Operational aspects of screw feeder of transport gasifier with pellet burner

Larisa Gubacheva, Alexander Andreev, Darya Shevchenko

Volodymyr Dahl East-Ukrainian National University, Lugansk, Ukraine

S u m m a r y . The article presents experimental investigation of the influence of worm conveyor load index and screw pressure by fuel column on the working conditions of the transport gasifier feeder with pellet burner.
K e y w o r d s : pellets, industrial transport, transport gasifier, automatic pellet burner, entire screw, ribbon screw.

INTRODUCTION

The decrease of expenses for transportation by industrial vehicle can be achieved by partial transformation into local alternative fuels use [Samylin 2005]. This could be performed by equipping the vehicles with the producer plant system generating producer gas from the agricultural wastes, forest and wood processing industry. The global vehicle park concentrated in this sphere is 10 - 120 billions items. [Geletukha 1998, Samylin 2005].

Currently, all the professionals who are interested in the technology and design of transport gasifiers, face a shortage of technical information [Ovsyanko 2007, Fomin 2005, Yudushkin 1955, Obemberger 1998, Shchadov 2007].

OBJECTS AND PROBLEMS

Development of the transport gasifier construction is connected, first of all, with the choice of the original fuel. The analysis of the current literature shows that pellets should be considered as the most promising solid fuel for transport gas generator. Straw, sunflower and buckwheat husks, canola, hemp, wood wastes are the raw material for the pellets production [Geletukha 1998, Obemberger 1998].

For pellets gasification a pellet burner is used. The conveying body of it is the screw [Hasler Ph , Jorgensen 1996].

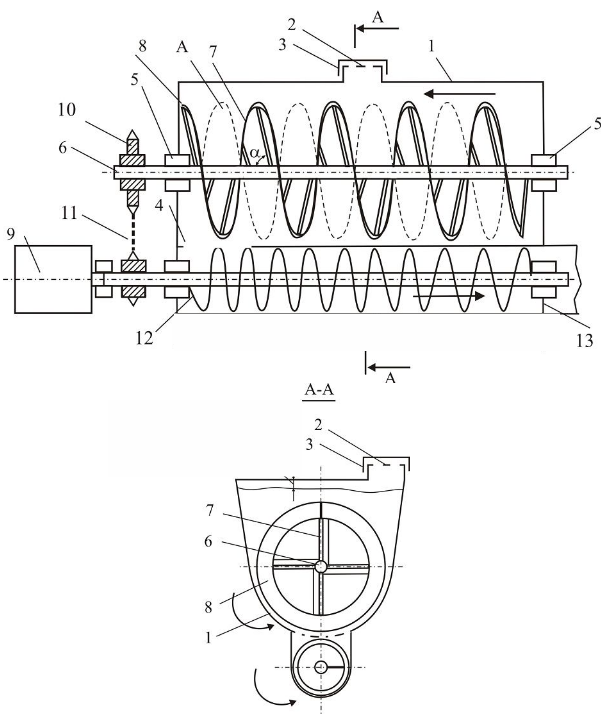

Fig. 1. The scheme of the screw feeder of transport gasifier with the pellet burner: 1 – hopper - turner; 2 – loading hatch; 3 – hatch cover; 4 – discharge window; 5 – bearing assemblies; 6 – upper ribbon screw shaft; 7 – transient ribs-blades; 8 – ribbon screw; 9 – actuator; 10, 11 – drive wheels; 12 – lower entire screw; 13 – housing

To transport fuel to the pellet burner we have developed and patented the scheme shown in fig. 1 [Samylin 2005, Yudushkin 1955, Tokarev 1955]. The basic working elements are: the upper ribbon screw 8 in the hopper 1 low entire screw auger 12 in the housing 13. The fuel is transported from the hopper 1 by the ribbon screw 8 into the housing 13 through the discharge window 4. Further the fuel is transported with screw auger 12 into the pellet burner.

To get into the combustion zone, the fuel must rise to a certain height. A pillar of fuel, putting pressure on the lower screw, may change the terms of its operation. Simultaneously the working conditions of the lower screw will be affected by the coefficient of filling it with fuel.

The purpose of the work was to study the joint effect on the lower screw, which is a part of the gas generator feeder, the coefficient of filling the screw and pressure on him by the rising pillar of fuel.

Wood pellets were used for the research. Their physical and mechanical properties are shown in table. 1.

