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***O. T. Kairbay[1], A. V. Mazdubay[2], I. A. Shumeyko[3]**
[1,2,3]Toraighyrov university, Republic of Kazakhstan, Pavlodar
*e-mail: oljaskairbaev@mail.ru

## *EXPERIMENTAL STUDIES OF THE DEPENDENCE OF TOOL PERFORMANCE ON DESIGN PARAMETERS*

*The comparative analysis allowed us to consider the equipment for processing solid household waste (SHW), tool designs, to monitor the work processes and come to the conclusion about their low level of resource conservation and not rational wear. There was also a high level of demand for collapsible tools for equipment for processing SHW. A collapsible tool has been designed for equipment for processing SHW, after that an algorithm for calculating the design parameters of the tool was developed, which was included in the tool design program for equipment for processing SHW in Microsoft Office Excel. This program allows you to design a tool model in accordance with the design parameters, technical characteristics of the equipment, needs and capabilities of the activity. The article presents the developed method of computer modeling to determine the optimal design parameters of a tool for equipment for processing SHW, the results of testing 3D models of tools for equipment for processing SHW in different variations. The materials of this work can be used in the educational process as a methodological guide and/or recommendations for computer modeling, analysis and selection of tool designs for recycling equipment.*

*Keywords: SHW recycling, utilization, SHW, solid waste, tool.*

**Introduction**

In [1, 2], the applied devices, equipment for crushing SHW and existing designs of tools for recycling SHW are analyzed.

The experimental study was performed in the APM FEM application of the Kompas 3D program [3]. It was necessary to determine the types of loads and their values before conducting the experiment. In this experiment, there are the following loads[4]:

– resistance to shear cutting of the processing material;

– friction force-sliding of the tool blade on the recycling material;

– angular speed.

To determine the resistance to shear cutting of the material, the following formula was used [5].

$$\tau = \frac{4}{5} \times \sigma_{в}$$

where $\sigma_{в}$ – tensile strength

The values of the tensile strength of the processing materials are presented in table 1 [5, 6, 7].

Table 1 – Values of the tensile strength of processing materials

| Material | MPa | N/mm$^2$ |
|---|---|---|
| PE | 10-36 | 10-36 |
| PP | 49 | 49 |
| PS | 34-58 | 34-58 |
| PVC | 34-61 | 34-61 |
| Steel 45 (chip) | 630 | 630 |

The obtained values of the resistance to shear cutting of materials are presented in table 2.

Table 2 – Values of the resistance to shear cutting of materials

| Material | MPa | N/mm$^2$ |
|---|---|---|
| PE | 8-32 | 8-32 |
| PP | 39 | 39 |
| PS | 27-47 | 27-47 |
| PVC | 27-49 | 27-49 |
| Steel 45 (chip) | 504 | 504 |

To determine the friction force-sliding of the tool blade on the material, the friction force-sliding formula was used

$$F_{fr} = k \times N$$

where $N$ – the strength of the normal reaction of the support;
$k$ – sliding friction coefficient.

Steel 45 (chip) was chosen as a material for the experiment, as the material with the highest value of the resistance to shear cutting. The sliding friction coefficient when moving steel on steel with an angular speed of 25 rpm will be 0.1125 [8].

$$F_{fr} = 504 \times 0,1125 = 56,7\frac{N}{mm^2}$$

As the rotation speed of the shredder shaft is 25 rpm, the angular speed value is 150°/s.

Materials and methods of research

Variable parameters of the tool design [9, 10]:

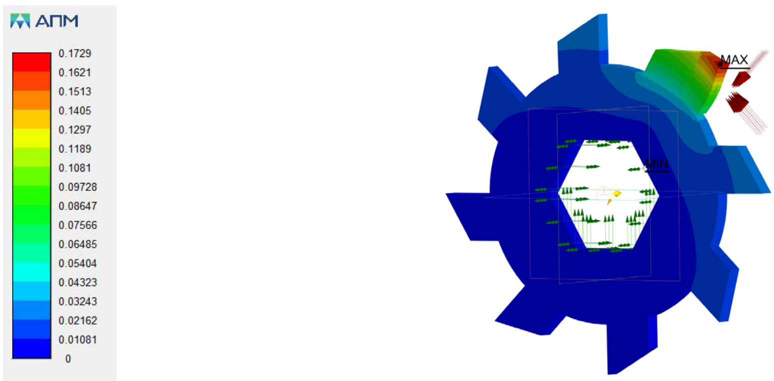
1 Housing type: a) cast; b) welded; c) collapsible.

