

ENGINEERING SCIENCES

COMPARATIVE ANALYSIS OF THE ENERGY CONSUMED BY NEEDLE BAR MECHANISM AND THE MECHANISM DRIVING THE FEED DOG OF A TOP DRIVE SEWING MACHINE

Assistant prof. *Elena Atanasova Blagova*, PhD student
Bulgaria, Blagoevgrad, South-West University "Neofit Rilski", Faculty of engineering,
department "Mechanical engineering and technologies"

DOI: https://doi.org/10.31435/rsglobal_wos/30092019/6684

ARTICLE INFO

Received: 17 July 2019

Accepted: 23 September 2019

Published: 30 September 2019

KEYWORDS

sewing machines,
analysis,
energy,
needle bar mechanism,
feed dog mechanism.

ABSTRACT

The paper focuses on the energy consumed by two mechanisms of sewing machine for straight lockstitch (stitch line 301): needle driving mechanism and the transporting mechanism. The first mechanism - needle driving, is a simple structure, but it is the most dynamic one. The second - to moving the fabrics, is the most complicated mechanism of the sewing machine. A comparative analysis of the energy consumed by the two mechanisms for the implementation of their propulsion is made. The correct work of the machine, the seam quality and the quality of the entire sewing product depend to a large extent, on the workings of these two mechanisms. The needle is driven by a slider-crank mechanism, while for the movement of the connected details, at the distance one step is done by a working part - a feed dog. It is attached to a carrier and its trajectory is a closed planar curve, close to the ellipse. The feed dog receives the horizontal and vertical component of its motion from two conditionally separate kinematic chains that have a common drive. The aim is analytical research and comparative analysis of the energies of needle bar mechanism and a mechanism driving the feed dog of the sewing machine. The energy consumed by each of the links of chains, of the chains themselves and total energy consumed by each of the two mechanisms for a full turn of the main shaft of the machine was studied. A comparative analysis of the energies and their distribution was carried out during the working process and the free movement of each of them. The results of the comparative analysis are presented in graphs and diagrams. It can be seen that the energy consumed by the needle mechanism is significantly greater than that of the transport mechanism. This fact is due to the much higher speeds of the links of the first one.

Citation: Elena Atanasova Blagova. (2019) Comparative Analysis of the Energy Consumed by Needle Bar Mechanism and the Mechanism Driving the Feed Dog of a Top Drive Sewing Machine. *International Academy Journal Web of Scholar*. 9(39), Vol.1. doi: 10.31435/rsglobal_wos/30092019/6684

Copyright: © 2019 **Elena Atanasova Blagova**. This is an open-access article distributed under the terms of the **Creative Commons Attribution License (CC BY)**. The use, distribution or reproduction in other forums is permitted, provided the original author(s) or licensor are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

1. Introduction. As a basic method of connecting the details in the garment industry, the method by a sewing thread has been mainly used. The most common application in practice are the universal sewing machines (SMs) for stitch class-301 (lockstitch formed with two threads). In order to form a stitch, several basic mechanisms in the sewing machine (SM) interact: the needle, the thread take-up lever, the loop taker (shuttle) and the feed dog (FD). The trend is to improve the machine to

increase productivity, improve service conditions and stitch quality. For this purpose, many improvements have been made to the SM's design mechanisms [1].

New possibilities for improving the process of forming stitch are provided by studying, analyzing and optimizing the kinematic and dynamic parameters of the Needle Bar Mechanism (NBM) and the Feed Dog Mechanism (FDM) when they interact with the other mechanisms in the SMs. A number of studies have been conducted in [2-11] as well as in many others.

The first mechanism (NBM) is with a simple structure, but it is the most dynamic one. Stitch quality, seam strength, and sewing machine's productivity depend largely on his work. The second mechanism (FDM) is the most complicated of the SM's mechanisms and also influences significantly the productivity, the quality of the stitch line and the sewing product.

By the mechanisms of each machine that perform the necessary movements, the mechanical energy is transferred from the source to the executive links. Studying their dynamics is a complex and labor-intensive task. It can be simplified by examining the change of energy and its distribution between the units of the mechanism over a certain period of time.

By applying the kinetic energy theorem, the law of conservation of mechanical energy and the basis of virtual work, it is easier to find the relations between kinematic (velocity, acceleration) and dynamic (forces, moments, mass characteristics) parameters of the rigid bodies' movement and of the rigid body systems. There is no need to be studied the differential law of motion. Therefore, an important issue for the SM's work is the distribution of energy between the units of the mechanisms and its change over the period of working of a machine.

