СЕВЕРНЫЙ (АРКТИЧЕСКИЙ)
ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ
ИМЕНИ М.В. ЛОМОНОСОВА

Comprehensive study of the efficiency of pellets production (Комплексное исследование эффективности производства древесных гранул)

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SEWAN
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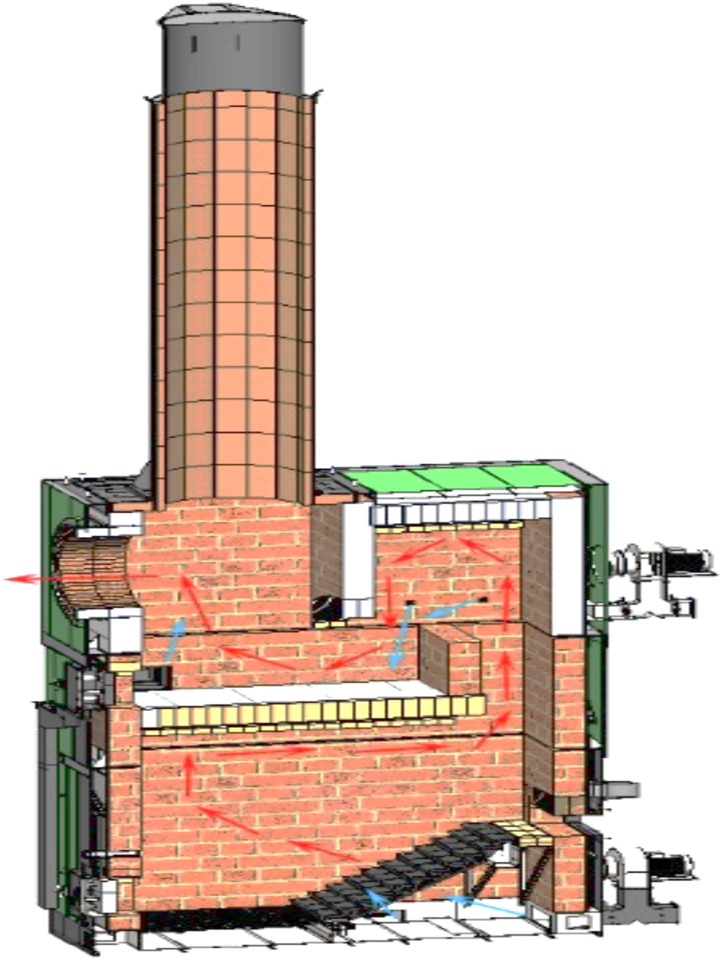
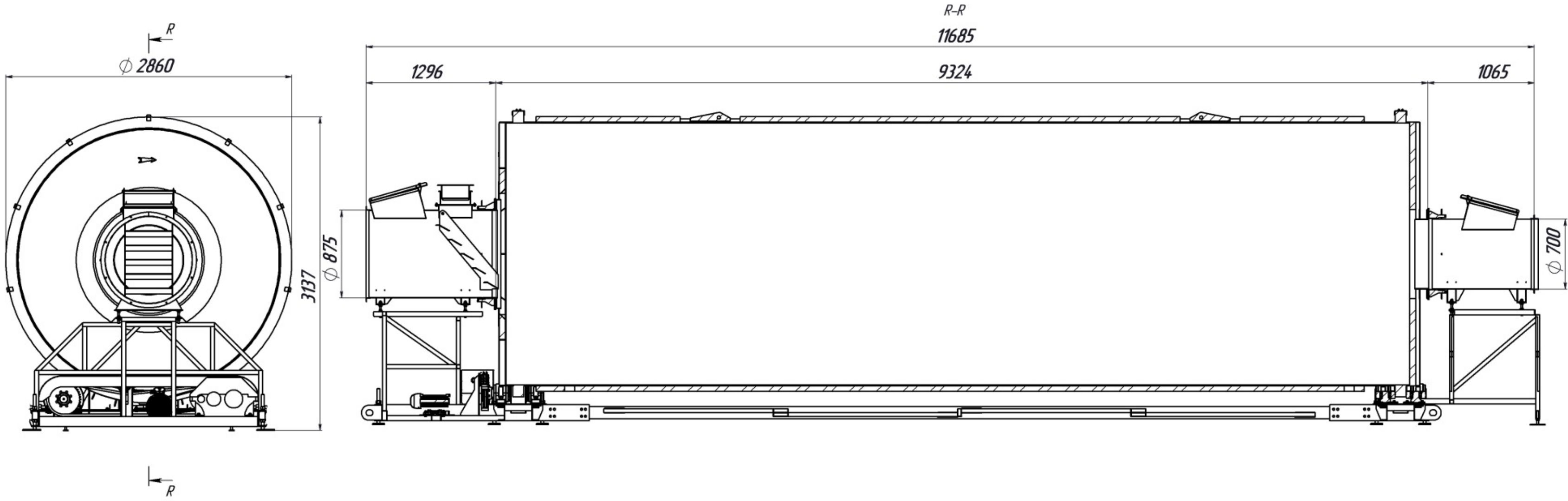
LLC ”Region-Les” pellet plant

Design of the heat generator and drum dryer «ABM-1,5»





Methods used in energy survey of pellet plant

- Electrochemical method implemented in industrial emission analyzers
- Pressure method for determining the volume of gas-air flows
- Ultrasonic method of liquid consumption, aspiration method for taking gas-air samples
- Thermal imaging, pyrometric and contact method for determining temperatures
- Combined relative and calorimetric methods
- Weight and chemical methods for determining the elemental composition of combustion products
- Scanning electron microscopy
- The method of abrasion of pellets circulating in the air flow when determining their durability and the sieve method for determining the grain-size distribution of materials

