EFFECT OF STABILIZER LENGTH ON THE PERFORMANCE OF HIGH PRESSURE DESCALING NOZZLES

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Abstract

Hydraulic descaling plays an important role in the surface quality of hot-rolled steel. Descaling occurs immediately before hot-rolling in order to eliminate layers of iron oxides on the surface. These oxides are called scales and form stratified layers. A hydraulic descaler consists of a row of high-pressure flat jet nozzles, i.e. descaling nozzles. Descaling nozzles are composed of several parts, one of which is the flow stabilizer. The stabilizer is an important part which attempts to minimize the turbulence of the flow within the system and contributes to the optimal performance of the nozzle. Currently, it is possible to choose from a wide variety of stabilizers according to the system operating conditions. This paper explores the influence of the length of a chosen stabilizer on the impact pressure distribution of the water flow. It was found that a longer stabilizer can significantly improve the performance of descaling nozzles. These findings can increase the performance of the descaler and reduce the production cost of hot-rolled steel.

Keywords: Scales, steel, hydraulic descaling, impact pressure, stabilizer

1. INTRODUCTION

The second largest branch of industry - the steel industry - currently focuses on high quality products. One key parameter is the quality of the product's surface. Most steel produced is heated above 900 °C. The hot steel surface reacts with oxygen in the surrounding atmosphere and oxides of ferrite and other elements are formed on the surface. These oxides are called scales. Scales are undesirable and decrease the quality of final product [1][1]. Scales influence the cooling intensity and the Leidenfrost temperature [2]. Hydraulic descaling is one of the most effective ways to remove hot scales [3, 4]. High velocity water streams impact hot scales on the surface and the scales are broken down and removed by these high-energy streams [5]. Some residual scales may remain on the surface and are rolled into the surface during the hot rolling process [6]. This problem is significant for steel grades with higher amounts of silicon. Steel producers require more efficient descaling systems. One way to increase the performance of descaling nozzles is to increase the water impact pressure when the stream hits the surface. This can be achieved by improving the water stabilizer, which is a part of high pressure descaling nozzles. Hrabovský [7] and Kvapil [8] studied the effect of stabilizer installation on the final performance of the water jet. The design of the stabilizers has improved over the last few years. Pressure loss was reduced in the stabilizer and the final impact pressure was increased. Stabilizers have also become longer and very long stabilizers with the same design can be found on the market. The effect of stabilizer length on the final impact pressure was studied experimentally and the results are presented in this paper.

2. IMPACT PRESSURE DISTRIBUTION MEASUREMENTS

Impact pressure distribution measurement is used to study spray characteristics such as spray width, spray depth, homogeneity of distribution along spray width, and maximum impact pressure. The raw data from this type of measurement are values of pressure dependent on position (X; Y) and can be displayed as a three dimensional graph, as in **Figures 1 and 2**.