The aim of the presented research is analytical study and comparative analysis of the energy used to drive the units, as well as the total energy of NBM and MTM of SM with upper driven:

- for one full turn of the main shaft of the machine;
- during the working and free movement of each of the mechanisms.

According to the classification made in [6], depending on the way of driving the chains for horizontal and vertical movement of the feed dog, the machines are with below and upper drive. In the study as an example of a machine with upper driven it was used Textima 8332.

2. Exposition. The carried out technological processes on the SM required proper operation of all machine mechanisms. In order to realize the most commonly used stitch line 301, the needle performs reciprocation motion in a vertical direction. The movement of the connected details, at the required distance (stitch line step), into lockstitch machines, is done most often by a working part - a FD.

The task of the NBM is to convert rotary motion of the main shaft into a vertical linear motion of the needle bar (NB) in which the needle is fixed. For this purpose, a slider-crank mechanism is most commonly used in SMs. In the recent years, the analytical methods: "instantaneous center of velocity method" [12], [13] and "modeling method" [14-18] have been proposed for the study of the mechanisms of textile and SMs.

In the Textima 8332 main shaft is located at the top of the SM. The motion is convert by a slider-crank mechanism with a crank 1, a connecting link 2 and a slider 3 - Fig.1. This slider-crank mechanism is in-line (axial). The line of motion of the needle passes through the center of rotation point O_1 of the crank O_1A . These mechanisms are simple in design, provide greater motion uniformity and smaller inertial forces than the offset (non-axial) crank-slider mechanisms. That is the reason they to be mainly used in modern high-speed SMs. The connection between the connecting link and the NB is direct - with an axle between them. A slider is used to stabilize the vertical motion of the NB.

In order to drive the FD and to perform the technological operations, FDM is required to provide the possibility of changing the stitch step and the direction of material movement (to tighten the seam at the beginning and at the end). The implementation of this condition requires the usage of branched poly-contour mechanisms. In Fig.2 is shown the mechanism with upper drive of SM Textima 8332. FDM consists of four, conditionally separate kinematic chains: for horizontal motion of the FD; for its vertical motion of the FD itself and for adjusting the stitch step (not shown in the figure). Both chains for horizontal and vertical movement of the FD have a common drive from the main shaft O_1 of the machine located at the top of the machine.

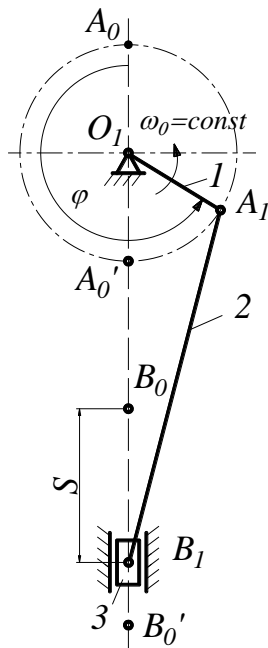


Fig.1. Kinematic scheme of the in-line crank-slider mechanism

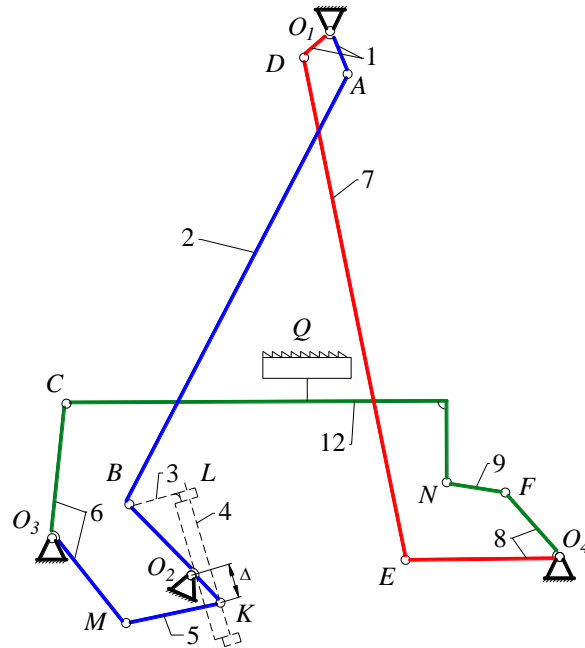


Fig.2. Kinematic scheme of the FDM of Textima 8332

The size of the stitch step needs to be adjusted before the start of the sewing process. This is done by the step adjustment chain by changing the position of point K. During operation of the machine, point K takes an invariably position relative to point O₂ on the axis 4 of the frame 3 and the distance between these two points is Δ = const. The basis for this assumption is the results of a study performed in [7]. After replacement of the actual FDM of Textima 8332 containing a III class Assur group, it is assumed that the chain for horizontal movement of the FD - O₁ABO₂KMO₃ is constructed of two consecutively linked hinged four-bar mechanism (O₁ABO₂ and O₂KMO₃). The results in [7] show that the error in this substitution is below 1%, which is within the acceptable range. For vertical movement of the FD is used the O₁ADEO₄ chain containing a hinged four-bar mechanism.

