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RESISTANCE OF FLOW IN FILM HOSES USED IN INSTALLATIONS OF PNEUMATIC TRANSPORT OF WOOD WASTE

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Abstract. Research was conducted in laboratory conditions on the pressure losses in film hoses made of pure polyester polyurethane with high flexibility and compressibility reinforced with a spring steel spiral. The measurements were conducted with use of 3-meter long sections, which were 80, 100, 150 and 200 mm in diameter. A mixture of sawdust, shavings and dust from working of softwood with the mass concentration in the carrying stream at the level 100 $g \cdot m^{-3}$ was used. Velocities of air flow were changed in the range from 10 to 25 $m \cdot s^{-1}$. The resistance of clean air flow was also determined.

Key words: resistances of flow, wood waste, pneumatic transport

INTRODUCTION

Specificity of construction and operation of exhaust installations for removal and transport to the destination of waste from the mechanical working of wood materials (sawdust, shavings and dust) causes a necessity of application of film hoses in many places. Sections of these pipes are most frequently situated in zones of the direct connection of the most complicated woodworking machines – versatile machines and CNC machines [Dolny and Adamczak 2002]. In all the events of film hoses usage in routes of the conduct of air carrying the particles of crumbled wood, there is a necessity of an accurate knowledge about the resistance of air flow in film hoses in order to design correctly and determine the pressure of the equilibrium in the joints of these woodworking machines and in the whole exhaust installations [Dolny 1999].

The research on the resistance of clean air flow and the resistance of the flow of two-component disperse system (air containing fine particles from the machining of the wood materials) in straight sections of the film hoses with different diameter at the variable dynamics of the air stream motion was undertaken with the purpose of gathering important design data. These data were a first stage of experimental description of

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the pressure losses in such components of exhaust systems interacting with woodworking machines.

MATERIAL AND METHODS

All the measurements, in the most often applied in industrial practice film hoses, were conducted in laboratory conditions. These hoses are made of pure polyester polyurethane with high flexibility and compressibility reinforced with the spring steel spiral [Materiały... 2002]. The flow resistance was determined for the 3-meter long sections, which are 80, 100, 150 and 200 mm in diameter. It was first done for the clean air and then for the two-component disperse system. The mass concentration of wood waste in this system was running at 100 $g \cdot m^{-3}$. Velocity of the air flow was changed in the range from 10 to 25 $m \cdot s^{-1}$.

Schematic diagram of the experimental system was shown on Figure 1.

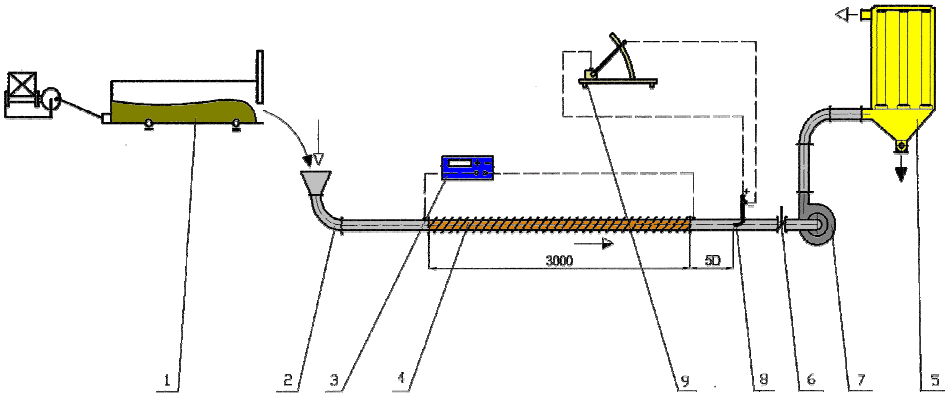

Fig. 1. Schematic diagram of the experimental system: 1 – feed device, 2 – charging hopper, 3 – differential manometer, 4 – film hose, 5 – dust extractor, 6 – gate valve, 7 – fan, 8 – Prandtl tube, 9 – liquid-column gauge
Rys. 1. Schemat stanowiska pomiarowego: 1 – urządzenie zasilające, 2 – lej zasypowy, 3 – manometr różnicowy, 4 – przewód elastyczny, 5 – separator, 6 – przepustnica, 7 – wentylator, 8 – rurka spiętrzająca Prandtla, 9 – manometr cieczowy

The very essential first part of this system is the feeding device. This device gives a possibility of receiving of required proportion of fed waste amount to volume of air flowing through the tested film hose. The feeding device was worked during the experiments with values of the efficiency shown in Table 1.

The last part of the experimental system is a dust extractor that catches all the waste particles, which enables to use this system without the risk of dust emission to the surrounding.