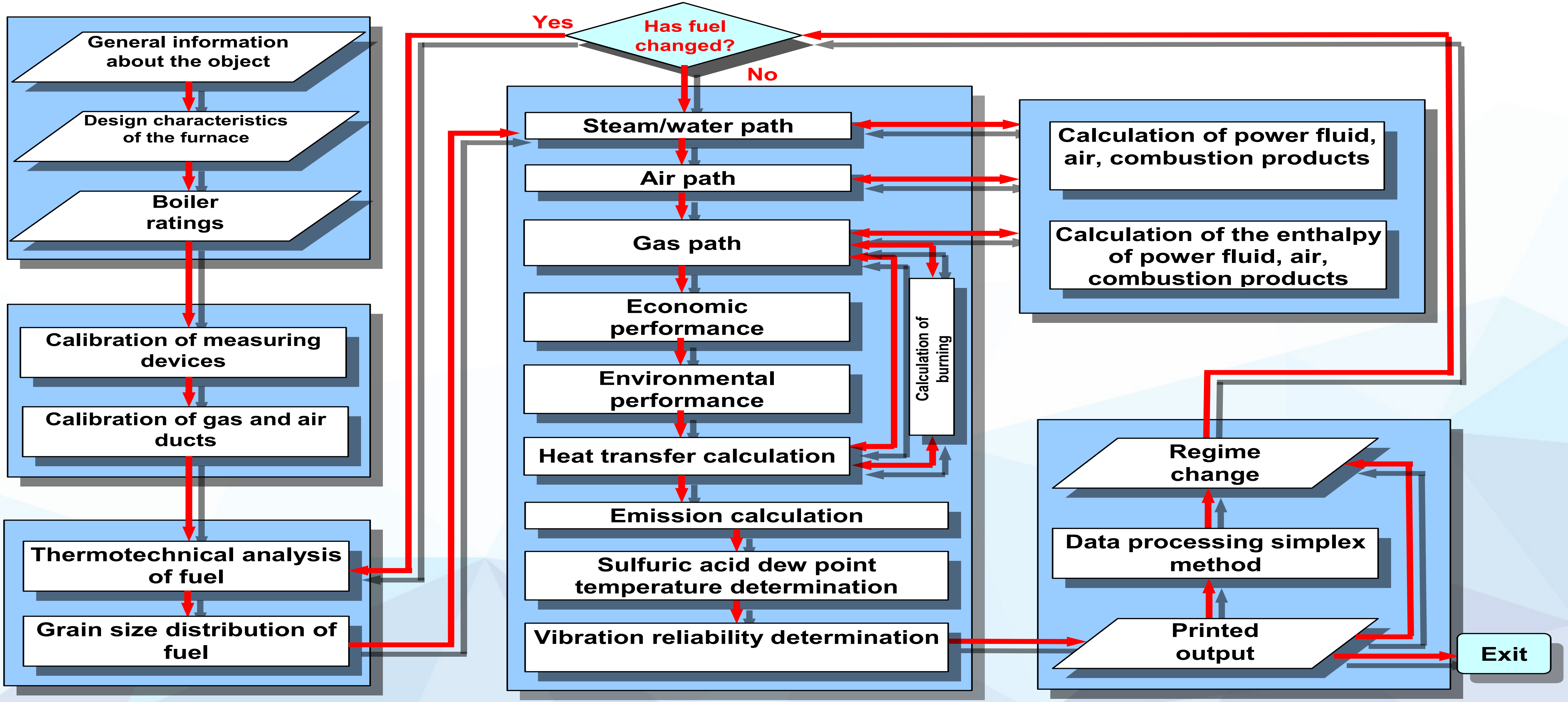
Results of energy tests of pelletizing lines

Value	Symbol, Dimension	Test No 1	Test No 2	Test No 3
Heat output of heat generator	Q, MW	1.96	1.98	1.97
Heat loss: incomplete combustion	q_3, %	1.12	0.93	1.13
carbon	q_4, %	0.09	0.09	0.09
external	q_5, %	6.23	6.06	6.10
sensible heat of slag	q_6, %	0.03	0.03	0.03
Gross fuel consumption	B, t/h	0.982	0.965	0.983
Emission of NOx	NO_x, mg/MJ	75	68	80
Emission of CO	CO, mg/MJ	168	163	175
Gross efficiency of the heat generator, taking into account the spark arrester	η_{hg}, %	92.54	92.89	92.66
Gas temperature in front of the dryer	$\vartheta_{d.a}$, °C	255	353	341
Excess air in drying agent	$\alpha_{d.a}$	9.29	8.02	9.04
The amount of evaporated moisture per 1 kg of raw material	ΔW, кг/кг	0.466	0.472	0.471
The amount of drying agent per 1 kg of raw material	q_1, кг/кг	7.369	4.677	4.845
Gas temperature behind the dryer	ϑ_{flue}, °C	79	83	82
Excess air in flue gas behind the dryer	α_{flue}	9.44	8.17	9.19

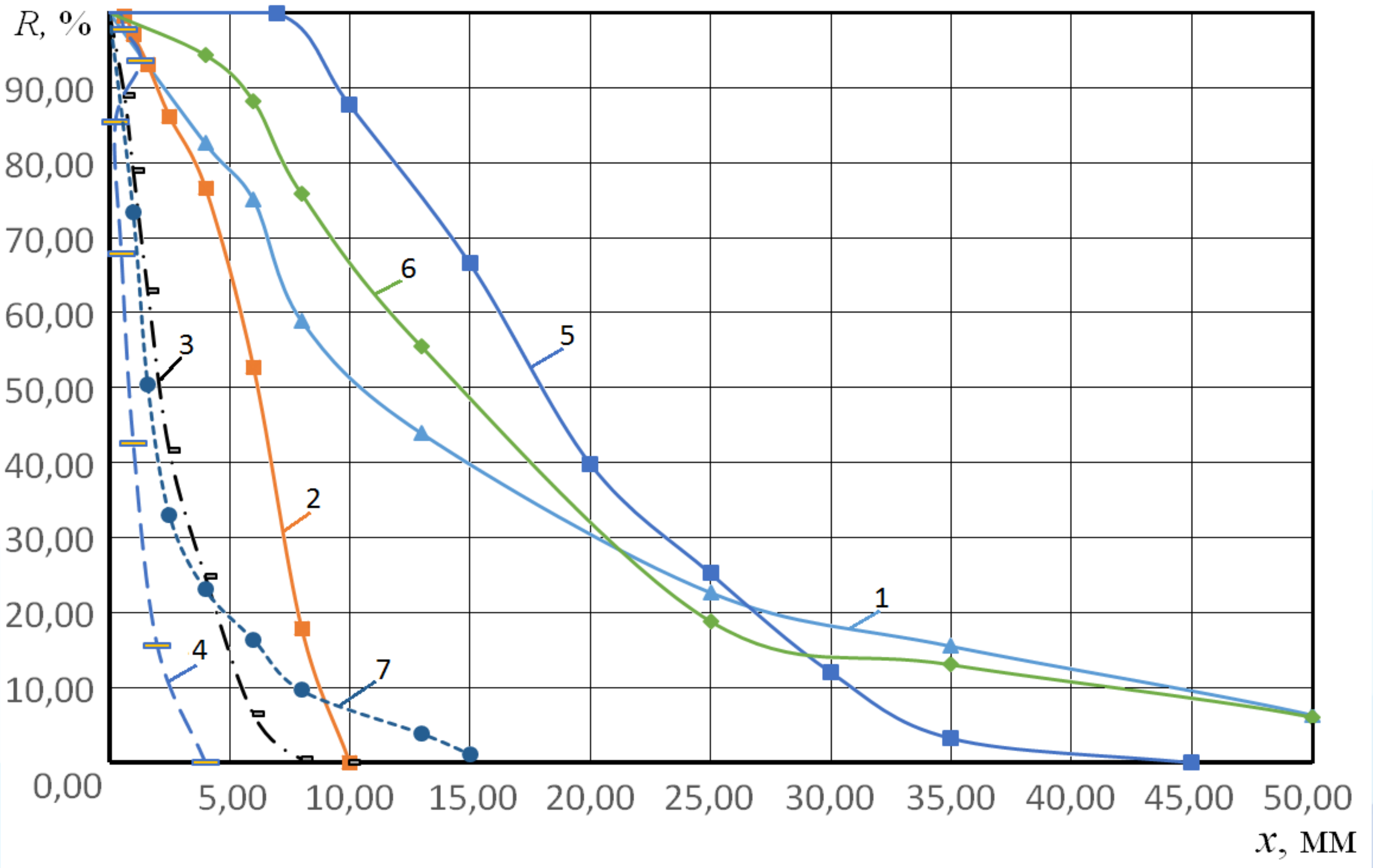
Results of energy tests of pelletizing lines