2 Material of the cutting part: a) steel 65; b) steel 45.

3 Housing material: a) steel 65; b) steel 45.

Table 3 – Accepted design parameters of the tool design for solid waste processing equipment

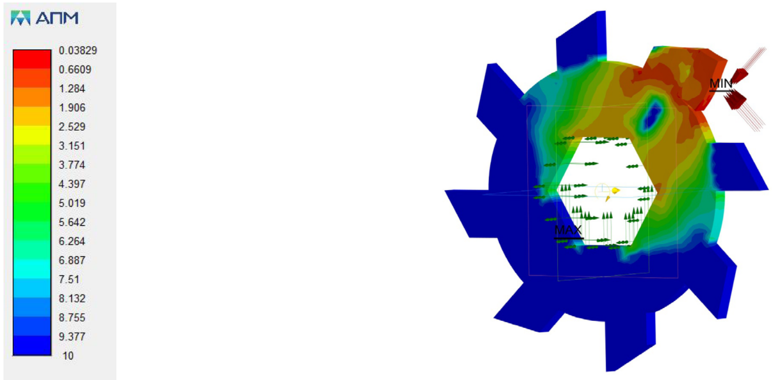
<table>
<tr><th>Variable tools</th><th>Accepted design parameters of the structure</th></tr>
<tr><td>а) housing type – collapsible;<br>б) material of the cutting part – steel 65;<br>в) housing material – steel 45</td><td rowspan="6">- major diameter of the housing blade is 106 mm;<br>- the minor diameter of the housing blade is 86 mm;<br>- the width of the housing blade is 5 mm;<br>- overall dimensions of the edge – 10x5x5 mm;<br>- the landing hole of the blade and ring (inscribed circle diameter) – 36 mm;<br>- the diameter of the distance ring is 55.9 mm;<br>- the width of the distance ring is 6 mm.</td></tr>
<tr><td>а) housing type – collapsible;<br>б) material of the cutting part – steel 45;<br>в) housing material – steel 45</td></tr>
<tr><td>а) housing type – collapsible;<br>б) material of the cutting part – steel 65;<br>в) housing material – steel 65</td></tr>
<tr><td>а) housing type – welded;<br>б) material of the cutting part – steel 65;<br>в) housing material – steel 45</td></tr>
<tr><td>а) housing type – cast;<br>б) material of the cutting part – steel 45;<br>в) housing material – steel 45</td></tr>
<tr><td>а) housing type – cast;<br>б) material of the cutting part – steel 65;<br>в) housing material – steel 65</td></tr>
<tr><td>1-generated<br>а) housing type – collapsible;<br>б) material of the cutting part – steel 65;<br>в) housing material – steel 45</td><td>- major diameter of the housing blade is 106 mm;<br>- the minor diameter of the housing blade is 76.4 mm;<br>- the width of the housing blade is 5 mm;<br>- overall dimensions of the edge – 14.8x5x8 mm;<br>- the landing hole of the blade and ring (inscribed circle diameter) – 32 mm;<br>- the diameter of the distance ring is 55.9 mm;<br>- the width of the distance ring is – 6 mm.</td></tr>
</table>




a) b)

a) scale of values of total linear displacements;
b) topography of total linear displacements

Figure 1 – Method of measuring total linear displacements under loads on the example of a 1-generated tool