The mixture of sawdust, shavings and dust arisen directly during the machining of wood was used for the measurements of the resistances of flow during the transport of wood waste. Dimension characteristic of this mixture was shown on Figure 2.

Table 1. Efficiency of feed device
Tabela 1. Wydajność urządzenia dozującego

Diameter of film hose Średnica przewodu mm	Air flow velocity, $m \cdot s^{-1}$ – Prędkość przepływu powietrza, $m \cdot s^{-1}$			
	10	15	20	25
60	170	254	340	424
100	471	707	942	1 178
150	1 060	1 590	2 120	2 560
200	1 884	2 826	3 768	4 710

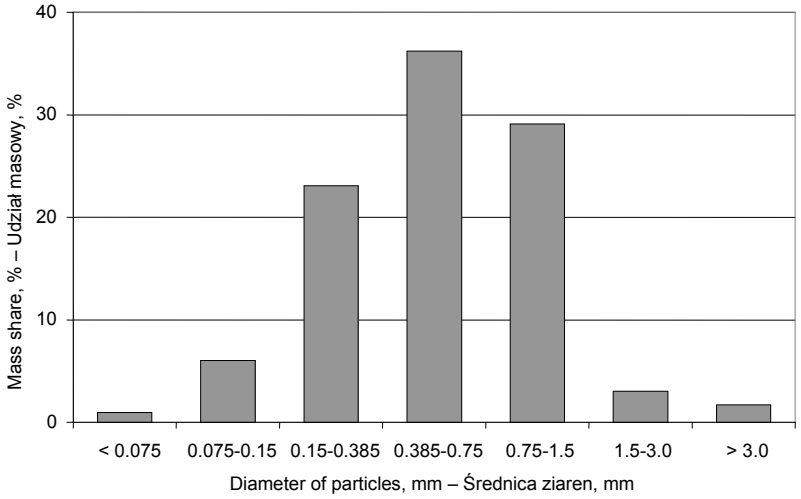

Fig. 2. Average grain-composition of waste used in tests
Rys. 2. Średni skład ziarnowy odpadów użytych do badań

The other basic properties of wood waste had the following values: density of repose – 208 $kg \cdot m^{-3}$, density of shaken layer – 277 $kg \cdot m^{-3}$, slippery angle – 35°, angle of repose – 44° and average humidity – 5.4%. In each of the experiments samples were used separated from the experimental batch prepared for all the tests. The measurements of the air flow velocity were done with the help of the Prandtl tube placed in straight section of the pipe made of the steel sheet mounted behind the tested film hose. The resistance of flow in these was measured with the use of the digital differential micromanometer.

RESULTS

The results of the measurements were shown in a graphic way. First they were presented for the whole 3-meter long sections in relation to clean air (Fig. 3) and then as unit values (in conversion to 1-meter film hose – $Pa \cdot m^{-1}$) in comparative expression for the clean air and for the two-component disperse system (Fig. 4). The dynamic pressure

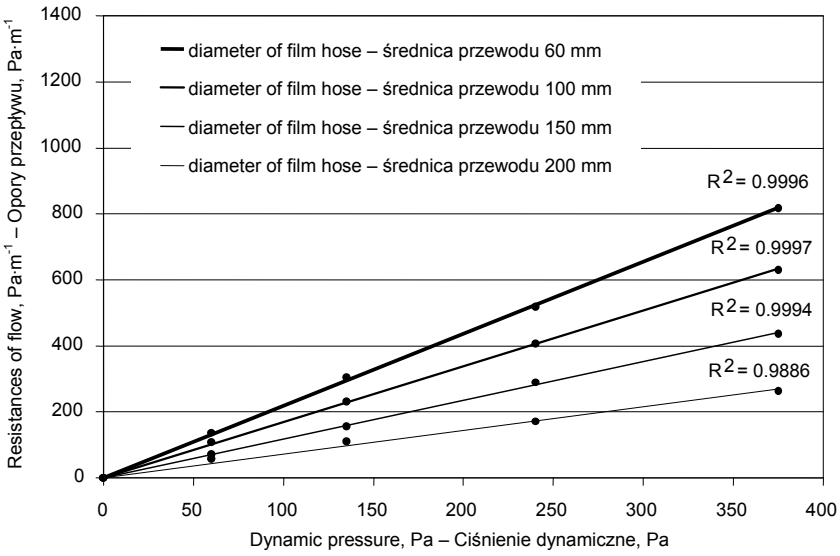

Fig. 3. Resistances of clean air flow in dependence on dynamic pressure
Rys. 3. Opory przepływu czystego powietrza w funkcji ciśnienia dynamicznego

