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CONTENT

RESEARCH OF SOLAR WATER HEATERS MODEL

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Annotation

This paper is inspired of idea to investigate possibilities to use solar energy for water heating in Lithuania. Lithuania is somewhere between central and north Europe. So that's mean that geographical position is not as favorable as it is in Mediterranean region but as harsh as it is northern Europe. The investigation is interesting and actual because this paper presents the first steps investigate small thermosiphon solar thermal system. Thermosiphon solar thermal systems are more common in south but not in central or even in north of the Europe. The author made theoretical calculation how water temperature in the solar water heater depends on the time and compare calculated data with real measurements.

Key words: *solar water heating, solar collector, collector efficiency, thermal energy measurement, thermosiphon solar thermal system*

Introduction

The basic principle common to all solar heat systems is simple: solar radiation is collected and the resulting heat converted to a heat transfer medium – usually a fluid. The heated medium is used either directly (example for heating tap water) or indirectly (heat exchanger).

This technology is mainly used for:

- domestic hot water and space heating,
- district heating,
- industrial process heat,
- air conditioning and cooling.

Generally, this paper is related to small domestic hot water heating. There to types of small domestic hot water heating thermosiphon systems and forced circulation systems.

In Southern Europe, solar domestic hot water (SDHW) preparation is mainly supplied by thermosiphon systems. These systems, robust, efficient and easy to build, consist of a solar collector with a capacity between 0.7 and 2.1 kWh (between 1 and 3 m²) and a hot water storage unit with a volume of usually 80 to 150 liters for a family of four. A thermosiphon system relies on the natural convection principle to circulate the heat transfer liquid between collector and storage. In this type of installation storage must be above the collector [1].

Because of its simple principle – without the need for sensors, controllers or pumps – and because they are normally used in rather sunny regions and thus do not need to be very efficient, small thermosiphon systems can be very cheap. In the world's largest market, China, systems are available for less than 100 EUR; even in Mediterranean countries; the cost of a newly installed thermosiphon system often does not exceed 1000€ [2].

The only simple controllers sometimes used with thermosiphon systems to switch the backup heater. Simple controller can measure the temperature in the tank and switch the backup heater during the night or in the morning. Also it can be used in colder climate to protect system from freezing.

Forced circulation systems using a pump to move the heat transfer fluid between collector and storage are almost exclusively used in Central and Northern Europe, since it is not usually possible to install the storage tank on the roof above the collector. In addition, the integration of the solar thermal system in central heating systems is easier if the storage tank is located within the dwelling (typically the basement). In Central and Northern Europe, a typical SDHW system consists of 2 or 3 solar collectors with a capacity between 2.1 and 4.2 kWh (3 to 6 m²) and hot water storage with a volume of 200 to 400 liters for a family of four. [1, 3].

Due to more complicated system the cost of a newly installed forced circulation system is between 3500-5000 1000 € (incl. VAT and installation). [2].

The aim of this paper is evaluate the heat exchange between the termosiphon type water heater and environment.

Tasks to reach objectives:

- Calculate energy losses through water tank wall due to different insulation thicknesses.

- Estimate the amount of time during which the water in tank from the maximum temperature decrease to the temperature which is still proper for consumption.
- Compare the theoretical calculations with the results of practical measurements

For years, larger solar thermal systems have been rigorously measured and often connected for remote monitoring and controlling. The rationale is that a failure or under performance of the system can quickly result in high costs – because heat, which could have been supplied by the solar thermal system, must then be generated by electricity, fossil fuels or biomass, all of which are not usually provided free of charge. With smaller systems, this is different: The additional costs of complex (remote) metering and monitoring are proportionally very high. Furthermore, as in smaller systems savings in absolute terms are also smaller, this makes the additional costs of metering and monitoring almost prohibitive. In Germany, a guideline from the Association of German Engineers (VDI 2167) recommends that the additional costs of metering should not be higher than half the expected annual savings. For smaller solar thermal systems this can be a very small amount. [2]

To upgrade (adding measurement features) small solar thermal system, which already have controller cost no more than 100 € (few temperature sensors and flow meter). But if the system was not designed for heat metering, such upgrading remains expensive about 400 €, plus installation costs).

For example, if small thermosiphon costs 800 €, an additional 100 or even 400 € for metering would increase the investment costs from 12.5 to 50%. Today, most small solar hot water systems (especially those of the thermosiphon type) are not metered at all and no information on the actual yield or even the correct performance of the system while in operation exists. And of course such system is not connected to a communications network.

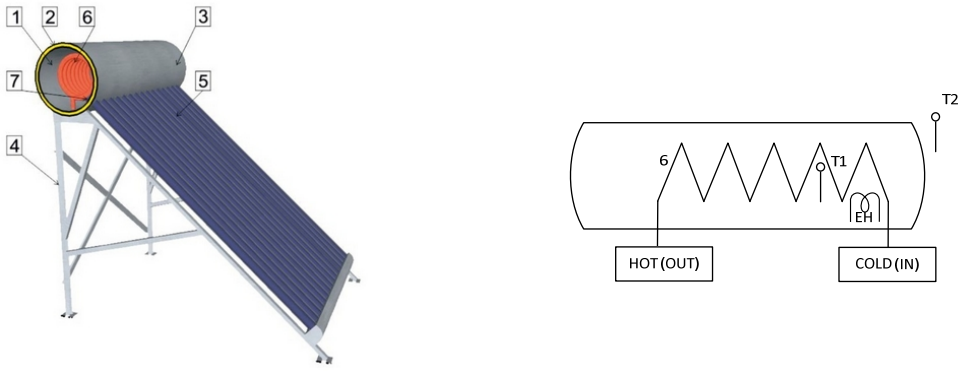
Thermal resistant and temperature dynamics of thermosiphon water heater

The thermosiphon water heater parameters are shown on table 1 and construction is shown in figure 1.

Table 1

Characteristic of water heater tank

Name of parameter	
Thickness of polyurethane foam thermal isolation, δ	0,055m
Inner length h_vid	1,860 m
Outer length h_isor	1,970 m
Inner cylinder diameter, d_vid	0,350 m
Outer cylinder diameter , d_isor	0,460 m
Conductivity of the insulation material, λ	0,03W/mK



a) b)

Fig. 1. Construction of the thermosiphon water heater

a) [4]; inner structure b). In figure: 1. 0,41 mm SUS304B the inner tank is made of stainless steel; 2. 55 mm polyurethane foam thermal isolation; 3. 0,5 mm SUS430 outer tank layer is made of Stainless steel; 4. 1,2 mm SUS201 holding construction is made of Stainless steel; 5. 24 units three-layered 58/1800 vacuum tubing solar collector; 6. SUS316 Stainless steel heat exchanger; 7. Stabilized silicone steel; T1 tank water temperature in level 15 cm; T2 – air temperature sensor; EH – electrical heater.

First of all, the effectiveness of the insulation material layer was calculated. When the inner (water) T_I and outer (weather) T_O temperatures were selected it is possible to calculate theoretical energy loses through water tank walls (Equation 1):

$$Q = R \cdot S\,(T_I - T_O); \quad (1)$$

where S surface area of accumulative water storage tank:

$$S = 2 \cdot S_s + S_p; \quad (2)$$

S_s accumulative water storage tank sidewall surface area:

$$S_s = \pi d h; \quad (3)$$

S_p accumulative water storage tank base surface area:

$$S_p = \pi \left(\frac{d}{2}\right)^2. \quad (4)$$

The data required to calculate S_s and S_p are submitted in table 1.

The thermal resistance of water storage tank walls is calculated using formula 5:

$$R = \frac{\delta_n}{\lambda}; \quad (5)$$

The thermal resistance of the insulation foam was counted for 4 different δ_n values: 0.055 m (current thickness of the device under test), 0.075 m, 0.1 m, 0.15 m.

The energy loss (Q, J), dependence on dT $dT = T_I - T_O$), using different thicknesses of insulation materials δ_n (different color lines), are given in Figure 2, (wind effect and loses through vacuum tubes was not taken in to account).

The calculation results observed in figure 2 are more theoretical. Observed curves showing losses when the difference between indoor and outdoor temperature is constant. So this calculation shows only theoretical losses, but does not reflect the situation when the temperature in the tank decrease, but the outdoor temperature remains stable. In this case, the difference between the temperature inside and outside of the water tank decreases, resulting in a decrease in energy losses.