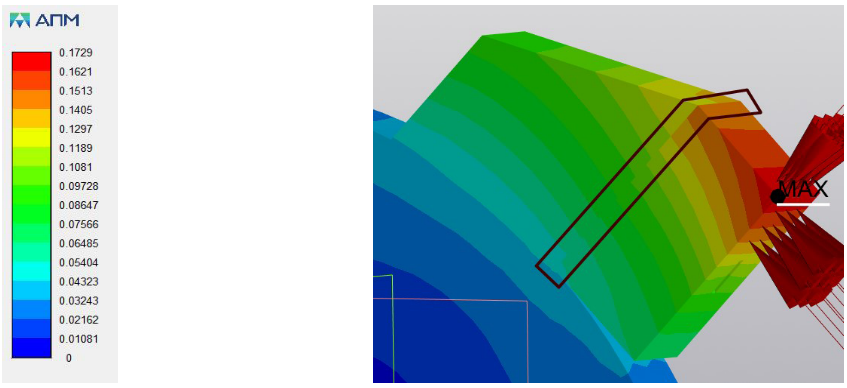



a) b)

a) scale of values of safety margin coefficients;

b) topography of safety margin coefficients.

Figure 2 – Method of measuring the safety margin coefficients under loads on the example of a 1-generated tool

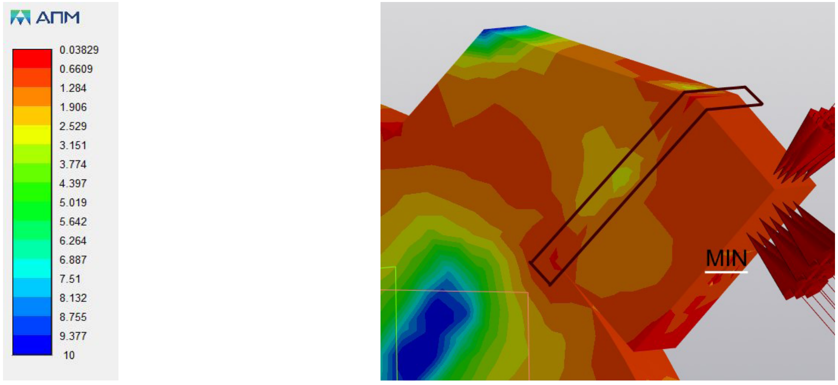



a) b)

a) scale of values of total linear displacements;

b) topography of total linear displacements

Figure 3 – Method of measuring total linear displacements at the place of joint of the cutting part with the housing under loads on the example of a 1-generated tool



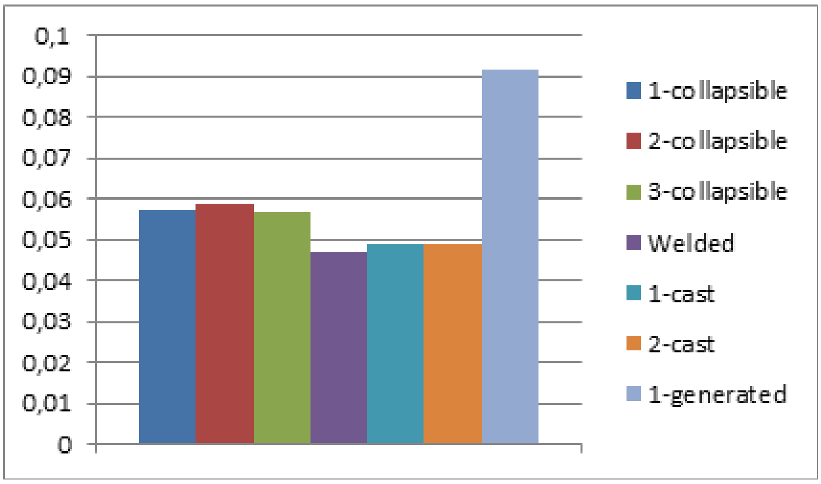

a) b)

a) scale of values of safety margin coefficients;
b) topography of safety margin coefficients.