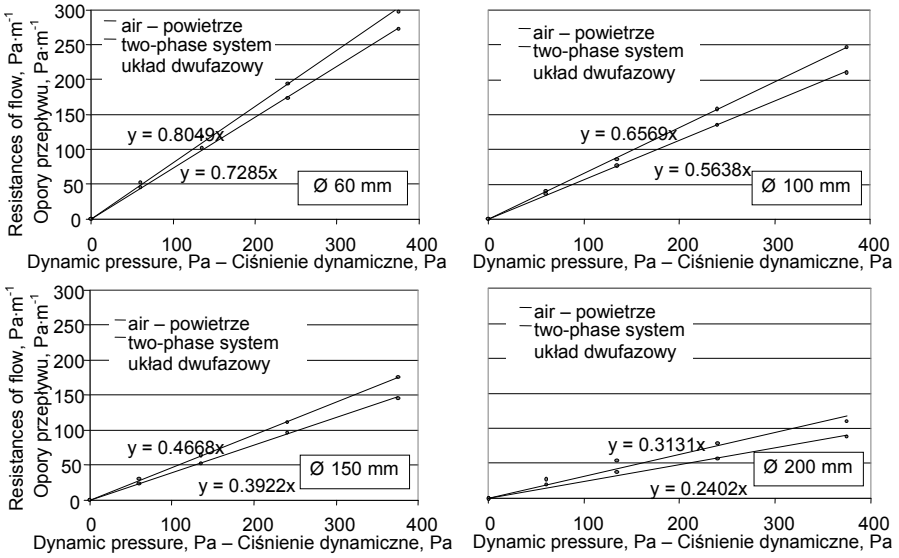

Fig. 4. Unit resistances of flow in straight sections of film hoses in dependence on dynamic pressure
Rys. 4. Jednostkowe opory przepływu w odcinkach prostych przewodów elastycznych w funkcji ciśnienia dynamicznego

was the quantity of reference in both cases. Such an arrangement of setting of the results gives a possibility of a very clear presentation of the differences, which are outlined between both flow situations.

The flow resistance during the transport of wood waste inside the film hose is found at the average level by about 15% higher than during the flow of clean air. There is an upward trend of these disproportions along with the increasing diameter of the film hoses (Fig. 5). This trend has a clear connection with the decrease of the resistances of the clean air flow because of that the resistances of flow of the two-component disperse system are compared with the base with lower value. Absolute differences between the resistance of the clean air flow and the resistance of flow of the two-component disperse system remain each other very similar in all the diameters of the tested film hoses.

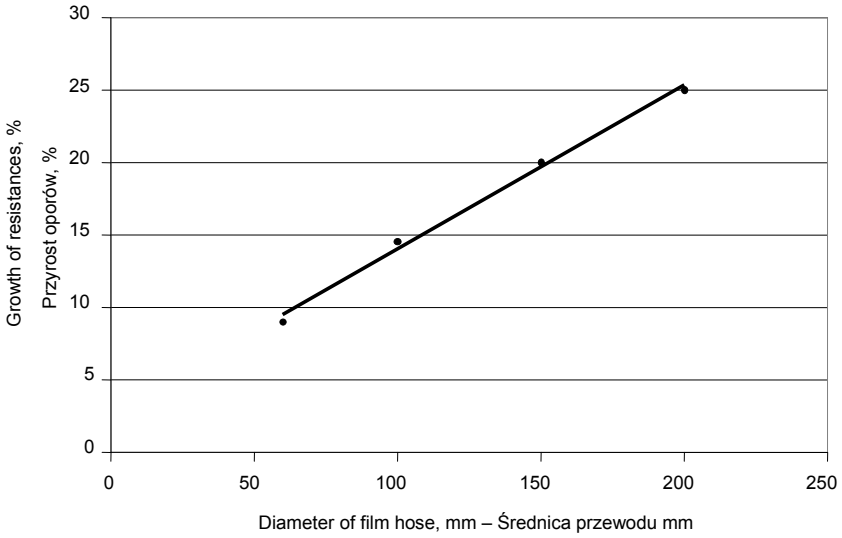

Fig. 5. Changeability of resistances of flow during waste transport with velocity 25 $m \cdot s^{-1}$ in dependence on diameter of film hose
Rys. 5. Zmienność oporów przepływu w funkcji średnicy przewodu w transporcie odpadów z prędkością 25 $m \cdot s^{-1}$

As a result of the analysis of the absolute values of the resistances of air flow in conditions of transport of wood waste a very clear decrease of these values was found alongside with increasing of the film hose diameter (Fig. 6). There are 2.7 times falls at the transport velocity of 10 $m \cdot s^{-1}$ and 3.3 times falls at the velocity of 25 $m \cdot s^{-1}$ in the considered range of diameters, from 60 to 200 mm.

