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# DEVICE FOR PNEUMATIC OVERLOAD OF FUEL PELLETS

**Industrial production of fuel pellets involves transporting them over long distances, which is associated with significant costs. Usually pellets are transported by the special trucks or plastic bags in the awning trucks. Study of speed circling and transport of widespread agricultural crops and fuel pellets are given in the article. Parameters of transportation of fuel pellets are similar to the parameters of cereal crops, which is why pneumatic conveyors can be used for transportation fuel pellets. As a result of research, installation for overloading of pellet was proposed. The installation consists of a high pressure fan, unloaded cyclone and flexible product pipeline with pipe for air intake. Cyclic mode of work of installation eliminates using the expensive gateway or screw feeding device.**

**Keywords: fuel pellet, speed circling, speed transportation, pneumatic conveyor**

## INTRODUCTION

Great energy intensity Ukrainian industry, low efficiency of heating systems of housing and communal complex of the country and the high price of imported energy are contribute to the use of energy-saving measures. One such measure is the use of alternative energy sources such as biofuels, including fuel briquettes and pellets.

Production of fuel pellets in Ukraine in recent years has gained significant volumes, because sources of raw materials are powerful. Pellets are made from peat, waste of woodworking and forestry industries, and waste of agriculture - straw, maize and scales of sunflower seeds.

Industrial production of fuel pellets involves transporting them over long distances, which is associated with significant costs. Usually pellets are transported by the special trucks (pneumatic conveyors) or plastic bags (BIG-BAG) in the awning trucks. However, the cheapest way to transport large quantities of fuel pellets over long distances is rail transportation.

However, the process of overloading railway wagon requires significant labor costs and lasts a long time. In this regard, the process should be mechanized.

The basis for the installation of pneumatic overload fuel pellets is installation of agricultural grain-overload. The main elements of installation are high pressure fan, conveyor cyclone, and gateway or screw feeding device and flexible product pipeline with pipe for air intake.

Such equipment from Chinese, Russian, German and Belgian is present on the Ukrainian market. However, they cost from 250 thousand UAH (capacity 10÷15 t/h) to 2.2 million dollars USD (capacity 140 t/h).

Our task is to determine whether this design is suitable for overloading of fuel pellets and to determine the optimal modes of its operation.

The main features that characterize the motion parameters of fuel pellets in the air stream first should be identify. There are quick circling, speed transportation and mass concentration of the mixture [1, 2].

## 1. ANALYTICAL STUDIES

For analytical determination of these parameters we use known analytical dependencies. The calculations are carried out for pellets with a diameter of 6÷8 mm, length 15÷30 mm and a density of 650 kg/m$^3$.

Speed circling was determined by the empirical formula S.N. Svyatkov [3]:

$$v_c = 0.14\sqrt{\frac{\rho_M}{\left(0{\cdot}02 + a/h\right)\cdot \rho_{air}}} \text{ [m/s]} \tag{1}$$

where:

$\rho_M$ - density of moving material [kg/m$^3$],

$a$ - factor depending on the shape of the particles (for particles of square or circular cross-section $a$ = 1.1),

$h$ - particle thickness [mm],

$\rho_{air}$ - density of air [kg/m$^3$].

For a specified range of geometric dimensions of fuel pellets speed circling will be in the range $v_C$ = 7.2÷8.2 m/s.

Speed transporting of air that is required for horizontal moving pellets at a pressure close to atmospheric pressure may be determined by the formula [4]:

$$v_{tr} = a\sqrt{\rho_{air}/1000} + BL^2 \text{ [m/s]} \tag{2}$$

where:

$a$ - factor depending on the diameter of the transported material (for diameter within 1÷10 mm value of coefficient a within $a$ = 16÷20),

$B$ - coefficient that depends on the nature of the transported material, for fuel pellets accept $B = 3.5\cdot 10^{-5}$,

$L$ - distance of transport (accepted 10 m).

In these initial parameters speed of transportation will be $v_{tr}$ = 14.5 m/s.

We compare the results of speed circling and speed transportation of agricultural crops for which the pneumatic conveyors are used (Table 1) [4, 5].

