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 Research Article

Design Of The Industrial Prototype Of A Screw Press Device And Evaluation Of Its Technical Parameters

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ABSTRACT

This study presents the theoretical and experimental results obtained in the design of an industrial prototype of a variable-pitch screw press developed for coal briquette production. The design process considered the following operational parameters: screw compression force — 2.5 kN, nozzle diameter — 25 mm, working chamber diameter — 100 mm, and a five-step screw with a maximum pitch of 80 mm decreasing by 5 mm per step, operating at a rotational speed of 1.5 rev/s. For a feed material density of 1346 kg/m³ and a press capacity of 2500 kg/h, the total electric motor power, gearbox transmission ratio, and overall press dimensions were determined. The implementation of the proposed design and method demonstrated a twofold reduction in briquetting costs, thereby enhancing overall economic efficiency. Industrial trials confirmed that the developed screw press fully satisfies the technical requirements for industrial application of this class of machines. The calorific value of the produced briquetted fuel ranged from 750 to 800 °C, while introducing a raw material mixing process at 95 °C was found to reduce

emissions of sulphur oxide (SO₂) by 1.8 times, magnesium oxide (MgO) by 1.23 times, and anhydrous sodium carbonate (Na₂CO₃) by 1.36 times relative to the permissible exposure limit (PEL).

KEYWORDS

Screw press; nozzle; screw pitch; volumetric flow; permissible exposure limit (PEL); working chamber; calorific value.

INTRODUCTION

Based on the results of theoretical and experimental studies, as well as mathematical modelling, preliminary requirements and a technical specification were developed for a variable-pitch screw press designed for coal powder briquetting.

In performing the design calculations, the following parameters were applied: screw compression force of 2.5 kN, nozzle diameter of 25 mm, working chamber diameter of 100 mm, a screw with five steps and a maximum pitch of 80 mm decreasing by 5 mm per step, and a rotational speed of 1.5 revolutions per second. For a material density of 1346 kg/m³ and a press capacity of 2500 kg/h, the total electric motor power, gearbox transmission ratio, and overall dimensions of the press were calculated.

Initially, the filling coefficient of the working chamber was determined. For this purpose, the volumetric mass flow of the material within the working chamber of the device was calculated based on the specified parameters.

The given parameter values are presented below:

- Compression force: $F = 2.5 \text{ kN}$ (2500 N)

- Nozzle diameter: 25 mm
- Working chamber diameter: 100 mm
- Screw pitches: 80, 75, 70, 65, and 60 mm
- Screw rotational speed: 1.5 rev/s (90 rev/min)
- Material density: 1346 kg/m³
- Press productivity: 2500 kg/h
- Temperature of the material supplied to the press: 96°C

Results of the theoretical study: The mass flow rate of the material in the working chamber is determined according to the following formula, kg/s [1, 2, 3]:

$$G_{m.o} = \frac{G_{q.u}}{3600} \quad (1)$$

Here, $G_{q.u}$ represents the performance capacity of the screw press, which in the design calculations is taken as 2500 kg/h. In this case, the mass flow rate of the material in the working chamber is determined as follows, kg/s.

$$G_{m.o} = \frac{G_{q.u}}{3600} = \frac{2500}{3600} = 0,7 \quad (2)$$

The volumetric flow rate of the material depends on the mass flow rate within the working chamber and is calculated according to the following equation, kg/s [4, 5, 6, 7]:

$$V_{m.o} = \frac{G_{m.o}}{3600} \quad (3)$$

By substituting the given values into equation (5.2), the volumetric flow rate of the material is obtained, kg/s [9, 10, 11, 12].

$$V_{m.o} = \frac{G_{m.o}}{3600} = \frac{0,7}{3600} = 0,00019 \quad (4)$$

The cross-sectional area of the working chamber is calculated using the following formula, m²:

$$A = \pi R^2 \quad (5)$$

Here, R is the radius of the working chamber and is defined as $R = D/2$, with $\pi = 3.14$. Thus, equation (5.3) can be expressed as follows, m [13, 14, 15, 16, 17]:

$$A = \pi \left(\frac{D}{2}\right)^2 \quad (6)$$

By substituting the numerical values into equation (4), the cross-sectional area of the working chamber is determined, m².

