Journal of Metallic Materials 2022, 74 (1), p. 4–8

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DOI: 10.32730/imz.2657-747.22.1.1

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Forming 2022

THE ANALYSIS OF THE ROLLS COOLING AT PUSH BENCH IN ROLLING MILL PLANT ŽP A.S.

ANALIZA CHŁODZENIA WALCÓW WALCARKI PRZEPYCHOWEJ WALCOWNI ŽP A.S.

This article deals with a comprehensive analysis at roll cooling of push bench on a rolling mill during the rolling process of semi-finished products used for the production of seamless tubes. An important issue that we deal with in this issue is the influence of the cooling parameters using special programmable nozzles of various types with the required flow and water pressure on the final surface temperature of the extruder rollers, at finish quality of shell. The experiment will address the problem of determining the cooling efficiency of different types of nozzles on an experimental device for testing the heat transfer coefficient during cylinder cooling. During experiments maintains development of deformation processes in stands of push bench.

Keywords: *roll, push bench, cooling, shell, nozzle*

W artykule przedstawiono kompleksową analizę procesu chłodzenia walców walcarki przepychowej w walcowni podczas procesu walcowania półproduktów wykorzystywanych do produkcji rur bez szwu. Ważnym zagadnieniem w tym temacie jest wpływ parametrów chłodzenia za pomocą specjalnych programowalnych dysz różnego typu o wymaganym przepływie i ciśnieniu wody na końcową temperaturę powierzchni walców walcarki przepychowej, co wiąże się z końcową jakością tulei. Eksperyment będzie dotyczył problemu wyznaczania wydajności chłodzenia różnych typów dysz na urządzeniu doświadczalnym do badania współczynnika przenikania ciepła podczas chłodzenia rolek. Podczas wszystkich eksperymentów zachowano przebieg procesów odkształcania w klatkach walcarki przepychowej.

Słowa kluczowe: *walec, walcarka przepychowa, chłodzenie, tuleja rurowa, dysza*

1. INTRODUCTION

The push bench is used for rolling a billet a mandrel bar (elongation molding with a bottom) with a maximum length of 2.5 m. The mandrel bar is inserted into the billet and pushed by the push bar by the rolling stands at a maximum rolling speed of 6 m·s^{-1}. The hollow semi tube is conveyed from the elongator in front of the push bench, which is shown in Fig. 1. The pushing bench rollers do not have their own drive. They roll on the material due to its rectilinear movement and friction [1–5]. Hollow semi tubes with a wall thickness of 3.0–12.5 mm can be produced [5].

The determination of the range of calibers is made according to the calculation [5]:

- *→ diameter of mandrel bar + 2× magnifying shell wall + tolerance according to technology*

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Fig. 1. Push bench at the rolling plant ŽP. a.s [5]

Rys. 1. walcarka przepychowa w walcowni ŽP. a.s [5]

The range of calibers consists of fixed calibers and adjustable calibers. According to the last fixed calibers, they are then determined to be adjustable so that the resulting dimension fits with the specified calibers [3–5].

2. METHODOLOGY AND INSTRUMENTS FOR TEMPERATURE MEASUREMENT

The already tested prototype of OMEGA K-type thin foil thermocouple probe (TC) was used and long-term measurements of the surface temperature of the push bench rollers were performed [6–8]. This methodology was used because it was proved as reliable during rollers cooling of the push bench. The measurement is performed with the scale water switched off, when a TC probe is placed in the middle of the caliber and electrical signal is transmitted to the PC via a USB cable. The following conditions were met to verify the measurement [6–10]:

