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# LABYRINTH STYLE ASPIRATION HOOD

**Alexander Borisovich Goltsov, Valerii Anatolevich Uvarov, Boris Fedorovich Podporinov, ArtemSergeevich Seminenko, AllaIvanovna Alifanova**
Belgorod State Technological University named after V.G. Shukhov,
Russia, 308012, Belgorod, Kostyukov str., 46.
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**Abstract:**

Reduction of dust load on the filters of local exhaust ventilation is achieved by improving the exhaust suction and shelters. This article focuses on the research aspiration of the shelter the place of loading belt conveyors. Investigated the effect of the ratio of structural size (length of cover width of cover, the Reynolds number in the cavity of the inner box and the height of the shelter) proposed the suction cover on the volume of aspirated air and dust concentration. Identified rational relationship between structural dimensions of the designed shelter. During industrial experiment studied the influence of the studied parameters on the concentration of dust in the air is aspirated, the aspirated volume of air and the mass ablation from the suction cover. It is established that for any set of input parameters, there is preferred a combination of both, when the dust concentration in the aspirated air, the dust discharge and the volume of aspirated air are committed to minimum.

**Key words**: aspiration, dust catching, aspiration hood, ejection

## Introduction.

Local exhaust ventilation plays the most active role among engineering tools of sanitary working conditions at the shopfloor. At the plants related to lose materials processing this role is performed by aspiration systems which provide dust containment in the places of its origin [1, 2, 3, 4].

Currently there are over 60 various constructions of aspiration hoods of belt conveyors' loading areas [3, 5, 6]. In most cases the usage of the recommended hoods is an engineering challenge due to complexity of their construction and large outline dimensions[1, 7].In this regard the significanceof the hood's construction design for usage in confined spaces of installation is evident as it allows influencing the process of air ejection by the overload material.

**Methods.** This paper presents the principles of detection of reasonable construction and operating parameters of aspiration hood, received as a result of the studies conducted.

As follows from the analysis of different hood constructions we faced the challenge of developing an improved hood construction having less overall sizes in comparison to the existing ones, the prototype model of which served the labyrinth style hood [8]. The advantage of this hood construction is the presence of double walls effects (consistent rarefaction) and inertial dust laying (dust particles separation from air flow when changing the direction of its movement). The only disadvantage of this construction can be considered as the presence of the horizontal shelf on the inner duct where dust might accumulate. The improved hood design was suggested(figure 1) [9] key feature of which was the absence of the inner duct horizontal surface, or rather its modification in the form of double-pitch roof to prevent dust accumulation on the inner duct surface and possibility of maximum approach of aspiration funnel to belt conveyor and gutter [10, 11].

To determine reasonable construction and operating parameters of the aspiration hood of belt conveyors' loading places we performed series of studies aimed to performing of quantitative assessment of the aspirated air volume, its dust concentration and also exposure of the most reasonable correlation of the overall dimensions of the suggested hood construction.

Researches were conducted on the industrial aspiration installation the principal diagram of which is represented in the figure 2.