Table 1. **Speed circling and speed transportation of some agricultural crops**

| Nr | Material | Speed circling [m/s] | Speed transportation [m/s] |
|---|---|---|---|
| 1 | Fuel pellets | 7.2÷8.2 | 14.5 |
| 2 | Rye | 7.5 | 22÷26 |
| 3 | Wheat | 9.8 | 12÷27 |
| 4 | Maize | 12.3 | 14.5÷27 |
| 5 | Soybean | 14.3 | 18.6÷27 |

As seen from the material, parameters of transportation of fuel pellets are closed to the parameters of agricultural crops. Speed transportation of fuel pellets are closed to maize and wheat and speed circling of fuel pellets are closed to rye. This indicates that pneumatic conveyors can be used to transportation of fuel pellets.

## 2. EXPERIMENTAL STUDIES

To verify the calculated values we determine an actual speed circling of fuel pellets using an experimental installation (Fig. 1).

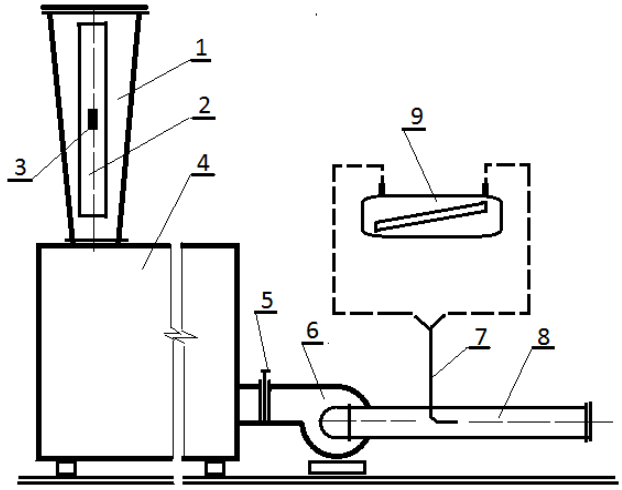


Fig. 1. Scheme of experimental installation: 1 - cone pipe, 2 - sight glass, 3 - experimental exemplar, 4 - chamber static pressure, 5 - shiber, 6 - fan, 7 - Prandtl-Pito tube, 8 - metering area, 9 - micromanometer

Laboratory installation to determine the speed of circling of particle consists of a conical tube circling height $H = 680$ mm, on both ends of which metal grid established. The minimum diameter of the pipe circling is $d_{min} = 100$ mm, its maximum diameter is $d_{max} = 200$ mm. In height of pipe intermediate values of diameters are placed.

Air is blown into the tube circling by fan. The camera to static pressure is set for smoothing of pulsation airflow. Rectilinear air duct ($d_{ZD}$ = 100 mm) is equipped by shiber and is set to determine the air flow in suction pipe fan. Air flow is determined by the speed at metering air duct. To determine the velocity of air, dynamic pressure is determined by Prandtl-Pito tube that attached to the micromanometer by flexible hoses.

The value of dynamic pressure is determined by the screenings of micromanometer h. Then the air flow velocity in metering air duct is given by (FZD = $7.85 \cdot 10^{-3}$ m$^2$):

$$v_{ad} = \sqrt{\frac{2ghk}{\rho_{air}}} \text{ [m/s]} \tag{3}$$

where:

$g$ - acceleration of gravity, 9.81 m/s$^2$,

$h$ - the screenings of micromanometer [mm],

$k$ - conversion factor of micromanometer,

$\rho_{air}$ - air density at a given temperature [kg/m$^3$].

The fan productivity should be changed by using shiber. Mode set such that fuel pellets are suspended in a conical tube. Diameters of the conical part of the tube in which pellets are located are determined. Actual speed circling is determined by known values of air flow and cross-sectional area tapered pipe. For these sizes of fuel pellets circling speed is in the range of 7.5÷8.0 m/s, which agrees well with the calculated values.

## 3. RESULTS AND DISCUSSION

The results allow us to offer a simple, effective, and most importantly, inexpensive installation for overloading pellets. The installation consists of a high pressure fan, unloaded cyclone and flexible product pipeline with pipe for air intake (Fig. 2).

Fans VVD series can be used for installation capacity of 12÷15 t/h. Their specifications: consumption of 1500÷2000 m$^3$/h, pressures of at least 4000 Pa and capacity 18÷22 kW. Fans of this series are presented on the Ukrainian market, and their cost prices in the first quarter of 2015 are in the range of 20÷25 thousand UAH [6].