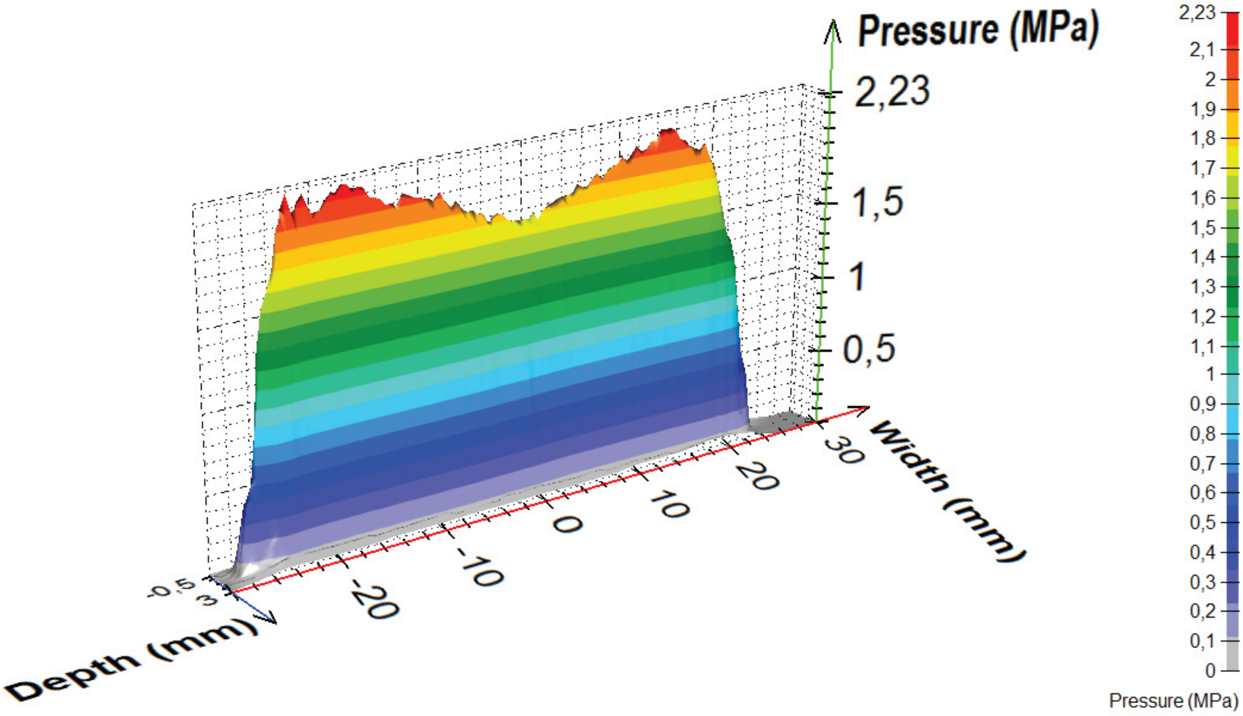

Figure 1 Impact pressure distribution from experiment E1 (nozzle A, parameters summarized in **Table 1**)

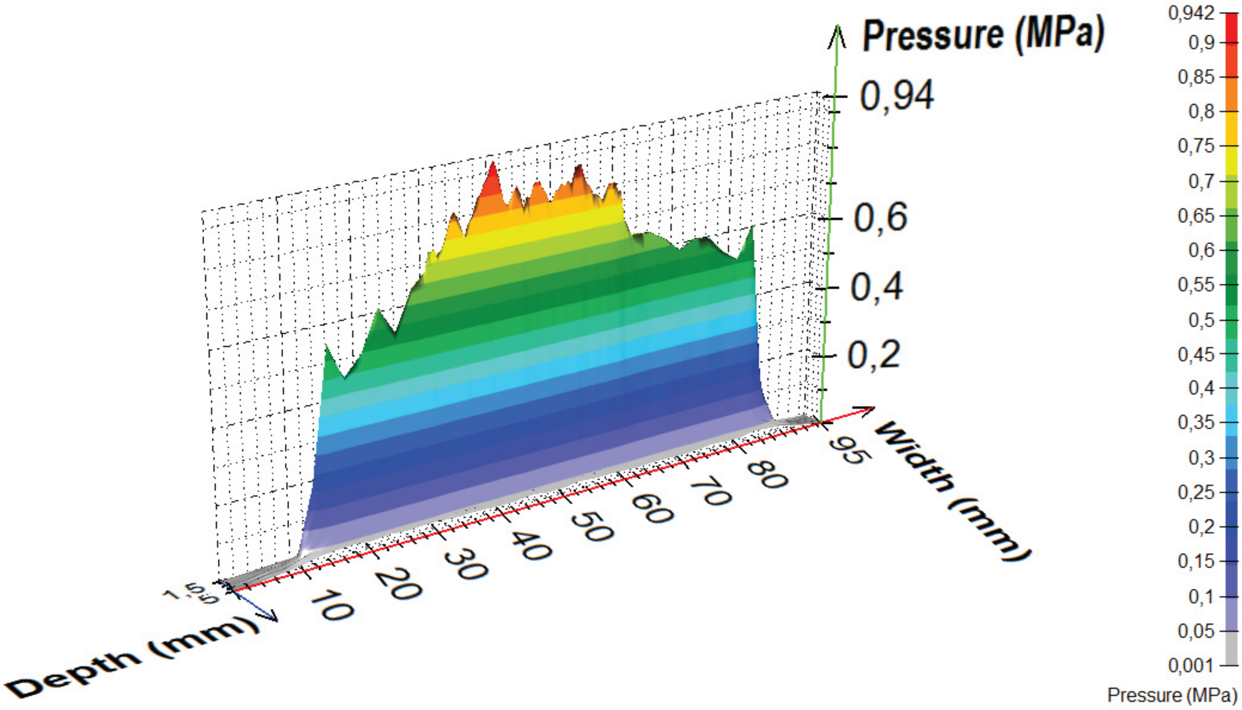

Figure 2 Impact pressure distribution from experiment E5 (nozzle B, parameters summarized in **Table 1**)

Impact pressure measurements were carried out using a laboratory measuring device. The device is illustrated in **Figure 3**. A selected nozzle sprayed a plate which was equipped with a pressure sensor. The radius of the active area of the pressure sensor was 0.1 mm. The plate moved along the X and/or Y axes. The movement was controlled by computer so the entire investigated area was scanned. Pressure caused by the impact of water on the surface was recorded as a position dependent value and the data was collected in a data acquisition device (DAQ).