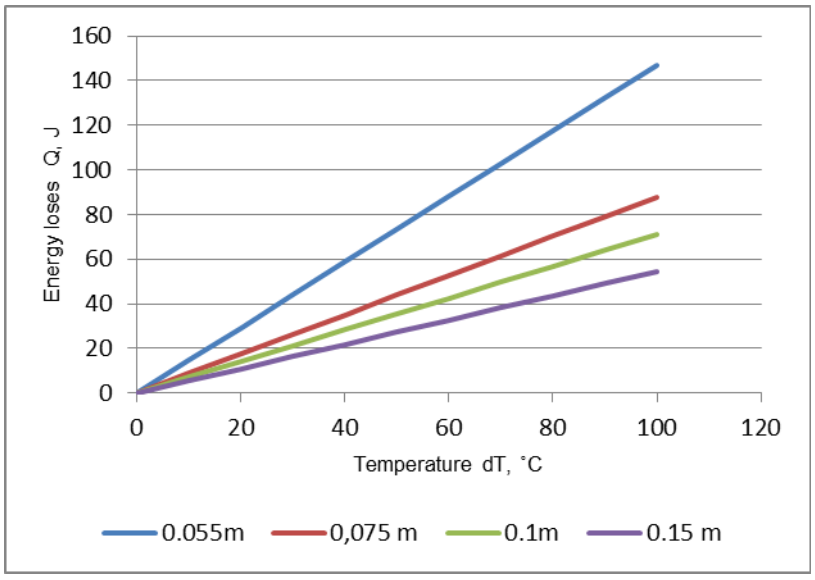


Fig. 2. The energy loses Q dependence on dT, using different thicknesses of insulation materials δ_n (different color lines)

According calculation results (figure 2) it is possible to reduce energy loses: ~ 40 % if the insulation thickness increased from 5.5 cm to 7.5 cm, by ~ 51 % if the insulation thickness increased from 5.5 cm to 10 cm; ~ 63 % if the insulation thickness increased from 5.5 cm to 15 cm when outside temperature is + 10 ° C.

The calculation how the temperature of the water in the tank changes according to time was performed. Equation 1 allows calculating instantaneous losses (J). The equation 1 was modified to equation 7 which allow calculating energy losses in time interval ($\Delta\tau$).

Heat flow through the walls of the water storage tank during time period:

$$Q_k = R \cdot S\,(T_I - T_0) \cdot \Delta\tau; \qquad (7)$$

where *R* – thermal resistance obtained from formula 5 (according parameters from table 1); T_I – water temperature; T_0 – weather temperature; S – the surface area of the water storage tank obtained from formulas 2 – 4; $\Delta\tau$ – time period for calculation of energy loses.

When calculating the energy loss through water tank walls over time, it was assumed that accumulated energy is not used for tap water heating. Also was assumed that the system does not have any external influences as wind and etc.

In order to calculate the temperature of tank water dependence over time using equation 7, it is necessary to know the amount of energy accumulated in the tank water.

Accumulated energy in the tank water:

$$Q_{H2o} = c_{H2O} \cdot m \cdot (T_{I1} - T_{I2}); \qquad (8)$$

Where c_{H2O} – specific heat capacity of water (c_{H2O} =4200 J/(kg·°C) or 1,163 (W·h)/(kg·°C)), T_{I1} – max. temperature of water T_{I2} – min. temperature of water, *m* - the water mass calculated from the volume *V*:

$$V = \pi r^2 \frac{d\_vid}{2} = 178{,}953\ \text{cm3}; \qquad (9)$$

If accepted that ρ_{H2O}=1000 (kg/m³)), water mass *m* = 179 kg.

Further it was assumed that the reason of decrease water temperature in the tank is losing water energy Q_{H20}, because of heat Q_k loss through the tank walls to environment, over the time $\Delta\tau$.

From this assumption, can be stated that the water temperature in the tank is a function of time, energy loss through thermal insulation and the amount of stored energy in the water:

$$T=f(Q_{H20},, Q_k, \Delta\tau), \qquad (10)$$

In this case, equating equation 7 with equation 8, the next expression was created:

$$Q_k = Q_{H2o} \qquad (11)$$

In equation 7 and 8 was used such note (because the system of energy exchange between water and air is being studied):

$$T = T_I = T_{I1}. \qquad (12)$$

In further calculations was assumed that the outdoor minimum temperature $T_0 = 10^{\circ}C$. Such a temperature is more typical for the early autumn or for the later spring nights, when the solar water heater collects energy per day and needs to keep high temperature of the water overnight. During the summer, the amount of solar energy is excess and the night temperatures are higher. Using the equation 11, the temperature T function from the time $\Delta\tau$ was extracted:

$$T = \frac{1674\tau + 14{,}8\Delta\tau}{100 - 1{,}48\Delta\tau}, \qquad (13)$$

This function is suitable for use at a positive outdoor temperature.

Using equation 13, the water temperature drop curve in water heater was obtained. (Figure 3). It was assumed that there was no solar energy during the calculated period.

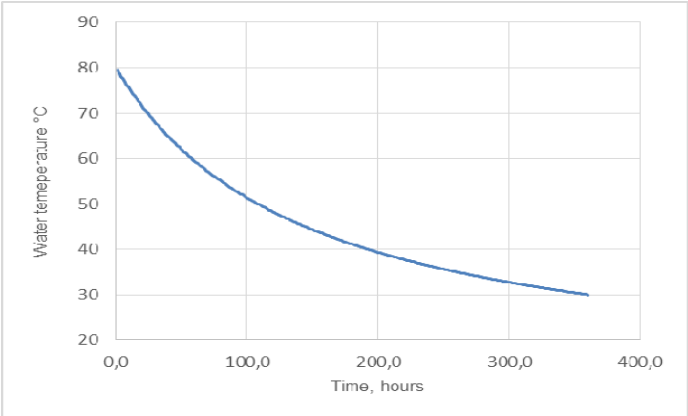


Fig. 3. The water temperature in the solar water heater depending on the time, (the temperature loss is only due to the difference between the outside and the internal temperature) when outdoor temperature is $T_0 = 10°C$.

The authors accepted that the minimum temperature of water which are suitable for domestic use is +40°C – +45˚C. According this acceptation and curve from figure 3 can be stated that the temperature decrease from 80˚C to 40 – 45˚C within 140-180 hours or 6-7 days. Also was assumed that the system does not have any external influences such as wind or water consumption which can decrease temperature much faster than it was shown in figure 3.

Another important factor was to calculate the dynamics of the internal temperature of the solar water heater at a negative outdoor temperature. It was calculated assuming that the outdoor temperature $T_0 = -10°C$. This minimum temperature is typical for January – February months. Using equation 11, the temperature T function from the time $\Delta\tau$ was extracted:

$$T = \frac{16747 - 14{,}8\cdot\Delta\tau}{168 + 1{,}48\cdot\Delta\tau}, \qquad (14)$$

Practical examination

The experiment was held in winter time so the electrical water heater was use to increase the temperature of water in tank (described table 1 and figure 1) till +65°C. When the temperature reached 65°C, the electrical heater was switched off. The weather temperature outside and water temperature inside the tank was measured using digital temperature sensors. The weather temperature T_0 during experiment was between $-5°C \div +2°C$. After switching off the electric heater, the temperature variation in the water tank was observed and the comparison with the theoretically calculated data was executed. Theoretical calculation was made using equations 13 and 14. The results are given in Figure 4.

In figure 4 large differences between real situation and theoretical calculation was observed. The main reason can be the wind effect which was not included in theoretical calculation but make big influence in real situation; other reason energy loses through vacuum tube connection and improper quality of insulation material or insulation layer.

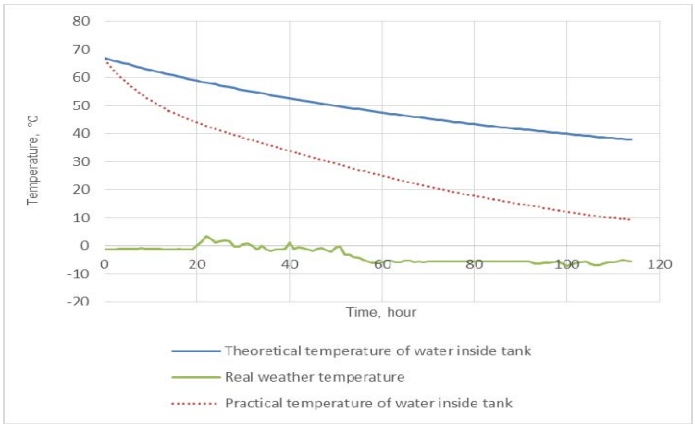


Fig. 4. Comparison of the actual temperature in the water tank with theoretical calculations (for theoretical calculation the temperature loss is only due to the difference between the outside and the internal temperature) when outdoor temperature is $T_0 = -5°C \div +2°C$.