$$A = \pi \left(\frac{D}{2}\right)^2 = 3,14 \cdot \left(\frac{100}{2000}\right)^2 = 0,00785 \quad (7)$$

If the average screw pitch is $L_{sh} = 0.07$ m, the theoretical volume per screw revolution, taking into account the filling coefficient, is calculated by the following formula, m³/rev:

$$V_{t.x} = AL_{sh} f_{t.k} \pi \quad (8)$$

Assuming the filling coefficient for screw press devices is $f_{t.k} = 0.65$, the theoretical volume per screw revolution is as follows, m³/rev [18, 19, 20].

$$V_{t.x} = AL_{sh} f_{t.k} \pi = 0,00785 \cdot 0,07 \cdot 0,65 = 0,00035$$

At a screw rotational speed of 1.5 rev/s, the theoretical volumetric flow rate per revolution is obtained, m³/s.

$$V_{t.x.t} = 0,00035 \cdot 1,5 = 0,00053$$

Considering the pressed material density $\rho_m = 1346$ kg/m³, the actual performance of the device is determined as follows, kg/h.

$$G_{q.u} = 0,00053 \cdot 1346 \cdot 3600 = 2596$$

Therefore, when the material is in this state and at a temperature of 96°C, the screw fills approximately 65% of the total working volume of the device with the supplied material. This value represents the degree of compression of the press and can be accepted as a realistic parameter in the design.

The conversion of the screw's axial compression force into a torque under ideal conditions is determined according to the following formula, N:

$$M_{b.m} = F_{s.k} \cdot \frac{L_{sh}}{2\pi} \quad (9)$$

Here, $F_{s.k}$ is the compressive force of the screw, N. The value of $F_{s.k}$ is determined based on the required mechanical strength of the briquettes, as defined in GOST 21289-2018 (0.6–0.9 kg/cm²). In the present study, the compressive force of the screw was taken as 2500 N, selected as the optimal value based on the mathematical model. Thus, the torque of the screw shaft is determined as follows, N·m [8].

$$M_{b.m} = F_{s.k} \cdot \frac{L_{sh}}{2\pi} = 2500 \cdot \frac{0,07}{2 \cdot 3,14} = 27,85 \quad (10)$$

The obtained value represents the calculated torque under ideal operating conditions of the screw. However, in real conditions, this value does not directly provide the actual compressive force or the precise power required for the drive system. In practice, it is necessary to consider the frictional forces acting between the screw blades and the shaft, as well as the physical and chemical properties of the pressed material.

Typically, the mechanical efficiency coefficient is taken within the range $\eta = 30\text{--}40\%$, and the coefficient representing the material's physical-chemical characteristics is taken as $\beta = 2\text{--}4$. Under these assumptions, the torque of the screw shaft under real operating conditions is determined as follows, N·m.

$$M_{b.m.x} = \frac{M_{b.m}}{\eta} \cdot \beta = \frac{27,85}{0,35} \cdot 3 = 238,7 \quad (11)$$

If the screw rotational speed is $\omega = 1.5$ rev/s, its angular velocity will be as follows, rad/s.

$$\omega = 2\pi n = 2 \cdot 3,14 \cdot 1,5 = 9,42 \quad (12)$$

Accordingly, the required electric motor power for the briquetting process under real operating conditions is determined as follows, W.

$$P = M_{b.m.x} \omega = 238,7 \cdot 9,42 = 2248 \quad (13)$$

From the calculation results, it is observed that during the briquetting process of coal powder with additional binders, the total energy consumption amounts to approximately 2248 W (or 2.2 kW). The ratio of the total power consumption to the mechanical efficiency coefficient ($\eta = 35\%$) defines the additional power required for real operation. Therefore, for the studied process, an electric motor with a power rating of 3 kW is recommended. Based on the parameters given above, the main overall dimensions of the screw press device were determined as follows:

Screw length — approximately 0.8 m; total press length — 1.3 m; width — 0.8 m; height — 1.4 m; total weight — 350 kg.

Table 1 presents the technical parameters of the variable-pitch screw press for coal powder briquetting, and Figure 1 illustrates its structural diagram.