Value	Symbol, Dimension	Test No 1	Test No 2	Test No 3
Raw material moisture before and after dryer	W_t^r, %	54.14/14.20	54.14/13.20	54.14/13.30
Ash content of raw materials before and after dryer	A^d, %	0.34/0.36	0.34/0.36	0.34/0.36
Volatile yield before and after dryer	V^{daf}, %	84.50/84.28	84.50/84.25	84.50/84.25
Lower calorific value of raw materials before and after the dryer	Q^r_i, MJ/kg	7.316/15.88	7.316/16.09	7.316/16.07
Gas temperature after the dust collector	$\vartheta_{\text{пу}}$, °C	76	77	76.5
Specific consumption of equivalent fuel per 1 ton of pellets	*в*, kg of r.f/t	272.1	218.9	225.4
Moisture of pellets	W_t^r, %	7.40		
Ash content of pellets on dry and ash free weight	A^d, %	0.37		
Volatile yield on dry and ash free weight	V^{daf}, %	84.25		
Apparent density	ρ_a, g/cm^3	1.15		
Bulk density	ρ_b, g/cm^3	0.64		
Mechanical durability	DU, %	98.51		
Lower calorific value	Q^r_i, MJ/kg	17.342		

Multiblock program-methodological complex

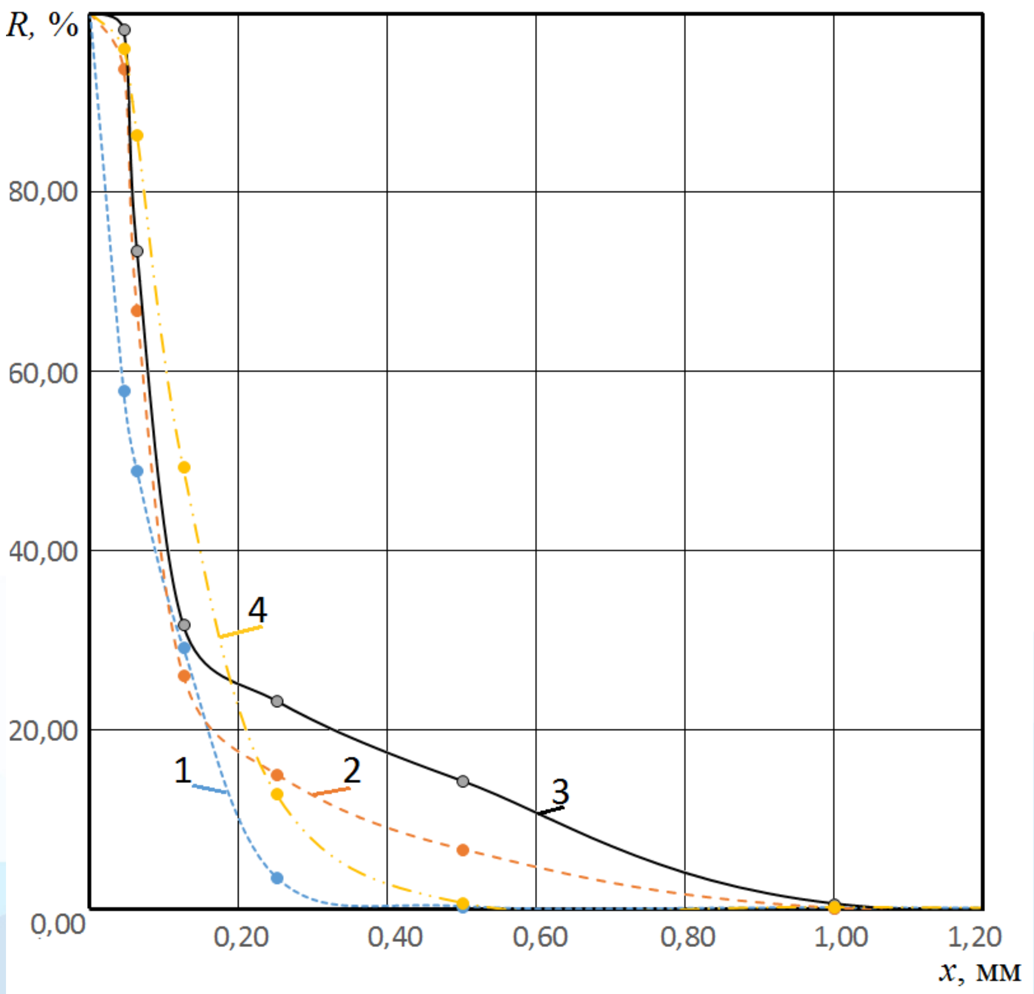


Changes in the fractional composition of wood material in the process of pelletizing and the operation of the heat generator



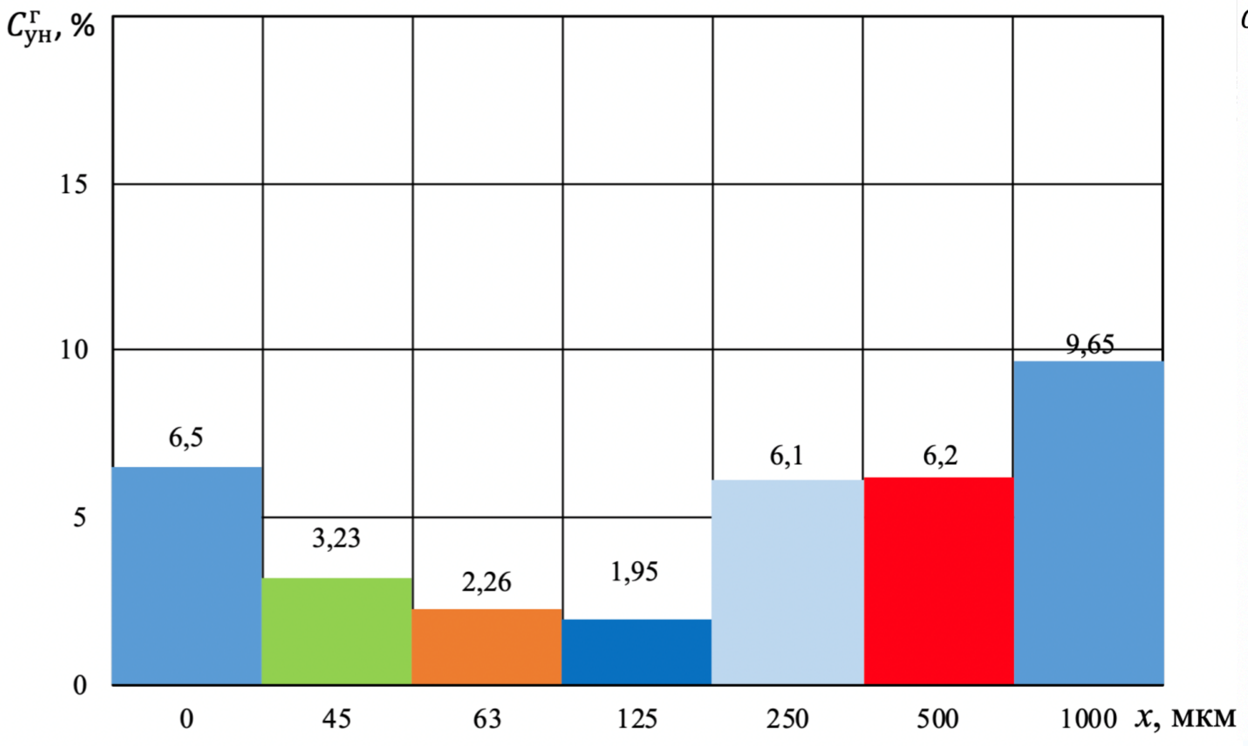
1 –feedstock to the disc separator; 2 - raw material, screened out in the aerosolver; 3 - raw materials after drying and aerosoldering; 4 - finely dispersed wood material in front of the pelletizer; 5 - pellets; 6 - fuel for the heat generator; 7 - slag from the furnace

