BRNO UNIVERSITY OF TECHNOLOGY FACULTY OF MECHANICAL ENGINEERING

Heat Transfer and Fluid Flow Laboratory
Brno University of Technology, Faculty of Mechanical Engineering

# HYDRAULICKÉ ODSTRANĚNÍ OKUJÍ

**Petr Kotrbáček**
Laboratoř přenosu tepla a proudění
Fakulta strojního inženýrství
Vysoké učení technické v Brně
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Mobil: +420 604229527
www.heatlab.cz

**91. SEMINÁR**
**OCELOVÉ PÁSY**
16.10. 2024
KONGRES Hotel Roca,
Južná trieda 1590/117,
Košice, Slovenská Republika

# Brno University of Technology

BUT BRNO


LARGEST TECHNICAL UNIVERSITY IN CZECH REPUBLIC

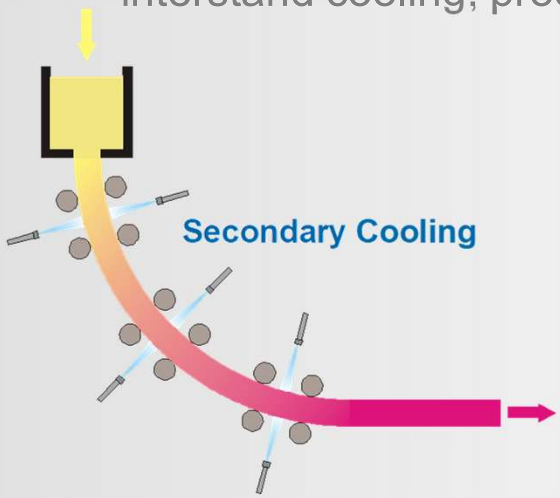
| Brno University of Technology |
|---|
| Faculty of Architecture |
| Faculty of Business and Management |
| Faculty of Chemistry |
| Faculty of Civil Engineering |
| Faculty of Electrical Engineering |
| Faculty of Fine Arts |
| Faculty of Information Technology |
| Faculty of Mechanical Engineering |
| |
| Total students (23/24): **9 572** |
| |
| Founded 1 899 |

# Faculty of Mechanical Engineering, HEATLAB

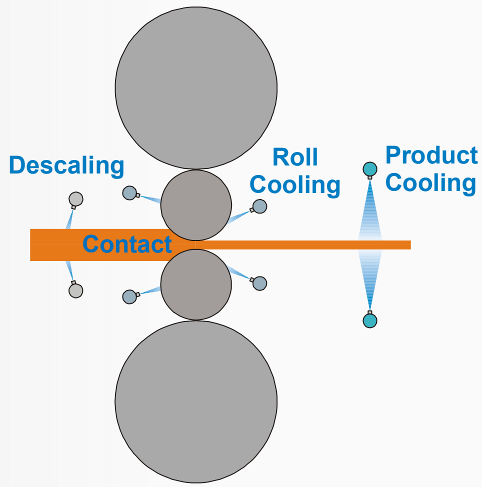

# Research

Experimental research of heat transfer (boundary conditions), Numerical models of cooling,

Investigation of spray cooling in continuous casting, hydraulic descaling, work rolls cooling, interstand cooling, product cooling and in-line heat treatment.



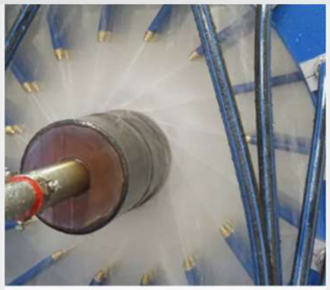

**Continuous Casting**




**Rolling and heat treatment**

# Research

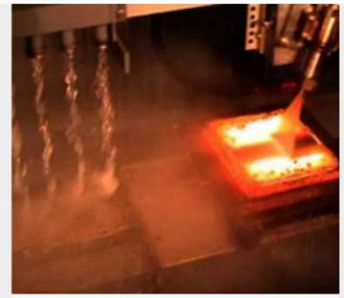
Spray Cooling



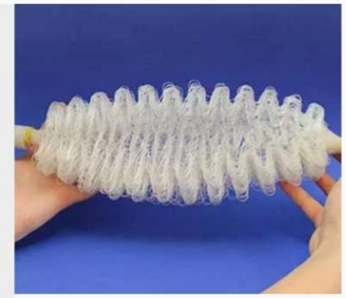
Heat Treatment

Continuous Casting

Roll Cooling

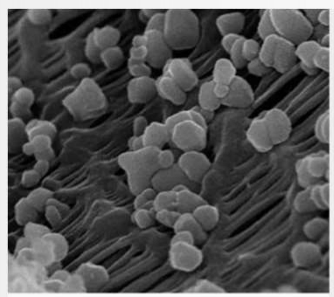


Hydraulic Descaling

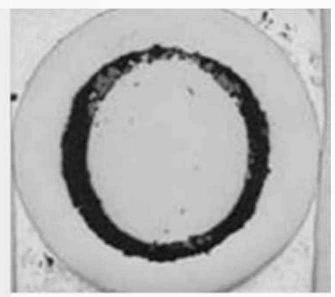


Polymeric Heat Exchangers with Hollow Fibres

- Type and size of nozzle
- Pressure
- Flow rate
- Spray height
- Spray configuration
- Overlapping



Separation Processes



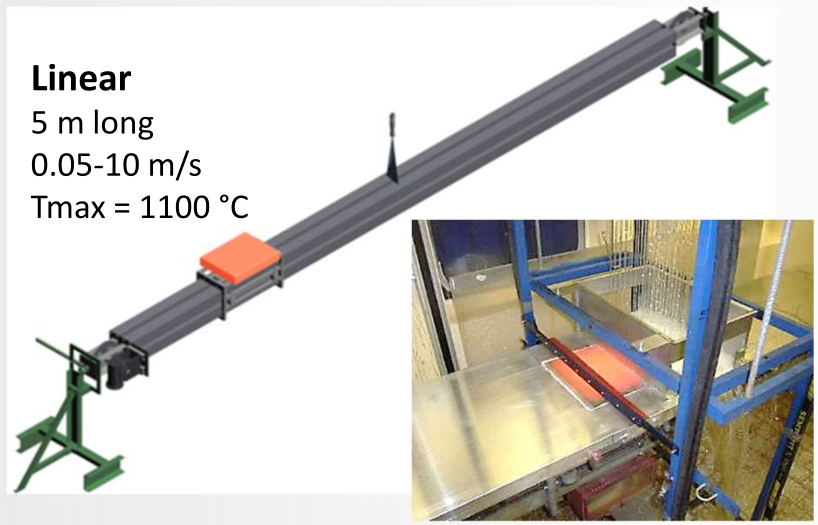
Inverse Heat Conduction Problem

- Impact angle
- Impact pressure
- Surface temperature
- Surface quality
- Circumferential velocity
- .....