Table 1. Physical and Mechanical Properties of the Pellets

Properties	Numbers
Friability:	
Coefficient of internal friction, f	0,3076
Coefficient of internal shear , f_{σ}	0,3307
The angle of repose, α_0 hail	25
Efficient angle of friction, $\delta_{э}$	0,3255
Mobility Index, m_i	0,0554
The bulk density of compacted pellets, kg/m3	690
The coefficient of friction at rest:	
on steel f_c	0,671
on plastic $f_{п}$	0,444
Bridging:	
Bridging holes diameter	40
Fluidity:	
Diameter of the outlet, mm	41
Discharge coefficient	0,315
Exhaust velocity cm3 / min.	15

The design parameters of the lower screw: screw housing diameter - 80 mm, diameter of the screw on the outer edge - 60 mm, the step of the auger thread - 60 mm, the diameter of the screw shaft - 20 mm. The frequency of rotation of the lower auger - 80 rev/min (constant in all the experiments). The fill index of the lower screw was ranged between 0.2 - 0.6 by changing the frequency of rotation of the upper ribbon screw. Discharge window size between the upper and lower screws remained constant at 55 mm. Discharge window size was taken from the experimentally defined diameter of bridging holes - 40 mm. Through the hole of less size the fuel is not flowing.

To the output end of the housing, where the lower screw is situated, we fixed the pipe simulating the lift part of pellet burner. Nozzle height is 250 mm. The pipe had a calibration scale of fuel lifting height, mm. The calibration of pipe was pre-made, determining the mass of fuel corresponding to different heights it goes up: 10, 20, 30 ... 250 mm. With the ribbon screw the fuel from the tank - agitator was evenly fed into the housing of lower screw till jamming of the lower screw. At the time of jamming of the lower screw the power of the setting was turned off. After that we fixed the height of the pillar of fuel referring to the plate where the housing of the lower screw was installed. The pipe, filled with the fuel, was removed, and fuel was weighed. Critical pressure of the fuel on the lower screw, at which the jamming of the lower screw took place, was defined as the ratio of the mass of fuel in the nozzle at the jamming moment (G_m) to the efficient surface square of the screw (F):

$$P_{кр} = \frac{G_m}{F}. \quad (1)$$

When the diameter of the screw on the outer edge is 60 mm and the diameter of the screw shaft is 20 mm $F = 2400\ mm^2$.

The performance of the screw feeder was determined with the ratio:

$$П = \frac{G}{t}, \quad (2)$$

where: G – the current mass of the fuel in the pipe, corresponding to a given height of its healing;

t – the lifting time of fuel to this height.

Current pressure of the fuel on the screw was calculated by the equation:

$$P = \frac{G}{F}. \quad (3)$$

Experiments have shown that as the loading index of the lower screw increases from 0.2 to 0.6 so the maximum height of fuel healing in the nozzle decreases rapidly, and the most intense as increasing the loading index from 0.2 to 0.4.

When the loading index of the lower screw is 0.2 the maximum height of fuel healing is 190 mm, with a loading index 0.4 - 90 mm, with a loading index 0.6 - 70 mm (fig. 2).

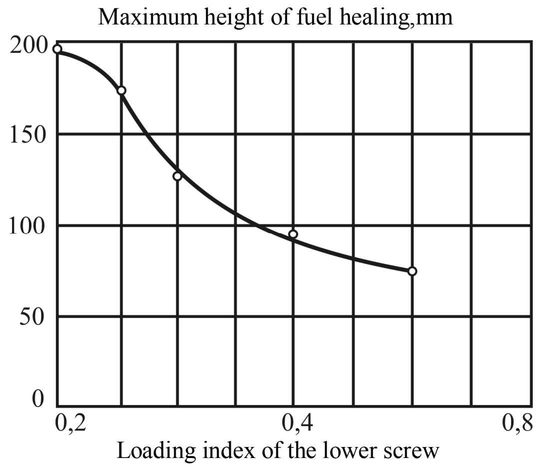

Fig. 2. The influence of the lower screw load index on the maximum lift height of the fuel in the pellet burner

Similarly, as the loading index of the lower screw increase the maximum mass of the fuel in the nozzle changes (fig. 3) and the maximum fuel pressure to the lower screw (fig. 4), defined with the formula (1).

The observed deeds in the lower screw acting can be explained by using the basic principles of the theory of passive areas. Passive areas are formed on the auger surface of the screw. In the passive areas the fuel particles with the friction forces are pressed against the surface of the screw and are not transported, rotating along with the screw. When the height of the pillar of fuel over the screw increases the mass of the fuel over the screw and the fuel pressure at the screw increases. As a consequence, the friction between the auger surface of the screw and fuel enlarges. The increase of the friction between the surface of the screw and the fuel enhances the passive area on the screw.

