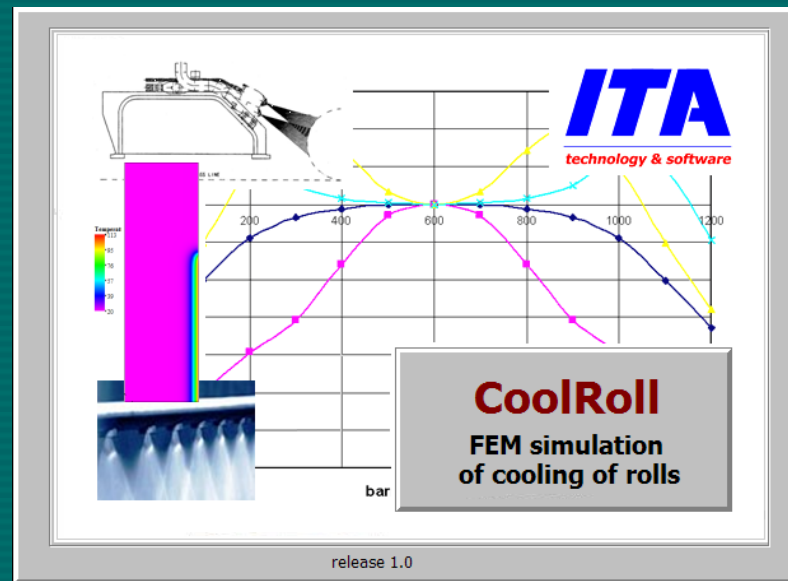


CoolRoll

Concept of the software for the FEM simulation of cooling of rolls



CoolRoll – FEM simulation of cooling of rolls

Introduction

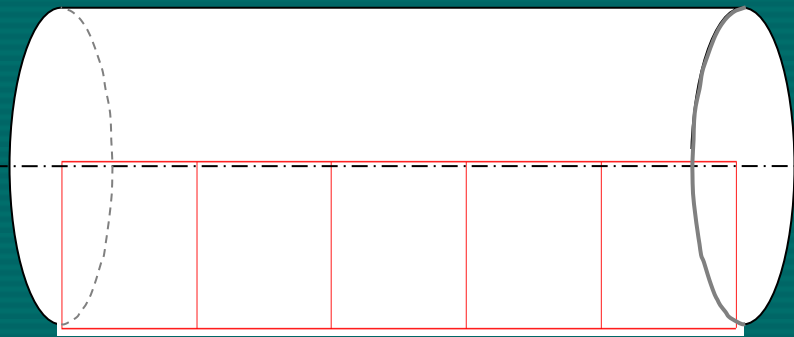
CoolRoll is FEM based software developed by ITA Ltd. for computer simulation of various cooling strategies of rolls during their rolling campaign.

CollRoll pre-processing enables user friendly formation of FEM model, specification of heat transfer boundary conditions and roll campaign.

CoolRoll enables non-stationary heat transfer analysis coupled with elastic analysis to calculate temperatures and deformations and stresses caused by temperature changes in thermal loaded rolls.

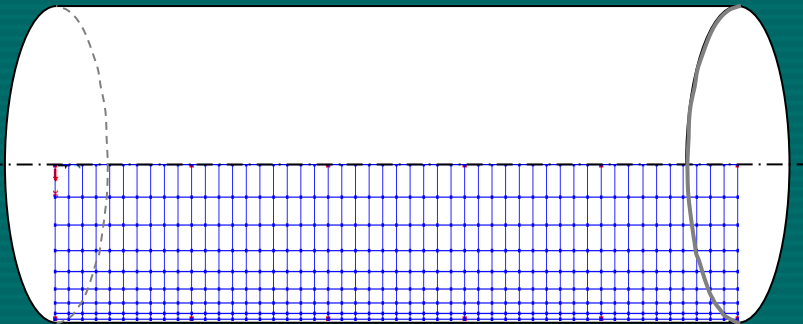
CoolRoll – FEM simulation of cooling of rolls

Work Roll FEM Model – Geometry & Mesh



WRoll Geometry:

- flat cylinder defined by diameter and length,
- specified number of lengthwise segments

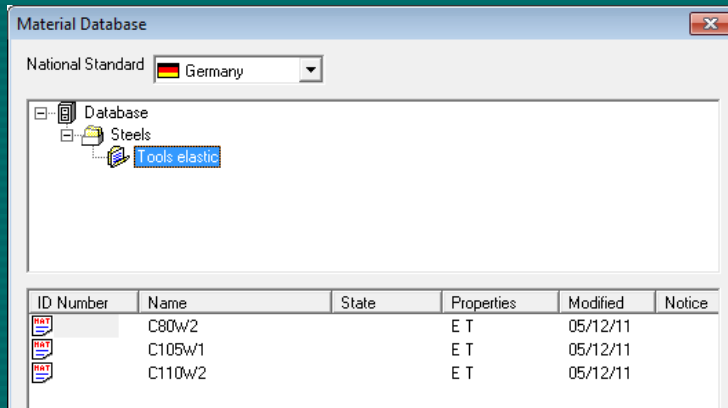


WRoll Mesh:

- mesh made of linear 4node finite elements,
- automatic meshing.