# Laboratory experiments for steel industry


**Rolls**
ø636 and ø318 mm
0-12 m/s
Tmax = 320 °C

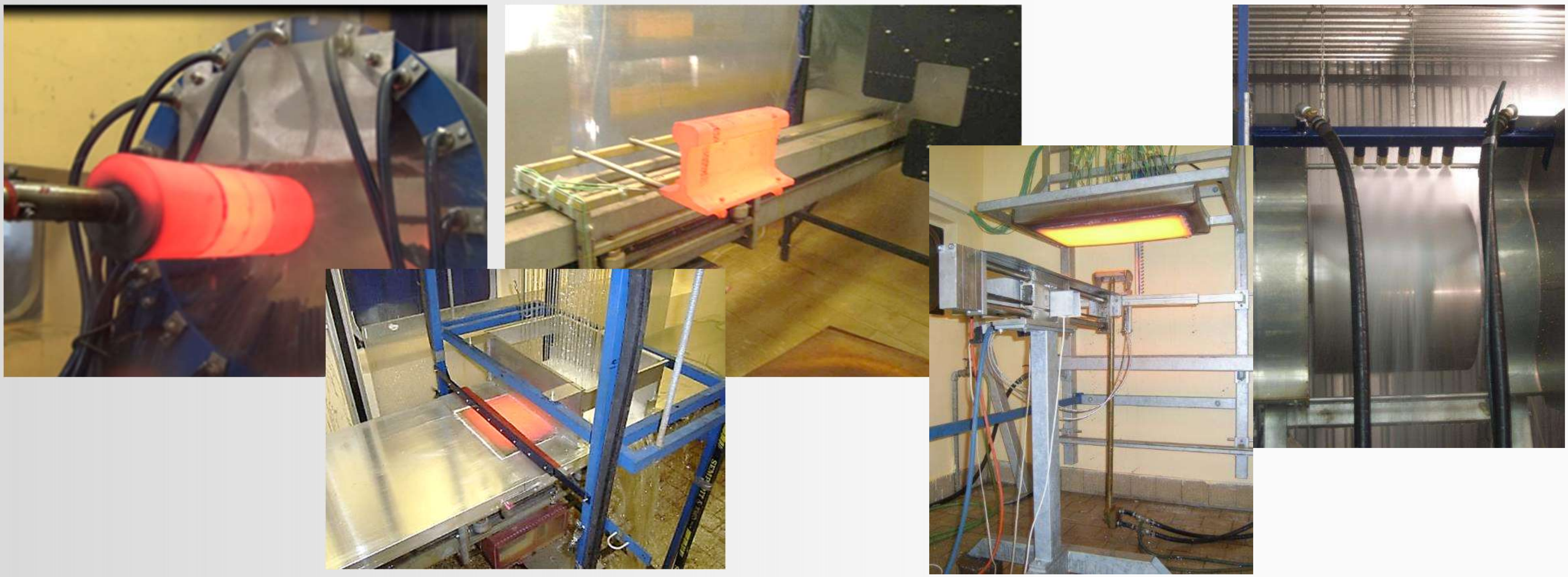
**Cooling water** (up to 90 °C)
30 l/s, 25 bar
2 l/s, 450 bar



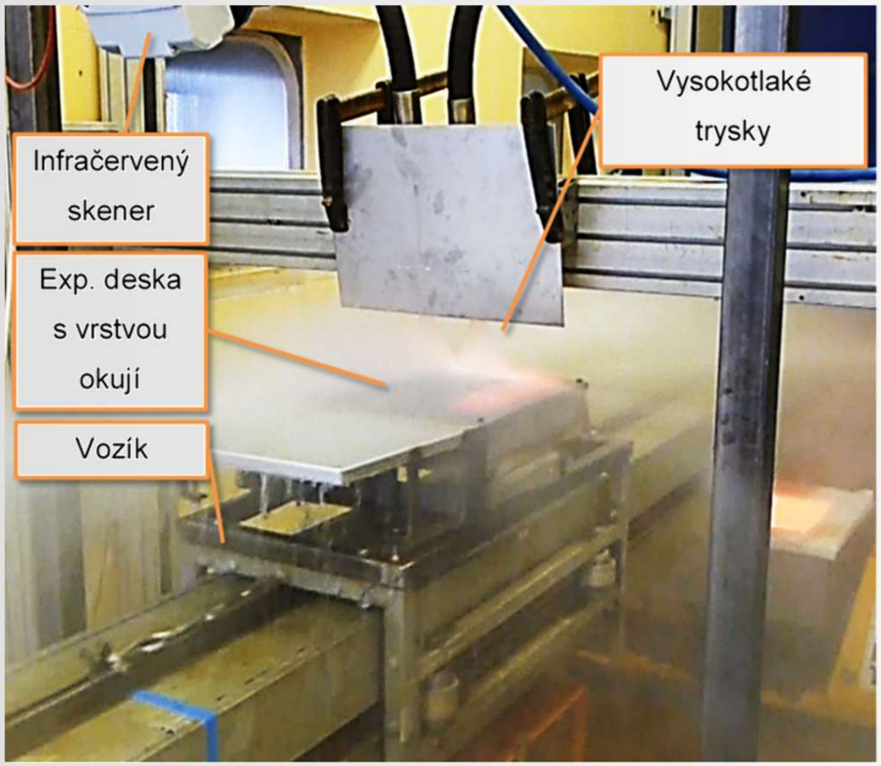
**Linear**
5 m long
0.05-10 m/s
Tmax = 1100 °C