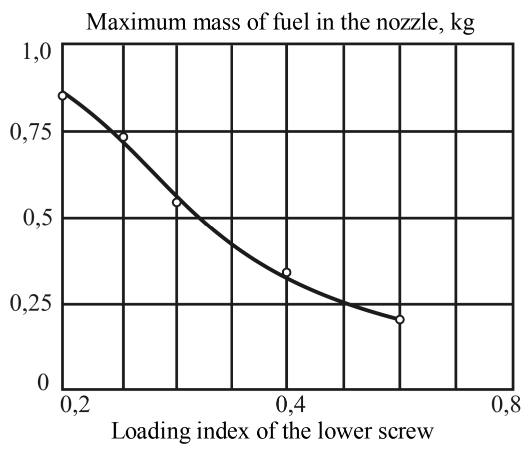

Fig. 3. The influence of the load index of the lower screw on the maximum weight of fuel in the nozzle over the screw

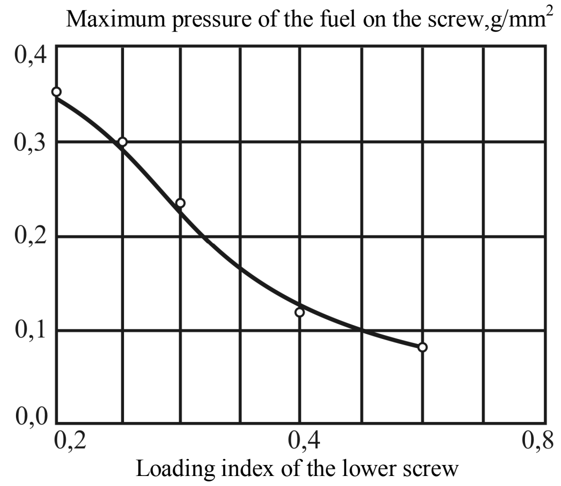

Fig. 4. The influence of the load index of the lower screw on the maximum fuel pressure on the screw

Having passed the passive area, the fuel particles are moved back through the screw shaft, thus reducing its efficiency. At some critical loading index of the screw and a certain critical pressure fuel on the screw the fuel volume, thrown-back over the screw blades will exceed the amount of the fuel transported forward. In this case the jamming of the screw will inevitably happen. To jam the screw to beat the working space around two or three outgoing blades is enough. This supposition is confirmed by a recorded video of the operating process and jamming the lower screw, and also the decrease of the screw productivity with rising fuel pressure on it (fig. 5). Before the jamming the screw outgoing blades extensively stoke the fuel back, and the intensity of such abandonment strongly increases with the lower screw load index increase.

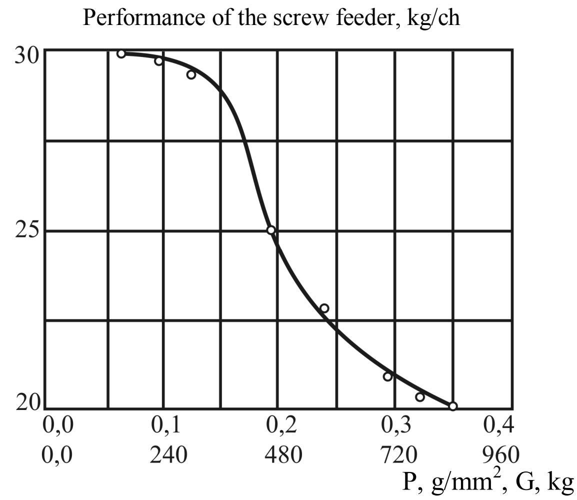

Fig. 5. The effect of fuel pressure on the screw (P) on the feeder performance of the transport gas generator with pellet burner at the loading index of the screw 0.2

Thus, while designing the screw feeder it is necessary to consider the pressure of fuel in the pellet burner on the screw. The range of the influence of fuel pressure on the feeder functioning is highly dependent on the loading index of the screw. With the increase of the loading index of the screw, the maximum allowed fuel pellet pressure on the screw is reduced considerably. The higher pressure leads to screw jamming. With increasing fuel pressure on the screw, the feeder performance is greatly reduced.

CONCLUSIONS

1. The approach of constructing was proved in the frame of the planned experiment of the regressing dependence of the screw auger performance on the following factors: the loading index of the screw, fuel pressure on the screw, screw angle to the horizon, the frequency of rotation of the screw.

2. At increasing the loading index of the conveying screw, the allowable fuel pressure on screw is greatly reduced, and, consequently, the allowable height of the fuel healing. With the loading index of the screw 0.2, the allowable fuel pressure on it is 0.35 g/mm2, with the loading index of the screw 0.3 - 0.23 g/mm2, with the loading index of the screw 0.4 - 0.14 g/mm2, with the loading index 0.6 - 0.09 g/mm2.

3. The recommendations on the limiting the loading index of the screw while increasing the fuel pressure on the screw are general in nature and could be implemented for screws of any diameter.