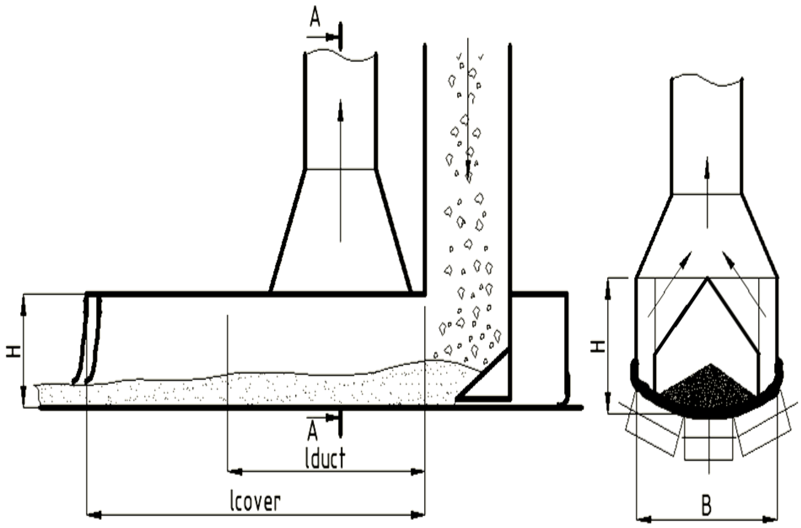


**Figure 1.The developed aspiration hood**

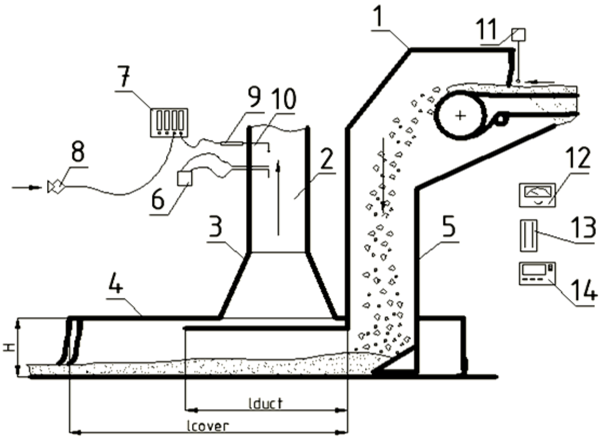


**Figure 2.** Principal diagram of the pilot plant: 1 – upper cover; 2 – aspiration system air pipe; 3 – aspiration funnel; 4 – lower cover; 5 – gutter; 6 – differential pressure indicator; 7 – aspirator; 8 – intake; 9 – allonge; 10 – dust sampling probe; 11 – thermal anemometer; 12 – aneroid barometer; 13 –aspirated hydrometer; 14 –combined device

Lower cover of the experimental installation is designated to be folding to change the constructional parameters. The height of material drop is 3.5 m (MO-1) and 2 m (MO-2), the gutter cross-section is 0.35x0.3.

The air from the covers was sucked off by the ventilators VRP-100-45-10 (MO-1) and VCP 7 – 40 №5 (MO-2), productivity of which was regulated by the chimney valves. The research of construction and operating parameters influence on massive dust loss from the cover was conducted at the MO-1 installation. The study of ejected air volumes during overloading of wet heated materials was perfumed at the MO-2 installation.

During the MO-1 experiment the geometric parameters of the cover were being varied, also the sampling was performed in order to identify dust concentration in the aspirated air and work area air.

The main variable factors of the experiment are the ratio of the inner duct length and conveyor belt width, ($L_{duct}$/B); Reynolds number in the cover cavity, $Re_{duct} \cdot 10^{-5}$; ratio of the distance between the gutter and the cover outlet and conveyor belt width, $l_{cover}$/B; ratio of cover height and conveyor belt width, H/B; on the aspiration air volumes $Q_a$, $m^3$/sand dust concentration in the aspirated air$C_a$, mg/$m^3$.

**Main part.** Basing on the results of the research conducted the regression equation was received (1) and the graphs constructed (figure 3, 4, 5, 6)

$$\frac{M_1}{M_2} = 3.17 - 1.69\frac{L_{duct}}{B} - 5.13\frac{H}{B} - 1.42\frac{l_{cover}}{B} + 1.71\left(\frac{L_{duct}}{B}\right)^2 + +4.38\left(\frac{Re_{duct}}{10^5}\right)^2 + 6.47\left(\frac{H}{B}\right)^2 + 0.37\left(\frac{l_{duct}}{B}\right)^2; \qquad (1)$$

Judging by the graphs given we see that the Reynolds number increase up to $0.318 \cdot 10^5$reduces dust concentration in the aspirated air and at the same time ensures increase of the volumes of the air deleted from the cover [12]. Aspirated air volume increase is caused by dynamic pressure increase in the cover cavity, for this reason higher rarefaction has to be sustained in the cover in order to prevent dusting into the working zone air. Dust concentrations reduce with Reynolds number increase is explained by air-dust flow outlet speed increase which leads to its higher separation.In the figure 3 there is the influence of the average Reynolds number graph in the cover cavity $Re_{duct} \cdot 10^{-5}$ on the aspirated air volumes $Q_a$ and concentration of dust in it $C_a$.