– longitudinal position of the TC sensor in the middle of the caliber [6–10],

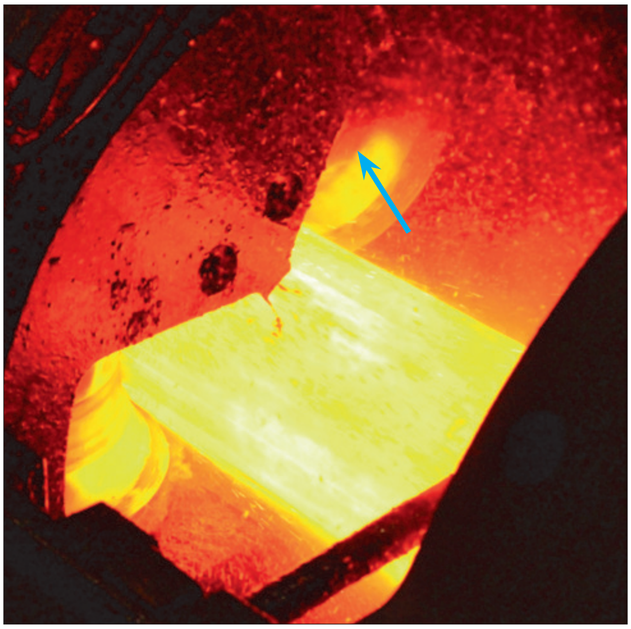

Fig. 2. Detailed view on the working surface of the push bench roll with arrow pointing at the measurement spot when using [6–10]

Rys. 2. Szczegółowy widok powierzchni roboczej walcarki przepychowej, strzałka wskazuje miejsce pomiaru

– perpendicular orientation of TC sensor to touching plane in the middle of the caliber,
– minimization of the angular velocity of TC sensor, relative to the touching point on the caliber surface [6–10],
– minimum TC sensor settling time 5 seconds in position under above conditions [6–10].

The measurement was performed on all push bench baskets during normal peel production [8–10].

3. METHODOLOGY AND INSTRUMENTS FOR PRESSURE MEASUREMENT

An important parameter for the design of the controlled cooling system of the push bench rollers and new nozzles was important to determine the operating pressure on the nozzles during normal operation. The pressure was determined using a electronic pressure gauge in the range 0–6 bar, connected to a battery source [11] (Fig. 3).

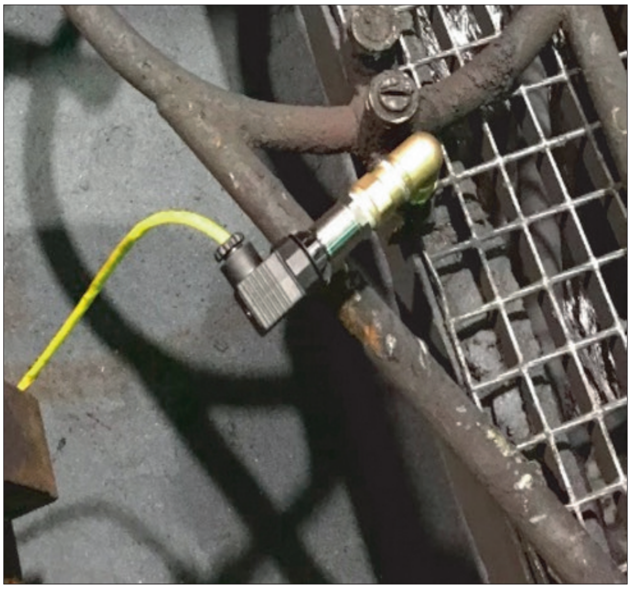

Fig. 3. Electronics pressure sensor connected to cooling ring of push bench [11]

Rys. 3. Elektroniczny czujnik ciśnienia podłączony do pierścienia chłodzącego walcarki przepychowej

4. METHODOLOGY AND INSTRUMENTS FOR HEAT TREATMENT COEFFICIENT MEASUREMENT

The experiment consisted of two consecutive parts. In the first part, the measurement and calculation of the heat transfer coefficient for currently used nozzles was performed to map the current state of operation. In the second part, the nozzle was measured, replacing the original nozzle configuration [12–14].

The suitability of the nozzle has been discussed and may be replaced in the future. From the calibers used, two (large and medium) were selected, one from stand 3.1, the other from stand 4.5, on which the cooling effects of two types of nozzles will be examined and compared (Fig. 4) [12–14].

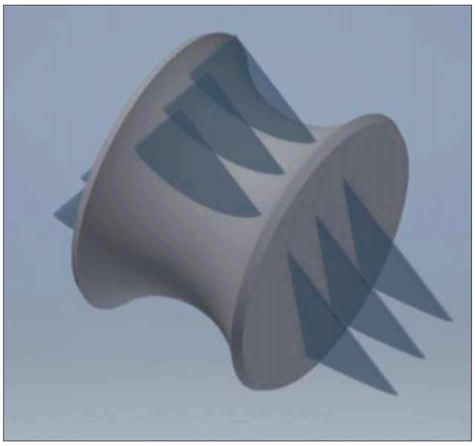

Fig. 4. Location of currently used flat nozzles [13]
Rys. 4. Lokalizacja stosowanych dysz płaskich

Heat transfer coefficient (HTC) measurement was performed on a small test cylinder (Fig. 5) with a diameter of 355.6 mm and width of 600 mm. Evaluation of measured HTC showed an illogical course in comparison to individual experiments. When all experiments were performed, the experiment was repeated once again, to verify the repeatability of the results. However, HTC values significantly discoursed from the original measurement. Therefore, the sensors were checked on presence of microcracks and this suspicion was confirmed [12–14].