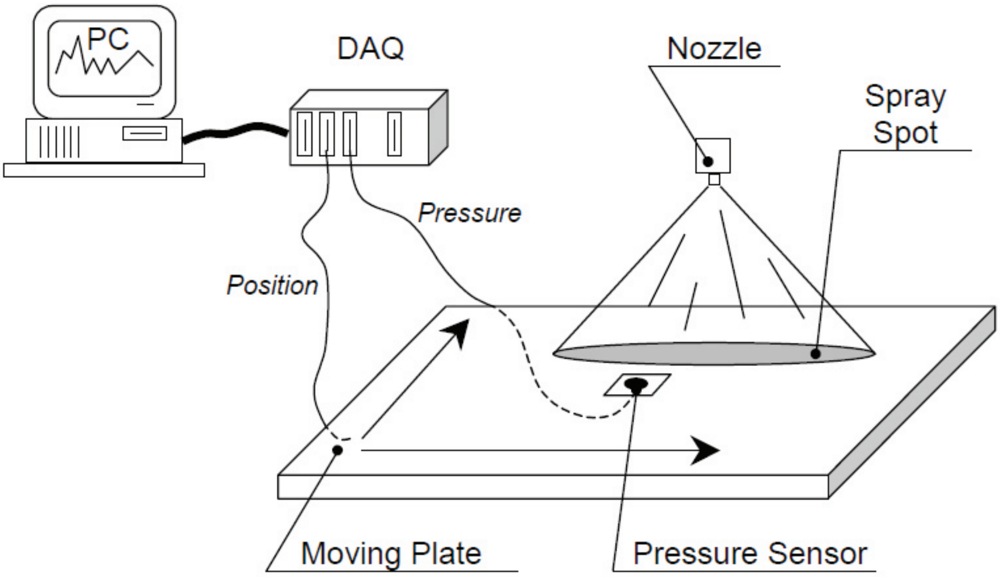

Figure 3 Diagram of experimental apparatus for impact pressure distribution measurements

3. NOZZLE AND STABILIZER SETTINGS

Two types of nozzles and three types of nozzle stabilizers were used for the experiments. The first two types of stabilizers were compatible with Type A nozzles and the last type of stabilizer was compatible with Type B nozzles. Two lengths were available for Type 1 nozzle stabilizers (121 mm and 130 mm) and two lengths were available for Type 3 nozzle stabilizers (101 mm and 225 mm). The Type 2 nozzle stabilizer was very similar to the Type 1 but was a slightly older design.

The Type A nozzle produced 25.5 l / min at 20 MPa, with a 3° spray angle. The nozzle was tested in 3 experiments with 3 different stabilizers. Feed pressure was set to 20 MPa. The nozzle distance from the plate was 75 mm and the inclination angle was set to 0° (i.e. the water jet was perpendicular to the moving plate).

The Type B nozzle produced 17.3 l / min at 20 MPa with a 52° spray angle. The nozzle was tested in 2 experiments with 2 different lengths of stabilizers. Feed pressure was set to 20 MPa. Nozzle distance from the plate was 75 mm and the inclination angle was set to 15°.

The configurations are summarized in **Table 1** and include the length of the corresponding stabilizers.

Table 1 List of experiments (*parameters specified by nozzle producers)

Experiment	Nozzle	Spray angle* (°)	Inclination angle (°)	Length of stabilizer (mm)	Pressure (MPa)	Flow rate at 20 MPa* (l / min)
E1	A	30	0	121 (Type 1)	20	25.5
E2	A	30	0	130 (Type 1)	20	25.5
E3	A	30	0	130 (Type 2)	20	25.5
E4	B	52	15	101 (Type 3)	20	17.3
E5	B	52	15	225 (Type 3)	20	17.3

4. RESULTS AND DISCUSSION

Impact pressure distribution measurements were taken for all five configurations in **Table 1**. The Type A nozzle produced more uniform impact pressure along the spray width (see **Figure 1**) than the Type B nozzle (see **Figure 2**). The coefficient of variation for the Type A nozzle was 10 % and the impact pressure had a local minimum in the central area while the Type B nozzle had maximum impact pressure in the center. Its coefficient of variation reached 25 %.