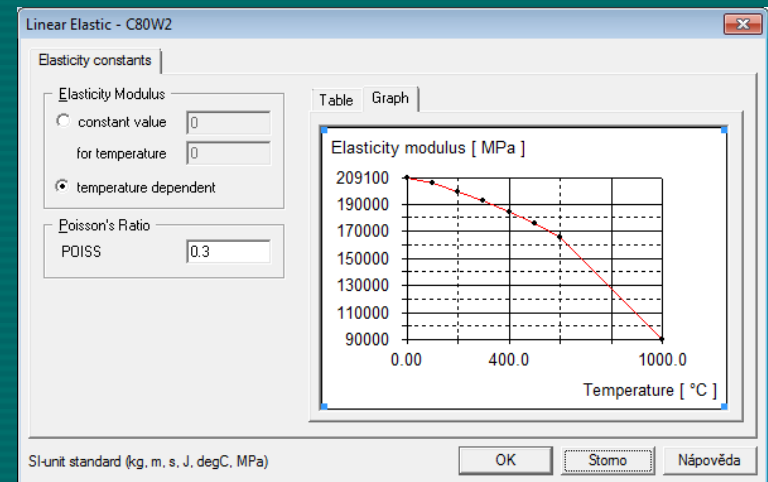
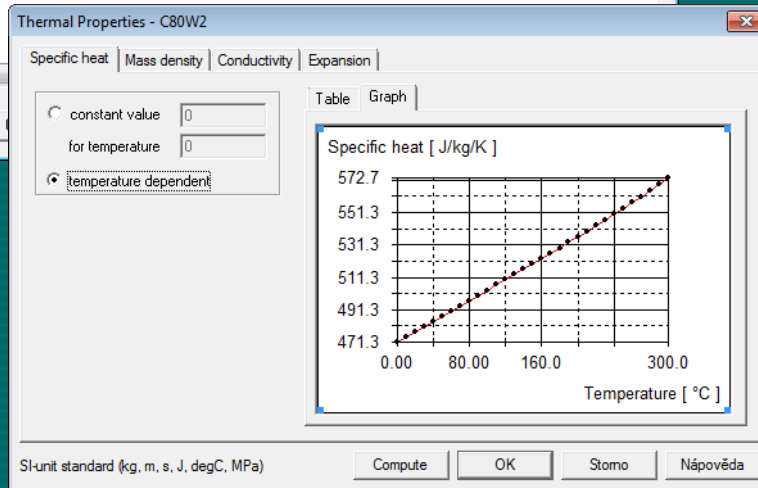
CoolRoll – FEM simulation of cooling of rolls

Work Roll FEM Model – Material Properties



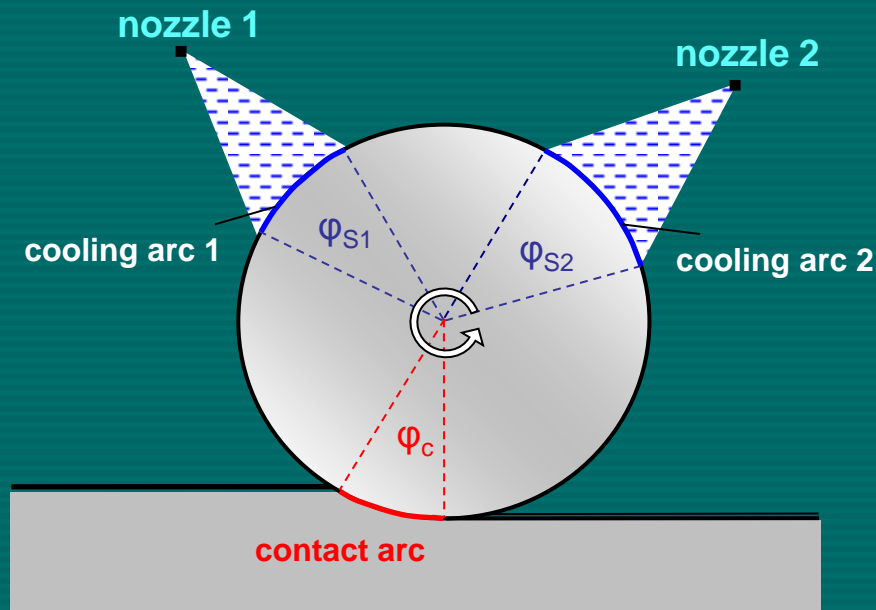
Material Database:

- thermal properties (specific heat, density, conductivity and thermal expansion)
- elastic properties (elasticity modulus, Poissons ratio)



CoolRoll – FEM simulation of cooling of rolls

Work Roll FEM Model – Heat Transfer conditions



Problem of the model dimension:

FEM model of the WRoll is created in the lengthwise plane but boundary conditions change in transversal plane as well