Results of the study of the grain size distribution of fly ash and wood dust

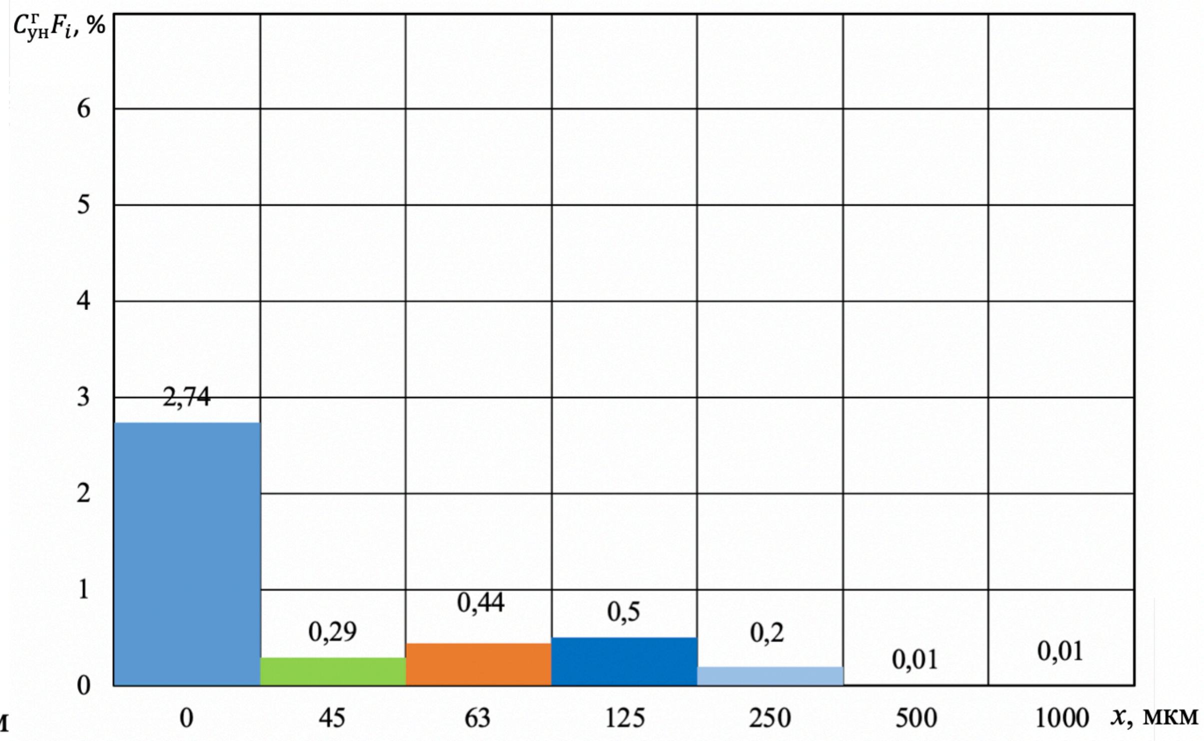


1 – ash caught by the spark arrester; 2, 3, 4 - wood dust captured by bag filters of aspiration lines:
2 - cooling unit; 3 - pneumatic conveying systems for dried material after the mill; 4 - non-granular material

Investigation of fly ash trapped by a spark arrester

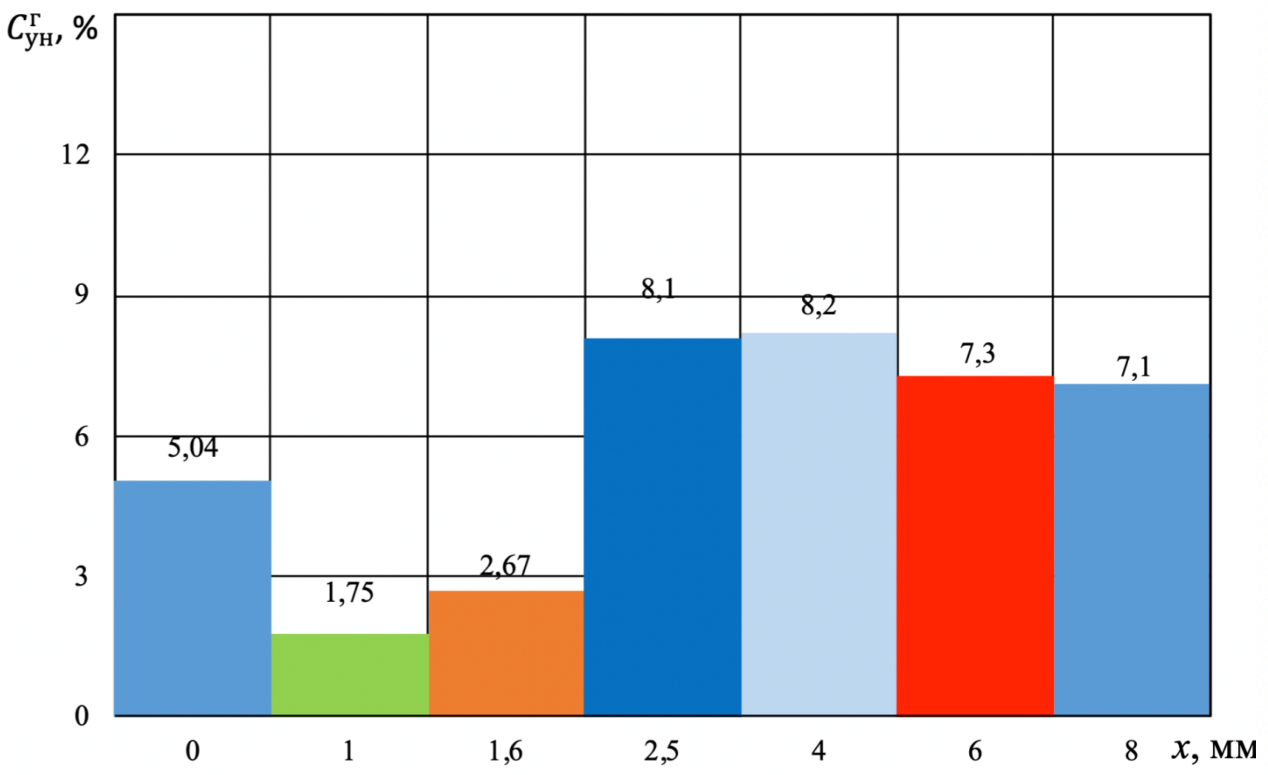


Fractional content of combustible substances (*n*= 0.821)

