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Modelling of the Parameters of Air-Flow in Pneumatic Nozzles for Linking Staple and Filament Yarns. Part II: Results of the Average Speeds and Asymmetry of the Air Stream Flowing Out of the Nozzle

Abstract

This article presents the results and analysis of the values of the average speeds of the air stream at the outlet planes of the interlacing duct of nozzles for the pneumatic linking of filament and staple yarns. The average speeds of the air-flow at the outlet planes of the nozzle were determined on the basis of the results of local speeds at different points on these planes. The methodology and measuring apparatus, designed and constructed at the Textile Research Institute (Instytut Włókiennictwa - IW) were described in Part I of this article. Part II presents an analysis of the different internal structures of the interlacing nozzles and their influence on the level and modelling (symmetry or asymmetry) of the air stream flowing out from both of their sides, that is at the outflow planes (inlet and outlet of the yarn).

Key words: pneumatic nozzle, air-flow parameters, air stream, air speed, stream asymmetry.

Introduction

Part I of this article [9] presents the methods and results of measurements of the local speeds of the air stream at the outflow planes of the interlacing duct

of nozzles for the pneumatic linking of staple and filament yarns. The particular variants of the nozzles differ from each other in the shape of the outlet planes and some other constructional features. The research works conducted gave us

very interesting observations and inspired us for further investigations aiming to determine the levels of the average speeds at the outlet planes of the interlacing duct, the influence of the air pressure which is supplied to the nozzles and of their constructional features on modelling the level and scale of the speeds of the air stream flowing out from both sides of the nozzle. The research work presented in this article is necessary to show that asymmetrical nozzles (designed at IW) are innovative solutions on a global scale and that they require further investigation, both individual and comparable to those already elaborated [1, 6 - 8, 10, 11]. The innovative character of asymmetrical nozzles, elaborated at IW, refers to the specific construction design of the yarn interlacing duct. There is an asymmetry of the cross-sections of the yarn interlacing duct in relation to the inlet of air (the air duct), while the surface planes of cross-sections A_1 and A_2 of the outlet are different from both sides ($A_1 \neq A_2$). The yarn interlacing duct in the asymmetrical nozzles changes in a convergent or segmental way [9].

Table 1. Example variants of the nozzles of different construction design investigated - their structure; $U_k^{(x)}$ Position of the air duct in relation to the interlacing duct; where: || - perpendicular; \ \ or // - at an angle, ← direction of yarn interlacing process, A_1 i A_2 - surfaces of the cross-section of the interlacing duct in the outflow planes, at the outlet and inlet, respectively; F - surface of the cross-section of the duct delivering air to the interlacing duct.

Symbol	Longitudinal scheme, cross-sections: interlacing duct - A_1 , A_2 , air duct - F		Structural features				
			$U_k^{(x)}$	Surface range			
				A_1/A_2	A_1/F	A_2/F	
1	2		3	4	5	6	
I. Nozzles with a symmetrical yarn interlacing duct							
IW 02.02	A_2		A_1		1	~2.6	~2.6
02.10	A_2		A_1		1	~2.9	~2.9
02.35	A_2		A_1		1	~2.1	~2.1
IW 03.04	A_2		A_1	\ \	1	~1.3	~1.3
02.12	A_2		A_1	\ \	1	~2.3	~2.3
06.25	A_2		A_1	\ \	1	~1.3	~1.3
II. Nozzles with an asymmetrical yarn interlacing duct							
Convergent duct							
IW 04.08.a			A_1		~3.0	~2.1	~0.7
IW 04.08.a'	A_2		A_1		~1.7	~1.5	~0.9
IW 05.03					~1.4	~1.8	~1.4
IW 05.02	A_2		A_1	//	~1.4	~1.8	~1.4
Segmental duct							
IW 02.02.a	A_2		A_1		~4.0	~2.6	~0.6
IW 02.08.a	A_2		A_1		~4.0	~2.6	~0.6
IW 06.01	A_2		A_1		~2.0	~1.3	~0.6
IW 06.02	A_2		A_1	//	~2.0	~1.3	~0.6

Aim of the research

The aim of this research was to model the level of speed and scale (symmetry or asymmetry) of the air stream flowing out from both sides of the pneumatic nozzle by introducing an innovative internal construction design and changing the air pressure.