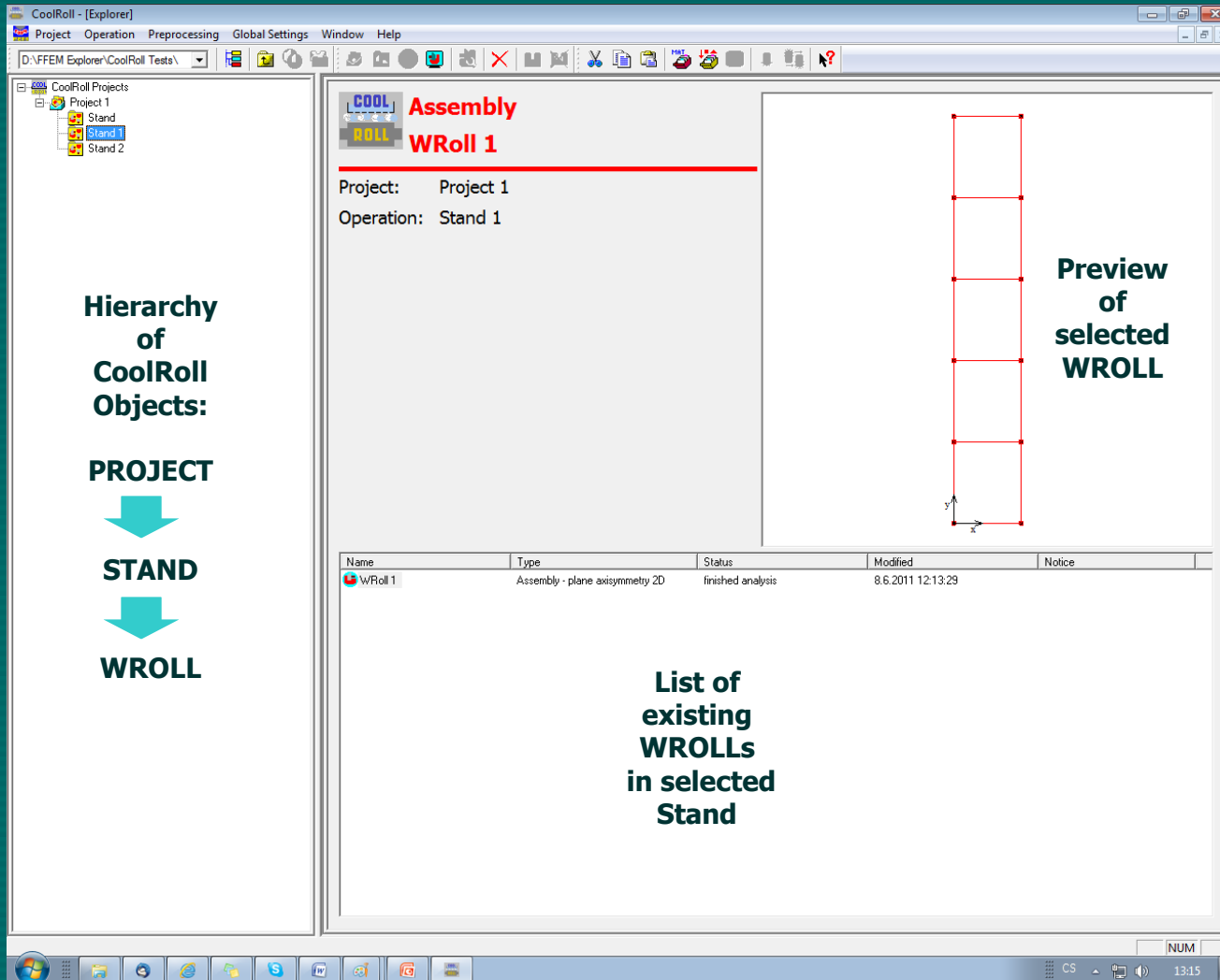
special pre-processing of Heat Transfer conditions was developed!

Special pre-processing of Heat Transfer (HT) Conditions:

- HT conditions for each arc are specified,
- time sequence of HT conditions for one rotation of the WRoll is created,
- time sequence of HT conditions for one pass or one pause between passes is created,
- temperature of the WRoll for each pass or pause between passes is calculated by 1D FEM module (average temperature from the surface to the centre of the WRoll)
- average HT conditions (heat transfer coefficient and ambient temperature) for each pass or pause between passes are calculated

CoolRoll – FEM simulation of cooling of rolls

User Interface – Main CollRoll Window



CoolRoll – FEM simulation of cooling of rolls

Pre-processing Wizard 1 – Work Roll FEM Model

Work roll - Dimensions, Properties & Cooling headers

Roll dimensions

Diameter [mm]

Barrel length [mm]

Roll properties

Initial temperature [°C]

<< Roll Material

Material database

Cooling headers - lengthwise distribution

symmetrical configuration

	Length [mm]	Mesh density	Headers
L1	100.00	standard	<input checked="" type="checkbox"/>
L2	50.00	standard	<input checked="" type="checkbox"/>

Mesh density in radial direction

Cooling headers - circuit distribution

	L [mm]	FI [deg]	BETA [deg]	KSI [deg]
C1	50.00	70.00	80.00	90.00
C2	150.00	60.00	50.00	120.00