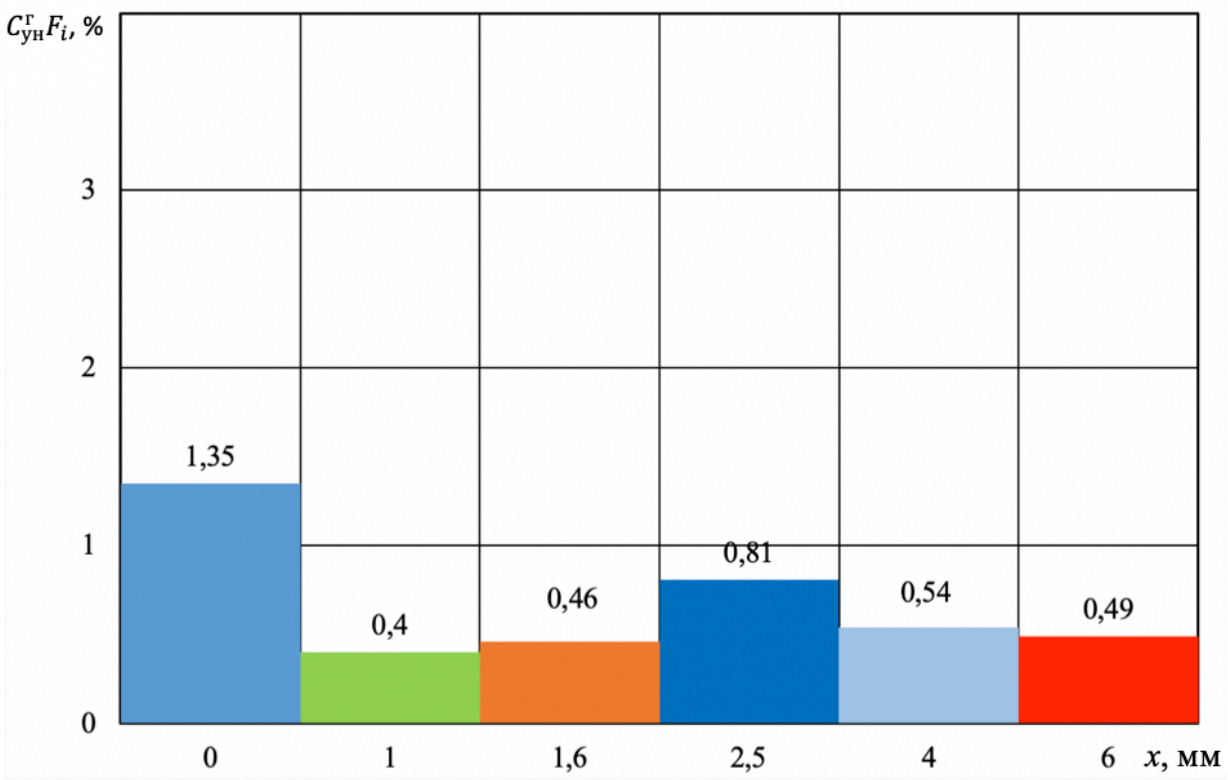


The content of fuels, considering the mass fractions

Investigation of focal residues from the heat generator furnace

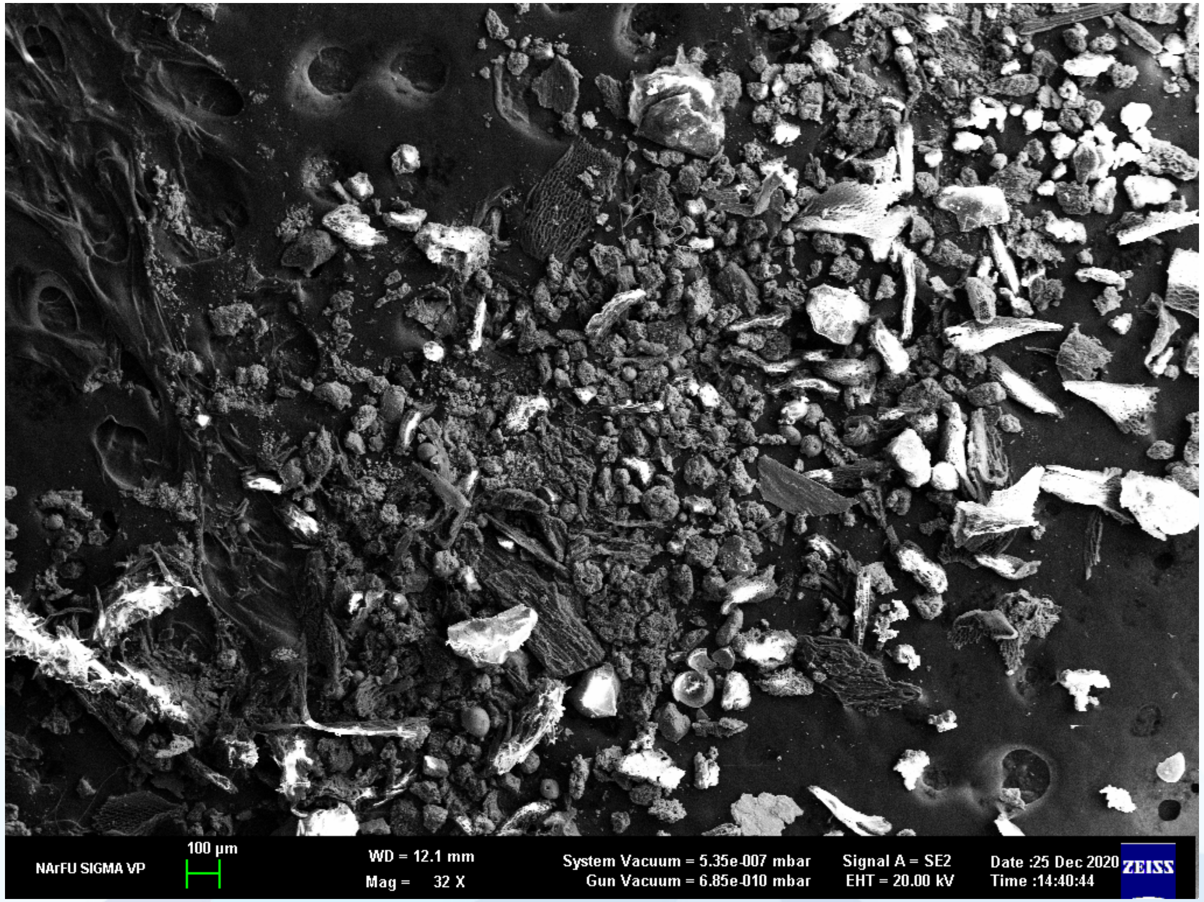


Fractional content of combustible substances (*n*= 0.852)