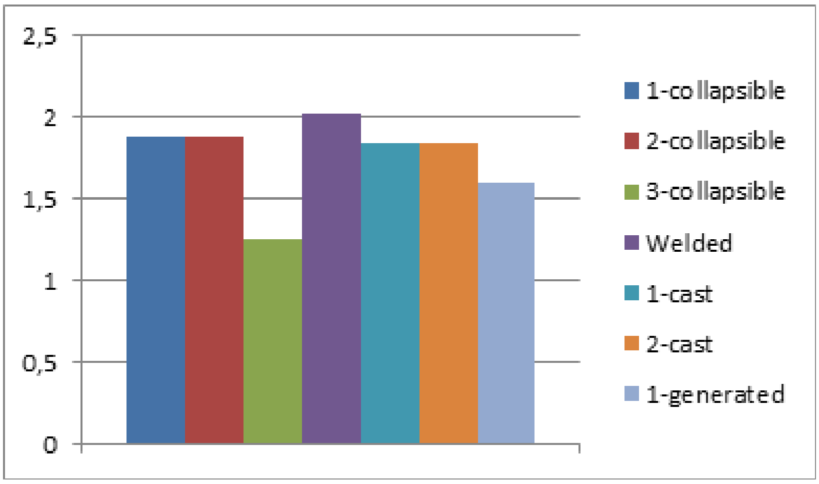
Figure 4 – Method of measuring safety margin coefficients at the cutting part's place of joint with the housing under loads on the example of a 1-generated tool

**Results and discussion**

First is identification of the optimal type of construction. From the graphical dependencies and the values of mechanical characteristics at the cutting part's place of joint with the tool housing can be seen that the minimum value of the total linear displacement 0.047275 mm has a welded housing type. The maximum value of 0.09187 mm for the 1-generated collapsible housing type with the material of the cutting part is steel 45, the housing material is steel 45.



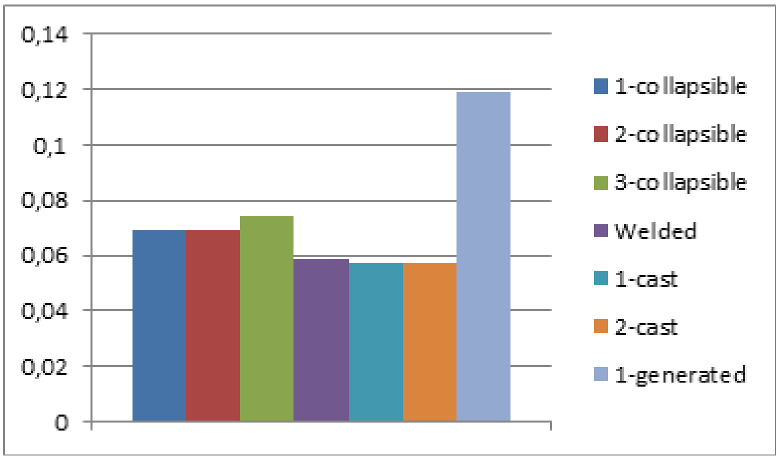

Graph 1 – Values of the total linear displacement at the cutting part's place of joint with the tool housing, mm



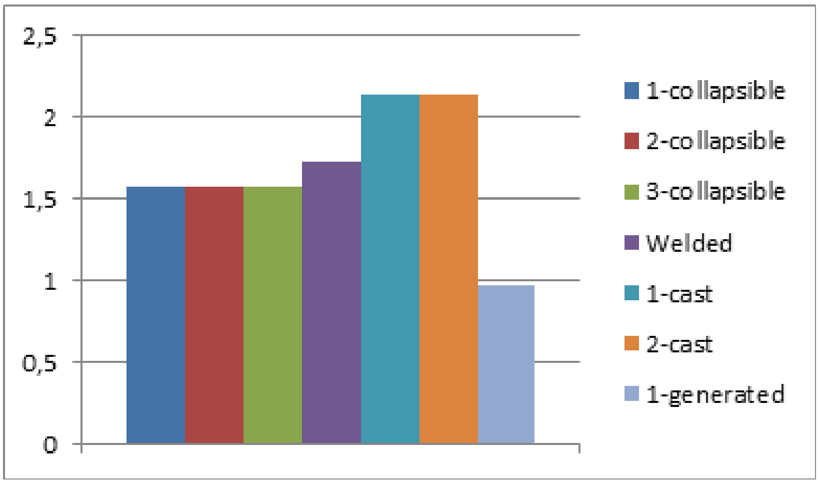

Graph 2 – Values of the safety margin coefficients
at the cutting part's place of joint with the tool housing