Specification of cooling headers in transversal plane:

- L = distance from the roll surface
- FI = angular position of the nozzle
- BETA = spraying angle
- KSI = skew angle of the nozzle

Specification of lengthwise cooling segments

< Zpět Stomo

CoolRoll – FEM simulation of cooling of rolls

Pre-processing Wizard 2 – Campaign & Technology

Work roll - Technology & Cooling strategy

Work roll campaign

Group of passes	Product 1
Number of identical passes	50
Pass - Technology	
Pass - Work roll cooling	
Group of passes	Product 2
Number of identical passes	40
Pass - Technology	
Pass - Work roll cooling	
Group of passes	Product 3
Number of identical passes	30
Pass - Technology	
Pass - Work roll cooling	
Group of passes	Product 4
Number of identical passes	
Pass - Technology	

Technology parameters

Group of passes: Product 1

Entry thickness [mm]	7.00
Exit thickness [mm]	5.00
Entry length [m]	30.00
Strip / Plate width [mm]	1500.00
Exit speed [m/s]	5.00
Roll revolutions [1/min]	30.00
Rolling force [MN]	10.00
Pause between passes [s]	8.00
Pause till next group [s]	10.00
Friction coefficient	1.00
Strip / Plate temperature [°C]	200.00

Technology parameters:

Rolling time [s]:	8.40
Number of revolutions:	16.80
Contact arc [deg]:	0.57
Exit length [m]:	42.00

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Technology parameters of selected pass

Group of passes = specified number of identical passes separated by time pause

CoolRoll – FEM simulation of cooling of rolls

Pre-processing Wizard 3 – Campaign & Cooling strategy

Work roll - Technology & Cooling strategy

Work roll campaign

Group of passes	Product
Group of passes	Product 1
Number of identical passes	50
Pass - Technology	
Pass - Work roll cooling	
Group of passes	Product 2
Number of identical passes	40
Pass - Technology	
Pass - Work roll cooling	
Group of passes	Product 3
Number of identical passes	30
Pass - Technology	
Pass - Work roll cooling	
Group of passes	Product 4
Number of identical passes	20
Pass - Technology	

Work roll cooling strategy

Group of passes:

Lengthwise segment	HT conditions
L1	HTC
Circuit segment	HTC
on / off	<input checked="" type="checkbox"/>
Circuit segment	HTC
on / off	<input checked="" type="checkbox"/>
Circuit segment	HTC
on / off	<input checked="" type="checkbox"/>
Circuit segment	HTC
on / off	<input checked="" type="checkbox"/>
Lengthwise segment	HTC

no spraying between passes Contact HT conditions

no spraying between groups Air cooling conditions

< Zpět Další > Storno

Heat transfer conditions for:

- water cooled segments
- air cooled segments
- segment in contact with rolled piece

Heat Transfer Definition

Name: |spraying1|

Description:

Heat Transfer Coefficient

constant [W/m²/K]: 1500

depending on temperature

Emissivity

constant [-]: 0

depending on temperature

Ambient temperature [°C]: 20

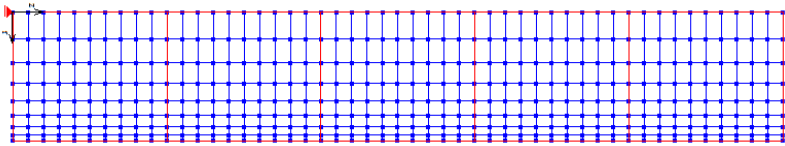
OK Cancel

CoolRoll – FEM simulation of cooling of rolls

Pre-processing Wizard 4 – FEM Analysis options

Work roll - FEM model & Analysis options

Preview of the FEM model



Monitoring Points List

	Depth	Length
MPoint1	0	11.3
MPoint2	30	11.3

Analysis Options

- thermal camber & stresses
- Temperature criterion: 0.005
- Max. number of iterations: 200
- save results each: 1 time step

Number of time steps

<input type="checkbox"/> Product 1	30
pass rolling	10
pass pause	10
<input type="checkbox"/> Product 2	30
pass rolling	10
pass pause	10
<input type="checkbox"/> Product 3	30
pass rolling	10
pass pause	10