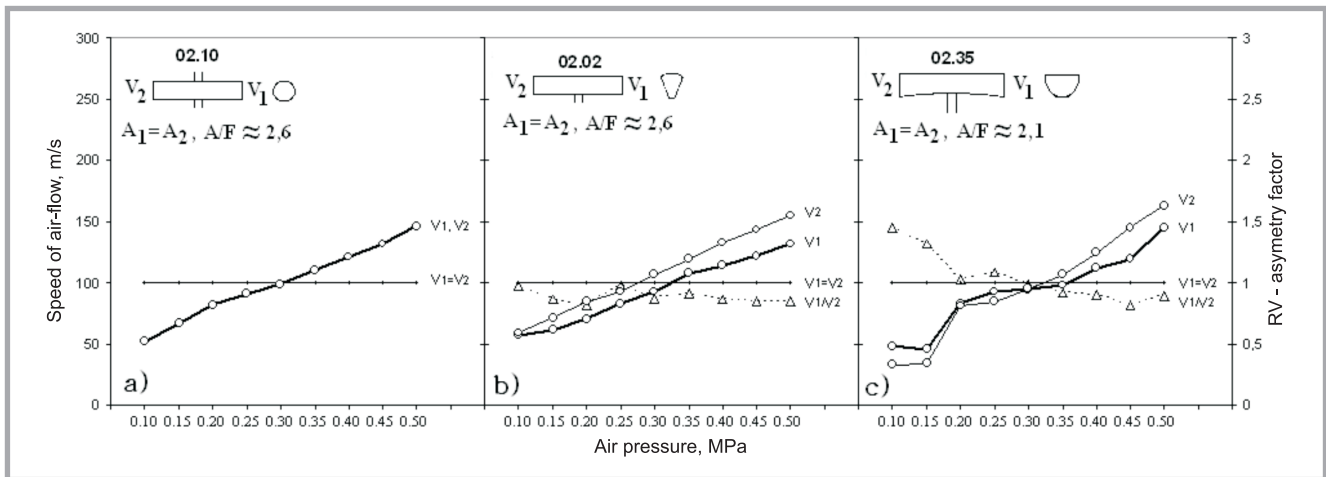


Figure 1. Modelling the parameters of air-flow for nozzles with a symmetrical interlacing duct and perpendicular air duct.