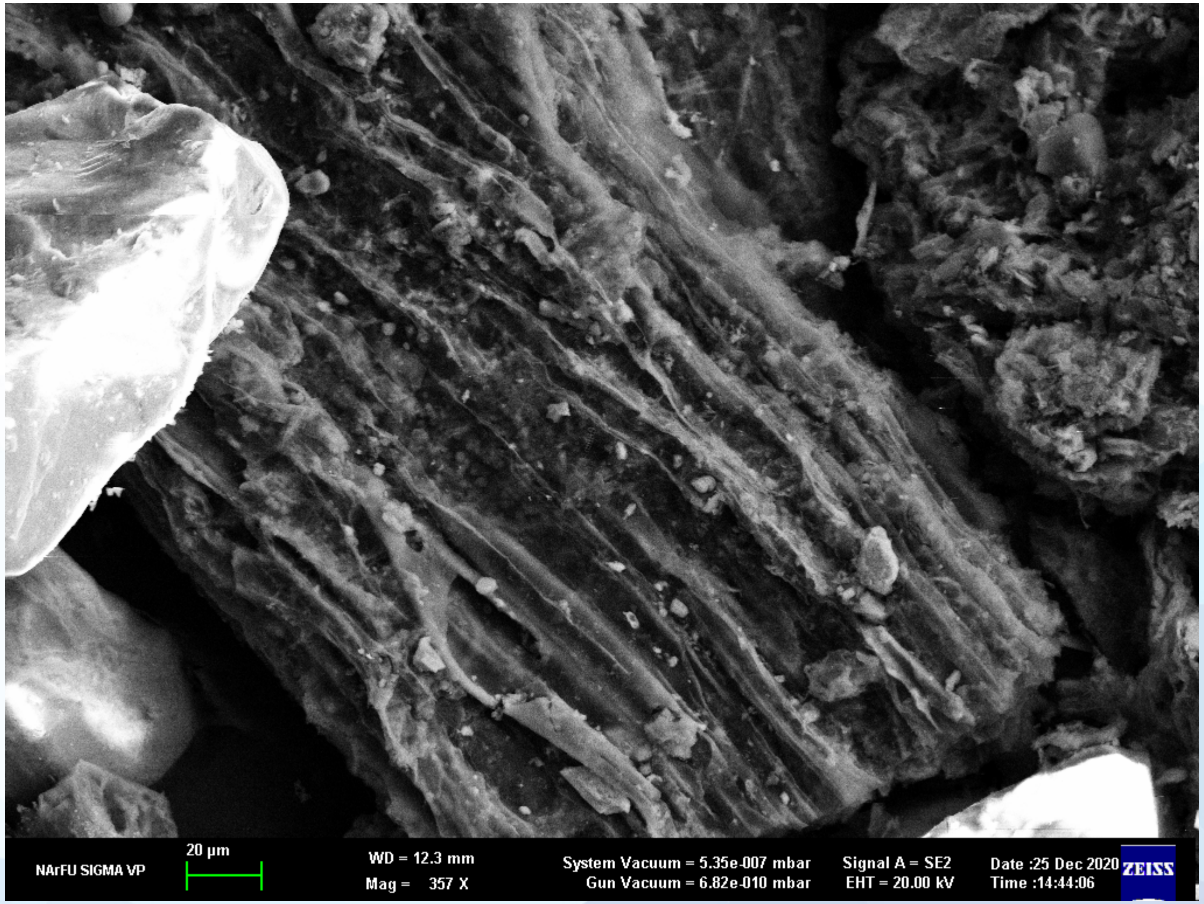


The content of fuels, considering the mass fractions

Microscopic examination of particles emitted into the atmosphere

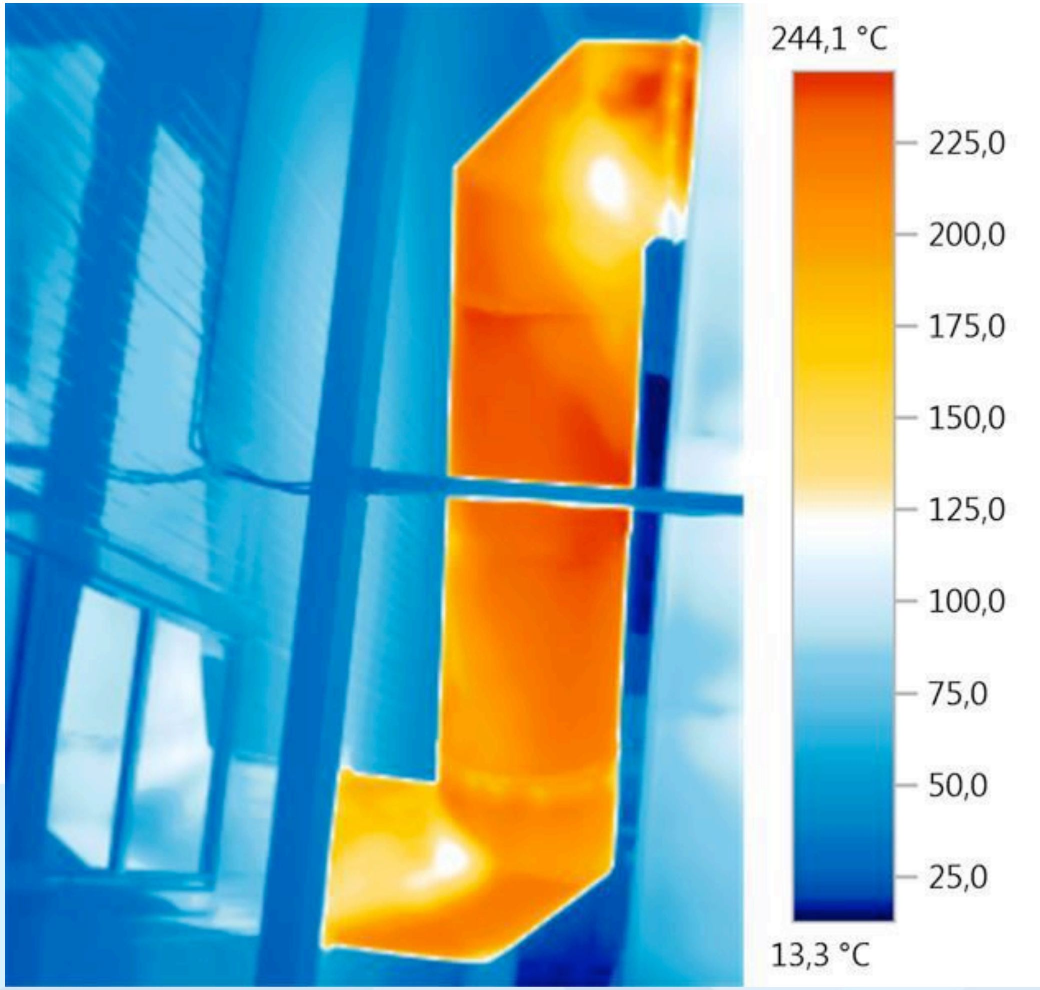