The FD is installed on the rocker (coupler link) CN of the five-bar mechanism O₃CNFO₄ and performs a general plane motion. The FD is driven simultaneously by the chains for horizontal and vertical movement, which consist of units, some having a general plane motion, and others rotating about one axis.

The Law of Conservation of Energy is valid for the mechanical energy in the NBM and FDM at Textima 8332. The current study ignores the potential energy generated by the rising of the center of gravity and the deformation of the links as it is negligible. Only the kinetic energy is considered in the energy balance. Friction is not considered in the study. The resistance exerted by the material being treated is also not taken into account since the force is different for different types of material and it would not be correct to work with generalized values.

Each mechanism is a mechanical system of connected rigid bodies. According to König's theorem, the kinetic energy of such a system, at every time is a sum of the energies of its links (n number):

$$E_{kj} = \frac{1}{2} \sum_{i=1}^n (m_i V_{s_{ij}}^2 + J_i \omega_{ij}^2) \quad (1)$$

where: E_{kj} – the kinetic energy of the mechanism in this moment, kg.m²/s²;

m_i – the mass of the i-th link, kg;

V_{s_{ij}} – the velocity of the center of gravity of the i-th link in the j-th moment, m/s;

J_i – the moment of inertia of the i-th link, with respect to an axis passing through the mass' center of the link, for the general case of planar motion, kg.m²;

ω_{ij} – the angular velocity of the i-th link, s⁻¹.

In [3] was conducted a study on NBM using the mathematical apparatus proposed in [13]. The mass data, mass moments of inertia and kinematic characteristics of the links were taken into account according to them. Based on the above characteristics in [19] the kinetic energy of each unit and the total energy of the mechanism for the main shaft's one turn of the SM are determined.

The energy consumed by the FDM is determined in [20] using the information for mass, mass moments of inertia, and kinematic characteristics of the links according to the conducted studies in [10] and [11].

When studying the kinematics of the mechanisms, in the aforementioned studies, the "Method of the instantaneous center of velocity" [13], which is universal and easily applicable. This method the question of the particular values of trigonometric functions is solved (0, $\pi/2$, π , $3\pi/2$), the ambiguity of arc-functions, dividing by zero, numerical methods used, accuracy of work, etc.

By this method, the first two transfer function of the mechanism, respectively velocities, and accelerations, are determined by the instantaneous centers of velocity. It is present in summary form in the table 1.

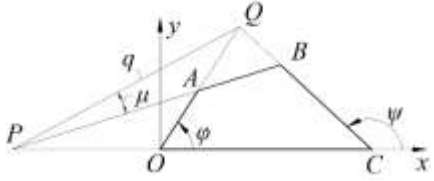
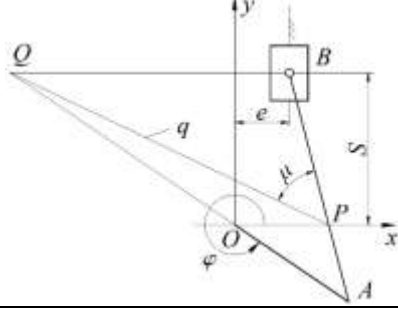
The studies were done with sufficient accuracy, discretely for 72 points in the range of motion of each unit. Generalized coordinate step: $\Delta\varphi = \frac{2\pi}{n} = 5^\circ$, where: $n = 72$. The rotation angle of the drive crank O_1A takes the following values: $\varphi = i \cdot \Delta\varphi$, where: $i = 0, 1, \dots, n$.

For mathematical calculations, a specialized software product was used MathCad 15. The results obtained, each of the parameters searched for, is entered into AutoCAD via a file .scr format. Thus, thanks to the capabilities of AutoCAD, the resulting graphics are sufficiently accurate. To determine the energy change for one revolution of the machine's main shaft, the AutoCAD graphics were used and graphical integration was performed.

The angular velocity of each of the units is a function of the angular velocity ω_0 of the drive unit, $\omega_i(\varphi) = f(\omega_0)$, where: φ - is the angle of rotation of the drive unit; f - is determined by the transfer functions of the mechanism [12].