The maximum values of impact pressure along the spray width were averaged for each experiment and the data is shown in **Figures 4** and **5** as average impact. The maximum impact is the overall maximum pressure from each experiment.

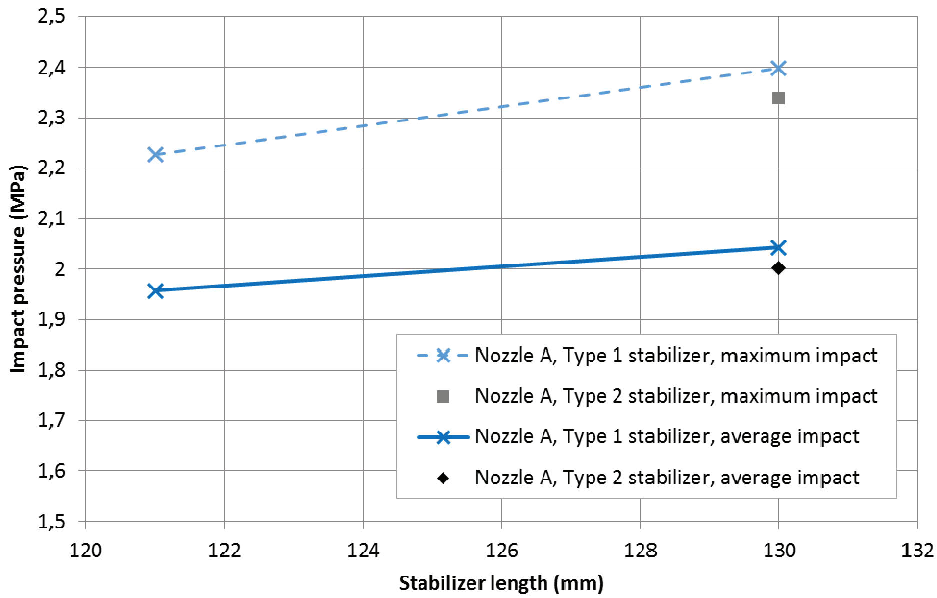

Figure 4 Results from measurements with Type A nozzle

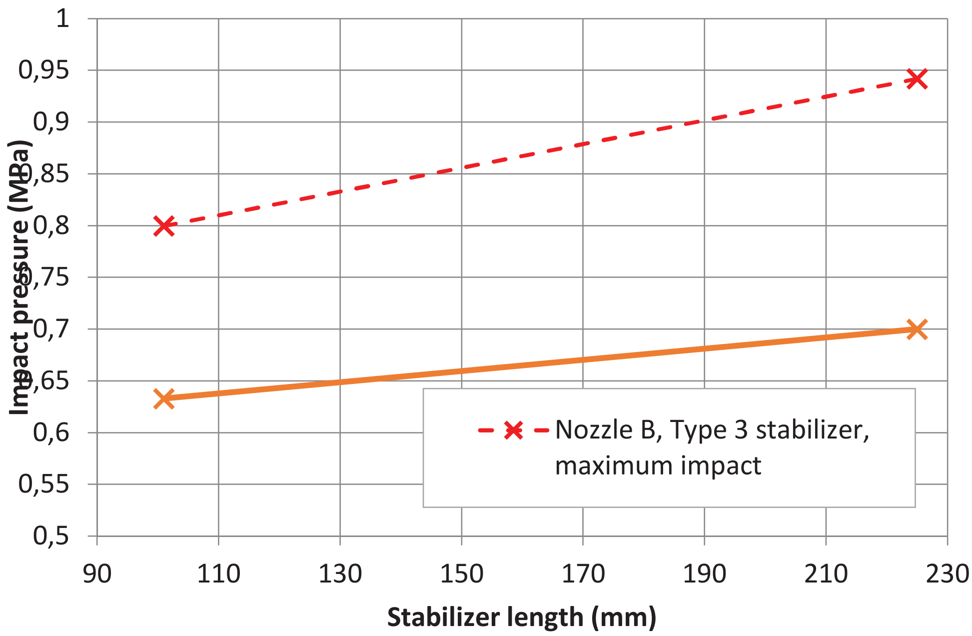

Figure 5 Results from measurements with Type B nozzle

The results showed that performance was reduced by only 2 % when the Type 2 stabilizer of the same length as the Type 1 stabilizer was used. When the length of the Type 1 stabilizer was reduced by 9 mm, the average impact was reduced by 4.2 % and the maximum impact was reduced by 7 %. When the length of the Type 3 stabilizer was significantly reduced by 124 mm, the average impact was reduced by 10 % and the maximum impact was reduced by 15 %. The analysis of the results showed that the reason for this reduced impact is different for Type 1 and for Type 3. In the Type 1 case, the overall impact force produced by the nozzle was decreased by 4.4 % when the shorter stabilizer was used which