trapped particles

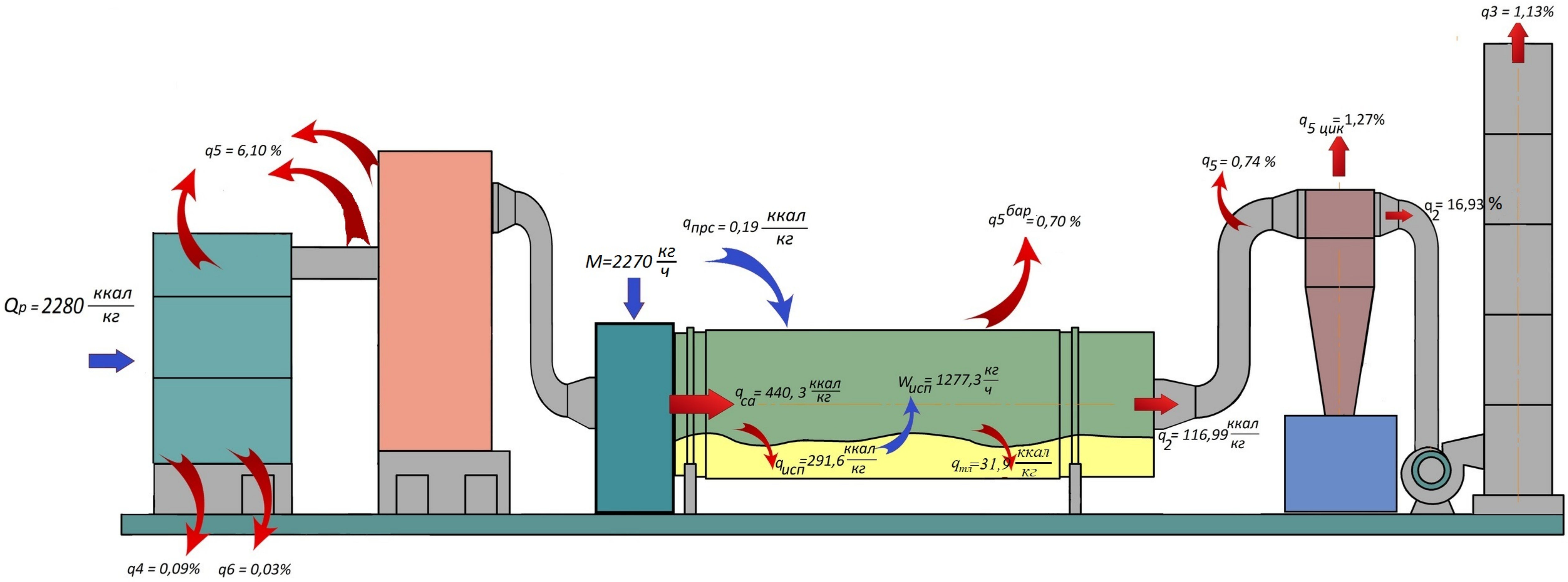


wood particles

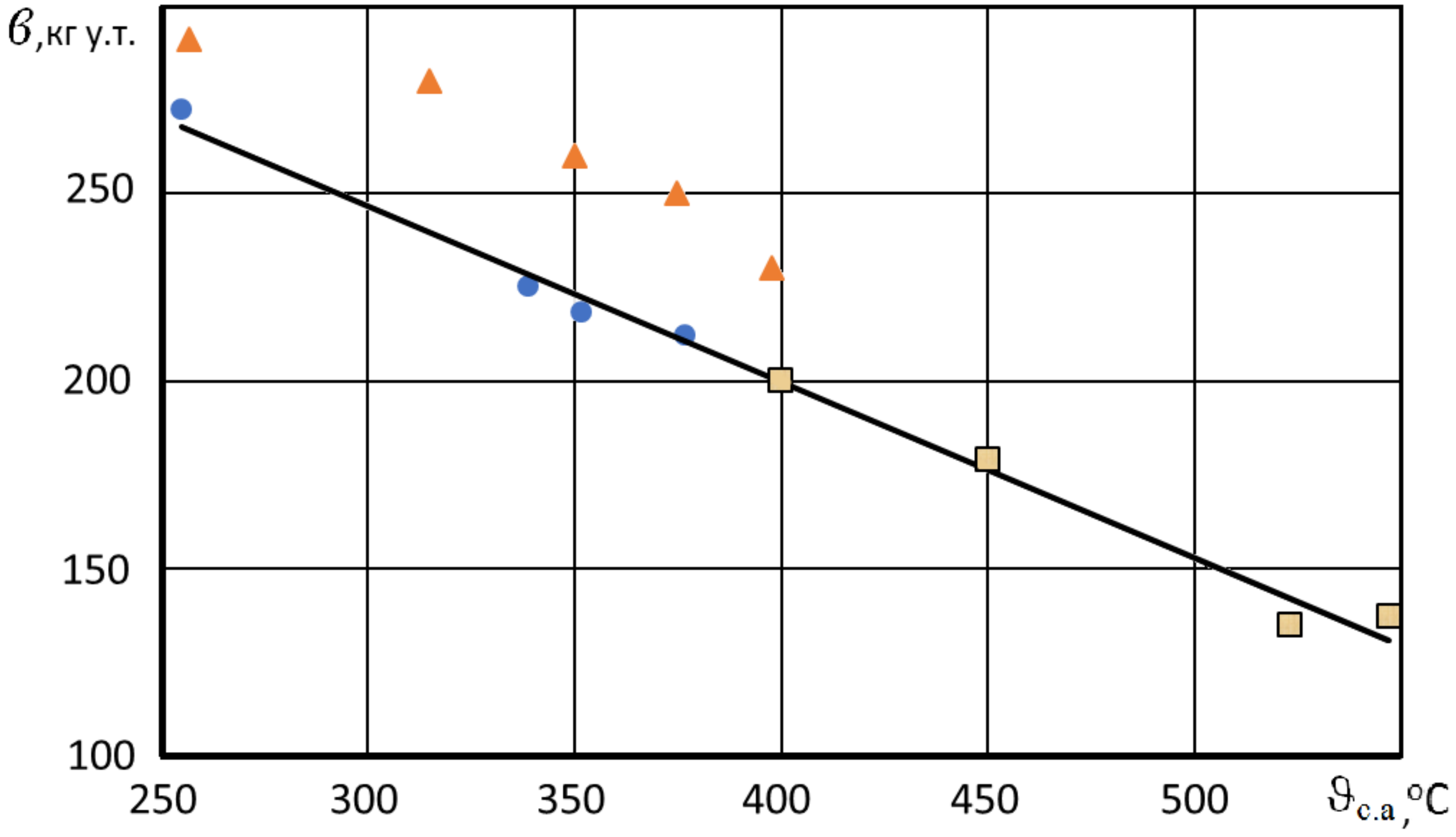
Thermal imaging of heat generator elements