Conclusions

According calculation it is possible to reduce energy loses by 40% if the insulation thickness increased from 5.5 cm to 7.5 cm, when outside temperature is + 10°C.

Theoretical calculation shows that the water temperature decrease from + 80°C to + 40 – 45°C in 6 – 7 days period, when outside temperature is + 10°C.

Temperature curve obtained after practical measurement have the same trend as theoretically calculated, but the measured and theoretically calculated temperatures still have large difference. This difference can be explained using inaccuracy of theoretical model and possible shortage of tested water tank.

Future works

Improve theoretical calculation model by introducing wind effect.

Check the quality of insulating layer using thermovisor.

Create metering and remote monitoring system for small thermosiphon type water heating system.

Measure produced solar thermal heat in thermosiphon type water heating system.

Acknowledgements

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MODELLING COMPUTER NETWORK PROCESES BY USING QUEUING THEORY

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Annotation

This article analyses e-learning network. It evaluates influence of network traffic parameters to its service quality. The empirical model of e-learning network is described. Based on the classical queuing theory methods mathematical model of the e-learning network M/M/m/N//LIFO was developed. The characteristics of data flow are described analytically: the average time of the packet existence in the system, the average number of packets, the probability of the packet being served, the average number of packets in the queue, the average time of the packet was waiting in queue. Formulas for the efficiency of the network service evaluation are described analytically according to the services provided in the network. Statistical simulation methods were applied for data flow delay estimation based on the results of the e-learning network traffic analysis.

Key words: *M/M/m/N//LIFO, computer network service theory, service efficiency, delay, queuing theory.*

Introduction

The network components and processes for efficient analysis of computer network packet flow must be mapped by using mathematical models and methods of queuing theory. Empirical studies confirm that the flow of computer network packets is self-similar (Samorodnitsky, 2006, Kaklauskas, Sakalauskas, 2008, Taqqu, Teverovsky 1998). This feature allows to predict traffic change and the results can be used to improve the quality of network service (QoS) by controlling packet delay, restricting fluctuations, packet loss in transport, data, and physical OSI (Open Systems Interconnection) layers (Salama, and etc. 2017, Yousefpour, and etc. 2017, Spurgeon, Zimmerman, 2014, Jankuniene, Priksaitis, 2010, Rutka, 2009, Kaklauskas, 2003). Quality assurance of the computer network service is one of the aspects of the theory developed by A. K. Erlong (Lee, Kumar, 2008). Erlang sought to establish method for determining the number of communication channels by analyzing the telephone network. This method would allow minimize call losses and service all subscribers of the network. Danish scientist V. B. Iversen has developed this aspect and called it tele traffic theory (Iversen, 1985, Iversen, 2005). Subsequently the basics of the queuing theory was developed by A. Chinchin, D. Kendall, J. Sztrik and many other scientists (Хинчин, 1963, Kendall, 1953, Sztrik, 2012). In Lithuania the queuing theory is being developed by Rindzevičius, Sakalauskas and other scientists. The queuing theory integrates a number of concepts specific to communication technologies: arrival rate (λ), service rate (μ), service time, load factor (ρ), cannel load factor (q), number of serviced channels (M), average service time of one packet ($\overline{X}$), average number of packets in the system ($\overline{N}$) and etc. (Lee, Kumar, 2008).

Computer network nodes are often subject to unpredictable congestion, and therefore efficient network management requires monitoring and forecasting network load and overload to maximize network service quality. It is established that the classical Markov models, used for evaluation of phone networks, is not suitable for modeling modern computer networks (Taqqu, Teverovsky, 1998). The empirical Surveys of Ethernet network flow by A. Erramilli, O. Narayan and W. Willinger in 1989 confirmed that Ethernet Flow Characteristics have fractal properties and is self-similar with long-range dependence. Later self-similarity was investigated by Kaj, Taggu, Samarodnitsky and many other scientists (Samorodnitsky 2006, Kaklauskas, Sakalauskas, 2008, Taqqu, Teverovsky, 1998). The properties of modern communication networks flows are evaluated using statistical analysis methods and mathematical modeling. The network flow is analyzed as a fractal process, characterized by a second-order statistical self-similarity and by fractal measure (Kaklauskas, Sakalauskas, 2008). To simulate and describe network processes it is recommended to use non-linear analysis (chaos theory) methods with estimation of heavy – tails, which characterize large network fluctuations (Василенко, 2004, Feder, 2013). The purpose of the research was to develop a mathematical model for analyzing packet traffic flows for e-learning servers and clients (students, lecturers and other pedagogical staff) for service quality evaluation, based on the paradigms of the theory of queuing. It is important to note that there is a great deal of network traffic self-similarity research (Thomson, and etc. 2018, Jeong, and etc. 2017, Kim, and etc. 2007) although similar

e-learning network traffic research by using queuing theory are absent. Initial research of the e-learning' computer network nodes flow confirmed their self-similarity (Kaklauskas, Sakalauskas, 2008, Kaklauskas, 2016). Measurement results were processed by calculating the correlation measure of aggregated rows, analyzing the attractors, evaluating the fractal dimension, calculating the Hurst index, using robust methods for stable random values measurement. The analysis of time series has shown that the measured flows are characterized by self-similarity and high traffic burstiness which affects data packet delays and its losses (Kaklauskas, Sakalauskas, 2013).

1. Empirical model of distance learning network

The analyzed e-learning network equipment is compatible with 802.3 (Ethernet / FastEthernet / GigabitEthernet) standard. Network segments serve customers at 100Mb, while the router with switches and server array connect 1000Mb (1Gb) speedways (Spurgeon, Zimmerman, 2014). The logical scheme of the e-learning network is provided in Fig. 1. The router is main network node, ensuring interoperability of the Ethernet and external network users with the e-learning' servers cluster. Queries are distributed through high-performance commutators (Jankuniene, Priksaitis, 2010, Kaklauskas, 2003).

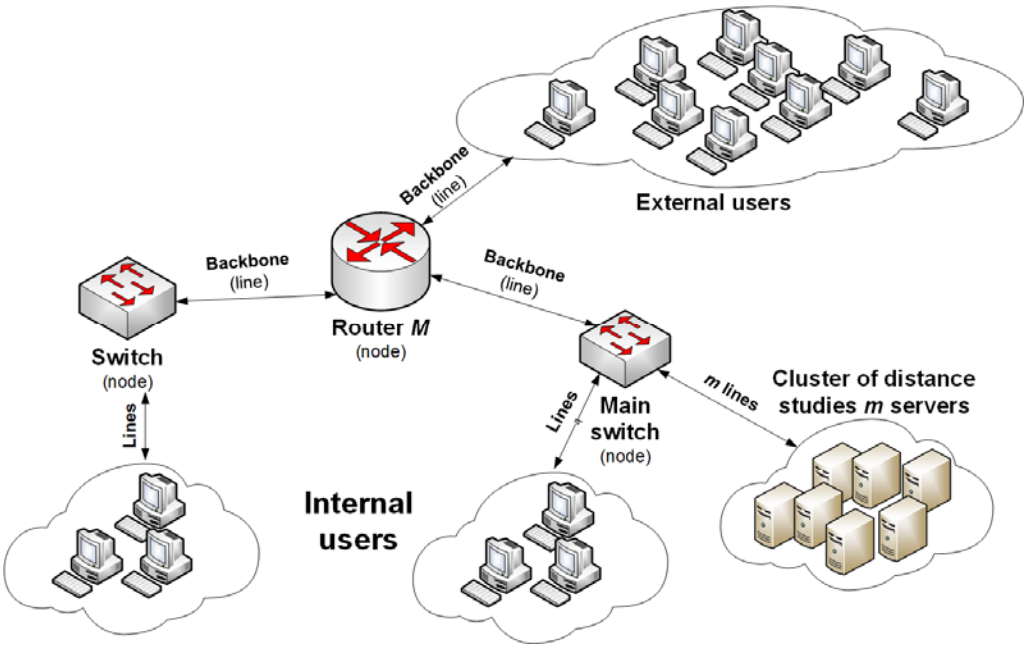

Fig. 1. The logical scheme of the distance learning subsystem

A router is used to form large networks, describe the routes of information streams, thus connecting various types of networks. The static and dynamic routing protocols can be used for data routing. The e-learning' network uses OSPF (Open Shortest Patch First) protocol, which generates links between other network nodes using the Deikstra algorithm for linked graphs G = (N, E), where N is a set of network nodes and E is lines connecting these nodes. This algorithm creates shortest routes - paths p from sender to recipient. The route list is generated by the algorithm (Tanenbaum, Wetherall, 2010, Kaklauskas, 2003):

- node M, which creates routing tables, sends all its network nodes a query to get information about weight coefficients of routing of connected lines, estimating the line speed;
- determines neighbors and their routes weighting coefficients are recorded on the first row of the route table, while the other weighting factors in that row are marked as infinity;
- now we calculate the weight coefficients from the nearest neighbor of M to its neighbors and write them in the second row of the routing table, rejecting the duplicate routes in the first row and the weight coefficients to other nodes marking as infinity;
- the calculations are continued until the coefficient of weight of each most distant from the M network node neighbor is evaluated.