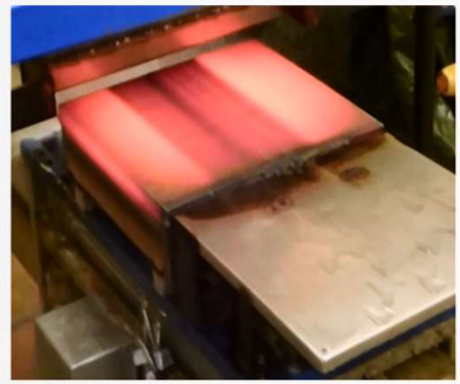

**Conti**
0-10 m/min
Tmax = 1250 °C

# Laboratory experiments for steel industry



# Linear stand – kvalita odstranění okují

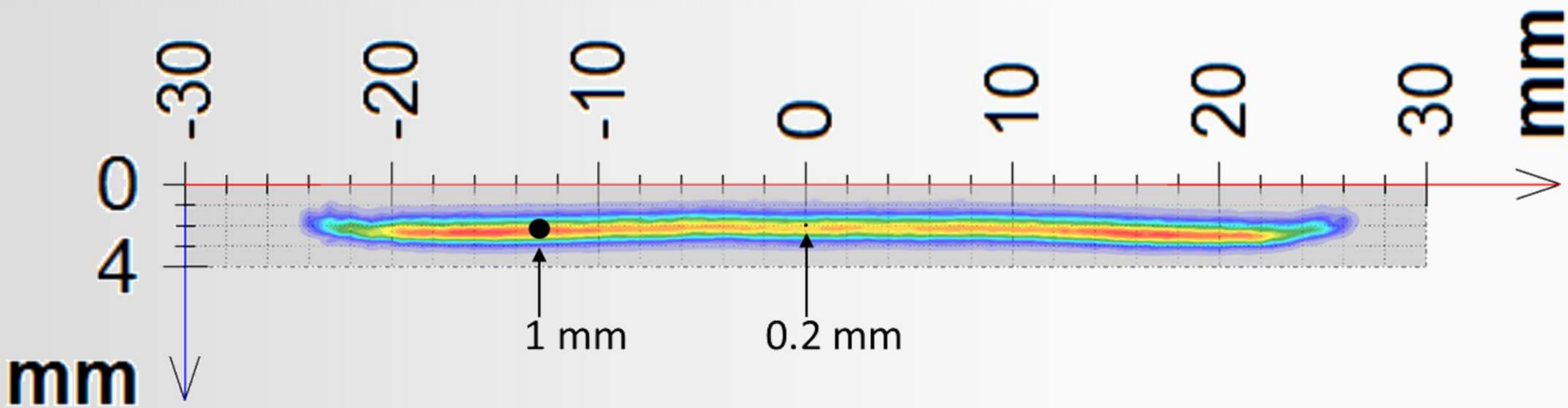


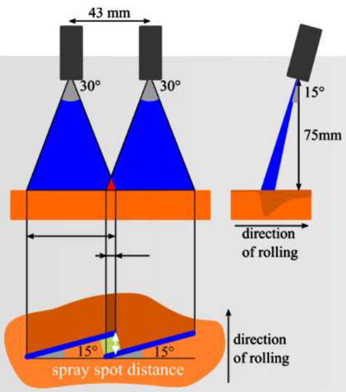
# Impaktní tlaky vysokotlakých trysek

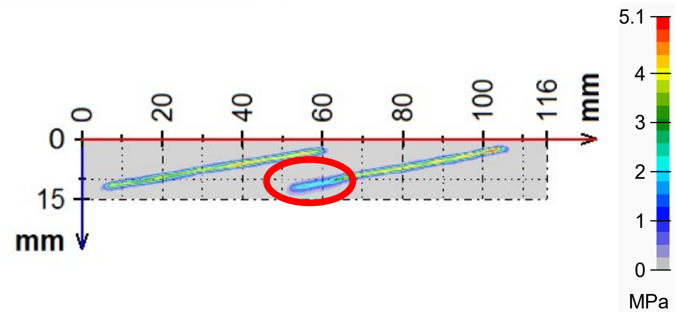
# **Impact pressure distribution** (size of pressure sensor 0.2 mm)

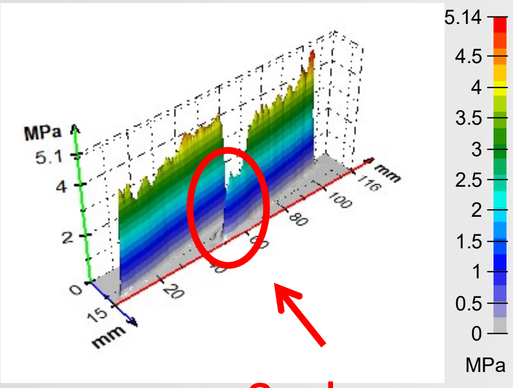
- Nozzle 30°, 180 bar, 24 l/s
- Height 75 mm, inclination angle 0°, twist angle 0°



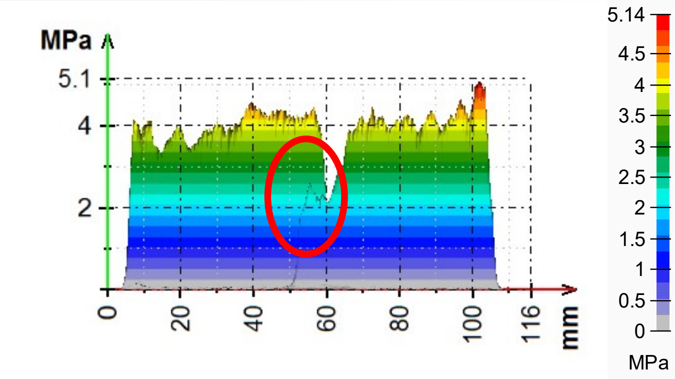
# Impact pressure distribution – Overlap