Fig. 5. Small test roll with 6 sensors [10]
Rys. 5. Mała rolka testowa z 6 czujnikami [10]

Water penetrates microcracks and affects measured data in unpredictable ways. Also, there was an error in the cylinder heating control loop and the temperature exceeded the limit allowed for solder used in the sensors. It was decided not to repeat experiments on any of the sensors on a small test cylinder and to repeat experiments on a larger diameter cylinder [12–14].

5. EXPERIMENTAL MATERIAL AND METHODS

The experiment carried out during rolling selected geometry of shell in push bench in condition of-Zeleziarne Podbrezová. Specific parameters of shell were not selected for this experiment. All measurements were carried out during the standard production schedule of Zeleziarne Podbrezova tube rolling plant. Actual measurements took place between two different steel grades of two different heats.

6. RESULTS AND DISCUSSION

The experiment was split into three stages:

Stage No. 1

- Measurement of surface temperature of rolls in stands.
- Measurement of surface temperature of rolls in stands with used candidate nozzles.
- The water flow rate for candidate nozzles was the same as for reference nozzles.
- Checking the condition of rolling stands.

Stage No. 2

- Measurement of pressure in cooling system in selected part.
- The pressure has the same condition for two types of nozzles.

Stage No. 3

- Measurement of heat treatment coefficient for both type of nozzles with difference flow rate (40 l/min. vs 32 l/min.).
- Measurement of surface temperature of small test roll with 6 sensors.

The values of 3 types of measured quantity are showed in followed tables.

The surface temperature of the push bench rollsis shown in Fig. 6.

The pressure measurement of cooling system of the push bench rolls is shown in Fig. 7.

After experiment carried out, it is appropriate for use nozzles with rate flow of 32.0 l/min. The differences between the individual measurements in the selected stand was caused with the free gaps between steel grades in the furnace.

The comparison of heat treatment coefficient according to nominal flow rate of nozzle is shown in Fig. 8.

Table 1. Temperature measurement of rolls in push bench stands [°C]

Tabela 1. Pomiar temperatury rolek walcarki przepychowej [°C]

Stage No.	Roll Stand No.	Measurement No.			Average temperature
		1	2	3	
1	2	35.1	35.2	35.0	35.1
	3	36.9	37.2	37.1	37.1
	4	38.0	39.9	39.9	39.3
	5	40.0	40.1	40.0	40.0
	6	41.3	40.9	40.2	40.8
	7	40.2	40.5	40.6	40.4
	8	43.2	43.5	43.1	43.3
	9	44.1	44.0	43.9	44.0
	10	44.9	45.0	45.1	45.0
	11	42.2	42.1	42.1	42.1
	12	40.0	39.9	40.0	40.0

Table 2. Pressure measurent of cooling system in push bench [bar]

Tabela 2. Pomiar ciśnienia układu chłodzenia walcarki przepychowej [bar]

Stage No.	Roll No.	Measurement		
		min.	max.	avg.
2	2 nozzles (40.0 l/min.)	1.3	3.0	2.6
	3 nozzles (40.0 l/min.)	1.3	2.1	1.7
	2 nozzles – new cooling ring (32.0 l/min.)	1.9	3.4	2.9

Table 3. Laboratory measurement of HTC coefficient

Tabela 3. Pomiar laboratoryjny współczynnika HTC

Stage No.	Nozzles	Measurement type	
		Water temperature [°C]	HTC [W/(m^2·°C)]
3	3×40 l/min.	21.6	6128
		18.1	6732
		20.0	6939
	2×40 l/min.	16.4	3645
		15.8	4408
		17.0	4024
	1×40 l/min.	16.8	2858
	2×32 l/min.	19.1	3105
		19.1	3676
		20.5	3895
	1×32 l/min.	21.0	2873
		20.0	2737
		20.5	2798