REFERENCES

1. **Los' L.V., Ivantsov V.V. 2010.:** Researches on the peculiarities of the construction of the transport gasifiers for gasification of crushed and briquetted straw // Visnyk ZhNAEU. № 2. – p. 118 – 139.
2. **Samylin A.A., 2005.:** Automobile Gas Generator - The Technology Of The Future // LesPromInform. №8 (30), p. 80-84.
3. **Geletukha G.G., Zheleznaya T.A., 1998.:** Technology Review Electricity Generation, Received From The Biomass While Gasification // Environmental Technology And Resource Conservation. № 3, p. 3-11.
4. **Aniskin V.I., Golubkovich A.V., Kurbanov K.K. 2005.:** Fuel made of agricultural biomass. Energy: economics, mechanics, ecology. № 1. – p. 47 - 50.
5. About The Alternative Kinds Of Liquid And Gaseous Fuels: Law Of Ukraine 14 January 2000 VR № 1391-XIV // The Bullitein of Verkhovna Rada of Ukraine. - 2000. - № 12.
6. The Cabinet of Ministers of Ukraine «On approval of the Energy Strategy of Ukraine till 2030» March 15, 2006 № 145.
7. **Bridgwater A.V.**, 8-10 April 2002.: Thermal conversion ofbiomass and waste: the status. Proc. of Conference "Gasification: the Clean Choice for Carbon Management", Noordwijk, the Netherlands, pp. 1-25.
8. **Fomin A.P., Neshin Y.I., Potapenko A. F., 2005.:** Processes For Obtaining Cobbed Fuel // Solid Fuel Chemistry, p. 36-43.
9. **Geletukha G.G., Zheleznaya T.A., 1999.:** An overview of modern technologies of burning wood for heat and electricity Part 1. // Environmental Technology And Resource Conservation. № 5, p. 3-12.
10. **Geletukha G.G., Zheleznaya T.A., 1998.:** Overview Of Biomass Gasification Technology // Environmental technology and resource conservation. № 2, p. 24-29.
11. **Hasler Ph , Candinas T. Nussbaumer Th**. Utilization of Ashes from the Combustion of Hay. Miscanthus, Hemp, Straw and Wood as of the 10th Europ. Bioenergy Conf. p. 192-195.
12. **Jorgensen U, Kristensen E.F., 1996.:** Europen Energy Crops Overview. Country Report for Denmark. Copenhagen : MAF, p. 83.
13. **Obemberger J., 1998.:** Decentralized Biomass Combustion : State of the Art and Future Development/ /Biomass and Bioenergy.Vol.l3, №1, p. 33-56.
14. **Ovsyanko A.D., 2007.:** Reference Book. Pellets: Russia, Belarus, Ukraine / A.D. Ovsyanko / St. Petersburg, Biofuel Portal WOOD-PELLETS.COM, p. 200.
15. **Pogrebnoi S.N., 2003.:** "GAZELLE" 3302/2705 / S.N. Pogrebnoi, A.A. Vladimirov / Third Rome, p. 342.
16. **Samylin A.A., 2005.:** Automobile Gas Generator - The Technology Of The Future // LesPromInform. №7 (29), p. 74-76.
17. **Shchadov V.M**., **2007.:** Integrated Processing Of Coal And Improving The Efficiency Of Its Use // M.: STC "Track", p. 292.
18. **Tokarev G.G., 1955.:** Vehiclar Gas Producer / G.G. Tokarev / Mashgiz. p. 205.
19. Technological Aspects Of Biofuel Burning// Alternative Energy,2007.: № 1,p.17-21.
20. **Yudushkin N.G., 1955.:** Generating tractors / N.G. Yudushkin / State Scientific And Technical Publication Engineering Literature, p. 242.
21. **Gubacheva L**., **Andreev A., Shevchenko D. 2012.:** Alternativt fuels for transhort. TEKA Commission of Motorization and Power Industry in Agriculture, XIA, p. 99-107.
22. **Golubenko A., Tsyvenkova N., Mulyar O., Romanushun O. 2012.:** Biomass standization as a base for its sufficient use. TEKA Commission of Motorization and Power Industry in Agriculture, XIA, p. 85-92

ОСОБЕННОСТИ РАБОТЫ ШНЕКОВОГО ПИТАТЕЛЯ ТРАНСПОРТНОГО ГАЗОГЕНЕРАТОРА С ПЕЛЛЕТНОЙ ГОРЕЛКОЙ

Лариса Губачева, Александр Андреев,
Дарья Шевченко

Аннотация. В работе экспериментально исследовано влияние коэффициента загрузки винтового транспортера и давления столба топлива на шнек на условия работы питателя транспортного газогенератора с пеллетной горелкой.
Ключевые слова. Пеллеты, промышленный транспорт, транспортный газогенератор, автоматическая пеллетная горелка, сплошной шнек, ленточный шнек.