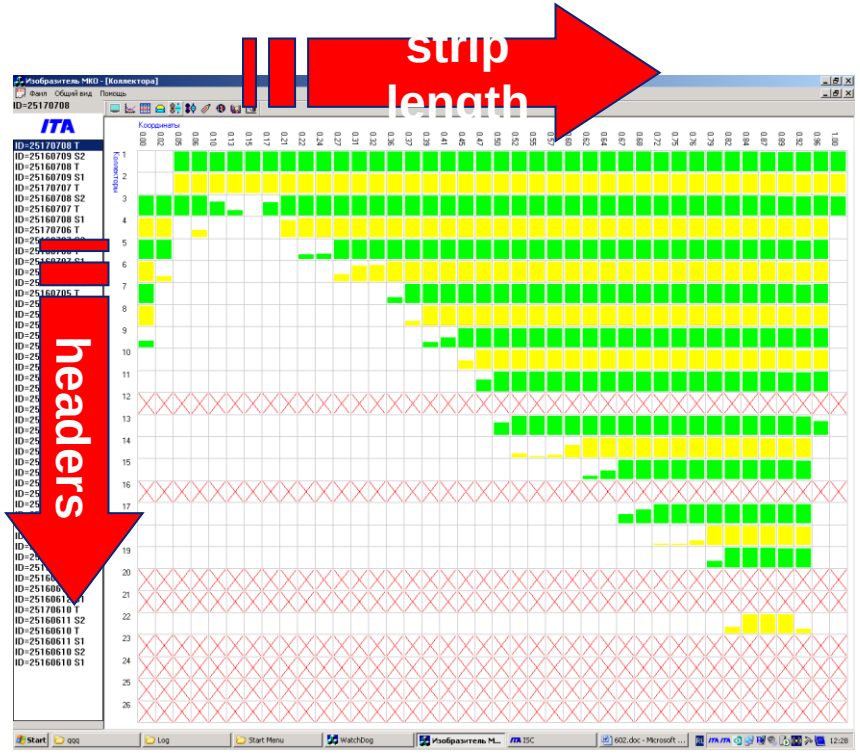
Increase of productivity
Velocity 21 m/s (2mm strip)



Comparison of cooling power (2mm strip)



Velocity 14 m/s



Velocity 21 m/s

Problems

Phase transformation during rolling :

Due to phase transformation an additional heat is generated, that depends on cooling rate, deformation and chemical composition of the steel. It is extremly complicated to reach the temperature tolerance in some steels rolled in party ferritic region.

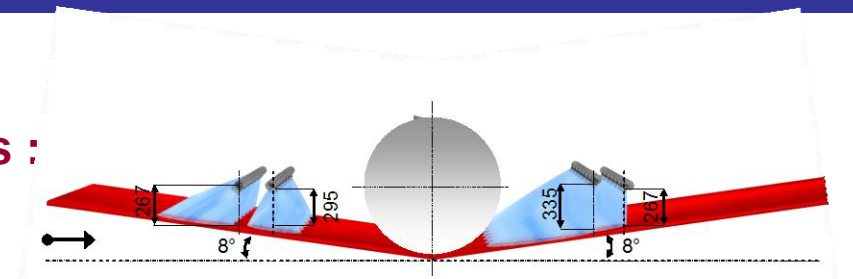
Strong skidmarks (old type furnaces) :

Temperature waves greater than 30°C can be eliminated but control range is considerably reduced.

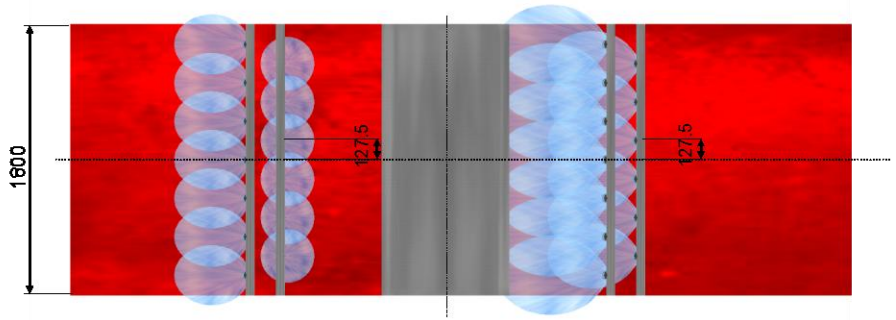
Temperature waves greater than 40°C skidmarks cannot be fully removed especialy in thick strips.

Recapitulation

Optimum solution of Cooling headers :



Nozzles with conical or flat beam



Effects of controlled ISC:

In thin strips (thickness less than 4mm)	deviation +/- 7 °C
In thick strips (thicker than 10mm)	deviation +/- 12 °C
Increase of rolling velocity in thin strips	30%