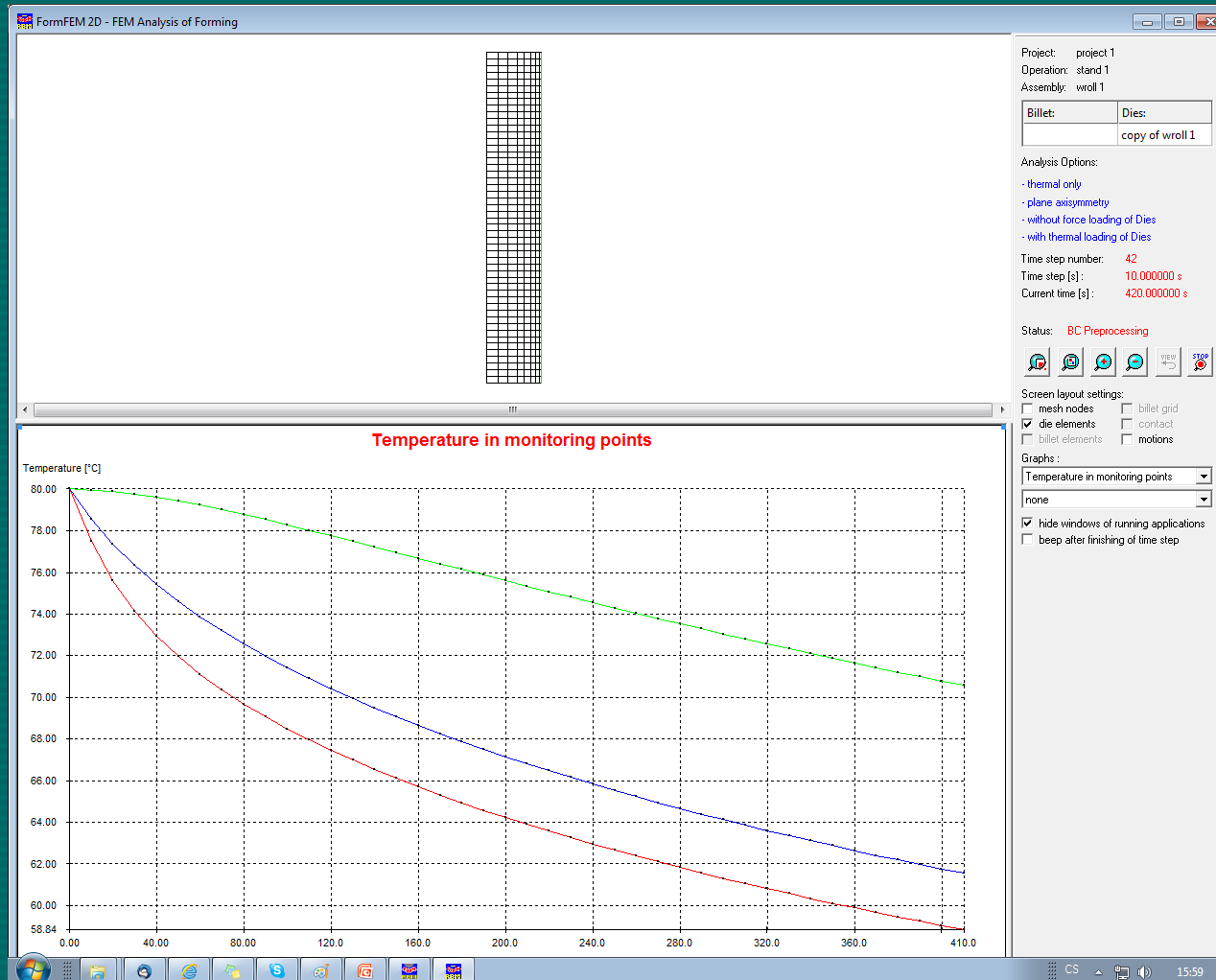
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Coordinates of points which time history will be saved in