From the same graphs and values of mechanical characteristics at the junction of the cutting part with the tool housing can be seen that the minimum value of the safety margin coefficient 1.2578 has a collapsible housing type with the material of the cutting part – steel 65, the material of the housing – steel 45. The maximum value is 2.0225 for the welded housing type. Thus according to the type of housing, the most optimal is the collapsible housing type with the material of the cutting part – steel 65, the material of the «housing» – steel 45.

Second is identification of the optimal material of the cutting part. From the graphical dependencies and values of the mechanical characteristics of the cutting part of the tool can be seen that the minimum value of the total linear displacement of 0.057545 mm has a cast housing type with the material of the cutting part – steel 45 and steel 65. The maximum value is 0.118875 mm for the 1-generated collapsible housing type with the material of the "cutting part" – steel 65, the material of the housing – steel 45.



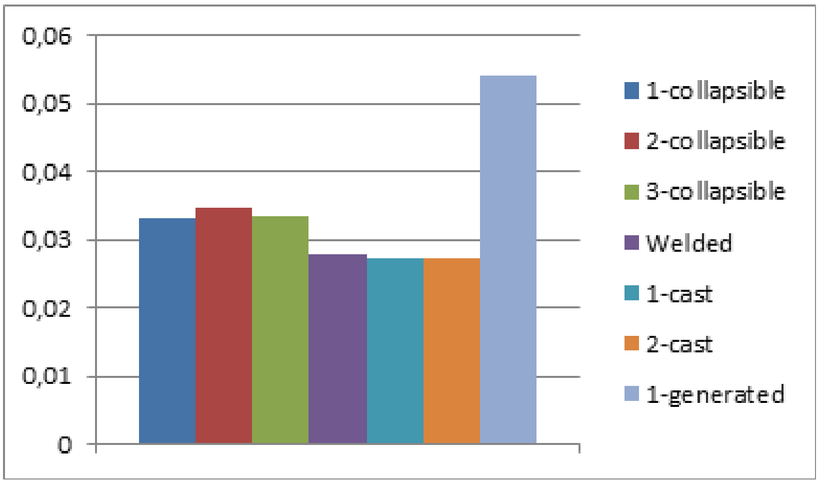

Graph 3 – Values of the total linear displacement of the tool cutting part, mm



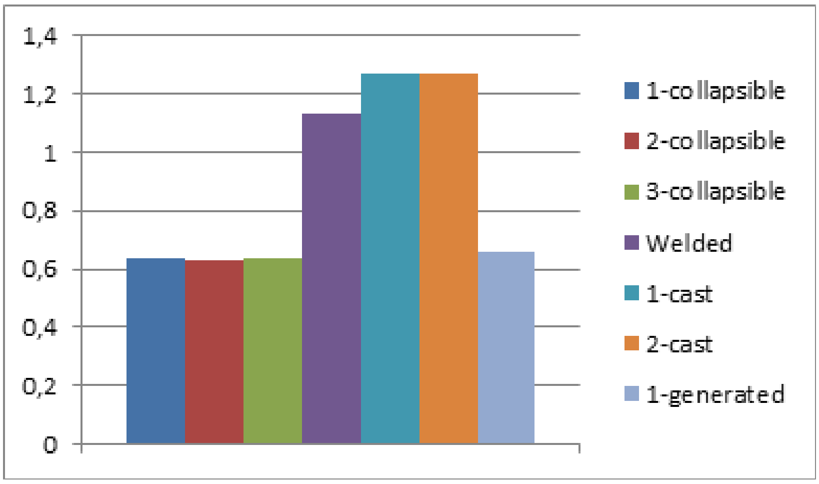

Graph 4 – Values of the safety margin coefficients of the tool cutting part

According to the following graphs and values of the mechanical characteristics of the tool cutting part can be seen that the minimum value of the safety factor 0.972145 has 1-the generated collapsible housing type with the material of the cutting part – steel 65. The maximum value of 2.13935 for the cast housing type with the material of the cutting part is steel 45 and steel 65. Thus the material of the cutting part is the most optimal steel 65.