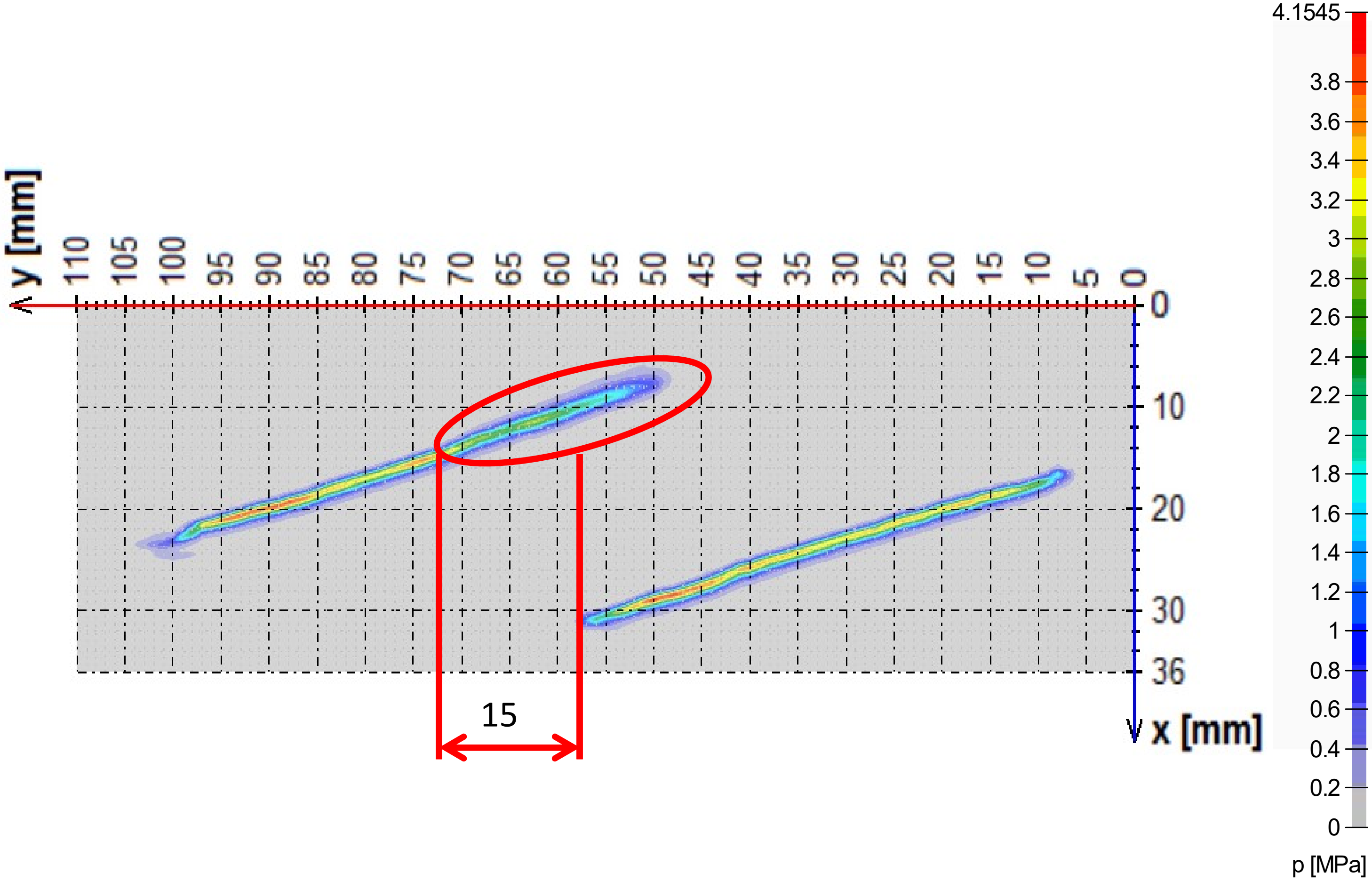




Overlap



# **Overlap and washout area** – impact pressure distribution

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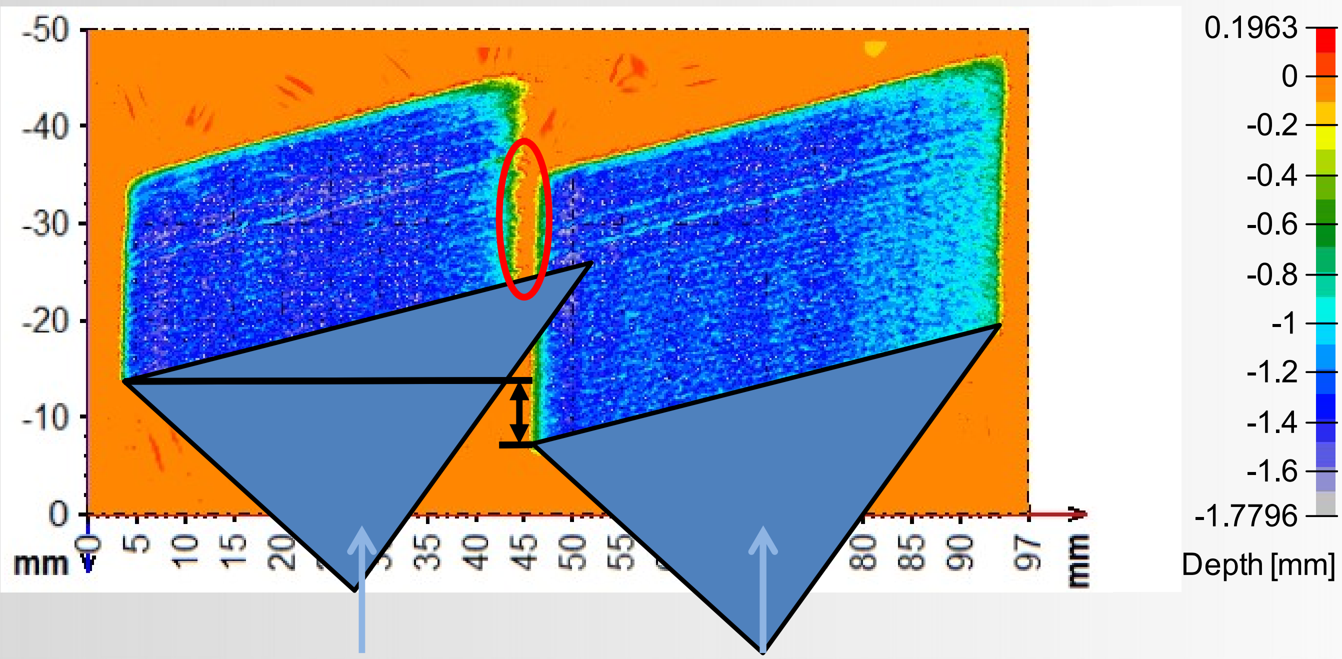
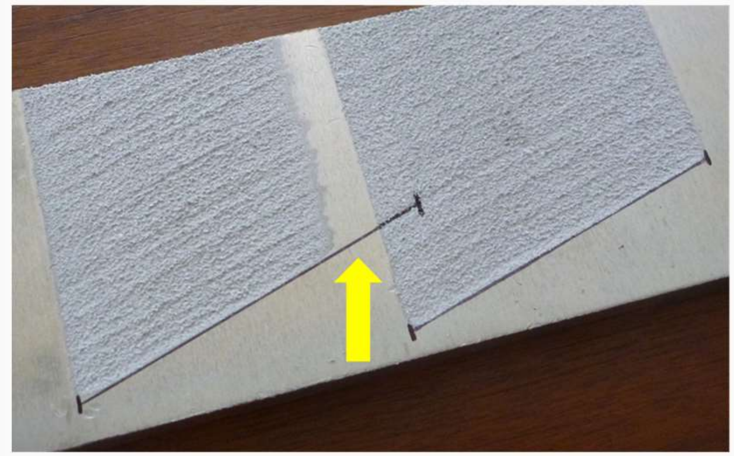
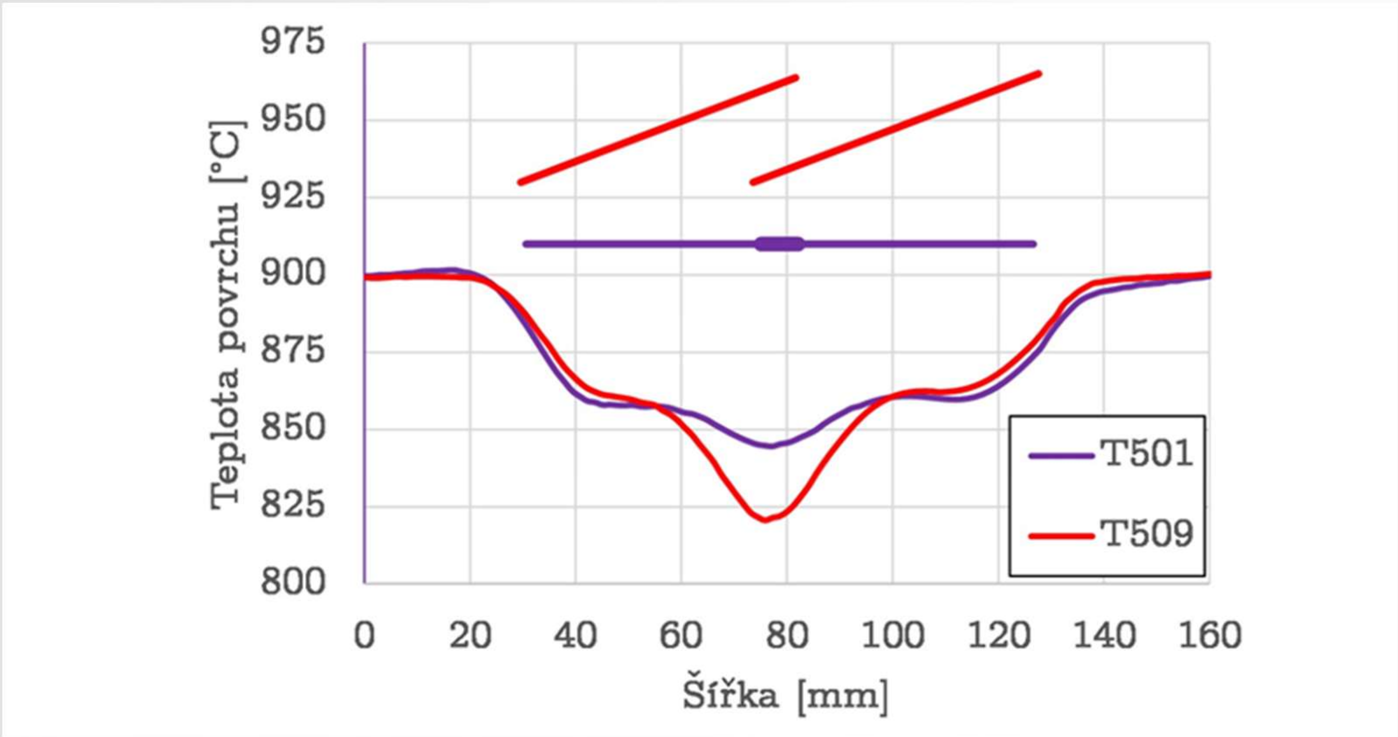
# **Overlap and washout area** – erosion tests on aluminum plate