Number of time steps in each pass and subsequent time pause

CoolRoll – FEM simulation of cooling of rolls

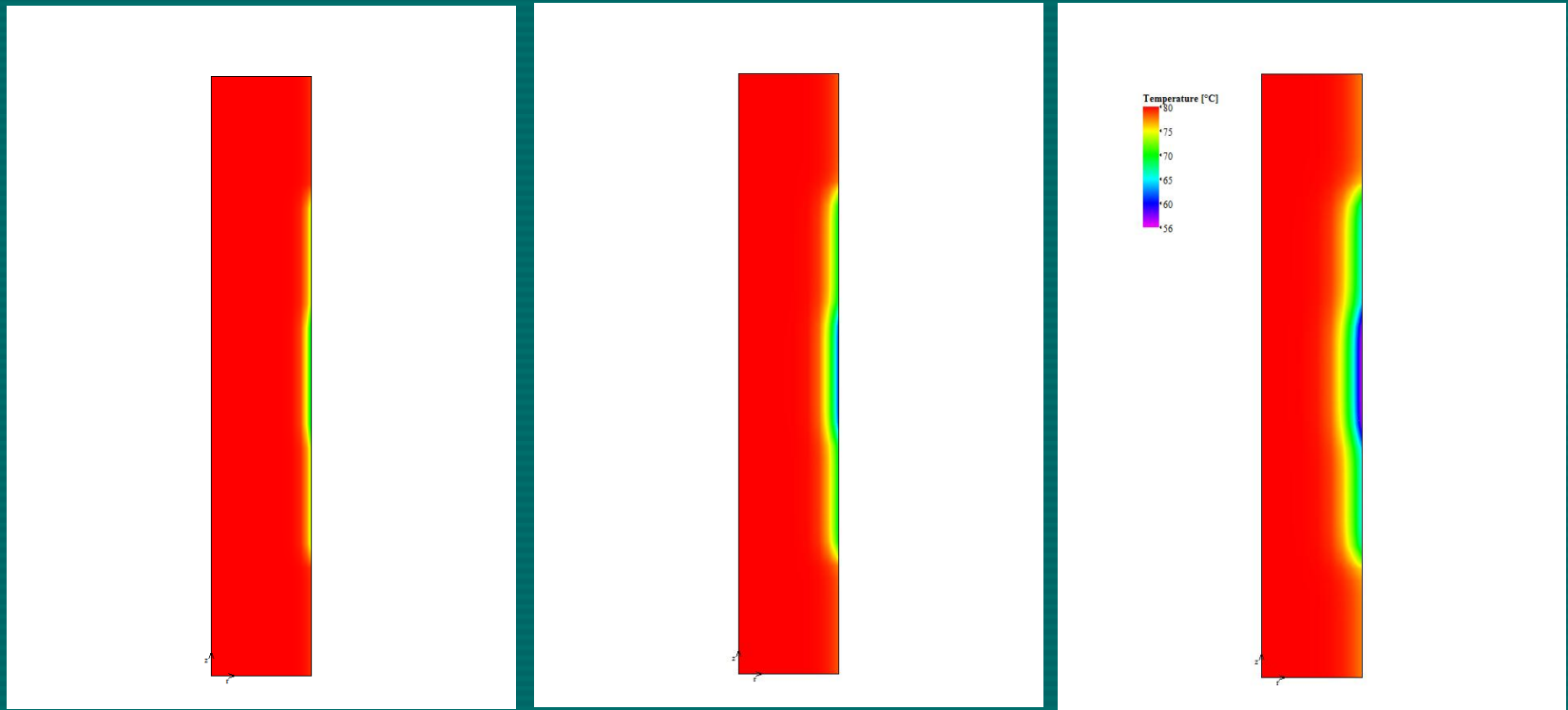
Screen of running FEM Analysis



CoolRoll – FEM simulation of cooling of rolls

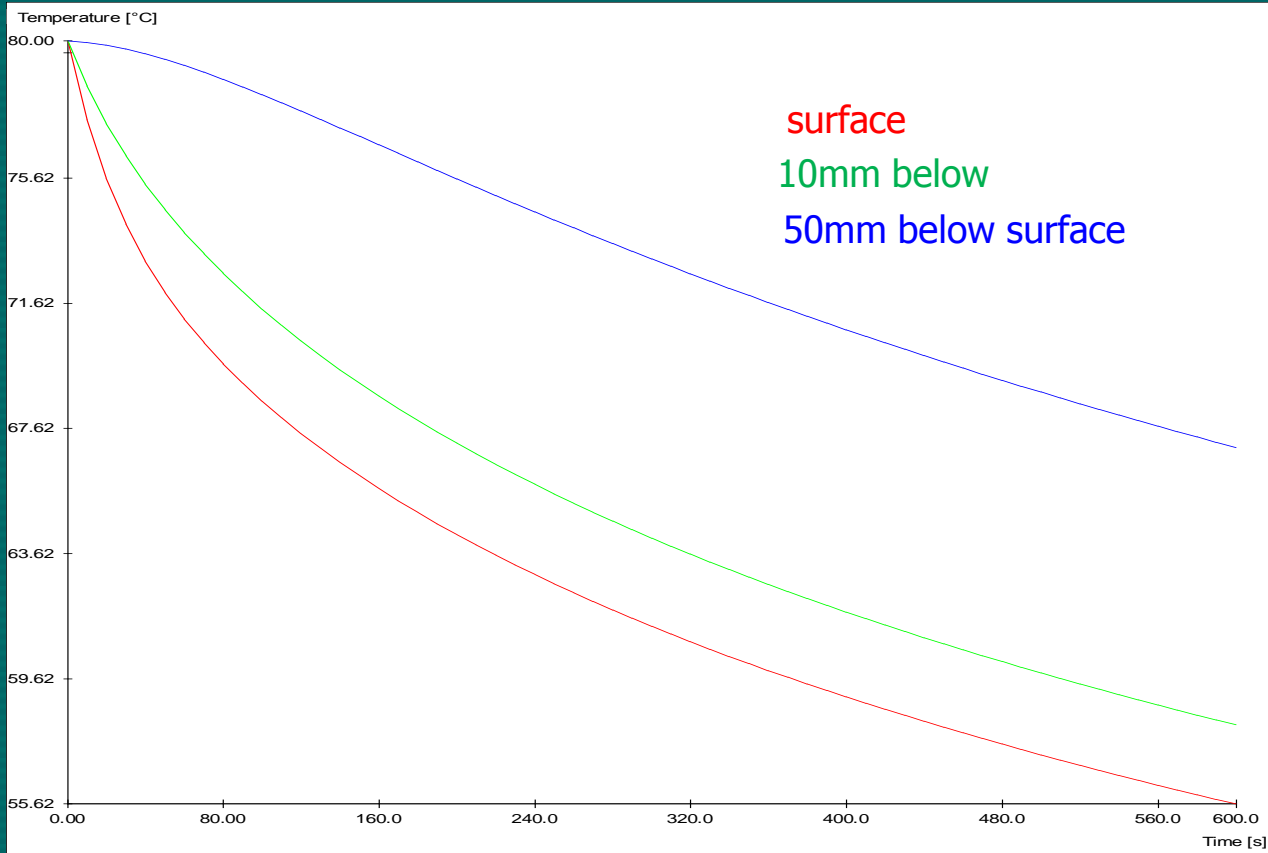
Post-processing of results

Temperature distribution in specified time of the roll campaign



CoolRoll – FEM simulation of cooling of rolls