Cyclic mode of work of installation eliminates using the expensive gateway or screw feeding device. In this case, the volume hopper of unloaded cyclone should be about 25% larger than the volume of container loading. For standard big-bags with size of basis 900 × 900 mm and a height of 1600, 1800, 2000 mm hopper volume should accordingly be 1.65, 1.85 and 2 m$^3$.

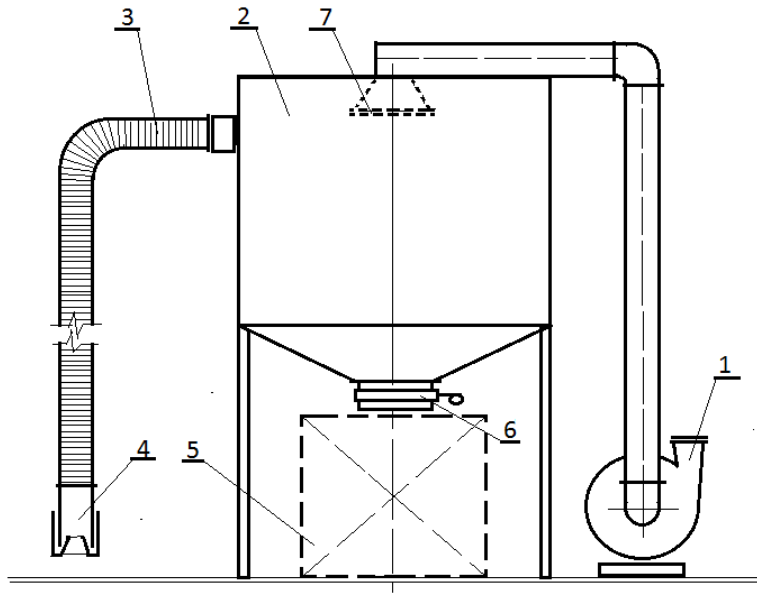


Fig. 2. Scheme of installations for overloading fuel pellets: 1 - high pressure fan, 2 - unloaded cyclone, 3 - flexible product pipeline, 4 - pipe for air intake, 5 - place setting of container (big bag), 6 - shiber, 7 - protective grid

The total installed cost of installation will not exceed 50 thousand UAH, which is five times less than the cheapest industrial model.

## CONCLUSIONS

Studies of speed circling and speed transportation of agricultural crops are presented in the article. Parameters of transportation of fuel pellets are similar to the parameters of cereal crops, which is why pneumatic conveyors can be used for transportation of fuel pellets. As a result of experimental research speed of circling was in the range of 7.5÷8.0 m/s and it is closed to analytical studies in which speed of circling is 7.2÷8.2. As a result of research, setup for overloading of pellet was proposed. Cyclic mode work of installation eliminates using the expensive gateway or screw feeding device. In this case, the volume hopper of unloaded cyclone should be about 25% larger than the volume of container loading.

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## URZĄDZENIE DO PNEUMATYCZNEGO PRZEŁADUNKU PELLET

**Przemysłowa produkcja pellet wymaga ich transportu na duże odległości, co wiąże się ze znacznym wzrostem ich ceny. Do transportu pellet zwykle wykorzystuje się specjalne samochody ciężarowe lub kontenery przeznaczone do przewozu materiałów granulowanych. W artykule przedstawiono badania nad własnościami związanymi z przeładunkiem oraz nad transportem plonów rolniczych i pellet. Analizowano prędkość przeładunku oraz powszechnie występujące sposoby transportu tych produktów. Stwierdzono, że parametry związane z przeładunkiem oraz sposoby transportu dla ziaren zbóż, kukurydzy, nasion strączkowych i oleistych oraz pellet są podobne. Zaproponowano wykorzystanie do przeładunku i transportu pellet przenośnika pneumatycznego przeznaczonego do transportowania oraz przeładunku plonów. Głównymi podzespołami urządzenia są wentylator wysokiego ciśnienia oraz przewód elastyczny do dozowania powietrza. Cykliczny charakter pracy urządzenia nie wymaga zastosowania drogiej bramy wjazdowej czy dozownika materiału.**

**Słowa kluczowe: pellety, prędkość przeładunku, prędkość transportu, przenośnik pneumatyczny**