Third is identification of the optimal housing material. From the graphical dependencies and the values of the mechanical characteristics of the tool housing can be seen that the lowest maximum value of the total linear displacement of 0.0274 mm has a cast housing type with a housing material – steel 45 and steel 65. The highest maximum value of 0.05404 mm is for the 1-generated collapsible housing type with the material of the cutting part – steel 65, the housing material – steel 45.




Graph 5 – Maximum values of the total linear displacement of the tool housing, mm




Graph 6 – Minimum values of the safety margin coefficients of the tool housing

Based on the same graphs and values of the mechanical characteristics of the tool housing can be seen that the lowest minimum value of the safety margin coefficient 0.633 has a collapsible housing type with the material of the cutting part – steel 45, the material of the housing – steel 45. The highest minimum value is 1.266 for a cast housing with a housing material – steel 45 and steel 65. Thus steel 45 is the most optimal for the housing material.

**Conclusions**

A method of computer modeling has been developed to determine the optimal design parameters of a tool for solid recycling equipment. Experimental studies of the dependence of mechanical characteristics on the design parameters of the tool have been carried out, namely: a) the housing type; b) the material of the cutting part; c) the material of the housing.

Based on the results of experimental studies with a tool for solid waste processing equipment, the following recommendations can be made:

– the housing type of the tool for solid recycling equipment should be taken collapsible, as the most rational, preserving the principle of resource conservation.

– it is recommended to use steel 65 as the material of the tool cutting part, as it has a high resource intensity;

– it is recommended to use 45 steel as the material of the tool housing, because the housing is least subjected to loads and wear in the production process.

REFERENCES

1 **Ф. Ла Мантия** (ред.); пер. с англ. под. ред. Заиков Г. Е. Вторичная переработка пластмасс / Ф. Ла Мантия (ред.); пер. с англ. под. ред. Г. Е. Заикова; Профессия. – Санкт-Петербург : Изд-во Профессия, 2006. – 400 с. – ISBN 5-93913-116-6.

2 **Каирбай, О. Т.** Анализ конструкций инструментов для переработки ТБО / О. Т. Каирбай // Международная научно-практическая конференция «XIV Торайгыровские чтения». – Павлодар, 2022. – С. 306–313.

3 Научно-технический центр «АПМ». APM FEM : руководство пользователя / Научно-технический центр «АПМ». – Королёв : Изд-во Научно-технический центр «АПМ», 2022. – 71 с.

4 **Николаенко, В. Л.** Прикладная механика. Расчет типовых элементов конструкций : учеб. пособие / В. Л. Николаенко. – Минск : Изд-во Гревцова, 2010. – 386 с.

5 Design of a Plastic Shredding Machine to Obtain Small Plastic Waste / A. D. Witman, C. M. Jason, M. C. Brian, N. T. Luis // International Journal of Advanced Computer Science and Applications. – 2021. – Vol. 12. – № 6. – P. 478–483.

6 **Дьяконов, О. М.** Исследование физико-химических и механических свойств стальной и чугунной стружки / О. М. Дьяконов // Литье и металлургия. – 2009. №4 (53). – С. 161–173.

7 Виды стружек // ООО «ВТ-МЕТАЛЛ», 2022. – [Электронный ресурс]. – URL: https://vt-metall.ru/articles/882-vidy-struzhek (Дата обращения: 08.01.2023).

8 Как найти коэффициент трения // МногоФормул.ру, 2022. – [Электронный ресурс]. – URL: https://mnogoformul.ru/kak-nayti-koyefficient-treniya (Дата обращения 08.01.2023).