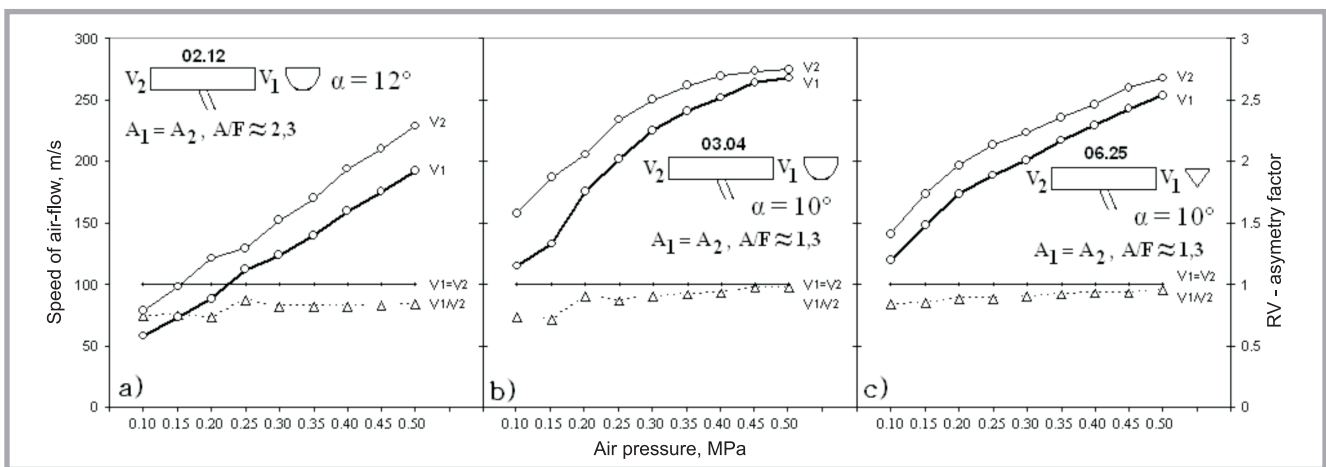


Figure 2. Modelling the parameters of air-flow for nozzles with a symmetrical interlacing duct and air duct placed at an angle.

Research material

The research material included 14 variants of nozzles for the pneumatic linking of staple and filament yarns, 10 of which were designed at the Textile Research Institute (nozzles marked with IW), whereas the other variants were designed by world companies manufacturing such elements (Heberlein, Temco, Fibreguide). The nozzles investigated were divided conventionally into 2 groups: those with a symmetrical yarn interlacing duct and those with an asymmetrical yarn interlacing duct (Analysis of the structure of pneumatic interlacing nozzles – Part I of the article). **Table 1** presents characteristics of the structural features of the nozzles investigated, as well as their simplified schemes and symbols.

Values of the average speeds V_1 and V_2 were determined on the basis of the results of the local speeds, presented in Part I of this article. For the nozzles investigated, the average values of the speeds

(V_1 and V_2) of air flowing out from the both sides of the interlacing duct at the outlet surfaces (A_1 and A_2) were determined.

Measurements were carried out for particular nozzles, changing the air pressure successively from 0.10 to 0.50 MPa (every 0.05 MPa), that is for 9 values of air pressure.

Results and discussion

Analysis of the average speeds of the outflow of the air stream

The results of the average speeds of the air-flow at the outlet planes of the interlacing duct and the factor of asymmetry of the average speeds of the air-flow are presented in **Figures 1, 2, 3** and **4**.

The stream of air fed to the yarn interlacing duct flows out from both sides of it; the scale of this stream and its speed (V) are determined by different construc-

tional factors simultaneously, including the following:

- longitudinal structure of the interlacing duct (symmetrical, asymmetrical – convergent and segmental);
- shape and dimensions of cross-sections of the interlacing duct (A);
- position of the air duct (perpendicular $k_p \parallel$, at an angle $k_p \backslash$) and value of the surface of its cross-sections (F);
- relation of the surface of the cross-section of the interlacing duct to the air duct (A/F).

The air pressure (p) at which the stream of air is fed through the delivering duct (k_p) to the interlacing duct (k_s) is the basic technological factor. In order to characterise the influence of this factor on the level of speeds of the air stream (V_1 , V_2) flowing out from both sides of the interlacing nozzle and on the distribution of its speeds, which is determined by the distribution factor RV , the changes in these parameters are presented in **Figures 1** and **2** (for nozzles with symmetri-