Table 1. Technical parameters of the screw press for coal powder briquetting

No	Parameter name	Unit of measurement	Value
1	Electric motor power	kW	3
2	Electric motor shaft speed	rpm	1000
3	Gearbox transmission ratio	rpm	1/25
4	Screw shaft torque	N·m	238.7
5	Mass flow rate of material in working chamber	–	0.7
6	Screw compressive force	kN	2.5
7	Screw length	mm	800
8	Working chamber diameter	mm	100

9	Working chamber length	mm	810
10	Total press length	mm	1300
11	Height	mm	1400
12	Width	mm	800
13	Product hopper capacity	kg	50
14	Hopper filling coefficient	%	65
15	Mechanical efficiency coefficient	%	35

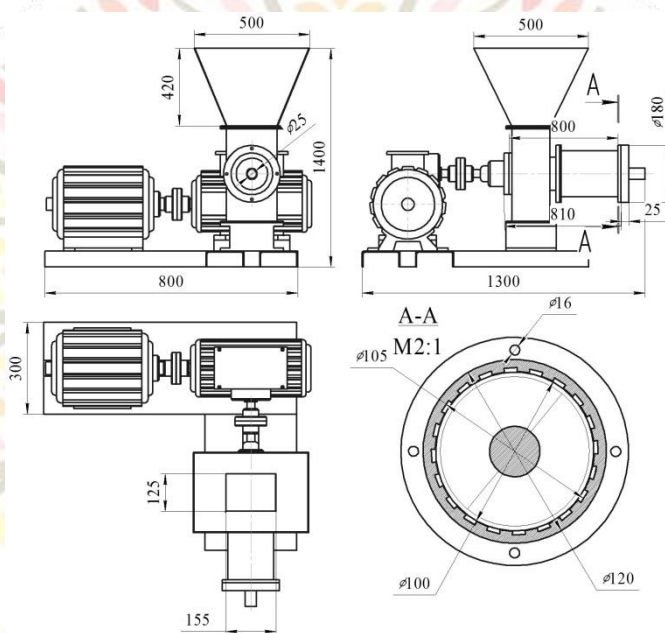


Figure 1. Structural diagram of the screw press device.

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RESULTS

Based on the selected parameters, an industrial prototype of the device was manufactured. Industrial trials of the improved variable-pitch screw press were conducted at “CLEAN MARKEN” LLC and the Fergana Regional Branch of the

Figures 2 and 3 illustrate the briquette production process using the developed screw press device.



Figure 2. View of the industrial prototype of the screw press.



Figure 3. Appearance of the produced briquettes.

- Binder content — 12%
- Kernel shell content — 24%
- Processing temperature during mixing — 96°C
- Screw compression force — 2.5 kN
- Nozzle diameter — 25 mm

At these parameter values, the briquette product exhibited a compressive strength of $\sigma = 0.78$ kg/cm², a combustion duration of $\tau = 110$ seconds, and an ash content of 11%. These parameters are considered critical in the evaluation of industrial trials [].

Initially, a binder mixture was prepared from alcohol stillage and paraffin waste in a 9:6 ratio. For each 1 kg of coal powder, 12% of a water-binder solution was added. The mixture contained coal fines smaller than 5 mm and 24% crushed fruit kernel shells. The components were mixed at a temperature of 96°C for 20 minutes.

For the experiments and to assess measurement accuracy, 50 kg batches of material were prepared

separately and successively loaded into the screw press. The tests were repeated five times for each batch. The obtained briquettes were dried under natural conditions for 24 hours.

The produced briquettes had a diameter of 25 mm, a length of 100 mm, and an average mass of 75 g. Each briquette sample was assigned an identification number and tested for compressive strength (σ , kg/cm²) and moisture content in accordance with standard requirements.

To determine these parameters, a VP-300 testing machine located in the laboratory of the Department of Applied Mechanics at Fergana State Technical University was used. The results of the industrial tests for briquette moisture and strength

(based on alcohol stillage, paraffin waste, and fruit kernel shells) are presented in Table 2.

Table 2. Results of industrial tests on briquette moisture and strength (based on alcohol stillage, paraffin waste, and fruit kernel shell additives).