The network routing is described by the formula, according to the classic network routing task: $\min \sum_{i,j} D_{ij}(F_{ij})$, when the selected traffic flow is subject to a restriction $\{x_p \mid w \in W, p \in P_w\}$, and the routes satisfy the conditions:

$\sum_{p \in P_w} x_p = r_w$ for all $w \in W$ and $x_p \geq 0$ for all routes $p \in P_w$.

The following denotation are used here: *W* – all possible pairs *w* "sender-recipient" set; P_w – sender and recipient hosts connecting pairs *w* set; x_p – road *p* flow; r_w – network traffic requirements for connection pairs *w*; F_{ij} – total flow passing e_{ij} line, i.e. $F_{ij} = \sum x_p$ and summing up is performed by adding all routes *p* transmitted over the e_{ij} line; $D_{ij}(F_{ij})$ – weight function associated with e_{ij} line technical characteristics such as packet loss factor, interference, speed (Kendall, 1953, Sakalauskas, 2000).

Switches in the computer network distribute information flows based on the sender and recipient addresses that are used to create network segments. The switches of 802.3 standards, showed in fig 1. have 48 100 Mb ports with automatic speed determining and two 1000Mb ports. Packets delay are no more than 13.3μs, queuing use LIFO (Last-in-First-out) method, the switch can store up to 8000 address tables, switching speeds of 13.6 Gbps.

2. M/M/m/N//LIFO network queuing model

According to the theory of queuing packet a stream that comes in and are serviced in the network of e-learning are simple flows (M) so their packets are distributed according to the Poisson law. The flow is characterized by stationary (in the time interval, the number of T-packets depends only on the length of the interval and does not depend on the position of interval T on the time t-axis), the ordinality (the packets forming the flow, come in the system only one, not in pairs, in threes, etc.) and without interactions (such packet flow is described by the number of packets in the intervals for any non-overlapping time intervals that does not depend on the number of packets that fall into other intervals). *m* is a number of servers. N is a number of packets in queue that are served by using the LIFO method. The number of packets coming to the system is unlimited. This model will help to assess the impact of the network parameters to the quality of network work QoS (Giambene, 2014, Sakalauskas, 2000).

The duration between appearance of packets in the analyzed network traffic is described by the exponential distribution $F(t) = 1 - e^{-\lambda t}$ with the density function $f(t) = \lambda e^{-\lambda t}$. The probable value (average) of the time between events τ is calculated – $\bar{\tau} = \frac{1}{\lambda}$ and the flow dispersion – $D^2\tau = \frac{1}{\lambda^2}$. This packet stream of computer networks in general is distributed according to the Poisson law:

$$P(N_{t,\tau} = k) = \frac{(Q_{t,\tau})^k}{k!} \cdot e^{-Q_{t,\tau}},$$

where $N_{t,\tau}$ is the number of packets received in the packets serving system or main switch during the time interval $(t, t+\tau)$, $Q_{t,\tau}$ is average traffic intensity during the time interval $(t, t+\tau)$ and calculated by $Q_{t,\tau} = \int_t^{t+\tau} \lambda(u)du$, where $\lambda(t)$ is traffic intensity in the time interval *t* and $\lambda(t) = \lim_{\tau \to 0} \frac{Q_{t,\tau}}{\tau}$. The network flow described by the Poisson law is characterized by the features of boundary superposition and the random rarefaction (Giambene, 2014).

If we do not consider the fact that the network data flow is fractal, then the M/M/m/N//LIFO system characteristics can be calculated using the classical formulas. The average time the package is present in the system is found by the formula:

$$\bar{T}_s = \frac{\overline{N_s}}{\lambda} = \frac{1}{\mu} + P_s \cdot \frac{1}{m\mu - \lambda},$$

where μ – traffic flow rate, λ – input flow rate, P_s – the probability that all service devices will be occupied when the packet comes in to the system. To calculate the average packet, stay time in the system it is necessary to evaluate the distribution of packet lengths in service system. Generally, in computer networks, the lengths of packets are distributed according to the

exponential law so the average of their length is calculated (Giambene, 2014, Sakalauskas, 2000). Average number $\overline{N}$ of packets in the system, when system load $\rho = \frac{\lambda}{\mu} = \lambda\overline{T_{pak}}$, is calculated according to the formula:

$$\overline{N} = \sum_{k=0}^{\infty} kp_k = m\rho + \rho\frac{(m\rho)^m}{m!}\frac{P_s}{(1-\rho)^2}.$$

The probability that all service facilities will be occupied during while packet's transition to the system is found by the formula:

$$P_s = \frac{\frac{\rho^m}{m!}}{\left[\frac{\rho^m}{m!} + (1-\rho)\sum_{k=0}^{m-1}\frac{\rho^k}{k!}\right]}.$$

The average number of packets in the queue is:

$$\overline{N_Q} = P_s\frac{\rho}{1-\rho}.$$

Average packet waiting time in the queue is calculated as:

$$\overline{W} = P_s \cdot \frac{1}{m\mu - \lambda}.$$

3. Evaluation of the efficiency of e-learning computer network service

The evaluation of effectiveness of e-learning computer networking is related to the services provided in it. It should be noted that in the network there is used e-learning environments. To maintain these environments there are used services:

- web server (Apache), serving the e-learning' environments via http (Hyper Text Transfer Protocol) protocol over logical port 80;
- a database server (MySql) for storing information and serving customers through a 3306-logical port.

In addition to these core services, the network provides additional services that ensure the reliable proceeding of the core services:

- DNS - works by 53 logical port and ensures the exchange of domain names into the numerical format of IP addresses;
- Packets serving Mysql protocol that provide client and MySql server connection setup and data transmission over the network: Handshake Initialization Packet, Client Authentication Packet, OK Packet, Error Packet, Command Packet, Result Set Packet;
- Eight methods of http protocol that ensures high quality customer service: head, get, post, put, delete, trace, options, connect;
- ICMP protocol service packets for network devices control: Echo Reply, Destination Unreachable, Source Quench, Redirect Message, Echo Request, Router Advertisement, Router Solicitation, Time Exceeded, Parameter Problem: Bad IP header, Timestamp, Timestamp Reply, Information Request, Information Reply, Address Mask Request, Address Mask Reply, Traceroute;
- Service package Hello in OSPF routing protocol;
- Other non-recognized packages circulating in the e-learning computer network for servicing other services.

Investigations have shown that the number of network service packets in the total traffic does not exceed one percent (Jankuniene, Priksaitis, 2010, Lemoine, 2004). The network model that is being analyzed complies with the Ethernet standard for the local area network, so the standard formula can be used to calculate its efficiency:

$$E = \sum_{i=1}^{S}\varphi_i P_i(t),$$

where φ_i – the importance of the service *i*, where $\sum_{i=1}^{N}\varphi_i = 1$, $P_i(t)$ – the probability of providing the service *i* at any time *t*, S – the quantity providing services in the network. The data packets from users to servers goes through the routers and switches (Fig. 1) which means that the standard formula needs to be rewritten according to estimation of the Router-Switch's

service path and considering that all e-learning users are divided into lecturers (ensuring students group learning) and students:

$$E = \sum_{k=1}^{m} \phi_k \sum_{j=1}^{S} \varphi_{jk} \prod_{i=1}^{M_{kj}} P_{ijk}(t_{ijk}),$$

where m – the quantity of servers used in the network, S – the quantity of services provided, M_{kj} – quantity of services provided by switching nodes (including routers) (2 nodes), ϕ_k – server importance coefficient, φ_{jk} – the importance coefficient for the j-th service of the k-th server, P_{ijk} – the probability that from k-th server providing j-th service on service way will be working i-th switching node in all connection time t_{ijk}. The exponential expression $P_{ijk}(t_{ijk}) = e^{-\lambda'_{ijk} t_{ijk}}$ is used to calculate the probability P_{ijk}, where λ'_{ijk} – the frequency of the failure of the k-th server providing the j-th service through the i-th switch. If the reliability of a network depends on the importance of separate switches, then the efficiency of each switching device is calculated based on the formula:

$$K'_{sv} = \frac{\sum_{k=1}^{T} \phi_k \sum_{i=1}^{S} \varphi_{ik} \cdot n_{ik} \cdot t_{vi}}{\Delta t},$$

where n_{ik} – the amount of use of the k-th server's i-th service over time Δt, t_{vi} – the average time worked by the switching device for serving i-th service (Balaišis, Eidukas, 1999).