The mass of the links, the mass moments of inertia and the position of their mass centers are constant values. Therefore, the change of kinetic energy depends on the angular velocity only. For simplicity, in the current study is accepted $\omega_0 = 1$. Furthermore, the resistance of the jointed parts is not considered as it is different for each particular case and depends on the type of textile materials processed on the SM.

Table 1.

	
1	2
Four-bar mechanism	Slider-crank mechanism
<i>angular coefficient of the input unit OA</i>	
$k_{OA} = y_A / x_A$	
<i>angular coefficient of unit AB performing a general motion in a plane</i>	
$k_{AB} = \frac{y_B - y_A}{x_B - x_A}$	
<i>angular coefficient of rights BC (output unit)</i>	-
$k_{BC} = \frac{y_B}{x_B - x_C} \quad (x_C = L)$	-
<i>coordinates of the point Q, the absolute instantaneous center of velocity</i>	
$x_Q = \frac{k_{BC} \cdot x_C}{k_{BC} - k_{OA}} ; y_Q = k_{OA} \cdot x_Q$	$x_Q = \frac{y_B}{k_{OA}} ; y_Q = y_B$

Continuation of table 1.

1	2
<i>abscissa of the relative instantaneous center of velocity point P</i>	
$x_p = x_A - \frac{y_A}{k_{AB}}$	
<i>first transfer function of BC output unit</i>	
$\psi' = \frac{x_p}{x_p - OC}$	$S' = x_p$
<i>angular coefficient of the collinear axis q</i>	
$k_q = \frac{y_Q}{x_Q - x_p}$	
<i>angle between the collineation axis and unit AB</i>	
$tg \mu = \frac{k_q - k_{AB}}{1 + k_q \cdot k_{AB}}$	
<i>second transfer function of BC output unit:</i>	
$\psi'' = \frac{\psi' \cdot (1 - \psi')}{tg \mu}$	$S'' = S' / tg \mu$
<i>kinematic parameters (velocity and acceleration)</i>	
$\dot{\psi} = \psi' \cdot \dot{\varphi}$	$\dot{S} = S' \cdot \dot{\varphi}$
$\ddot{\psi} = \psi'' \cdot \dot{\varphi}^2 + \psi' \cdot \ddot{\varphi}$	$\ddot{S} = S'' \cdot \dot{\varphi}^2 + S' \cdot \ddot{\varphi}$

The working process (according to Fig.1) of the sewing needle begins at about 180° (the moment of penetration of the material) and finishes about 360° (when the needle leaves the material) - the rotation angle of the main shaft of the machine [3]. The period is 180° and consists of two phases - moving down to the extreme lower position (lower dead point) and upward movement until the needle leaves the material.

The results of the analysis of the energy consumption by the units of the NBM, carried out according to (1), are presented in Fig.3 and Fig.4. The study reveals that the energy peaks are at angles of rotation of the main shaft of the machine approximately 15°-20° after the start of the needle working and about 15°-20° before its end. The maximum energy values of the links of the mechanism are [19]:

- 1) of the connecting link $E_{k,AB} = 1,3864 \text{ kg.m}^2/\text{s}^2$ – at 195° and at 345° - Fig.3
- 2) of the executive link (needle bar) $E_{k,nb} = 4,3696 \text{ kg.m}^2/\text{s}^2$ – at 200° and at 340° - Fig.4.

Extremes of $E = E(\varphi)$ on the NBMs' rocker have abscissa that do not coincide with the abscissa of the extremes of $\omega = \omega(\varphi)$. This is due to the fact that the kinetic energy is proportional to both ω^2 and the reduced moment of inertia $J_r = J_r(\varphi)$, which is a function of φ .

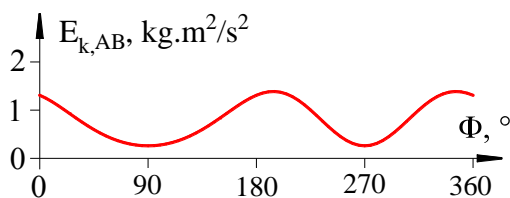


Fig.3. Kinetic energy of the NBM's rocker AB

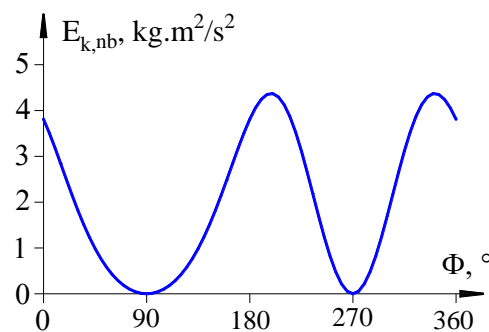


Fig.4. Kinetic energy of the NBM's needle bar

Much more complex is FDM (Fig.2). As mentioned above, it is built up of several conditionally separate kinematic chains. The movement of the FD over the needle plate is realized by rotating of the