is comparable to decrease of average impact. In the Type 3 case, the overall impact force produced by the nozzle was decreased by only 0.4 %. This means that the reason for the increased impact pressure is the redistribution of water (see **Figure 6**) and the water stream is more focused with the Type 3 stabilizer.

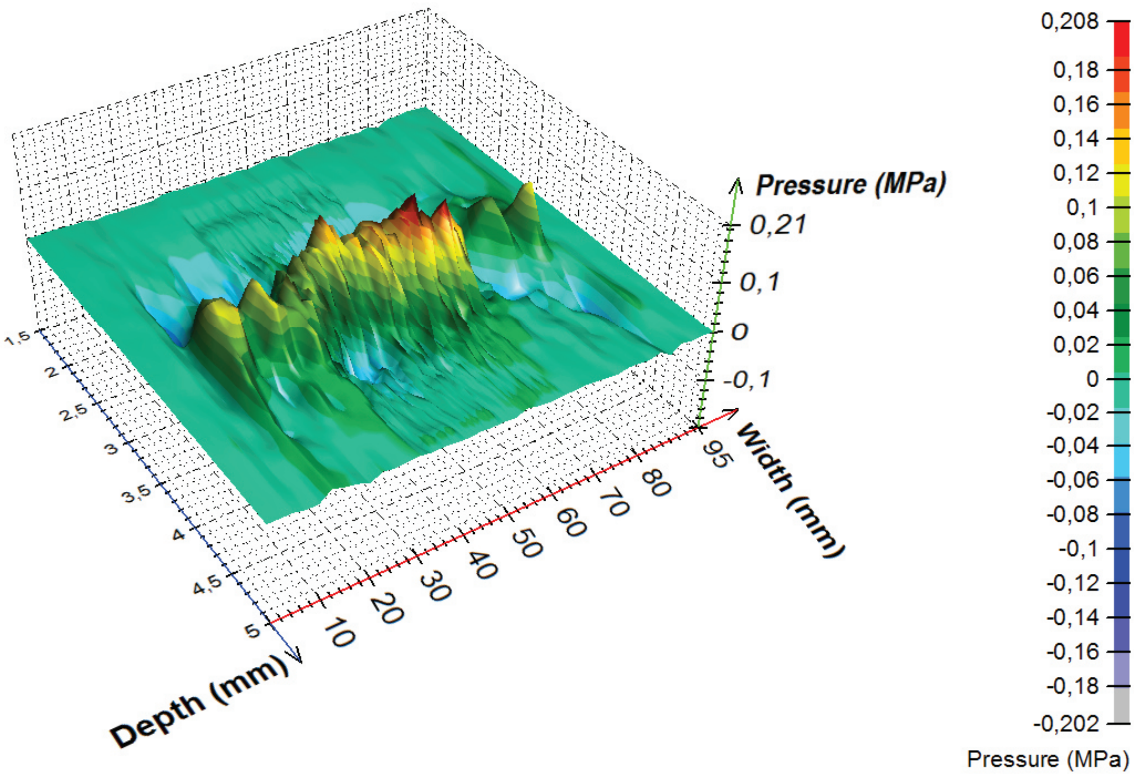

Figure 6 Difference of impact distribution, experiments E5-E4 (aspect ratio is not fixed for better resolution) (nozzle B, parameters summarized in **Table 1)**

5. CONCLUSION

The performance of high-pressure flat jet descaling nozzles was investigated using impact pressure distribution measurements. Two types of nozzles were used and two different lengths of stabilizers were used for each nozzle. It was found that a stabilizer can improve performance by 10 % when the length is significantly increased by 124 mm. Even a small 9 mm increase of stabilizer length can increase the performance by 4 %. The results showed that longer stabilizers should be used to achieve maximum descaling system performance.

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