The cover length increase leads to insufficient aspirated air volume increase due the increase of the air coming through looseness when maintaining rarefaction which prevents dusting of the air in the working zone. Dust concentration reduce in the aspirated air appears when increasing the cover length up to the ration of $l_{cover}/B$=1.9.

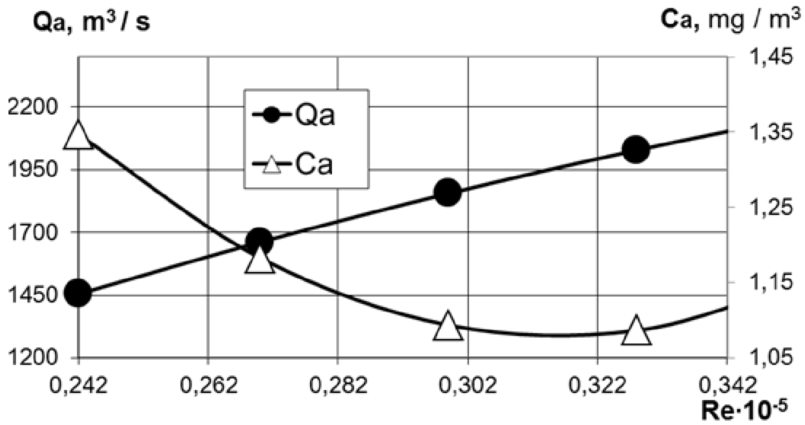


**Figure3.**Reasonable response function value from the Reynolds number with $l_{cover}/B$=1.9; $l_{duct}/B$=0.5; H/B=0.4

In the figure 4 there is the graph which shows the influence of the ratio of the space between the gutter and the outlet of the cover to the conveyor belt width ($l_{cover}/B$) on the aspirated air volumes $Q_a$ and dust concentration in it $C_a$.

In the figure 5 there is the graph which shows the influence of the ratio between the inner duct length and conveyor belt width ($L_{duct}$ / B) on the aspirated air volumes $Q_a$ and dust concentration in it $C_a$.