Post-processing of results

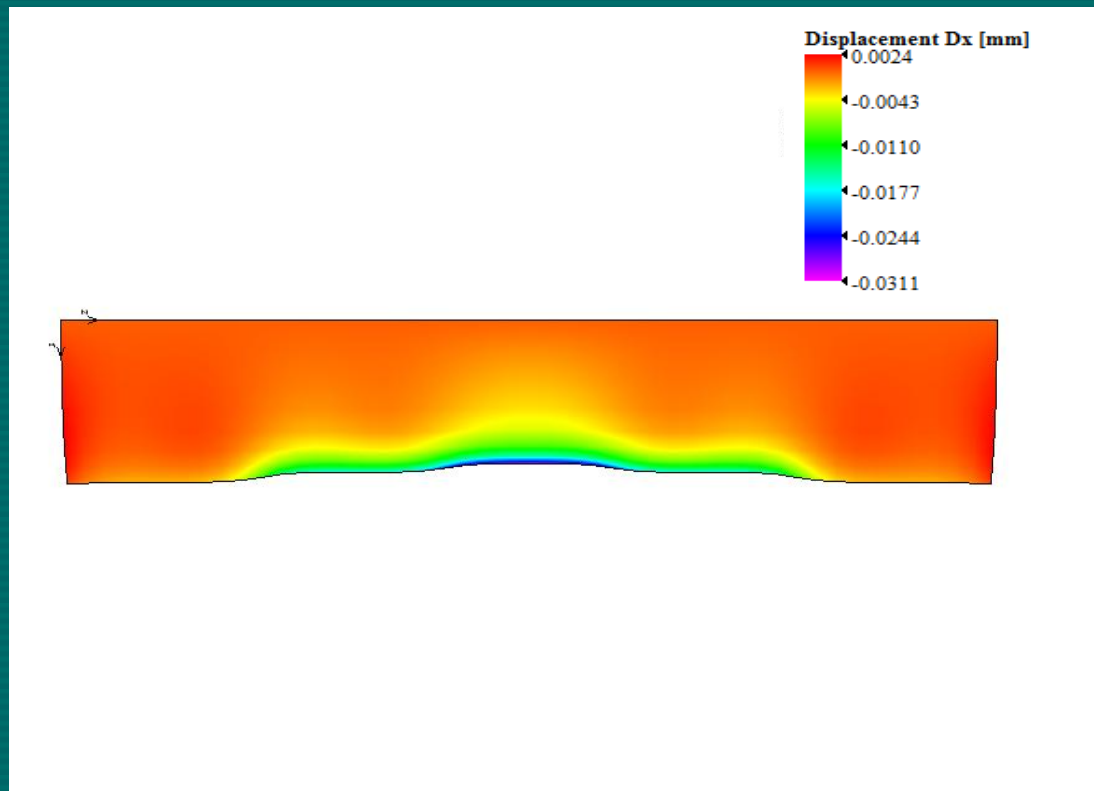


Time history of temperatures in specified monitoring points of the roll

CoolRoll – FEM simulation of cooling of rolls

Post-processing of results

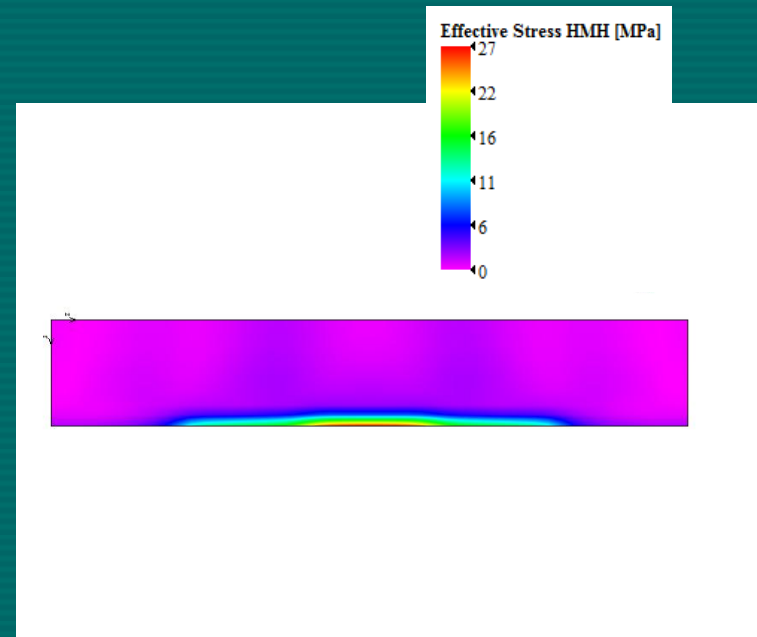
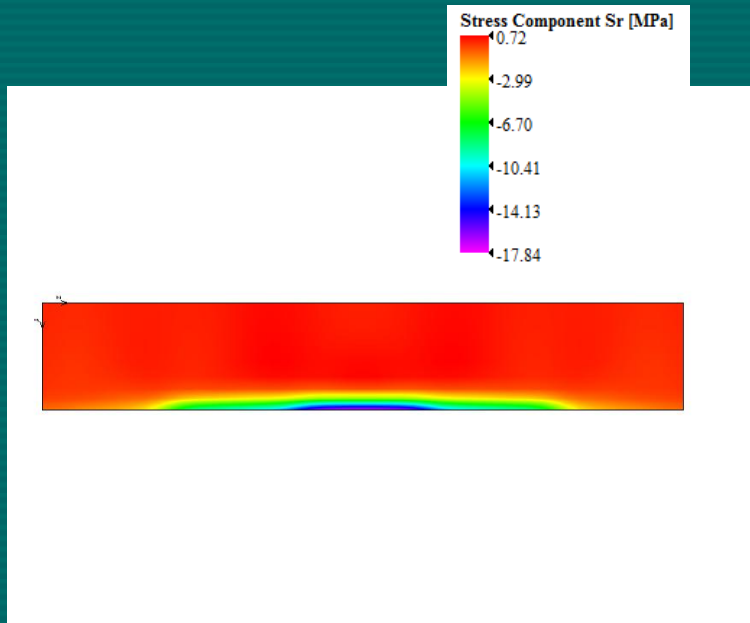
Deformation of the roll due to temperature changes in specified time of the roll campaign