4. Evaluation of data flow delay

The e-learning' computer network is characterized by the following qualitative indicators:

- Throughput, that is used to explain the amount of data which can be transferred during a specific time interval and is related to network segment speed, node transfer rate, and network transmission rate of used applications;
- packet loss – the amount or extent of data packets lost in each time interval;
- packet delay – the time, required to reach online study server from the student computer, that is related to the packet's propagation delay time t_{prop} (Propagation Delay) and $t_{prop} = \frac{L}{V}$, where L is the length of the physical line, the V – propagation line speed, Nodal processing delay t_{node}, Queueing time t_{que} and Transmission Delay t_{trans} and $t_{trans} = \frac{D}{B}$, where B is the bandwidth, and D is packets size measured in bits;
- Delay fluctuations (jitter) are changes in packet delay parameters during the studies, resulting from queues formed in network nodes, faults in the network, routing failures and social factors.

Delay for end users is calculated by adding up all four delay components (see Fig. 2), evaluating network nodes and is generally counted as a round trip time (RTT):

$$RTT = 2\left(t_{trans} + \sum_{i=1}^{N} (t_{node} + t_{que} + t_{prop} + t_{trans}) \right) + t_{serv},$$

where N – quantity of network nodes, t_{serv} – the time it takes for the package to be served on the server (Balaišis, Eidukas, 1999).

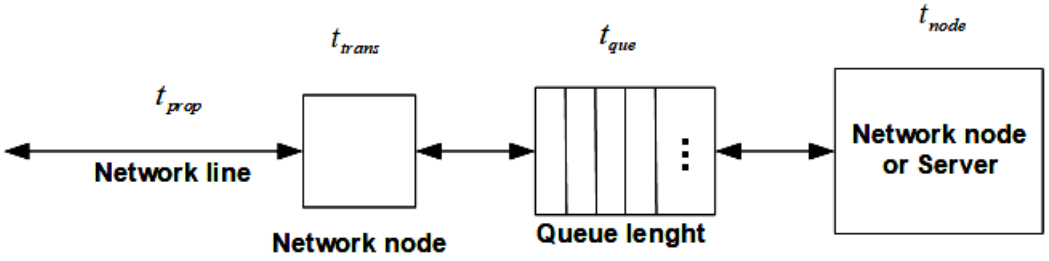

Fig. 2. Network Flow Delay Scheme

Conclusions

1. Based on the classical methods of service theory the mathematical model of the e-learning network M/M/m/N//LIFO was developed;
2. Empirical model of e-learning network was prepared;
3. The data flow characteristics was described analytically, and service model M/M/m/N//LIFT was designed;
4. The efficiency of the network service was described by using analytical formulas which dependes from services provided on the network;
5. The statistical simulation methods, based on the results of the distance learning network traffic analysis, were applied for estimating data flow delay.

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SYNERGY AND SYNERGY PARAMETER

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Annotation
Synergies in collective systems and its dependence on parameter of synergies are considered. As synergistic effect is only the result of collective self-organization system, there are proposed does not take into account the effects not related to collective self-organization under the synergistic effect calculation. This are proposed to define synergistic effect as a function of self-organizing measure of a collective system.

Key words: *synergy, synergy parameter, self-organization, cyber corporation, open system, GAP-analysis.*

The integration into the world economic community, competitive requirements capable of effective development at all levels of Government have led to the creation of corporate systems. Unlike a conventional system the corporate system to a much greater extent provides synchronization of efforts of each element of the system. This synchronization to a very large extent is accomplished by advanced information technologies using. The emergence of enterprise systems and cyber corporation significantly changed economic and political culture of our society. Problems of interaction of the elements and sub-systems of the corporate system in terms of education, synergy are now very topical and are not well understood [1].

For the first time the term "Synergetics" Haken was proposed as the concentrated expression of self-organization in the open system and its arrangements with competing environment [2]. Synergetics is a logical continuation of the cybernetic approach to collective system. An integral part of the Cyber-system is the dominance of negative feedback on the positive. It is the dominance of negative feedback ensures stabilization processes in the system. This does not mean the total absence of positive feedback that the system needed to ensure complacency results action system. In the presence of intense positive feedback to stabilize the system, you must maintain and the dominant negative feedback. It is hard to occupy a leading position on the competing market but even harder to hold on to positions of leadership. To stabilize the system leader is not possible to be guided by the examples of competing environment and system has had to spend large sums of money to identify gaps in its activities on the basis of only their interactions with potential consumers. So to maintain the required level of negative feedback producers of goods and services spend a lot of money on intensification of positive and negative reviews from customers. Some firms even injected material reward consumers for the most significant comments about their products and services.

Synergy based on system performance as the open revealed the formation of backward linkages. Open system generates their feedbacks on the basis of their interaction with competing environment. Only intensive contacts with the competing environment allow you to form a dominant negative feedback. As an open system view commits to undertake active in the collection and analysis of information related to the results of its activities. Open system does not mean the disclosure of its confidential information and technological secrets, but obliges us to receive information about competing surrounded by all legitimate means.

It is undisputed now restructuring the system with functional business process principle [3]. Business process structuring is possible and effective only within the system operating according to the principles of open systems. Business process structuring system provides, first of all, synchronization of open system elements both inside the business process and in the interaction of business processes. Such structured contacts can reduce the number of system elements, which should not exceed seven [4]. Business process approach provides a more transparent mechanism of interaction as elements within the system and contact systems with consumer and competitors. Active transition from functional business structuring process is hampered, to a large extent, the habit and the conservatism of the leaders, on the one hand, and the reluctance of some elements of the system to make its activities more transparent to the environment, on the other hand.

Rules of business-process approach are limited in the standard series ISO 9000. In accordance with this standard requires the Organization have to provide accountability for each business process. This reporting allows you to present the Organization's activities in a transparent and standardized functional uniform. The structuring reporting system according to

the standard ISO 9000 is not only fictitious but is a brake in the development of the system itself. The latter is connected with the fact that the activity of such a system is not transparent, and more confusing.

Business process approach is the basis for the transition from work in a group to group work in the system organization. The group work involves not only saving regulated action of each element of the system but also bottom-up. Bottom-up approach allows you to provide dynamic development of corporate system in the face of stiff competition from the external environment. Under group work collective self-organization system is supported by the transparency for all elements of the system as a whole and each element separately. Only teamwork ensures self-organization system to the peaks of intuitive decision-making by qualified members of the system.

Despite the undeniable advances in understanding mechanisms of functioning corporate system there are intractable problems [5]. These include [6]:

1. formation of self-organizing behavior of complex multidimensional objects;
2. using modern technologies and management techniques, dealing with management capabilities (synergism) of the elements of the system;
3. enabling the integration mechanisms that allow you to take advantage of specialization:
4. formalized description of mechanisms of functioning and decision-making.

The concept of synergy systems is a key activity in the corporate system. This notion can be defined by two items:

5. from the standpoint of comparative mapping system with other non-corporate systems;
6. from a position of self-sufficient operation of the corporate system.

From the perspective of the first approach a comparative quantitative analysis of corporate system and similar systems for assigning smaller level is carried out. In the article [6] it is offered to assess synergy by factor S_0:

$$S_0 = \frac{F(x_a + x_b)}{F(x_a) + F(x_b)} \quad (1)$$

where: (F) - the function of system performance

x - the capacity of the system.

According to (1) for the systems A and B alone and as part of the overall corporate merger value $S_0 > 1$ means positive synergism, value $S_0 < 1$ indicates the ineffectiveness of such a merger. However the value of S_0 does not reflect the fact that exploitation systems. Each element of the system is subject to varying degrees of exploitation, i.e. unreasonably reduced remuneration for maintaining synergy system. This value can be defined as Φ(x). Then the synergies system efficiency when merging A and B can be expressed by analogy with [5] coefficient S_1:

$$S_1 = \frac{F(x_a + x_b) - \Phi(x_a + x_b)}{F(x_a) - \Phi(x_a) + F(x_b) - \Phi(x_b)} \quad (2)$$

It is obvious that F() > Φ() and $S_1 > 0$. The value of $S_1 = 1$ means the synergistic effect of merge completely is absent in the joint system. The value of $S_1 > 1$ signifies that the synergetic effect of the joint system is higher than that of the systems A and B. The value of $S_1 < 1$ indicates not the prospect of merging A and B.