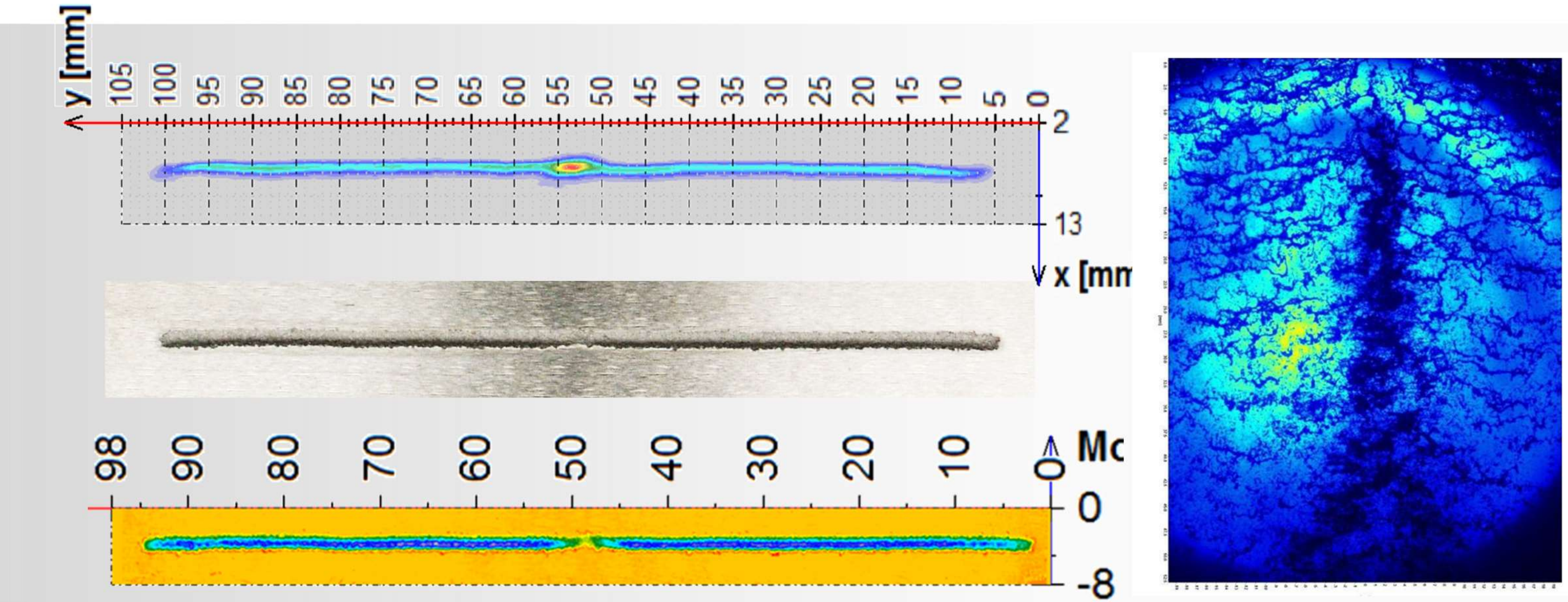



Inclination angle = 15°
Twist angle = 15°
Left nozzle offset = 10 mm

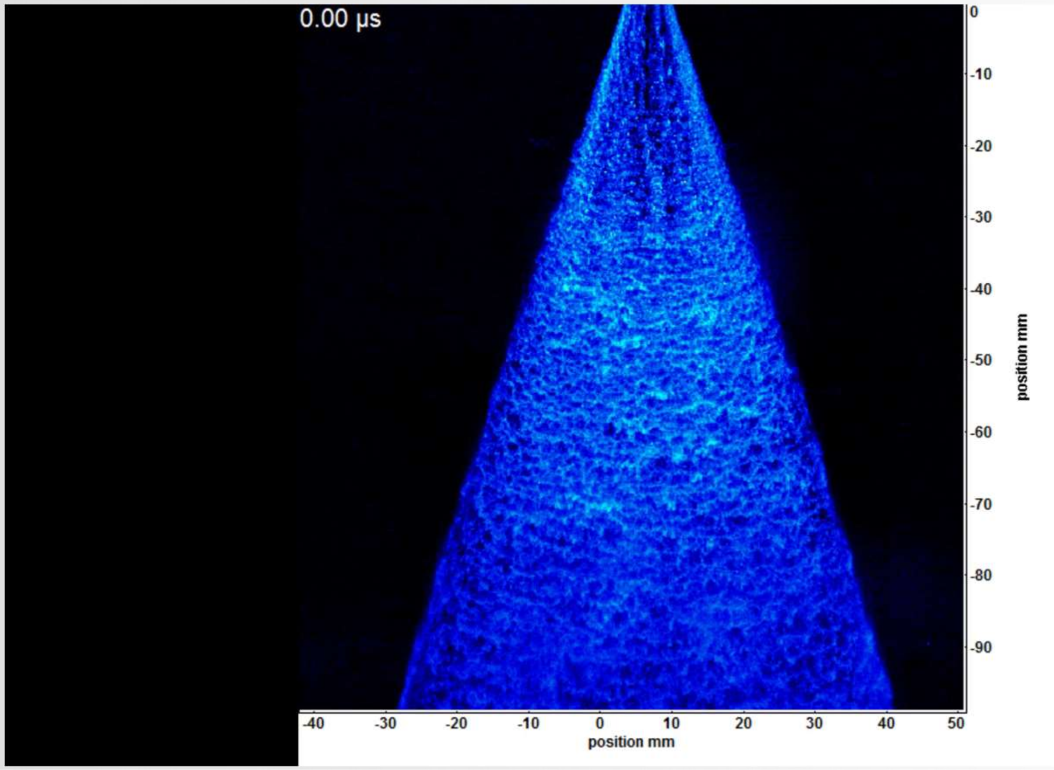
# In-line configuration



# In-line configuration



# Structure of the jet



# In-line configuration

**High Performance Hot Rolling Process Through Steel Grade_ Dependent Influencing of the Scale Formation and Flexible Descaling Control (HIPERSCALE)**