No	The percent age of binder, %	The percent age of grains, %	Processing temperature during the mixing process, °C	The compressive force of the screw press screw, kN	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
Briquette strength s, kg/cm ²									
1	12	24	96	2,5	0,74	0,70	0,71	0,74	0,73
Briquette moisture U, %									
1	12	24	96	2,5	8,4	8,9	8,6	8,6	8,5

The industrial trials conducted at “CLEAN MARKEN” LLC demonstrated that the obtained briquettes fully meet the technological requirements established for production, particularly the mechanical strength standard defined by GOST 21289-2018 [] (0.6–0.9 kg/cm²). For instance, in samples No. 1 to No. 5, an increase in briquette moisture content correspondingly led to a decrease in compressive strength, following the expected physical relationship. However, in samples No. 3 and No. 4, with a moisture content of 8.6%, a difference of approximately 0.3 kg/cm² in strength was observed. This deviation is attributed to the non-uniform distribution of fruit kernel shell particles within the briquette volume. Consequently, when organising the production process, attention must also be paid to this

parameter, ensuring thorough and homogeneous mixing of the material.

The analysis of the results revealed that all five briquette samples satisfied the mechanical strength criterion. Nevertheless, from both economic and technical perspectives, the briquette corresponding to sample No. 5 was found to be the most suitable for production conditions. A comparative analysis with existing briquette production processes showed that the proposed briquette exhibited nearly two-fold improvement in mechanical strength compared to those currently manufactured.

Industrial trials on the calorific value and environmental impact of the briquette products obtained under the above-mentioned parameters

were carried out at the Fergana Regional Branch of the Enterprise for Waste Recycling, Realisation and Utilisation. In these experiments, the ignition and burnout duration of the briquette (τ , s), the amount of ash generated during combustion (A , %), and the calorific temperature (t , °C) of the produced briquettes were measured [22, 23, 40].

The experiments were conducted in the following sequence: each of the five briquette samples was separately combusted under natural conditions, and the temperature during complete glowing was measured using an ARKOM PR1550+ infrared thermometer (measurement range –50 to 1550 °C, accuracy ± 1.5 °C). The results of these experiments are presented in Figures 4 (a, b, c) and in Table 3.



Figure 4a. Initial glowing stage of the coal briquette.



Figure 4b. Full glowing stage of the coal briquette.



Figure 4c. Final stage of complete combustion of the coal briquette.



Table 3. Results of industrial tests on the ignition and burnout duration, ash and sulphur content, and calorific temperature of briquettes (based on alcohol stillage, paraffin waste, and fruit kernel shell additives).

Nº	Binder content, %	Kernel shell content, %	Processing temperature during mixing, °C	Screw compression force, kN	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Ignition start time of briquette τ_1 , seconds									
1	12	24	96	2,5	37	36	37	38	37
Complete burnout time of briquette τ_2 , seconds									
1	12	24	96	2,5	128	129	125	131	129
Ash content formed during combustion A , %									
1	12	24	96	2,5	14	14	14	13	14
Sulphur content formed during combustion S , %									
1	12	24	96	2,5	17	18	18	17	16
Calorific temperature of the produced briquette, t , °C									
1	12	24	96	2,5	865	869	872	878	883

The results of the industrial trials were reviewed by specialists from the Fergana Regional Committee for Ecology. According to their assessment, the calorific value of the produced briquette fuel increased by approximately 1.2% compared to existing briquette fuels. Furthermore, due to the application of a temperature-assisted mixing process for coal powder and binders, along with a preliminary drying technique, the sulphur content in the briquettes was found to be 10% lower than the permissible limit.

The evaluation also revealed that the produced briquettes are more convenient for consumers to use, providing higher heat output and improved fuel efficiency. In addition, the amount of ash

generated during combustion was approximately 15% lower compared to conventional briquettes.

CONCLUSION

The proposed method and device, when applied in practice, were found to reduce the cost of briquetting by approximately twofold, thereby enhancing economic efficiency. Experimental results confirmed that the industrial application of the developed screw press fully meets the technical requirements established for this class of equipment.

Industrial trials demonstrated that the calorific value of the produced briquette fuel ranged from 750 to 800 °C. Moreover, the application of a raw

material mixing process at 95 °C resulted in a reduction of sulphur oxide (SO₂) emissions by 1.8 times, magnesium oxide (MgO) by 1.23 times, and anhydrous sodium carbonate (Na₂CO₃) by 1.36 times compared to the permissible exposure limit (PEL).