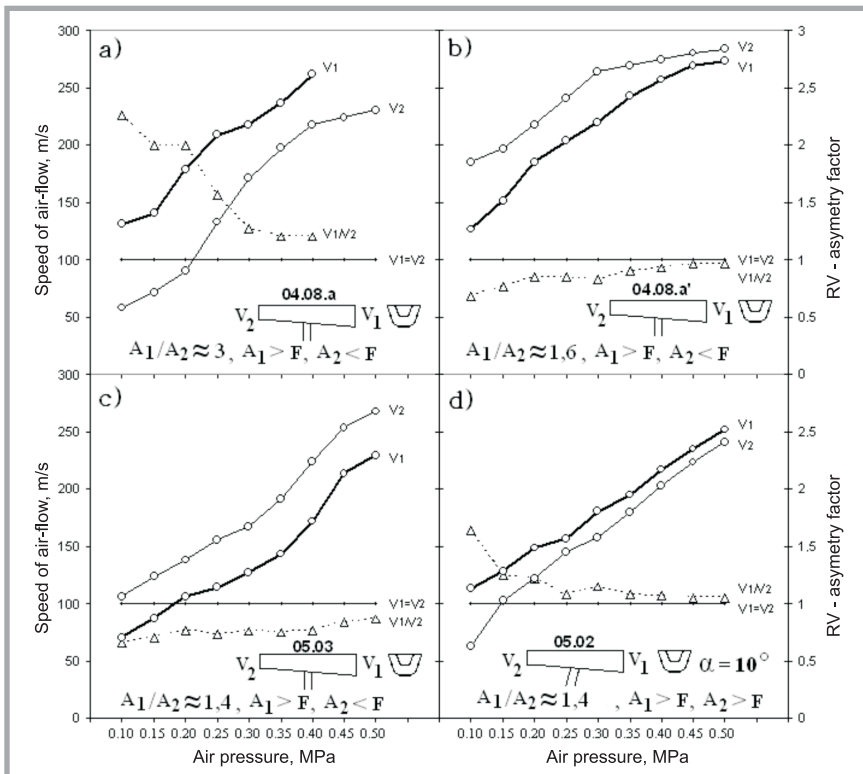


Figure 3. Modelling the parameters of air-flow for nozzles with an asymmetrical convergent interlacing duct.

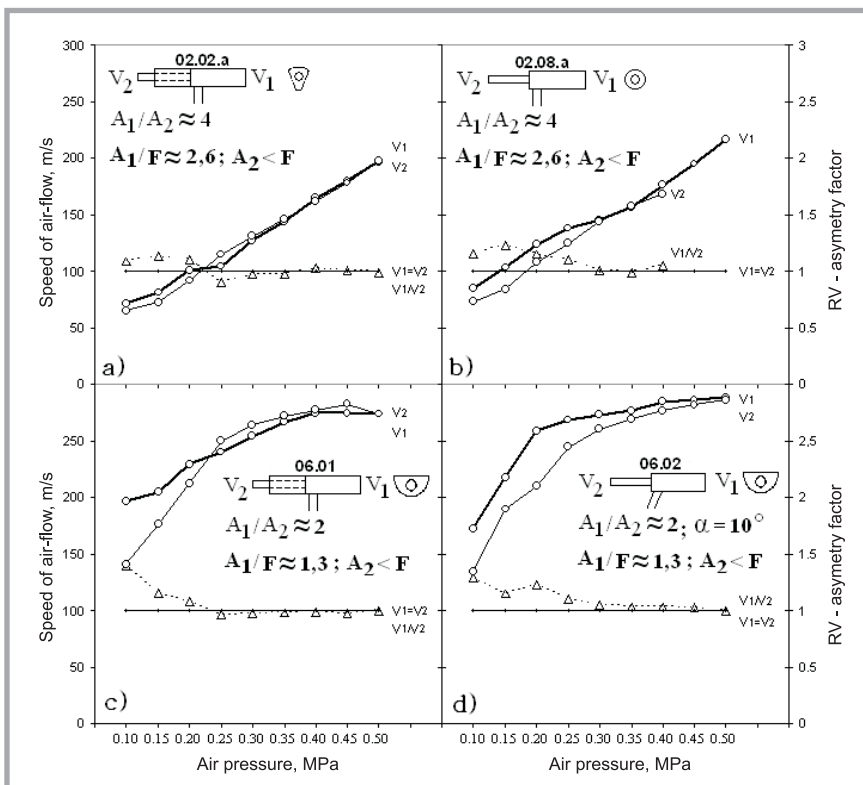


Figure 4. Modelling the parameters of air-flow for nozzles with an asymmetrical segmental interlacing duct.