Code: RFSR-CT-2014-00010

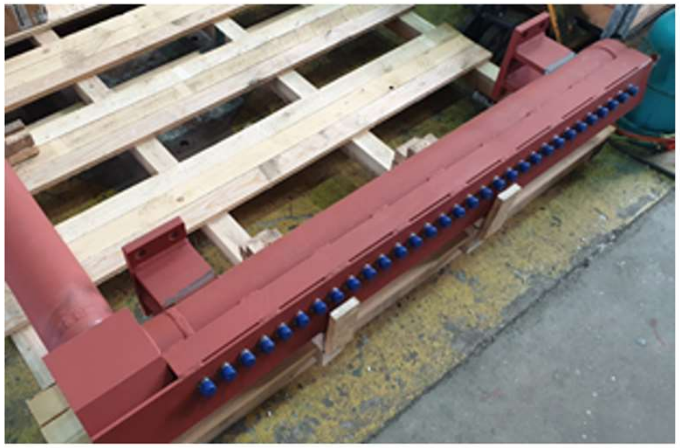
Duration: 7/2014-12/2017

Financing: Research Fund for Steel and Coal

## Progresivní vysokotlaké hydraulické systémy

Období řešení: **01.07.2017 — 30.09.2019**

| | |
|---|---|
| ÚTVARY | Laboratoř přenosu tepla a proudění<br>- spolupříjemce (01.01.2016 - 31.12.2018)<br>Vysoké učení technické v Brně<br>- odpovědné pracoviště (01.01.2016 - 02.08.2019)<br>SIGMA DIZ spol. s r.o.<br>- příjemce (01.01.2016 - 31.12.2018) |
| ZDROJE FINANCOVÁNÍ | **Evropská unie** - OP PIK - Aplikace |



# Uplatnění výsledků v praxi, ekonomický dopad, neekonomické přínosy

Celkový hydraulický výkon stávajícího ostřiku okují pro horní stranu ostřiku je pak:

P = Q (l/s) * p (PMa) * počet trysek = 71,04/60 * 15 * 17 = **301,9 kW**.

Celkový hydraulický výkon nového optimalizovaného ostřiku okují pro horní stranu ostřiku je:

P = 34,29/60 * 15 * 24 = **205,74 kW**.

Úspora energie pro horní a spodní ostřik okují potom činí 2 * 96 = 192 kW.

Při celoročním provozu (310 dní) a 12 hodinovém vytížení denně lze předpokládat úspory 714 240 kWh. Primární ostřik je ve válcovnách často instalován ve dvou sadách, takže dostáváme úspory **1 428 000 kWh za rok.**

Pro další vyhodnocení přínosů nasazení nového ostřiku okují v tomto ukázkovém příkladu byl využit kalkulátor **EPA** (United States Environmental Protection Agency) na stránkách (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator):

Dle výpočtu z kalkulátoru EPA vyplývá, že snížení emisí $CO_2$ za jeden rok pro tento ukázkový příklad primárního ostřiku okují činí **1 010 tun**. Další vyjádření úspor dle kalkulátoru EPA je znázorněné na obrázku (Fig. 61).

# In-line configuration

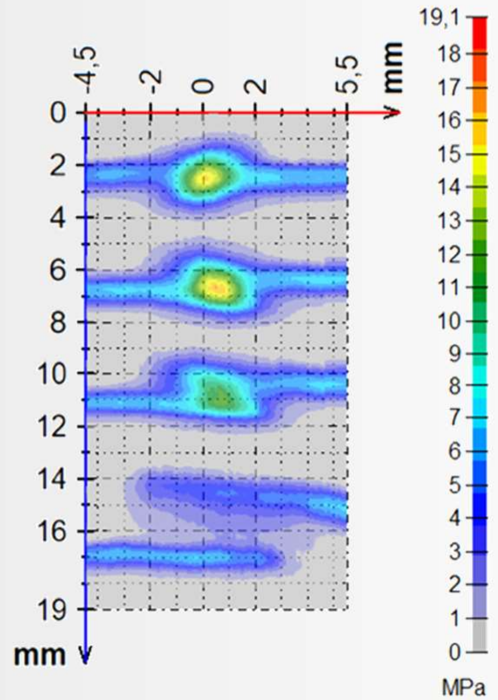
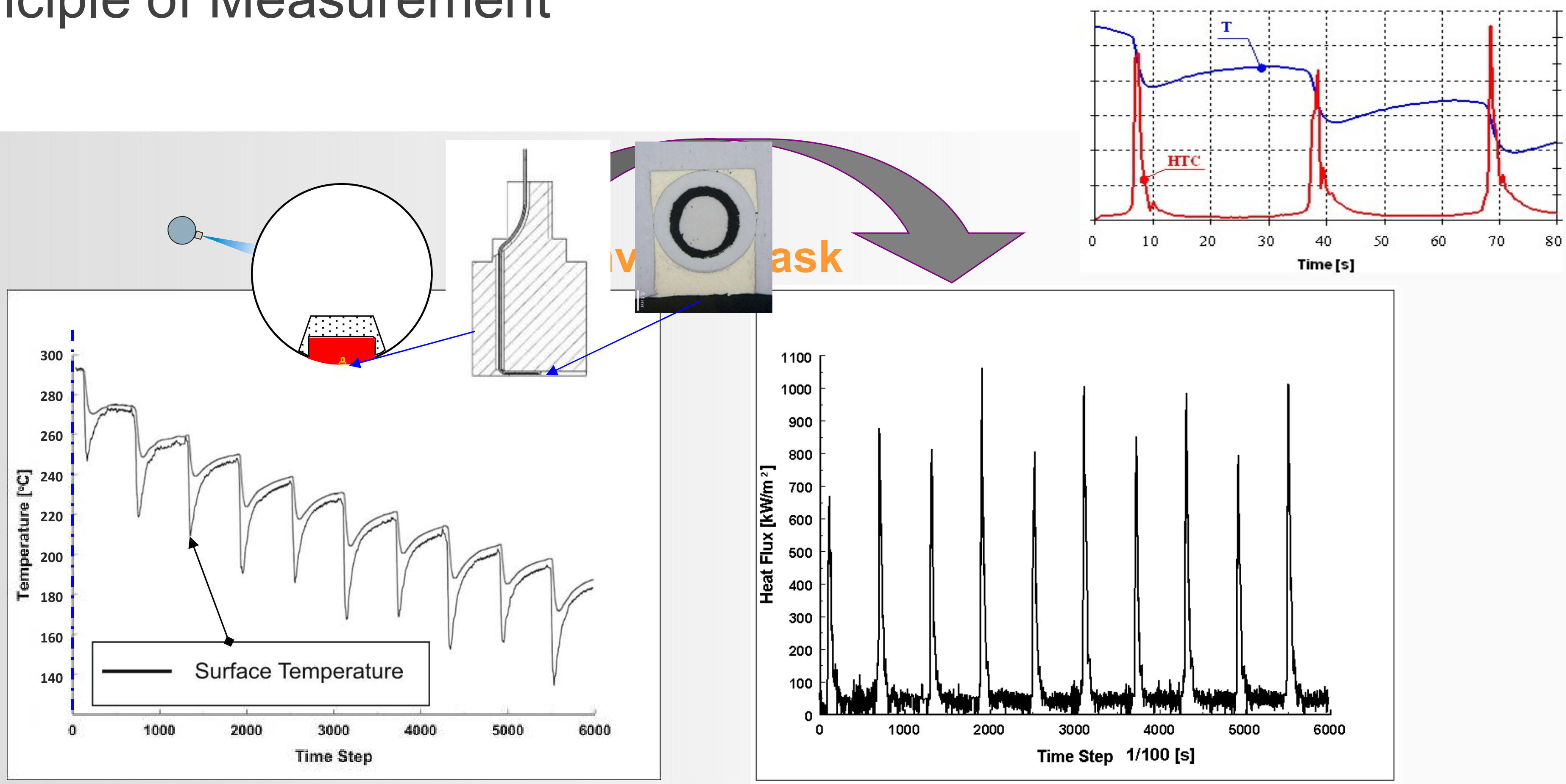