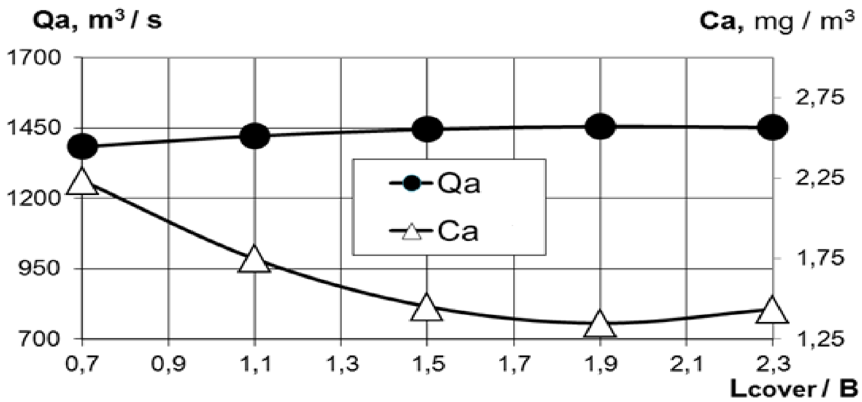


**Figure4. Reasonable response function value from $l_{cover}/B$ with Re = 24200; $l_{duct}/B$=0.5; H/B=0.4**

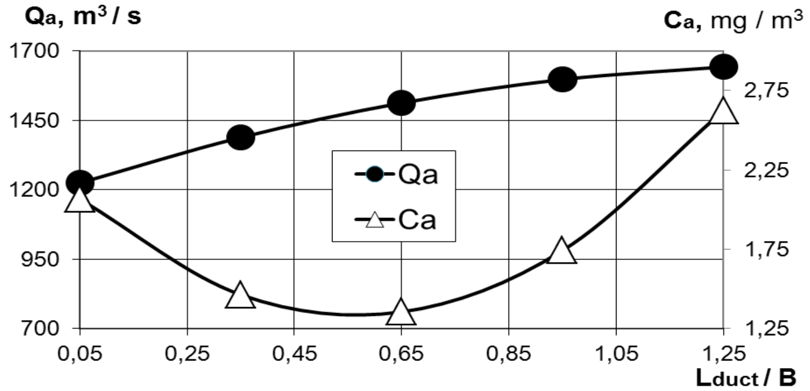


**Figure5.Reasonable response function value from $l_{duct}$/B with$l_{cover}$/B=1.9; Re=24200; H/B=0.4**

In the figure 6 there is the graph which shows the influence of the ratio of the space between the gutter and the outlet of the cover to the conveyor belt width ($l_{cover}$ / B) on the aspirated air volumes $Q_a$ and dust concentration in it $C_a$.

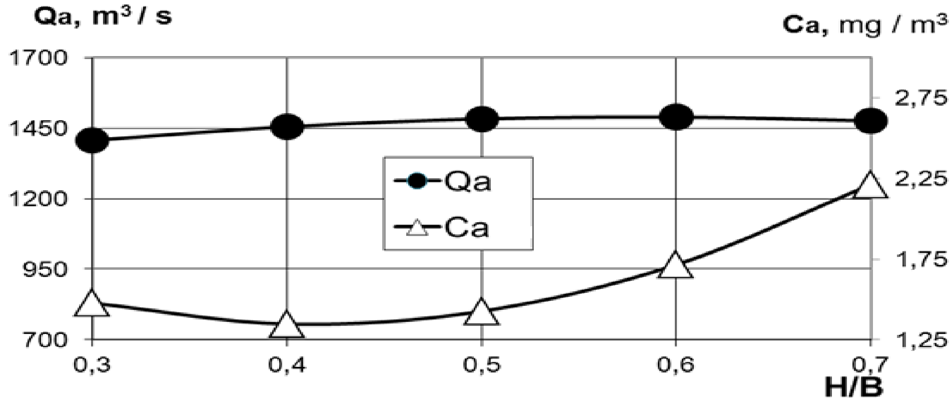


**Figure6.Reasonable response function value from H/B with $l_{cover}$/B=1.9; Re=24200; $l_{duct}$ / B=0.5**

When increasing the cover height the sucking torch is deleted from the aspiration funnel to prevent dusting from the cover and it is necessary to maintain higher rarefaction in it which on the whole leads to insufficient aspiration air volume increase (see figure 5). The cover height increase triggers dust concentration increase in the aspiration funnel, which is not connected with inner flows structure change in the cover which contribute to more intensive dust particles entrainment with the air aspirated from the cover.

Having analyzed the experiments data and the regression equations based on them we can conclude that there is a reasonable combination of the factors studied ( $Re_{duct} \cdot 10^{-5}$, $L_{duct}$/B, H/B, $l_{cover}$/B), which ensure reduce of dusting from the aspirated cover.

Overall dimensions ratio values of the suggested cover constructions were defined with which it is possible to reach minimum value of response function –massive dusting from the aspiration cover M = $c_a \cdot Q_a$,(mg/s) [13]and correlation between dusting of the developed cover ($M_1$) and of the cover with the double walls and rigid partition ($M_2$).

Simplex method was used to solve this issue.

Sequence of calculations made with simplex method can be divided in two main phases:

- finding the initial top of the acceptable solutions set,

- serial transfer from one top to another which leads to objective function value optimization.

**Conclusions.** During the process of finding a solution on this task it was found out that for each set of input parameters $\frac{L_{duct}}{B}$, $\frac{Re_{duct}}{10^5}$, $\frac{H}{B}$, $\frac{l_{cover}}{B}$ there isa preferable combination of them when dust concentration in the aspiration air, dusting and aspirated air volumes go for minimum. Such combination of input parameters relates to this option:

$$\frac{L_{duct}}{B} = 0.5,\ \frac{Re_{duct}}{10^5} = 0.242,\ \frac{H}{B} = 0.4,\ \frac{l_{cover}}{B} = 1.9.$$

These studies approve of the usage of the new construction of the belt conveyors loading places cover which has smaller overall dimensions and at the same time keeps the covering effect by the double walls and rigid partition.

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