REFERENCES

1. Хакимов, А. А. (2024). Актуальность использования связующих при производстве угольных брикетов. *European Journal of Interdisciplinary Research and Development*, 27, 94-98.
2. Ахунбаев, А. А., & Хакимов, А. А. (2022). Сушка угольной мелочи перед брикетированием. *Universum: технические науки*, (9-1 (102)), 29-33.
3. Хакимов, А. А. (2022). Технология Получения Качественных Брикетов С Использованием Горючих Вяжущих Компонентов. *Central Asian Journal of Theoretical and Applied Science*, 3(6), 459-463.
4. Hakimov, A., & Vohidova, N. (2021). Relevance of the choice of binders for coal briquettes. *Scientific progress*, 2(8), 181-188.
5. Хакимов, А. А. (2021). Определение показателей качества угольного брикета. *Universum: химия и биология*, (5-2 (83)), 40-44.
6. Axmedovich, X. A., & Saidakbarovna, S. D. (2021). Research the strength limit of briquette production. *Asian journal of multidimensional research*, 10(5), 275-283.
7. Khakimov, A. A., Salikhanova, D. S., & Vokhidova, N. K. (2020). Calculation and design of a screw press for a fuel briquette. *Scientific-technical journal*, 24(3), 65-68.
8. https://meganorm.ru/mega_doc/norm/gost_gosudarstvennyj-standart/14/gost_21289-2018_mezhgosudarstvennyy_standart_brikety_ugolnye.html
9. Khakimov, A. A., Salikhanova, D. S., & Vokhidova, N. K. (2020). Calculation and design of a screw press for a fuel briquette. *Scientific-technical journal*, 24(3), 65-68.
10. Хакимов, А. А. (2020). Связующее для угольного брикета и влияние его на дисперсный состав. *Universum: химия и биология*, (6 (72)), 81-84.
11. A.A.Xakimov, N.Vokhidova, A.Abdulazizov. Coal powder pressing device. XI International Annual Conference "Industrial Technologies and Engineering – ICITE-2022" 126-128 pg
12. A.A.Xakimov. Sanoat chiqindilaridan bog'lovchi sifatida foydalanib ko'mir briketlari olishning dolzarbligi. Farg'ona politexnika instituti. Ilmiy-texnika jurnali. Maxsus son №23. 2024 yil. 9-13 betlar.
13. A.A.Xakimov. Importance of drying in obtaining briquettes. XI International Annual Conference "Industrial Technologies and Engineering – ICITE-2024" 312-315 pg
14. A.A.Xakimov. **Investigation of Emissions Released During the Combustion of Coal Briquettes Produced from Distillery Stillage**

and Paraffin Waste. American Journal of Applied Science and Technology. 2025.

- 15.A.A.Xakimov. Актуальность использования связующих при производстве угольных брикетов. European Journal of Interdisciplinary Research and Development. 2024.
- 16.Khakimov Akmaljon, Azizjon Isomidinov. Experimental study of the effect of technological indicators on the durability of coal briquettes. Universum. 2025.
- 17.Akmaljon Xakimov, Rasuljon Tojiev, Ikromali Karimov, Nasiba Vokhidova, Abdurasul Davronbekov, Avazbek Xoshimov, Muxammadbobir Xusanboyev, Oybek Soliyev, O'tkirbek Hamdamov. Research of the Process of Briquette Preparation from Coal Powder in a Screw Press. ICHELs.2024.
- 18.A.A.Xakimov. Sanoat chiqindilaridan bog'lovchi sifatida foydalanib ko'mir briketlari olishning dolzarbligi. Farg'ona politexnika instituti. ILMIY-TEKNIKA JURNALI. Maxsus son №28. 2024 yil. 9-13 betlar.
- 19.A.A. Xakimov. Maxalliy bog'lovchilar asosida olingan ko'mir briketi mustaxkamligini tadqiq etish. Farg'ona politexnika instituti. Namangan davlat texnika universiteti. Mexanika va texnologiya ilmiy jurnali. Maxsus son №1. 2025 yil. 500-504 betlar.
- 20.Khakimov A., Salihanova D. Problems of increasing the high combustibility of coal briquettes and analysis of additives // Universum: химия и биология: электрон. научн. журн. 2025. 10(136). URL: <https://7universum.com/ru/nature/archive/item/20907>.