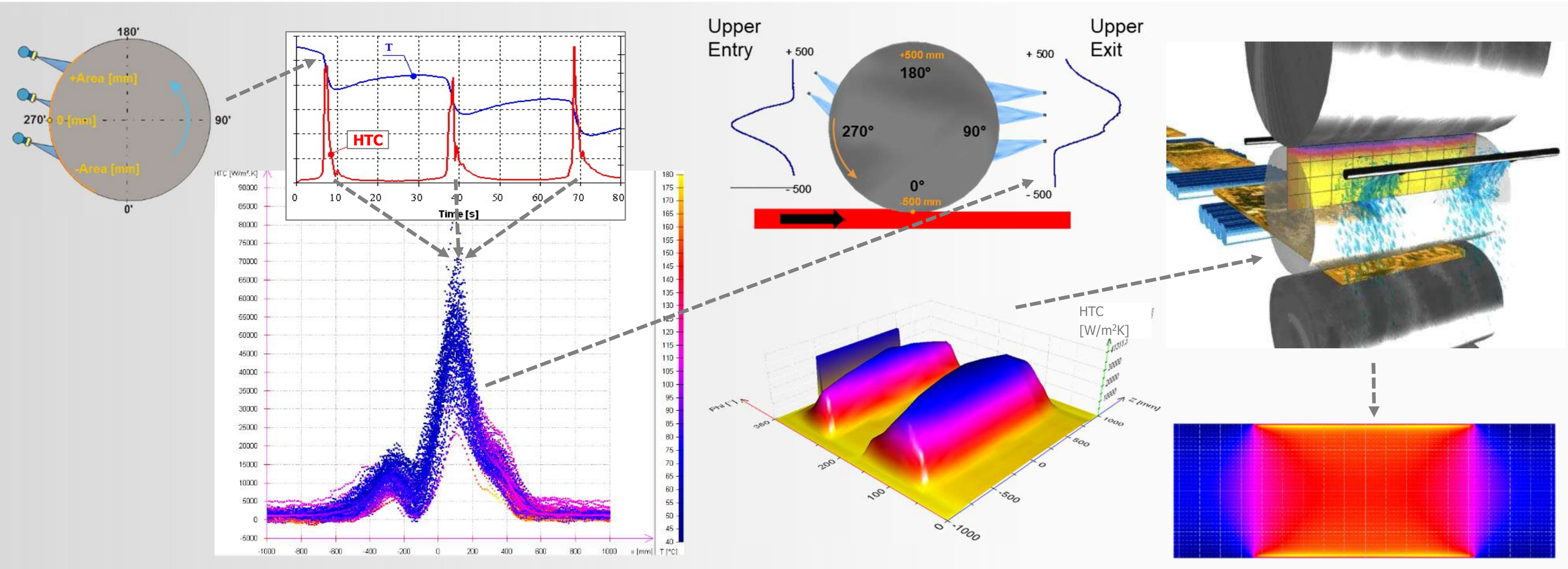

*Fig. 38* *Vliv úhlu natočení na rozložení impaktního tlaku. Odshora 0°; 0,4°; 1,25° a 2,5°*

# Principle of Measurement



# Data processing, HTC, Simulation

Experiment | Inverse task | Boundary conditions | Simulation



# Optimalizace chlazení

## **voestalpine Stahl**, Austria


- 2012, FM, F0-F6
- saved water: 41%, **24 000 l/min** for rolling line
- stop two pumps with **600 kW** motors
- savings were estimated at **600 000 EUR/year**
- reduction in **$CO_2$ emissions** of **3,156 tons per year**

## **US Steel Košice a s**, Slovakia

- 2015, HP 1700, H0-H11
- extension and prolongation of the rolling campaigns **111 plates → 131 plates**
- **saving of cooling water was 42 %**
- reduction number of water nozzles from **1230** to **868** nozzles

## **HYUNDAI STEEL**, Dangjin, Korea


*<Source>* [*https://en.yna.co.kr/*](https://en.yna.co.kr/) [*https://www.stuff.co.nz/*](https://www.stuff.co.nz/) [*https://www.hyundai-steel.com/*](https://www.hyundai-steel.com/)

- 2019
- increasing the efficiency of cooling the rolls
- economic benefits of the new cooling will be evaluated in the following period.