cal interlacing ducts) and in Figures 3 and 4 (for nozzles with asymmetrical interlacing ducts). The RV factor is calculated as a relation of speeds V_1/V_2 (V_1 – at the inlet of yarn leading to the interlac-

ing duct; V_2 – at the outlet of the nozzle). A value of $RV = 1$ indicates a symmetry of the outflow speeds ($V_1 = V_2$), whereas $RV > 1$ or $RV < 1$ indicates an asymmetry of the outflow speeds ($V_1 > V_2$ or $V_1 <$

V_2). An analysis of the results obtained showed that:

- For all the variants of the nozzles – with an increase in air pressure (the linking medium), the speed of the air stream flowing out from both sides of the interlacing duct increases as well.
- With an increase in speed, the asymmetry between the speeds of the air stream flowing out from both sides of the interlacing duct decreases.

■ In „go-through” nozzles with a **symmetrical interlacing duct** (the same dimensions of the interlacing duct from both its sides) and perpendicular air duct ($k_p \parallel$), there is a symmetry of the outflow of air, or the outflow is near-symmetrical. Constructional features of these nozzles and parameters of the air-flow (Figure 1) are as follows:

- $A_1 = A_2 > F$; $A/F \sim 2.1$ and 2.3 ; $k_p \parallel$
- $V_1 = V_2$ or $V_1 \approx V_2$ and $RV \approx 1$ ($0.9 - 1.0 - 1.1$)
- Average speeds: 50 – 170 m/s (for 0.10 – 0.40 MPa), the speeds are a bit higher for $A/F - 2.1$.

■ In „go-through” nozzles with an symmetrical interlacing duct and air duct at an angle ($k_p \setminus$), there is an asymmetry of the outflow of air, with the value of the speed higher from the slope direction of the air duct. Features of these nozzles and parameters of the air-flow (Figure 2) are as follows:

- $A_1 = A_2 > F$; $A/F \sim 1.3$ and 2.3 ; $k_p \setminus$
- $V_1 < V_2$ and $RV < 1$ ($0.7 - 0.9$) – asymmetry
- Higher values of speed for $A/F - 1.3$ (110 – 270 m/s with p : 0.10 – 0.40 MPa), rather than $A/F - 2.6$ (60 – 200 m/min with p : 0.10 – 0.40 MPa)

■ For a perpendicular air duct ($k_p \parallel$) and that at an angle ($k_p \setminus$), there is an asymmetry of the outflow of air in the nozzles of a new construction design, with an **asymmetrical convergent interlacing duct**, the surface dimensions of which being different on both its sides ($A_1 \neq A_2$), but with the same shapes. The relations between structural features and air flow features for these nozzles (Figure 3) are as follows:

- for $A_1/A_2 \approx 3$ and $A_1/F \approx 2.1$ and $A_2/F \approx 0.7$; $k_p \parallel$
 $V_1 > V_2$ and $RV > 1$ ($2.2 - 1.2$; with p : 0.10 – 0.40 MPa)
- for $A_1/A_2 \approx 1.6$ and $A_1/F \approx 1.5$ and $A_2/F \approx 0.9$; $k_p \parallel$
 $V_1 < V_2$ and $RV < 1$ ($0.7 - 1.0$; with p : 0.10 – 0.40 MPa)

- c) for $A_1/A_2 \approx 1.4$ and $A_1/F \approx 1.8$ and $A_2/F \approx 1.4$; $k_p //$
 $V_1 < V_2$ and $RV < 1$ (0.6 – 0.8; with p: 0.10 – 0.40 MPa)
- d) for $A_1/A_2 \approx 1.4$ and $A_1/F \approx 1.8$ and $A_2/F \approx 1.4$; $k_p //$
 $V_1 > V_2$ and $RV > 1$ (1.6 – 1.1; with p: 0.10 – 0.40 MPa).