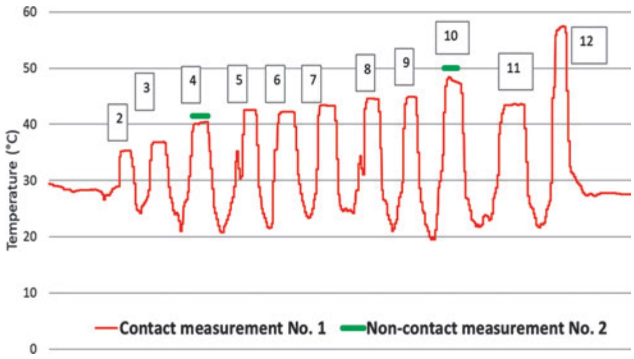

Fig. 6. Rolls surface temperature of the rolls in the push bench

Rys. 6. Temperatura powierzchni rolek rolek walcarki przepychowej

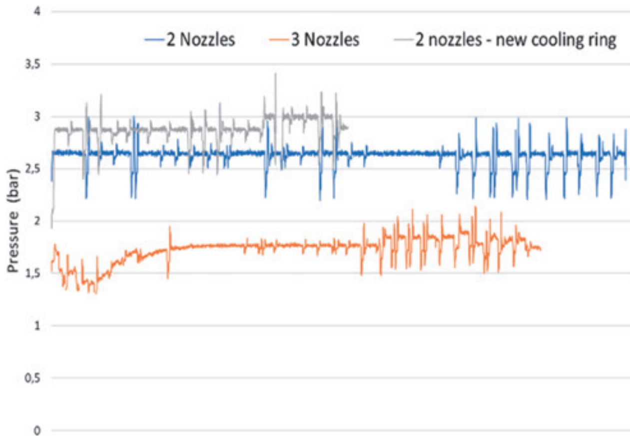

Fig. 7. Graphical view of pressure measurement of cooling system

Rys. 7. Wykres pomiaru ciśnienia układu chłodzenia

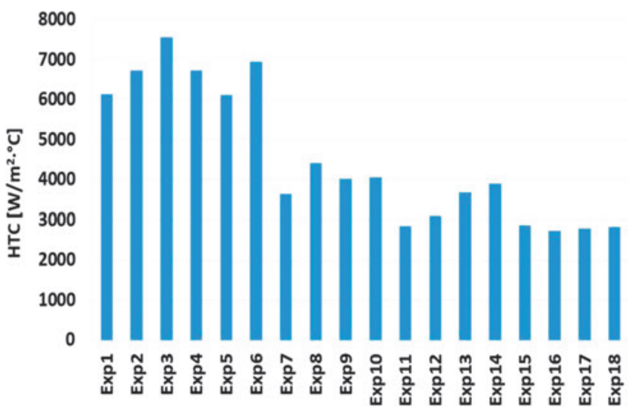

Fig. 8. Comparision of experiments according to measured coefficient HTC

Rys. 8. Porównanie współczynnika HTC dla przeprowadzonych eksperymentów

The results were obtained by direct pressure measurements on the cooling branch, according to nominal flows 40.0 l/min and 32.0 l/min (Tab. 2). Average nozzle pressure with a flow rate of 32.0 l/min is 2.9 bar, compared to a nozzle with a nominal flow of 40.0 l/min, where a pressure of 2.6 bar was achieved. The achieved pressure increase will ensure an optimal water jet pattern.

Nozzle with a flow rate of 32.0 l/min has a 20 % lower required flow rate, than a nozzle with a nominal flow rate of 40.0 l/min. Using a new configuration of two nozzles instead of three, the amount of required cooling water is reduced. The reflection of water jet towards the hollow semi tube is minimized and the distance is adjusted in a way the jet pattern should cover an entire width of the caliber cylinder. This can reduce the cooling intensity by about of 1/3. The new configuration cools the caliber just enough, correspondingly to HTC values measured on the specified caliber surface.

7. CONCLUSIONS

In close cooperation with ZP Tube Rolling Plant we have achieved significant results in the field of roll cooling for push bench. The results achieved were supported by results of modelling and simulation of heat transfer between the rolls and the shell [12–18].

Said optimization of the nozzles for cooling the rolls of the push bench is suitable not only for sufficiently intensive cooling, but also for maintaining the life of the rollers. Proper cooling of the push bench rollers to affect the accuracy and the fix geometric dimensions of the produced tubes.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-18-0418.

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