# Cooperation with industry

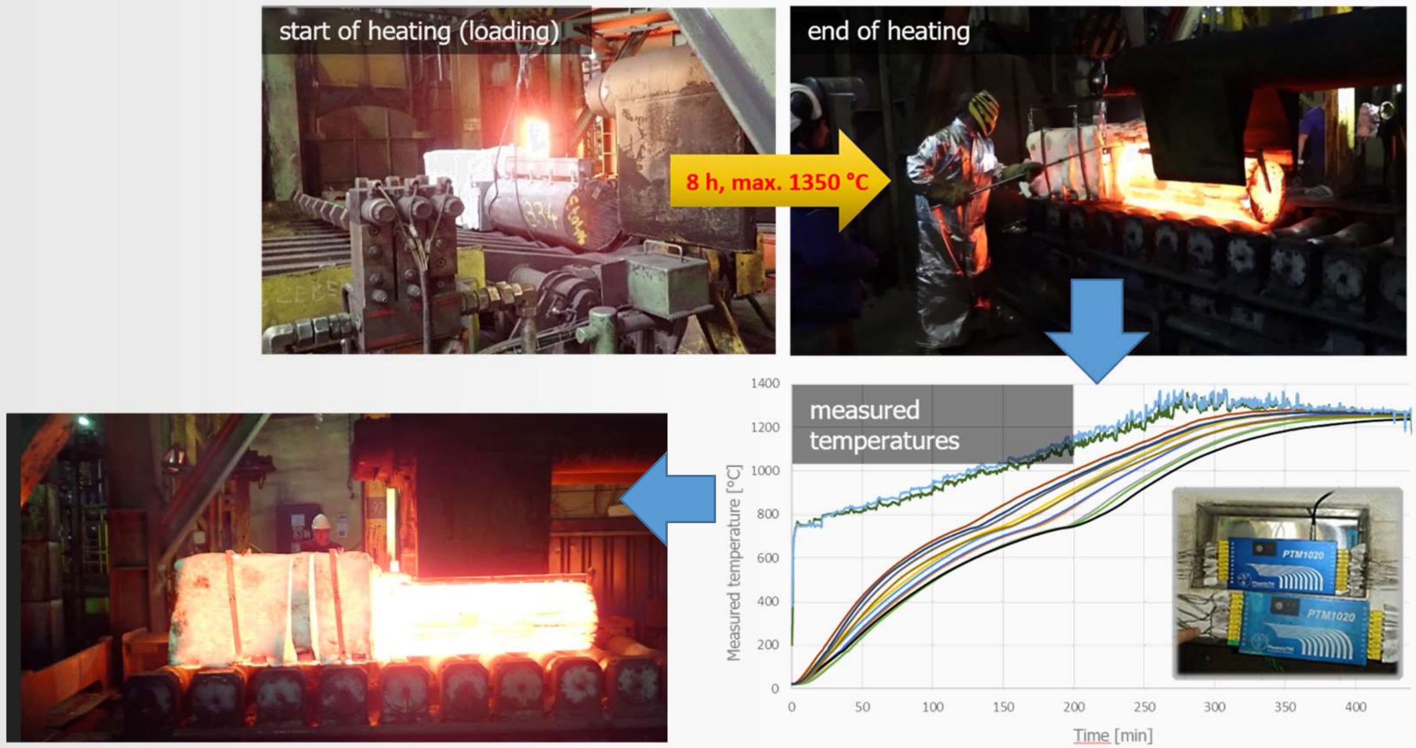

sij acroni
ALINVEST
Alcoa
AMAG AUSTRIA METALL
ANDRITZ
ArcelorMittal
ASU Arizona State University
AUBREN
AL AUTOMOTIVE LIGHTING
DANIELI
DELAVAN Spray Technologies
fives
Hanon SYSTEMS
HENNLICH
Honeywell
hydro system
LECHLER
LIBERTY
LU-VE GROUP
MANN+HUMMEL
posco
PRIMETALS TECHNOLOGIES
Severstal
SIEMENS
SINTEF
ŠKODA
spirax sarco
swerea MEFOS
U. S. Steel Košice, s.r.o.
University of Strathclyde Glasgow
United States Steel
USIMINAS
VÍTKOVICE
voestalpine
VUHZ
ŽELEZIARNE PODBREZOVÁ

# Cooperation with industry

- ABB, s.r.o., Czech Republic
- ACRONI Jesenice, Slovenia
- **AIT** Austrian Institute Of Technology, Austria
- AL INVEST, a.s., Czech Republic
- Alcoa Inc, United States
- **AMAG**, Ranshofen, Austria
- ANDRITZ Selas S.A.S., France
- ARCELOR MARDYCK, France
- ArcelorMittal Burns Harbor, USA
- ArcelorMittal Dofasco, Canada
- **ArcelorMittal** Global Research Center Chicago, USA
- ArcelorMittal Maizières Research SA, France
- ArcelorMittal Ostrava a.s., Czech Republic
- ArcelorMittal Riverdale Inc., USA
- Cogne Acciai Speciali S.p.a., Italy
- COMALCO, Australia
- Corus Technology BV Netherlands
- CORUS UK Limited, England
- CRM Group, Belgium
- **DANIELI**, Italy
- Davy Distington Ltd. UK
- Delavan Ltd., United Kingdom
- Evertz Hydrotechnik GmbH & Co. KG KG, Germany
- EVRAZ VÍTKOVICE STEEL, a.s., Ostrava, Czech Republic
- FEI, Czech Republic
- Fives Stein Ltd., France
- Hyundai NGV, Republic of Korea
- **Hyundai Steel**, Republic of Korea
- IRSID, France
- ISPAT Nová Huť, a.s., Czech Republic
- Kremikovtzi AD, Bulgaria
- Lechler GmbH, Germany
- Liberty Ostrava a.s., Czech Republic
- Mannesmann Demag AG, Germany
- Nová huť, Czech Republic
- **POSCO** E&C, Republic of Korea
- POSCO, Republic of Korea
- **Primetals Technologies** Ltd., Austria
- Primetals Technologies Ltd., Italy
- Severstal Cherepovets, Russia
- Sidenor I + D, Spain
- SIEMENS AG Germany,
- Siemens S.p.A., Marnate VA, Italy
- Siemens VAI Metals Technologies GmbH, Linz, Austria
- SIGMA DIZ, Czech Republic
- SIGMA Group, Czech Republic
- SINTEF, Norway
- Spraying Systems Co., USA
- Swerea Mefos AB, Sweden
- Škoda Auto a.s., Czech Republic
- **TATA Steel** UK, UK
- ThyssenKrupp Steel Europe AG, Germany
- Třinecké železárny a.s., Třinec, Czech Republic
- **U. S. Steel Košice**, Ltd., Slovakia
- United States Steel Corporation, USA
- USIMINAS, Brazil
- Vítkovické slévárny, spol.s r.o., Czech Republic
- **voestalpine Stahl** GmbH, Austria
- VÚHŽ a.s., Czech Republic
- ŽĎAS, a.s., Zdar nad Sazavou, Czech Republic
- Železiarne Podbrezová, Slovakia

# Optimization of billet heating in the furnace atmosphere - plant measurement

- Using a specially developed datalogger protection box, heating can be recorded up to 1350 ° C / 8 hours. We are able to design and realize operational measurements of heating and cooling modes for longer periods and various dimensions of billet.
- Using the mathematical model, the measured data can then be used to optimize the heating of materials in preheating step and continuous furnaces.



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