main shaft of the SM from 60° to 170° . This is the working process of the mechanism. It starts after the needle has completed its working process, i.e. it has left the material. The period is 110° and consists of two phases - raising and lowering. Its highest point of the FD is between 110° - 120° [11].

The results of the energy research of the links and the chains of the FDM are conducted according to (1) and are presented in Fig.5-7. The indices correspond to the numbers of the units according to Fig.2.

The energy of the chain for horizontal movement of the FD (Fig.5) is most significantly influenced by the energy of the coupler link AB by the six-bar mechanism $O_1ABO_2KMO_3$. At 160° and 340° rotation angles of the main shaft of the machine, the graph has extreme values, respectively $E_k = 62,96 \cdot 10^{-2} \text{ kg.m}^2/\text{s}^2$ and $E_k = 62,05 \cdot 10^{-2} \text{ kg.m}^2/\text{s}^2$ [20].

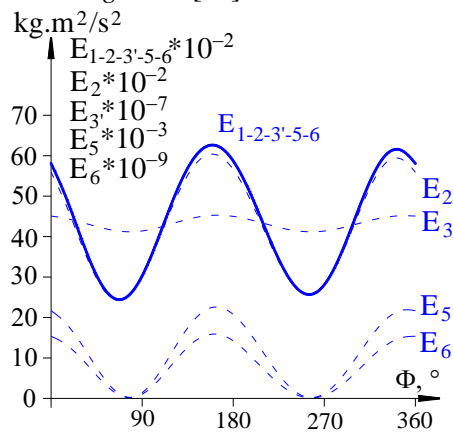


Fig.5. The kinetic energy of the chain of horizontal movement of the feed dog $O_1ABO_2KMO_3$ and its links

On the kinetic energy of the chain for vertical movement of the FD, the main effect cause the kinetic energy of the chain of DE of the four-bar mechanism O_1DEO_4 (Fig.6). The maximum values, $E_k = 18,46 \cdot 10^{-3} \text{ kg.m}^2/\text{s}^2$ and $E_k = 18,55 \cdot 10^{-3} \text{ kg.m}^2/\text{s}^2$ are achieved at the angles of rotation of the main shaft - 60° and 240° [20].

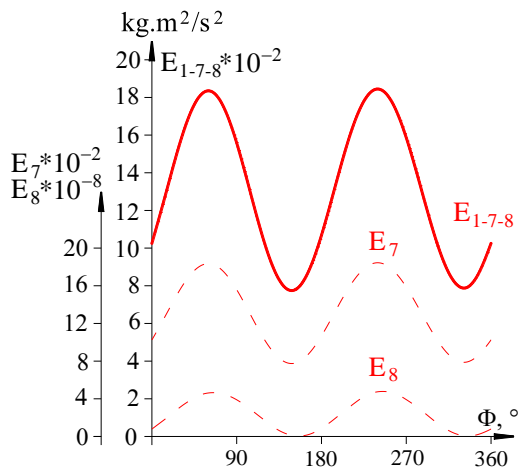


Fig.6. The kinetic energy of the chain of vertical movement of the feed dog O_1DEO_4 and its links

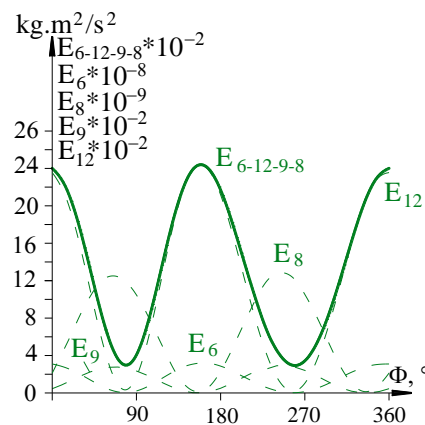


Fig.7. Kinetic energy of the chain of the feed dog itself O_3CNFO_4 and of its links

From the chain on the FD (the five-bar mechanism O_2CNFO_4), the energy of the bearer CN on which the FD is attached is greatest (Fig.7). CN performs plane motion. At the angles rotation 0° and 160° the chain has maximum values on the kinetic energy - $E_k = 24,01 \cdot 10^{-2} \text{ kg.m}^2/\text{s}^2$ and $E_k = 24,61 \cdot 10^{-2} \text{ kg.m}^2/\text{s}^2$ [20].