As at merging the two systems into a larger system *the* introduction of innovative technologies leads to reduction of expenses of rather separate element of system*,* most often the scale effect leads to increase in synergetic effect.

In terms of the synergetic effect the system integration process is also beneficial because an additional image associated with the scale effect. On the other hand, excessive monopolization in the system activity has an adverse effect on quality of activity results. It is connected with impossibility of adequate verification of qualitative indicators of a monopoly system activity due to lack of other examples on the market for such activities. An excessive monopolization also leads *to* uncontrollability *of* the exploitation process of each system element*,* including the unreasonably low remuneration for the maintenance of the system *activity*. *I*n most cases *m*onopolization is beneficial to the system itself but not beneficial to consumers and society as a whole. In many countries, in accordance with the legislation *the* proven monopolization fact allows you to enter an artificial division into smaller systems.

From the perspective of self-sufficiency any corporate system can be considered in a simplified form as a physical system with the target and not the target interaction of the system elements [7]. In such a system each element performs its work with a certain efficiency. If in the collective system each element actions are independent, the result of such a system you can define by the average of their efficiency. For example, many farmers who perform their work

independently of each other are the example of such an interaction. The synergy option (b) such a system is equal to zero. If the collective system synchronizes its actions, then ceteris paribus its synergy parameter can be determined factor from 0 to 100%. The parameter value synergy of 100% indicates full synchronization of the system element actions, when any item regulated system. For example, in physics, laser radiation, where oscillations of particles are tightly synchronized, is the example of 100% synergy parameter.

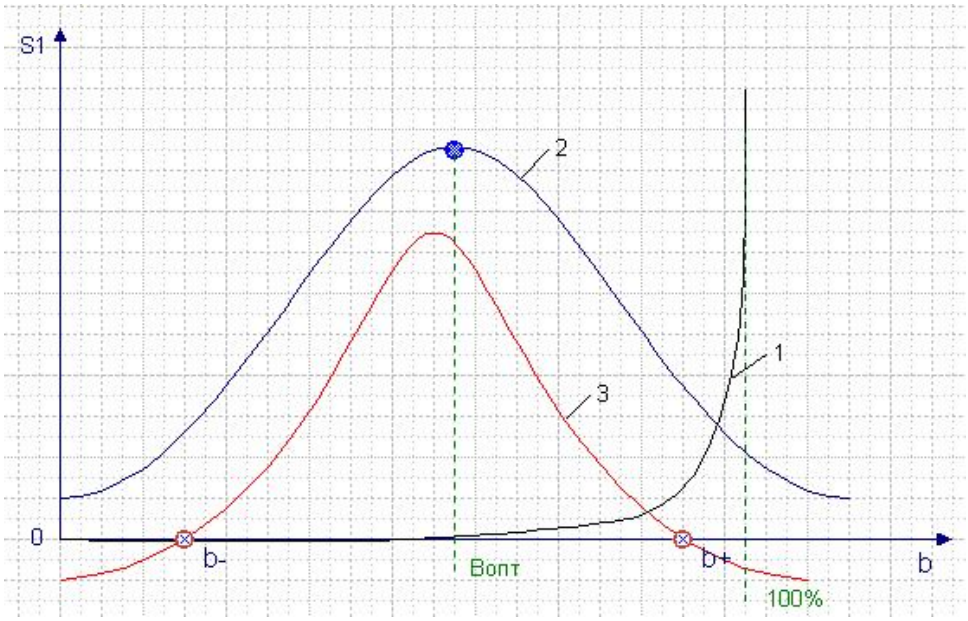

Fig.1. Typical synergy curves *from the* synergy *parameter*

Synergistic effect of corporate system is defined as a function from the synergy parameter. For a physical system the synergy effect is a monotonically increasing function from the synergy parameter with the achievement of its maximum when b= 100%, which is shown in Fig. 1 (the curve 1). In the economic system in contrast to physical the synergy effect is not a monotonically increasing function from the synergy parameter and has the appearance of the curve 2 (Fig. 1). This is due to the fact that when 100% synergy parameter the creative initiative of the system elements is completely suppressed, which requires additional time and money in addition to the duties regulated by the system. In the particular case depending on the system purpose can be maximum this curve and at 100% but it is only in the enterprises with a complete lack of creativity. However, even in systems with rigid process can be considered suspicious B_{onm} > 90% because even here must be a reserve upgrade processes. The value B_{onm} depends on the nature of the system: this is the smallest value in the scientific field and the largest in the area with a rigid standard tracking technology. Value B_{onm} is a compromise value defined as a result of the GAP-analysis. On the one hand, the company's manager in their official duties is trying to increase B_{onm} to achieve, in his view, the highest manageability of the system. On the other hand, the company marketer can track the greatest deviation B_{onm} relative to 100%. In the GAP-analysis process the manager and the marketer in particular and determine B_{onm} . Maintenance of B_{onm} is provided by the business processes structure of the organization and by the system of marketing channels with the customer. The creative initiative reserve in the system must be supported by both the material and moral levels. So when implementing advanced technologies, management should guarantee performers a fee for maintenance of B_{onm} and after the introduction of these technologies, which can be reflected in the relevant contract.

In general, the synergies efficiency curve would be as the curve 3 (fig. 1). When b= 0% and b= 100% the negative synergistic effect is the peculiarity of this curve.

The value of the parameter b can be considered as the minimum threshold of regularization in the system. In corporate systems, of course, b_- > 0% as the activity of such a system requires at least a minimum coordination of the system elements actions. In the absence of minimum regularization in enterprise system it can be considered impossible to introduce any information technology.

The implementation of a corporate package in the system allows the system to move from a learning organization to a qualitatively new learning organization. In the latter case the system learning process is the norm with settled relations between learners and trainees. Learners benefit by getting additional knowledges and trainees favorably to transfer new knowledges because their remuneration and the system efficiency as a whole depends on it.

The value of the b_+ is the threshold of the system regulation. The famous case of work "on instructions" in Japan was an example of such a regulation. The system regimentation is dangerous because it is not always possible to determine the deviation of the actual state of the system and formal indicators in accordance with statutory reporting.

Unlike the model curve of 3 (Fig. 1) the super strong nonlinear dependence effect can real take in an enterprise system by analogy with the bifurcation point in physical systems. If there is the bifurcation point in the system, the stepwise change of the synergistic effect is possible.

This effect cannot be considered only theoretically possible in the corporate systems where information technology is being intensively used. In this regard, it should be a very responsible approach to the selection of the software product, because the wrong decision in this choice may lead to a sharp decrease in future synergies. This decrease cannot be practically eliminated as it is required to replace the corporate information system with a more perfect one. With the database already created, you will have to completely update the huge corporate database when changing the package. In this regard, it is necessary tracking tool for implementing the package and its ability to quickly adapt the system interface when purchasing a corporate package. We should be suspicious of any packages implemented without using of object-oriented programming due to the limited capabilities of such systems in upgrading the interface part.

The introduction of modern corporate packages allows for more transparent interaction of the system and the competing environment in connection with the standardization of all accounts. This applies to the regulation of reporting positions and report forms for each position.

When the system functions, the question of identifying parameters that make the system closed is of particular importance. To identify such parameters it is necessary to use the full potential of the system. But it is not enough to reveal such parameters, it is important to know how to make the system open by one or another parameter.

It should be borne in mind that the mode of revaluation of its capabilities by each element of the system depends on the time in which the system was closed by the parameter. To ensure the adequacy of system behavior and its elements there is an optimal time of regularization before opening system for this parameter. If this time is less than optimal the system synergy will not be ensured by more dynamic destructive forces. If this time is greater than the optimum the standby mode turns the constructive forces in the destructive ones. The optimal time of the regularization is more significant in the implementation of the norms of legislation regulating the economic sphere of activity in a competing business environment. The most optimal one can be considered the linear closed system modernization mode in the open system with a modernization time of equal to a regularization time. Such a regime should provide for a gradual introduction of new regulated standards in the system activities, including the introduction of techniques for rating staff assessments from the standpoint of their influence on the self-organization of systems [8].

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ATTITUDE TO BULKY WASTE AND ITS MANAGEMENT IN ŠIAULIAI

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Annotation

Waste management system is a complex system characterized by large amounts of generated waste and a variety of waste types. Despite the progress made in the area of sustainable development since Rio de Janeiro Summit in 1992 and after The Johannesburg Summit in 2002 a lot of waste management issues still need to be resolved. This article discusses one of the waste management system parts - bulky waste and the situation of this waste management in Šiauliai town municipality. The results of this research are considered as the basis for resolving issues concerning bulky waste management.

