USE OF VENTURI JETS LOCATED OUT OF TUNNELS FOR THEIR VENTILATION DURING THE PERIODS OF TUNNELING COMPLETION OR AT THEIR RECONSTRUCTION

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LET ME GIVE YOU SOME BACKGROUND

In Russia safety norms prohibited to use only the nature draft for ventilation during of the tunnel driving. In this connection in the tunnel is being built barricade, in which installed fan for ventilation tunnel. Application of its ventilation schemes does not seem rational as it decreases mobility of the mining and construction equipment.

Four years ago after 6th International Conference in Graz during in technical visit we witnessed the fire test. Fan located at some distance from tunnel portal has been used for its ventilation.
The main objective of researches consisted in justification of a possibility of venturi jet use when tunnel driving is completed and through-flow ventilation is introduced.

Task - to establish a functional relationship between the venturi jet performance curves and air velocity in the tunnels.

Methods of investigation - physical and mathematical simulation of aerodynamic processes in tunnels with a venturi jet used as the draught source.

Layout of venturi jet in front of tunnel portal
PHYSICAL SIMULATION

Test installation

Layout and design of setup up for model experiments

Impellor

Frequency convertor

Electric battery
Installation of flap in the tunnel model

Full aerodynamic drag factor of the model

$$\zeta_T = \frac{8 \rho_a}{\pi^2 D^2} (1 + \xi_{ext} + \xi_g + \lambda_T \frac{L_T}{D_T})$$

Where $\xi_g$ local drag factor of the flap

$$\xi_g = \frac{\Delta T}{D_T} (L_{T,i} - L_{T,0})$$

Tunnel section without and with flag
Factors that affect the air velocity in the tunnel ($U_T$)

- internal diameter of the fan hole ($d_f$)
- output air velocity ($V_f$),
- tunnel length ($L_T$),
- distance from the venturi jet location to the portal ($L_{loc}$),
- hydraulic diameter of the tunnel ($D_T$),
- air density ($\rho_a$);
- full aerodynamic drag factor of the tunnel ($\zeta_T$): $\zeta_T = (1 + \xi_{ext} + \lambda_T \frac{L_T}{D_T})$, $\lambda_T$ is the friction factor; $\xi_{ext}$ is the local drag coefficient of the tunnel intake section.

Similarity criteria

$$Z_1 = \frac{8}{\pi^2} \zeta_T \frac{d_f^4}{D_T^4}; \quad Z_2 = \frac{D_T}{d_f}; \quad Z_3 = \frac{L_{loc}}{d_f}$$

Air velocity in the tunnel $U_T/V_f$

$$U_T/V_f = F \left[ (Z_1)^x \cdot (Z_2)^m \cdot (Z_3)^n \right]$$
RESULTS OF PHYSICAL SIMULATION

\[ U_T / V_f = 0.31 \cdot Z_1^{-0.48} \cdot Z_2^{-1.63} \cdot Z_3^{-0.26} \]

Average air velocity in model of tunnel, m/s

Distance between the fan and portal, cm

\[ L_T = 1.5 \text{ m}, \quad d_T = 27 \text{ mm}, \quad V_T = 27.7 \text{ m/s}. \]
MATHEMATICAL SIMULATION

Simulation model

Finite element grid

Boundary condition
# RESULTS OF MATHEMATICAL SIMULATION

<table>
<thead>
<tr>
<th>parameter</th>
<th>$L_{fun}$, m</th>
<th>$L_{loc}$, m</th>
<th>$D_{fan}$, m</th>
<th>$V_{fan}$, m/s</th>
<th>$H_{natural draft}$, Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>numerical value</td>
<td>10; 25; 40</td>
<td>150; 320; 740; 1100; 2730</td>
<td>1,0; 1,6</td>
<td>35,6; 32,8</td>
<td>0; 10; 20</td>
</tr>
</tbody>
</table>

Recycling zone
Their correlation with the physical modelling data (Slide 7) shows that the discrepancy does not exceed 15%.
RESULTS OF MATHEMATICAL SIMULATION

With take account nature draft

\[ \frac{U}{V_f} = 0.087 \cdot Z_1^{-0.93} \cdot Z_2^{-4.0} \cdot Z_3^{-0.09} \cdot Z_4^{-0.47} \]

Where \( Z_4 = \frac{h_{n.d.}}{\rho_a} \cdot V_f^2 \)
Practical application of research results

Determination of the natural draft critical values, in which the tunnel is not provided desired ventilation mode (Y1, Y2, Y3 – length tunnel)

Nature draft is directed opposite of direction action free jet
CONCLUSIONS

- The performed complex theoretical and experimental studies justified the possibility to use venturi jets located at the tunnel portal as the draught source for tunnel ventilation during construction and assembly operations provided a through air flow is present.

- The obtained dependences render it possible to determine the aerodynamic parameters and rational location of the venturi jets with reference to the tunnel portals.
Thank you very much for attention

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