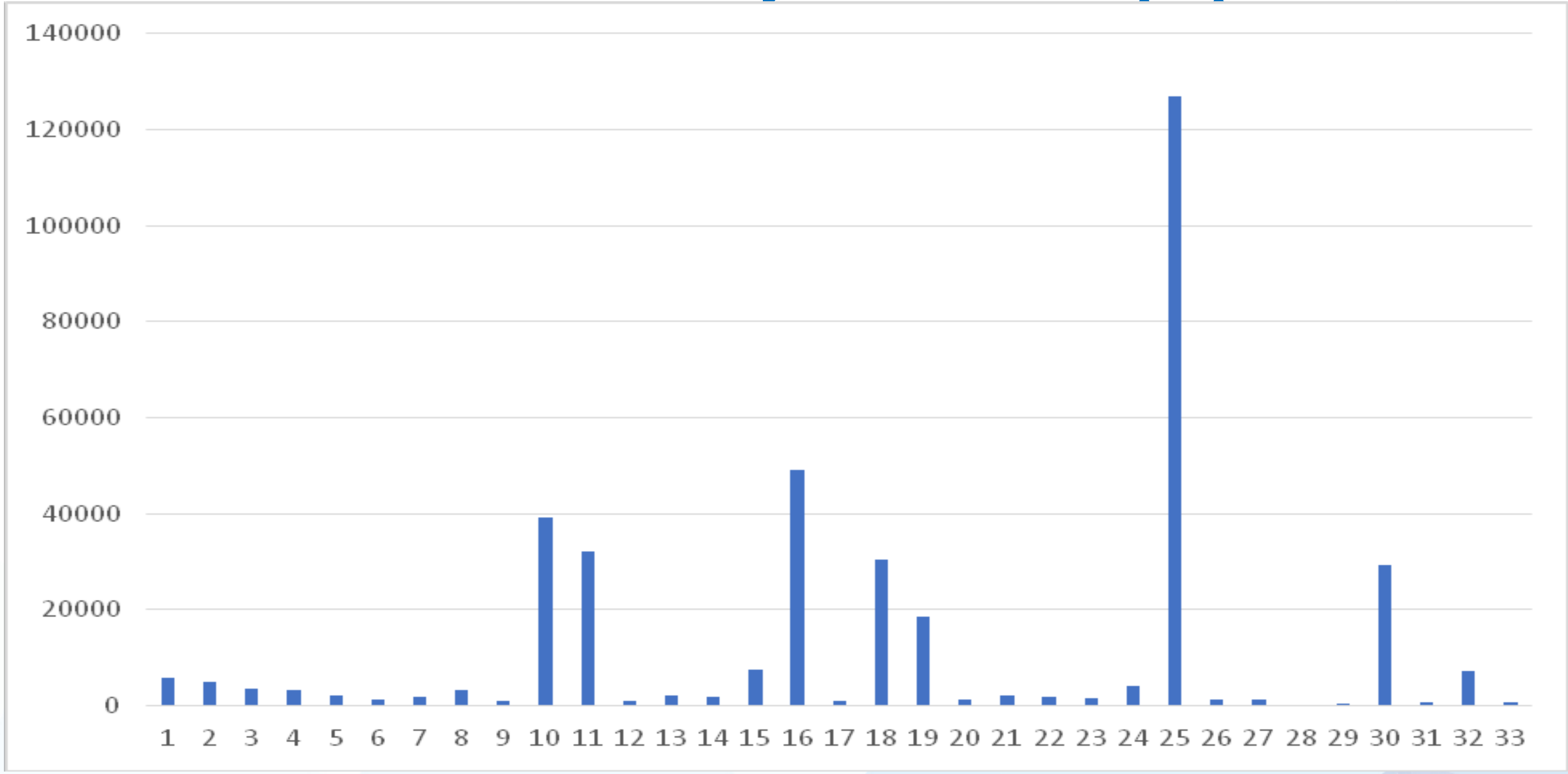
Components of the heat balance of the pelletizing line (Test No 3)



Influence of the drying agent temperature on the equivalent fuel consumption for the production of 1 ton of pellets



Power consumed by electrical equipment, W



1, 2, 3, 4 – hydroelectric stations No. 1, No. 2, No. 3, No. 4; 5 - L-shaped conveyor, 6 - disc separator, 7 - scraper conveyor, 8 - twin-screw feeder, 9 - magnetic separator, 10 - raw material crusher, 11 - fan, 12 - sluice conveyor, 13 - distributor hopper, 14 - dispenser screw, 15 - drying drum, 16 - smoke exhauster, 17 - sluice transfer loader No.1, 18 - dry material crusher, 19 - fan, 20 - sluice transfer loader, 21 - scraper conveyor, 22 - distributor bunker, 23 - screw dispenser, 24 - mixer, 25 - pellet press, 26 - scraper conveyor, 27 - elevator No. 1, 28 - cooling column, 29 - elevator No. 2, 30 - cooling fan, 31 - sluice reloader, 32 - fan of bulk residue, 33 - sluice reloader No 2

CONCLUSION

- The efficiency of the dryer is determined by the inlet temperature of the gases. The higher this temperature, the lower the fuel and energy consumption for the production of 1 ton of pellets.
- The efficiency of the heat generator has a decisive influence on the environmental performance of the pelletizing line. The design features of the heat generator made it possible to ensure low values of carbon loss and emissions of nitrogen oxides. However, the suboptimal air mode of operation of the heat generator, the absence in full of means for controlling the thermal and air mode, lead to increased generation of carbon monoxide, significant heat losses with incomplete combustion and increased consumption of electricity for traction.
- Large values of external heat loss for the heat generator are caused by the “half-open” layout of this production site, as well as the lack of thermal insulation on the gas ducts, the temperature in which was 255–353 °C. These facts also cause a decrease in natural draft, deterioration of the conditions for dissipation of exhaust gases and, accordingly, increase the cost of electricity for draft and reduce the life cycle of the equipment.

CONCLUSION

- The results of the study of the grain size distribution of the fly ash caught in the spark arrester showed that it has a high degree of polydispersity and a very fine fractional composition, which indirectly testifies to the high separation capacity of the afterburner chamber and the dynamic type spark arrester.
- The specific consumption of equivalent fuel for the production of 1 ton of pellets was 218.9–272.1 kg of reference fuel. With an increase in the temperature of the drying agent and the productivity of the installation, its amount decreases. The average specific power consumption for the production of 1 ton of pellets at an outside air temperature of minus 9–10 °C was 262.7 kWh.
- The results of the study of the granulometric composition of the dust caught in the bag filters of the pneumatic transport lines showed that it has a polydisperse, fine-fraction composition and belongs to the IV group of explosiveness, while the criteria for explosiveness have very high values of 9.389-9.401.

CONCLUSION

- The efficiency of the grinding process in mills, especially when grinding wet materials, has low values, since the energy consumption for the elastic deformation of the wood material is high. Based on this, when designing pellet plants, it is necessary to strive to minimize the amount of wood raw material sent to raw crushing mills through preliminary classification of wood raw materials by particle size.
- Studies have shown that the pellets of this plant in terms of thermal performance, mechanical durability, elemental and grain size distribution fully complies with the requirements of Russian and European standards.

Thank you
for your attention!

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