CoolRoll – FEM simulation of cooling of rolls

Post-processing of results

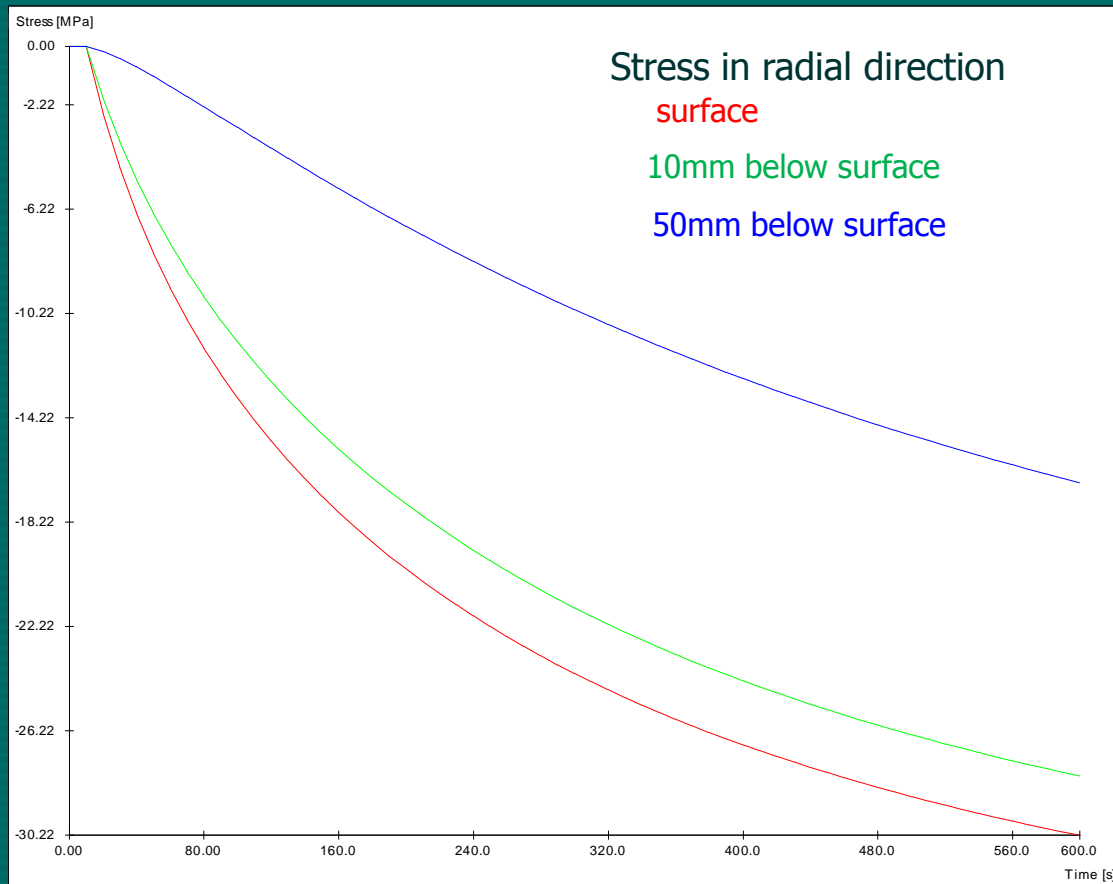
Distribution of stress components in specified time of the roll campaign



CoolRoll – FEM simulation of cooling of rolls

Post-processing of results

Time history of stress components in specified points of the roll



CoolRoll – FEM simulation of cooling of rolls

Summary