Key words: *bulky waste, questionnaire survey, bulky waste management sites.*

Introduction

The world population annually increases by about 80 million [12]. The rate of consumption is growing rapidly in both developed and developing countries. All this inevitably increases the growth of various waste quantities, changes in waste management systems and their negative impact on the Earth's ecosystem, which is no longer able to fully compensate for the consequences of human activity.

Waste management, as the activity of educating people and nation as the whole is rising questions of what to do with waste and how to manage it, has been developing gradually. In the past century, waste management was only associated with the collection and disposal of waste, but technologies have also improved with the changing age. As technologies improved and amount of waste is ever-increasing, the aim of the waste systems had to change from "collecting and disposing" to "reducing the amount of waste to be disposed" (Fig.1). [3].

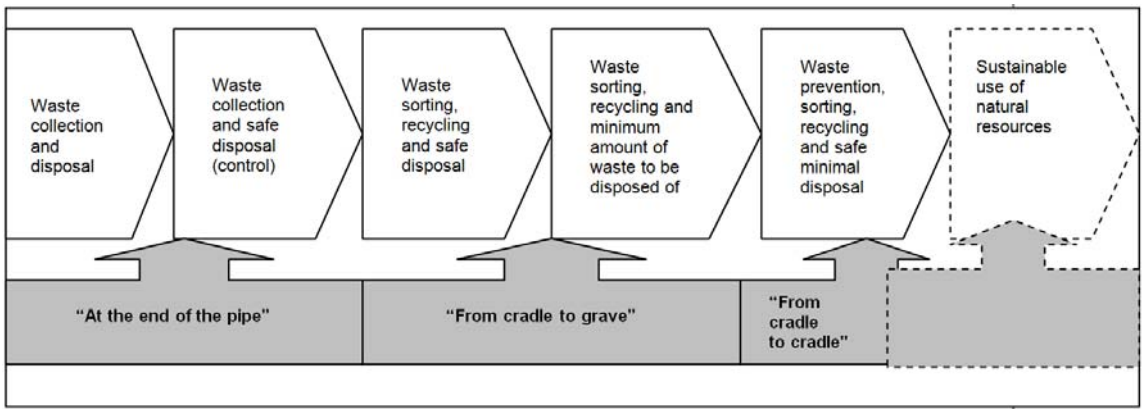

Fig.1. Change of waste systems

Thus, it's evident that sorting of secondary raw materials as well as sorting of bulk waste (after sorted waste can be reused) occurs when new components take part in the changing waste management system. When the waste management begins to be linked to the management of natural resources, then the aim becomes to maximize the conservation of natural resources, because not all natural resources are renewable.

Kan (2009) states that waste management elements seek to replace all raw materials with the recycled materials, collect information on materials needed to be recycled for further use, promote the reuse of waste, and properly distribute them on the storage sites as well as to create a flexible waste management system [13].

Vaišnoras (2011) puts emphasis on the importance of the waste management at the place of waste origin - sorting, storage and reuse [19].

Thus, waste management is a complex process that starts with the control of the generation of waste, the storage of waste, collection, transportation, transfer of waste to collectors or processors, the recycling, reuse and its disposal.

Waste management policy

European Union legislation and directives as well as the legal documents of the Republic of Lithuania have established priorities, principles, and measures to be followed in waste management in order to prevent emerging threats to human health and the environment. Waste management policy is based on administrative and economic measures. To this end, the European Parliament and Council adopted Regulation 2150/2002/EC on waste statistics, which allows for the collection and transfer of regular and comparable data on waste in EU countries Eurostat to The EU Statistical Office, and the collected statistics enables monitoring and evaluation of the implementation of EU waste policy. This statistics is needed to assess and identify the links between data on the generation of waste and information on usage of regional, national and global resources [6].

Changes in waste management are also closely related to EU waste legislation. The main legal act in this area is The Waste Framework Directive, which describes the waste management hierarchy: starting with prevention, preparation for reuse, recycling and disposal. The aim is to minimize the generation of waste and use the resulting waste as a resource and to minimize the amount of waste sent to landfills [5]. The Waste Framework Directive Together with other EU waste directives (end-of-life vehicles [7], waste of electrical and electronic equipment [8], waste batteries and energy reservoirs [9], packaging waste [10], etc.) specific goals are envisioned, for example: the amount of the municipal waste to be recycled in each EU country by 2020; 45% of batteries should be collected by 2016 and 70% of non-hazardous construction or demolition waste should to be recycled or recovered by 2020.

Lithuania has developed a waste management system based on the following key principles:

- The waste management system should be based on the hierarchy of European waste management principles, focusing first and foremost on a more fundamental principle. Three key waste management priorities were identified: waste avoidance, usage and safe disposal.
- The efficiency of the waste management system directly depends on the application of the principles of proximity and adequacy [1]. It is one of the basic principles of waste management, which states that waste must be treated and disposed of as close as possible to the place of waste origin [11].

The main law on waste management in Lithuania is the Law on Waste Management. This law establishes general requirements for waste prevention, recording, collection, storage, transportation, usage and disposal in order to avoid the negative effects of waste on human health and the environment, as well as the key principles of organization and planning of waste management systems. According to this law, the general requirements for waste management rules were detailed. They define precisely the terms related to waste management that meet the requirements of the European Union. The procedure for collection, storage, transportation, usage, disposal, recording, identification, declaration, sorting and marking of waste is detailed here [14].

Another no less important document in the field of waste management is the Law on Pollution Tax. The main purpose of this law is to encourage the pollutants to reduce pollution of the environment by means of economic measures, not to exceed the norms and to acquire appropriate environmental tools from the collected tax money [15].

In order to increase the efficiency of the waste management system, the Naional Waste Management Plan for 2014-2020 was approved. This plan outlines key guidelines on how the country's waste will be managed in the next few years. The plan declares that municipalities are responsible for organization of the municipal waste management systems necessary for the management of municipal waste in their territories and ensuring the functioning of these systems. The waste management goal is set in the National Waste Management Plan - to ensure the principle of universality when providing a public waste management service [20].

To ensure the implementation of the goals set in National Waste Management Plan for 2014 - 2020. Šiauliai Regional Waste Management Plan for 2014 - 2020 was developed for Šiauliai region. The plan states that Šiauliai Regional Waste Management Center is responsible for coordination of implementation of Šiauliai Region Waste Management Plan for 2014 - 2020. This plan is also being implemented by all the municipalities of Šiauliai region - Akmenė district, Joniškis district, Kelmė district, Pakruojis district, Radviliškis district, Šiauliai district and Šiauliai town. The plan also states that all waste holders are provided with a public municipal waste management service that meets the minimum quality requirements set by the Ministry of Environment of the Republic of Lithuania [17].

Current bulky waste management situation in Šiauliai region

The provision of a waste management service for each waste holder ensures that all municipal waste generated in the Šiauliai region is collected and managed. Container waste

collection system is used for collection of mixed municipal waste. Since 2009 all mixed municipal waste collected in Šiauliai region is transported for disposal only to the non-hazardous waste landfill in Šiauliai region, located in Jurgeliškiai village, Šiauliai district. Sorted municipal waste (tires, household renovation waste, electrical and electronic equipment) from municipal waste holders in Šiauliai region is accepted free of charge at 34 waste collection points and 9 bulky waste collection sites. In addition according to the established schedule municipal waste carriers periodically collect hazardous household, electrical and electronic equipment, used tires from the residents and deliver them to the bulky waste collection site. The collection and acceptance of this waste is announced in elderships, local press, television, Šiauliai Regional Waste Management Center, municipal websites, flyers and in other media [20].

The object of the research - management of bulky waste.

The aim of the research - to reveal how residents actually handle bulky waste.

Research objectives:

1. To evaluate the attitude of the residents of Šiauliai town to bulky waste management.
2. To determine ways of information presentation about bulky waste management and sites.
3. To determine what information is lacking for residents about bulky waste management.

Research methods

The most popular and most widely used research method is *questionnaire survey*. Thanks to this method with little means a large number of respondents can be interviewed in a short term.

The Questionnaire consists of a group of interrelated questions that require answers from respondents questioned. The content, quantity and order of the questions depend on the objectives of the study. During the questionnaire, the respondent is provided with a fixed set of questions in which each selected person answers same questions following the same pattern. The purpose of the questionnaire is not to find out the individual's opinion, but to determine a general description of the whole population.