9 Ножи для роторных шредеров и дробилок // Samaks, 2021. – [Электронный ресурс]. – URL: https://samaks.ru/nozhi-dlya-rotornyh-shrederov-i-drobilok.html (Дата обращения 08.01.2023).

10 Справочник технолога-машиностроителя. В 2 т. Т. 2. / Под ред. А. Г. Косиловой и Р. К. Мещерякова. – М. : Машиностроение, 1986. – 496 с.

## REFERENCES

1 **F. La Mantiya** (red.); per. s angl. pod. red. Zaikov G. E. Vtorichnaya pererabotka plastmass [Recycling of plastics] / F. La Mantiya (red.); per. s angl. pod. red. G. E. Zaikova ; Professiya. – Saint-Petersburg : Professiya publisher, 2006. – 400 p. – ISBN 5-93913-116-6.

2 **Kairbay, O. T.** Analiz konstrukcii instrumentov dlya pererabotki TBO [Analysis of tool designs for MSW recycling] / O. T. Kairbay // Mejdunarodnaya nauchno-prakticheskaya konferenciya «XIV Toraigirovskie chteniya». – Pavlodar, 2022. – P. 306–313.

3 Nauchno-tehnicheskii centr «APM». APM FEM: rukovodstvo polzovatelya [APM FEM: user manual] // Nauchno-tehnicheskii centr «APM». – Korolev : Nauchno-tehnicheskii centr «APM» publisher, 2022. – 71 p.

4 **Nikolaenko, V. L.** Prikladnaya mehanika. Raschet tipovih elementov konstrukcii : ucheb. posobie [Applied mechanics. Calculation of typical structural elements: textbook] / V. L. Nikolaenko. – Minsk : Grevcova publisher, 2010. – 386 p. – ISBN 978-985-6826-88-0.

5 Design of a Plastic Shredding Machine to Obtain Small Plastic Waste / A. D. Witman, C. M. Jason, M. C. Brian, N. T. Luis // International Journal of Advanced Computer Science and Applications. – 2021. – Vol. 12. – № 6. – P. 478–483.

6 **Dyakonov, O. M.** Issledovanie fiziko-himicheskih i mehanicheskih svoistv stalnoi i chugunnoi strujki [Investigation of physico-chemical and mechanical properties of steel and cast iron shavings] / O. M. Dyakonov // Casting and metallurgy. – 2009. – №4 (53). – P. 161–173.

7 Vidi strujek [Types of shavings] // «VT-METALL» LLC, 2022. – [Electronic resource]. – URL: https://vt-metall.ru/articles/882-vidy-struzhek (Date of application 08.01.2023).

8 Kak naiti koefficient treniya [How to find the coefficient of friction] // MnogoFormul.ru, 2022. – [Electronic resource]. – URL: https://mnogoformul.ru/kak-nayti-koyefficient-treniya (Date of application 08.01.2023).

9 Noji dlya rotornih shrederov i drobilok [Knives for rotary shredders and crushers] // Samaks, 2021. – [Electronic resource]. – URL:https://samaks.ru/nozhi-dlya-rotornyh-shrederov-i-drobilok.html (Date of application 08.01.2023).

10 Spravochnik tehnologa-mashinostroitelya Pod red. Kosilovoi A. G. i Mescheryakova R. K. [Handbook of a machine-building technologist]. In 2 t. T. 2. Ed. By. A. G. Kosilovoi i R. K. Mescheryakova. – Moscow : Mashinostroenie, 1986. – 496 p.