And here extremes of $E = E(\varphi)$ on the NBM's rockers have abscissa that do not coincide with the abscissa of the extremes of $\omega = \omega(\varphi)$. The kinetic energy is proportional not only ω^2 , but also the reduced moment of inertia $J_r = J_r(\varphi)$, which is a function of φ .

The analysis of the NBM energy balance reveals that the main influence on the total energy consumed and the law for its distribution has the kinetic energy of the NB (position 3 in Fig.1). The energy of the NBM (Fig.8) has two peaks - $E_k = 5,7416 \text{ kg.m}^2/\text{s}^2$, which are during the needle work - at 200° and at 340° [19].

Textima 8332 receives at the angles of rotation of its main shaft 160° and 350° (Fig.9) its maximum values ($E_k = 95,66 \cdot 10^{-2} \text{ kg.m}^2/\text{s}^2$ and $E_k = 93,72 \cdot 10^{-2} \text{ kg.m}^2/\text{s}^2$) of the total energy of the FDM [20].

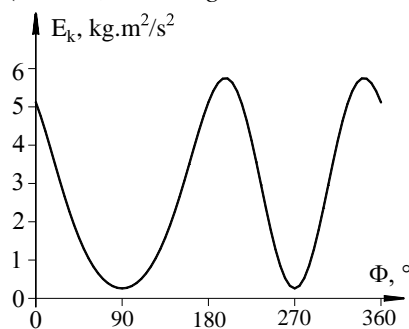


Fig.8. Kinetic energy of the NBM of Textima 8332

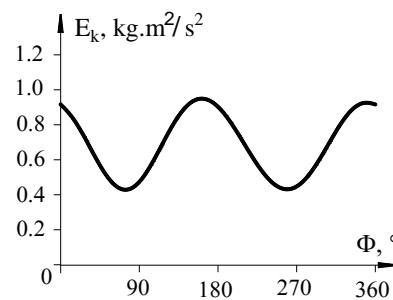


Fig.9. The kinetic energy of the FDM of Textima 8332

The results reveal that the NBM energy peak is nearly 6 times higher than that of FDM. This is due to the much higher speeds of the needle bar mechanism than the speed of the FD and its drive mechanism links.

The energy changing of the mechanism for a given period of time is equal to the work generated by the forces and moments acting on the links of the NBM and the FDM, for the same period.

The energy form of the motion equation is integrated:

$$\int_0^{2\pi} J \omega d\omega = \int_0^{2\pi} M(\varphi) d\varphi \tag{2}$$

taking into account that the work done by the external forces acting on the systems is:

$$A = \int_0^{2\pi} M(\varphi) d\varphi \tag{3}$$

where: A - the work performed by the external forces acting on the system in the 0 to 2π angle of rotation φ of the main shaft of the machine, $\text{kg.m}^2/\text{s}^2$;

J - the mass inertia moment, kg.m^2 ;

ω - the angular velocity of the main shaft, s^{-1} ;

M - the moment of active forces acting on the mechanism.

For each of the both considered mechanisms of Textima 8332, the total energy is determined for a full turn of the main shaft of the machine.

The distribution of the full energy consumed by the NBM is shown in Fig.10. Approximately 1/3 (28.57%) is applied by the mechanism's rocker and slightly over 2/3 by the NB - 71.43%. During the needle's working process, a slight increase in the energy consumed by the NB (from 71.43% to 74.15%) and a small reduction in energy consumed by the rocker (from 28.57% to 25.85%) was recorded.