Higher speeds of the outflow are characteristic for variants a and b of the nozzles (to 270 m/s) in comparison with variant c (230 m/s). Generally, these kinds of nozzles can be characterised by a much higher asymmetry of air flowing out from both sides of the nozzles than those with a symmetrical interlacing duct.

- In the nozzles of a new construction design with an **asymmetrical segmental interlacing duct (Figure 4)**, whose outlet surfaces have different shapes and dimensions $A_1 \neq A_2$, there is also an asymmetrical distribution of the outflow with the following directions:

- a, b) for $A_1/A_2 \approx 4$ and $A_1/F \approx 2.6$ and $A_2/F \approx 0.6$; $k_p //$
- $V_1 \geq V_2$ and $RV \geq 1$ (1.1 – 1.0; with p: 0.10 – 0.40 MPa)
 - Speed 60 – 170 m/s, p: 0.10 – 0.40 MPa
- c, d) for $A_1/A_2 \approx 2$ and $A_1/F \approx 1.3$ and $A_2/F \approx 0.6$
- $V_1 \geq V_2$ and $RV \sim 1$ (1.4 – 0.9; with p: 0.10 – 0.40 MPa); $k_p //$
 - $V_1 > V_2$ and $RV > 1$ (1.4 – 1.1; with p: 0.10 – 0.40 MPa); $k_p //$

Generally, variants c and d can be characterised by much higher levels of the speed of the air stream (120 – 280 m/s; p: 0.10 – 0.40 MPa) and by a much more diversified scatter of the outflow with an increase in speed than variants a and b (60 – 170 m/s; p: 0.10 – 0.40 MPa).

The investigations conducted show the diverse influence of the internal construction design of interlacing nozzles in the interlacing duct – air duct “node” on modelling the parameters of the air-flow – the medium linking the yarns. Determining the speed and asymmetry of the air-flow has inspired us to investigate further, which will allow us to get to know the linking medium acting at the outlet surfaces for various solutions of the nozzles investigated. These investigations will be the subject of our future research work.

Summary

The investigations on the speed of the air-flow showed the following:

1. An increase in air pressure increases the speed of the air stream flowing out from both sides of the interlacing duct and decreases the scatter of the level of the speeds between these two sides (decrease of asymmetry).
2. The scatter and level of the average speeds between the outlets of the nozzles depend on the following: the longitudinal shape of the interlacing duct (symmetrical, asymmetrical) and the dimensions of its cross-sections (A), as well as the position of the air duct (perpendicular, at an angle) in relation to the interlacing duct, and also the relation of the surfaces of the cross-sections of these ducts (A/F).
3. A symmetrical distribution of the outflow can be obtained only for nozzles with a „symmetrical” interlacing duct, with the air duct placed perpendicularly; in the other nozzles investigated, there is an asymmetry of the outflow. The IW constructions of the nozzles provide greater possibilities of modelling the asymmetry of the outflow.
4. The investigations conducted showed some possibilities and directions for modelling the parameters of the air-flow in interlacing nozzles by choosing suitable internal construction designs and air pressure. Determining the speed of the air stream flowing out from nozzles of different construction design helped us to determine other parameters informing about the intensity of the effect of the air on the yarns fed to be joined, which will be the subject of our future articles.

Modelling the parameters of the air-flow – medium linking staple and filament yarns in pneumatic nozzles is the key issue in achieving a high efficiency of the process as well as new effects of the joints and high-quality yarns. The new construction designs of IW is the way to achieve these goals.

Technological investigations on linking yarns with the use of the pneumatic nozzles newly developed are currently being conducted at the Textile Research Institute. The results and analysis of the influence of the air-flow parameters will be the subject of our future works.

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