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*О. Т. Каирбай[1], А. В. Маздубай[2], И. А. Шумейко[3]
[1,2,3]Торайғыров университеті,
Қазақстан Республикасы, Павлодар қ.
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## ҚҰРАЛДЫҢ ӨНІМДІЛІГІНІҢ ДИЗАЙН ПАРАМЕТРЛЕРІНЕ ТӘУЕЛДІЛІГІН ЭКСПЕРИМЕНТТІК ЗЕРТТЕУ

*Салыстырмалы талдау қатты тұрмыстық қалдықтарды (ҚТҚ) қайта өңдеу жабдықтарын, құрал-саймандар конструкцияларын қарауға, жұмыс процестеріне бақылау жүргізуге және олардың ресурс үнемдеудің төмен деңгейі және ұтымды емес тозуы туралы қорытындыға келуге мүмкіндік берді. Сондай-ақ, ҚТҚ қайта өңдеу жабдықтарына арналған жиналмалы типтегі құралдарға сұраныстың жоғары деңгейі анықталды. Қатты тұрмыстық қалдықтарды қайта өңдеу жабдықтары үшін жиналмалы типтегі құрал жасалды. Содан кейін Microsoft Office Excel бағдарламасында қатты тұрмыстық қалдықтарды қайта өңдеу жабдықтары үшін құралды жобалау бағдарламасына енгізілген құралдың дизайн параметрлерін есептеу алгоритмі жасалды. Бұл бағдарлама құралдың моделін дизайн параметрлеріне, жабдықтың техникалық сипаттамаларына, қызметтің қажеттіліктері мен мүмкіндіктеріне сәйкес жасауға мүмкіндік береді. Бұл мақалада ҚТҚ қайта өңдеу жабдықтары үшін құралдың оңтайлы құрылымдық параметрлерін анықтау үшін компьютерлік модельдеудің әзірленген әдістемесі, әртүрлі вариацияларда қатты тұрмыстық қалдықтарды қайта өңдеу жабдықтары үшін құралдардың 3D моделін сынау нәтижелері келтірілген. Бұл жұмыстың*

*материалдары оқу процесінде компьютерлік модельдеу, талдау және қайта өңдеу жабдықтары үшін құрал-саймандардың конструкцияларын іріктеу үшін әдістемелік құрал және/немесе ұсыныстар ретінде пайдаланылуы мүмкін.*

*Кілтті сөздер: ҚТҚ өңдеу, кәдеге жарату, ҚТҚ, қатты қалдықтар, құрал.*

***О. Т. Каирбай[1], А. В. Маздубай[2], И. А. Шумейко[3]**

[1,2,3]Торайгыров университет,

Республика Казахстан, г. Павлодар.

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## ЭКСПЕРИМЕНТАЛЬНЫЕ ИССЛЕДОВАНИЯ ЗАВИСИМОСТИ ПРОИЗВОДИТЕЛЬНОСТИ ИНСТРУМЕНТА ОТ КОНСТРУКТИВНЫХ ПАРАМЕТРОВ

*Сравнительный анализ позволил рассмотреть оборудование переработки твёрдых бытовых отходов (ТБО), конструкций инструментов, провести наблюдение за рабочими процессами и прийти к выводу об их низком уровне ресурсосбережения и не рационального изнашивания. Также был обнаружен высокий уровень спроса на инструменты разборного типа для оборудования по переработке ТБО. Сконструирован инструмент разборного типа для оборудования по переработке ТБО. Затем был разработан алгоритм расчета конструктивных параметров инструмента, который внесён в программу проектирования инструмента для оборудования по переработке ТБО в Microsoft Office Excel. Эта программа позволяет сконструировать модель инструмента в соответствии с конструктивными параметрами, техническими характеристиками оборудования, потребностями и возможностями деятельности. В данной статье представлена разработанная методика компьютерного моделирования по определению оптимальных конструктивных параметров инструмента для оборудования по переработке ТБО, результаты испытаний 3D модели инструментов для оборудования по переработке ТБО в различных вариациях. Материалы этой работы могут быть использованы в учебном процессе в качестве методического пособия и/или рекомендаций для проведения компьютерного моделирования, анализа и отбора конструкций инструментов для оборудований по переработке отходов.*

*Ключевые слова: переработка ТБО, утилизация, ТБО, твёрдые отходы, инструмент.*

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5,07 Mb RAM
Шартты баспа табағы 14,79. Таралымы 300 дана. Бағасы келісім бойынша.
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Тапсырыс № 4087

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов көш., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69

e-mail: kereku@tou.edu.kz
nitk.tou.edu.kz