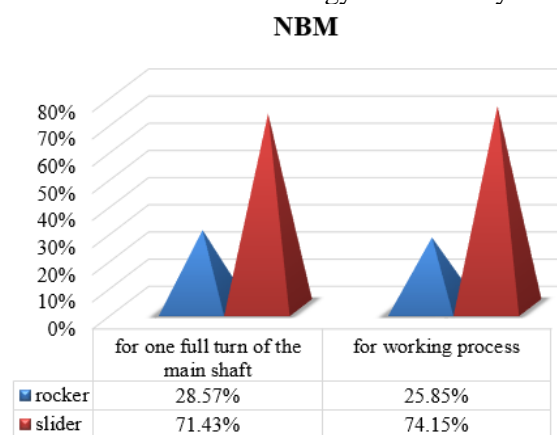


Fig.10. Distributed by units of the consumed energy by the NBM of Textima 8332

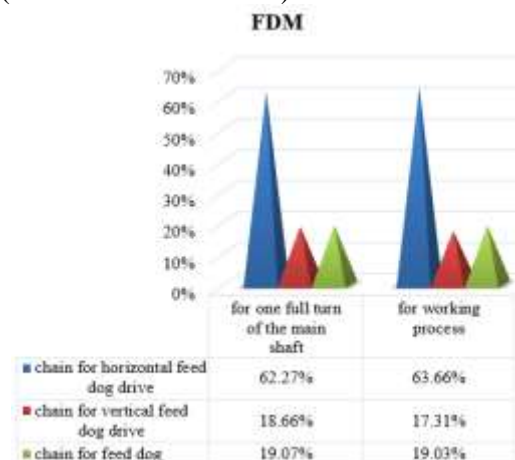


Fig.11. Comparison by links of the consumed energy by the FDM of Textima 8332

The total energy of FDM consumed for one full turn of the main shaft of the machine is distributed in ratios as follows (Fig.11): of the chain for horizontal displacement of the FD share is 62.27%, for the vertical movement chain - 18.66% and of the chain of FD - 19.07%. There is little change in the ratio of energy consumed by the chains of the mechanism during the FDM's working process.

To clarify the performance of both mechanisms, it is important to determine what percentage of energy is spent during their working process. It was found (Fig.12) that:

- over 60% (63.81%) of the total energy consumed by the NBM, for a full turn of the main shaft of the machine, is used to carry out needle's working process (from 180° to 360°).
- only about 1/3 (30.36%) of the kinetic energy of FDM is needed to perform FD's working process (from 60° to 170° turning angle of the main shaft).

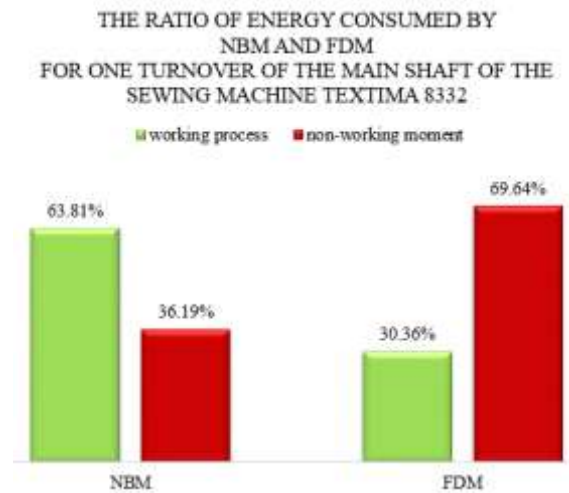


Fig.12. Comparison by energy consumed of the NBM and FDM for a full turn of the main shaft

3. Conclusions. A study for the energy consumed by the NBM and the FDM of the SM Textima 8332 was carried out. The energy consumed changing is evaluated for a full turn of the main shaft of the machine and during the both mechanisms' working processes. The results obtained from the comparative analysis provided the basis for the conclusions:

- the kinetic energy changing of the links of the both mechanisms and the conditional chains of FDM is cyclical, without sharp jumps;
- the main share in the total energy of the NBM, both for the full turn of the main shaft of the machine and during the needle's working stroke, has the energy of the NB (over 70%);
- in the total energy of FDM (for a full turn of the main shaft of a machine and during the working process of the FD), the largest share (over 60%) has the chain for horizontal displacement of the FD;
- both of maximum energies of the NBM are during the needle's working process. This would lead to an increment in the energy balance peaks of the entire machine, as its load is further increased by the resistance of the material penetration;
- over 60% of the total energy of the NBM is spent during a needle's working period, and only about 30% of the FDM's energy goes for realization of the FD's working process.

The NBM is composed of smaller number of links than FDM. However, the results of the comparative analysis revealed that the energy consumed by the needle mechanism is significantly greater. This fact is due to the much higher speeds of the links of the NBM. FDM is built up of several conditionally separate chains, each with number of links. In general, their dimensions, masses and moment of inertia are larger, but their speeds are smaller, which leads to less energy being used to drive the FD.

FDM consumes only about a 1/3 of its total energy to carry out the moving of the sewing's materials. The needle mechanism spends more than 2/3 of its total energy for needle's working period.