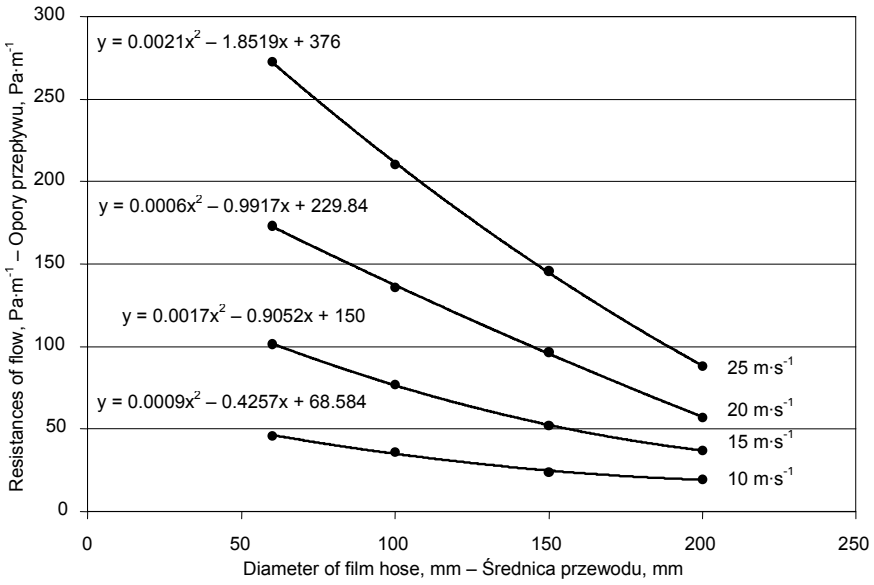

Fig. 6. Resistances of flow of two-phase system in film hoses with different diameter
Rys. 6. Opory przy przepływie układu dwufazowego w przewodach o różnej średnicy

CONCLUSION

The use of film hoses in the pneumatic transport and dedusting installations causes the appearance of the raised resistances of air flow in comparison with the pipes made of steel sheet. The pressure losses in straight sections of the film hoses in relation to the clean air are higher by about 30% than the analytical values for rigid pipes [Malicki 1977]. These differences may have an influence on the flow conditions in these installations.

Basic results obtained during this research may be useful first of all for the design calculations. They point at the growth of the resistances of flow in the film hoses at the moment of the appearance inside these hoses of the air stream carrying the waste from machining of the wood materials. At high concentrations of the solid phase (waste) the pressure losses in the long sections of the film hoses may begin to negative affect on the value of air stream. It may be a reason of deterioration of effect of the suction nozzles. In these situations one should introduce the appropriate corrections in calculations of junctions in the installations with these pipes.

REFERENCES

Dolny S., 1999. Transport pneumatyczny i odpylanie w przemyśle drzewnym [Pneumatic transport and dedusting in wood processing industry]. Wyd. AR Poznań [in Polish].

Dolny S., Adamczak D., 2002. Usuwanie drobnych odpadów drzewnych od obrabiarek CNC [Removal of fine wood waste from CNC machines]. Zast. Ergon. 1-4, 15-20 [in Polish].
Malicki W., 1977. Wentylacja i klimatyzacja [Ventilation and air conditions engineering]. PWN Warszawa [in Polish].
Materiały informacyjne firmy Masterflex [Master survey; in Polish].

OPORY PRZEPŁYWU W PRZEWODACH ELASTYCZNYCH STOSOWANYCH W INSTALACJACH TRANSPORTU PNEUMATYCZNEGO ODPADÓW DRZEWNYCH

Streszczenie. W warunkach laboratoryjnych przeprowadzono badania strat ciśnienia w kanałach elastycznych z poliuretanu poliestrowego charakteryzującego się dużą elastycznością i ściśliwością, ze spiralą wzmacniającą ze stali sprężynowej. Pomiary przeprowadzono na odcinkach o długości 3 m, w kanałach o średnicy 80, 100, 150 i 200 mm. Użyto mieszaniny trocin, wiórów i pyłu z obróbki drewna iglastego o stopniu koncentracji w strumieniu na poziomie 100 $g \cdot m^{-3}$. Prędkości przepływu powietrza zmieniano w przedziale od 10 do 25 $m \cdot s^{-1}$. Opory przepływu wyznaczono także dla czystego powietrza.

Słowa kluczowe: opory przepływu, odpady drzewne, transport pneumatyczny

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