REFERENCES

1. K. Trifonov. Innovations and trends in the development of sewing machines. *Journal "Textiles and clothing"*, ISSN 1310-912X, volume 9, pages 11-18, 2003. (in Bulgarian).
2. K. Pejchar and J. Beran. The dynamic analysis of the needle bar mechanism of sewing machines. *ACC Journal*, ISSN 1803-9782 (Online-<https://acc-ern.tul.cz/en/acc-journal>, Issue A), volume 2, pages 60-70, 2011.
3. D. Balabanova. *Research of needle bar mechanisms of the sewing machine*. Ph.D. Thesis, Technical University-Gabrovo, 2014. (in Bulgarian).

4. Bl. Paleva-Kadiyska. Comparative structural analysis of sewing machine material transport mechanisms - part 1. *Reference book of scientific papers, "Trends in the Development of Industrial Systems and Technologies"*, Blagoevgrad, pages 145-149, 2010, (in Bulgarian).
5. Bl. Paleva-Kadiyska. Comparative structural analysis of sewing machine material transport mechanisms - part 2. *Reference book of scientific papers, "Trends in the Development of Industrial Systems and Technologies"*, pages 150-156, Blagoevgrad, 2010. (in Bulgarian).
6. K. Trifonov K, Bl. Paleva-Kadiyska, Classification of mechanisms for transportation of material of sewing machines, *Journal „Textiles and clothing“*, ISSN 1310-912X, volume 6, pages158-163, 2010.
7. Bl. Paleva-Kadiyska. Effect of replacement of a real mechanism for transporting materials with a conditional one, *Journal „Textiles and clothing“*, ISSN 1310-912X, volume 7, pages185-189, 2012.
8. R. Rousev, Bl. Paleva-Kadiyska. Structural analysis of mechanisms for transporting material in sewing machines. *International scientific conference UNITECH 12- Gabrovo*, 16-17 November, Paper ISSN 1313-230X, volume II, pages 184-188, 2012.
9. R. Rousev, Bl. Paleva-Kadiyska. Structural and power valuation of mechanisms for transporting material in sewing machines. *International scientific conference UNITECH 12- Gabrovo*, 16-17 November, Paper ISSN 1313-230X, volume II, pages 189-193, 2012.
10. R. Rousev, Bl. Paleva-Kadiyska. Determination of the kinematic features of the feed dog of mechanisms for transportation of material of the sewing machines. *Journal „Textiles and clothing“*, ISSN 1310-912X, volume 3, pages 58-63, 2015.
11. Bl. Paleva-Kadiyska. *Research of mechanisms for transporting the sewing machine material*. Ph.D. Thesis, Technical University-Gabrovo, 2015. (in Bulgarian).
12. V. Galabov. *Synthesis of mechanisms in robotics*. Technical University, Sofia, 1992. (in Bulgarian).
13. V. Galabov, R. Rousev. Method of instantaneous centers of velocities for kinematic analysis of lever four-bar mechanisms, *Journal Reports*, Technical University, Gabrovo, ISSN 1310-6686, volume 44, pages 30-33, 2012. (in Bulgarian).
14. R. Rousev. Mathematical apparatus used in “method of models” for the study of slider – crank mechanism (RRRP), ARTTE, *Journal of the Faculty of Technics and Technologies-Trakia University*, pages 193-197, 2016.
15. R. Rousev. Mathematical apparatus used in “method of models” for the study of inverse slider – crank mechanism (PRRR). *Journal „Textiles and clothing“*, ISSN 1310-912X, volume 11, pages 17-21, 2016.
16. R. Rousev. Mathematical apparatus used in “method of models” for the study of four - bar linkage mechanism (RRRR), ARTTE, *Journal of the Faculty of Technics and Technologies-Trakia University*, pages 198 – 203, 2016.
17. R. Rousev. Mathematical apparatus used in “method of models” for the study of slotted link mechanism (RRPR); *Journal World Science № 12(28)* volume 1, pages 6-19, 2017.
18. R. Rousev. Determination of the kinematic characteristics of the GROSSE EJP 4 knife box drive mechanism by means of "Model methods". *Journal „Textiles and clothing“*, ISSN 1310-912X, volume 2, 52-56, 2018.
19. Paleva-Kadiyska Bl. Comparative analysis of the energies of needle bar mechanisms of the sewing machines. *Trakia Journal of Sciences*, Stara Zagora, 1313-3551 - ISSN TJS (online) (given for publishing)
20. Paleva-Kadiyska Bl., Study and analysis of energy of the mechanism driving the feed dog of the sewing machine Textima 8332, Open Access Peer-reviewed *Journal Science Review*, 7(7), vol.1, December 2017, pp. 30-34.