The questionnaire was prepared to evaluate the attitude of the inhabitants of Šiauliai town regarding the management of bulky waste. The questionnaire was designed in such a way as to get as precise answers as possible to the research questions of interest, and to help respondents to answer them as clearly as possible without rising additional questions. During the compilation of the questionnaire the recommendations and requirements for creation of the questionnaire were considered: questions in the questionnaire were written in the correct language easily understood by everyone, not offensive to the respondent, and most importantly, the questions asked were reflecting the real reality and the content of the problem under investigation [16].

The study material was processed by summing, calculating and comparing the data presented in the questionnaires. All data is reported in EUR millions as percentage.

Analysis of the research results

As far as waste management is concerned, the public awareness of waste management seems to be increasing, but often it is unfortunate to see various type of waste scattered around containers - old furniture, construction and demolition waste, household appliances, tires, etc. All these no longer usable items should be delivered to specially designated sites or points for that purpose or placed in special containers to be disposed of.

Description of respondents

150 respondents answered the questionnaire of which 96 were women and 54 were men. The respondents by age distributed as follows: the small part is made up by respondents up to 30 years old, and the rest (more than 68%) respondents 30-70 years old. According to respondents' place of residence the majority of respondents live in multi-apartment buildings - 72% and 28% live in private houses. According to education the data distributed as follows: the majority of respondents have higher education - 48%; secondary education - 30%; higher education - 14%; and basic education - 8%.

Attitude to what is a bulky waste. Since respondents are of various ages and backgrounds, it can be assumed that each of respondents has different perception of bulky waste definition. Most of Šiauliai town inhabitants (92.3%) believe that bulky waste is bulky household appliances, 82.7% think that it is furniture, 75% - doors, 71% - windows and 63% think that it is construction and reconstruction waste.

Attitude to bulky waste management. Respondents expressed their opinion on the management of bulky waste as follows: they take waste to a bulky waste disposal site (43.3%),

leave by the container (38.4%), and 18,3% leave by the container on bulky waste collection day.

Attitude to bulky waste management sites. With the expansion of municipal waste management system bulky waste disposal sites were equipped. They are an important part of an entire waste management system. The purpose of these sites is to provide residents with universal, accessible and high-quality public municipality waste management services. Respondents expressed their opinion on bulky waste management sites as follows: 75% of respondents know where they are and use them and 25% - do not know where there are or do not use bulky waste disposal sites. One of the reasons why respondents do not use bulky waste collection sites is lack of transport.

The comments of Šiauliai town respondents, regarding what would encourage them to deliver waste to the bulky waste collection site are presented in Table 1.

Table 1

What would encourage the delivery of waste to a bulky waste disposal site

Place of residence	Comments
Šiauliai town	payment for delivered waste
	more information
	longer working hours of sites on weekends
	reward for delivery
	having no transport to deliver waste to the site
	lack of information
	lower fee for waste

Attitude to information presentation about bulky waste management and sites. Analyzing the ways of information presentation about bulky waste, its processing and existing waste collection sites, it was determined that the most suitable ways of presenting information to the inhabitants of Šiauliai are the following: local press - (priority 1), programmes on this topic on TV (priority 2), information flyer (Priority 3), online media (Priority 4) and social network Facebook (Priority 5).

Attitude to the dissemination of information on bulky waste collection and sites. Very little waste is currently being collected at bulky waste disposal sites. Many of these sites are newly built, which means that inhabitants have little information about them, as well as information regarding what waste is admitted is lacking. Respondents' opinion distributed as follows: The inhabitants of Šiauliai lack information mostly about where there is the site (priority 1), which waste is accepted at the site (priority 2), what amount of waste can be delivered (priority 3), where to dispose / deliver waste (priority 4), whether there is a fee for delivered waste (priority 5), what is a bulky waste (priority 6) and the working time of the site (priority 7).

Conclusions

1. In order to find out how bulky waste is managed in Šiauliai, a questionnaire survey was conducted with 150 respondents interviewed. After analyzing the collected data, it was determined that only 43.3% of inhabitants deliver generated bulky waste to the bulky waste collection site, 38.4% leave by the container, and 18,3% leave by the container on bulky waste collection day.

2. The research showed that the most suitable ways of conveying of information presentation to the inhabitants of Šiauliai are the following: local press - (priority 1), programmes on this topic on TV (priority 2), information flyer (Priority 3), online media (Priority 4) and social network Facebook (Priority 5).

3. Very little waste is currently being collected at bulky waste disposal sites. Many of these sites are newly built, so it can be assumed that the population has little information about them. The inhabitants of Šiauliai lack information mostly about where there is the site (priority 1), which waste is accepted at the site (priority 2), what amount of waste can be delivered (priority 3), where to dispose / deliver waste (priority 4), whether there is a fee for delivered waste (priority 5), what is a bulky waste (priority 6) and the working time of the site (priority 7).

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STRUCTUAL REPRESENTATION OF MACHINE AND TOOL MACHINERY FOR KINEMATIC CHIP METAL BREAKING

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Annotation
The paper deals with research of the various aspects of kinematic metal chips breaking techniques in multi edge machining. The adaptive type machinery scheme synthesis is developed to clear the adaptive links role in the kinematic chips breaking process. The morphological characteristics analysis of chips breaking schemes is performed that makes it possible to design the new principal equipment constructions for the chip cutting and breaking when using the adaptive links between the separate cutting elements. The results of the mentioned synthesis are gathered in the table form and are described in detail. The integral logic function of the discrete cutting schemes is proposed to use in the choosing process of the necessary machinery.
Key words: *kinematic metal chips breaking, machines and tool equipment, multi edge machining, adaptive link, synthesis.*

Introduction

Manufacturing processes intensification in metal machining leads to the sharp increase in the mass of metal chips removing from the surface. Sometimes depending on the machining material the chips output goes up to 35.6% of the work piece mass.

In the machining process of the cementing and refractory materials (such as stainless, high-alloy and speed steels) as well as a lot of nonferrous alloys the metal chip takes a shape of a long continuous strip or spiral. In practice one cannot predict even the direction of its flowing. Such metal chip was named “continuous chip”. Its presence is the negative factor of the metal cutting machining [1].

The complexity of the chips breaking problem led to the various methods and techniques of it solving. Analyzing and systematization of the chip breaking and cutting methods allowed joining them into two large groups: natural and artificial. Natural methods examination gives it possible to discover the chip breaking mechanism and set a lot of purposeful ways to improve the most perfect of the artificial techniques that are more numerous.

Actuality and investigation main goal

So as it was discovered the search of new design and technology solutions of the methods and machinery for the chip breaking presents the actual engineering and scientific problem. Among the modern and effective chip cutting methods the kinematic chip breaking is of prominent value. This method allows reaching the stable forming of the chips elements of the calculated length not in regard with the material type. Essence of the kinematic chip breaking methods in the machining process with varying parameters lies in the periodical interruption of the machining process due to the setting some or that of cutting tool movement regularities relatively to the machined work piece.

Almost all of the known methods of kinematic chip breaking are based on the vibration cutting. That means that the cutting feed of constant value is imposed by the additional tool oscillation movements. In this way it can be advised to use in the internal surfaces machining the tool linear oscillations as the additional vibration movements as well as in the machining of the external surfaces – either the linear or swinging oscillations.

The investigations of the vibration machining processes are widely discussed in a number of the scientific and applied papers. These researches deal with the advantages of the vibration cutting in regard to the traditional schemes of the materials machining [1]. The results of the manufacturing implementation approved the effectiveness and prospective character of this kind of metal cutting machining as well. At the same time cutting with vibrations has some

shortcomings dealing with the additional dynamic loadings on the cutting tools and all the machine tool systems as a whole [2, 3].

The total elimination of these disadvantages is impossible but it is necessary to find in theoretical and experimental research of the vibration cutting process the optimal schemes, conditions and regimes that minimize the negative effects. In this way these tasks form the integrated problem to be solved [4].

Investigation results

The scheme synthesis of machinery for the chip breaking can be developed as a result of several procedures: at first – by integrating the kinematic features of the well-known schemes of discrete cutting; secondly – by defining the role of adaptive type links in these processes and at last by rationalization of the scheme variants regarding to the necessity of the certain machining conditions. In the given aspect only those schemes of chip breakage are discussed that directly include the axial oscillations of the manufacturing system elements in the feed direction taking into account that these oscillations make no influence on the machining accuracy.

The methods and machinery of kinematic chip breaking in metal cutting with axial oscillations can be composed in the integrated system basing on the principle kinematic schemes using (fig. 1-4).

At first let us compare four scheme variants of the kinematic chip cutting and breaking without using the adaptive links between the separate tools and in a case of adaptive type breaking.

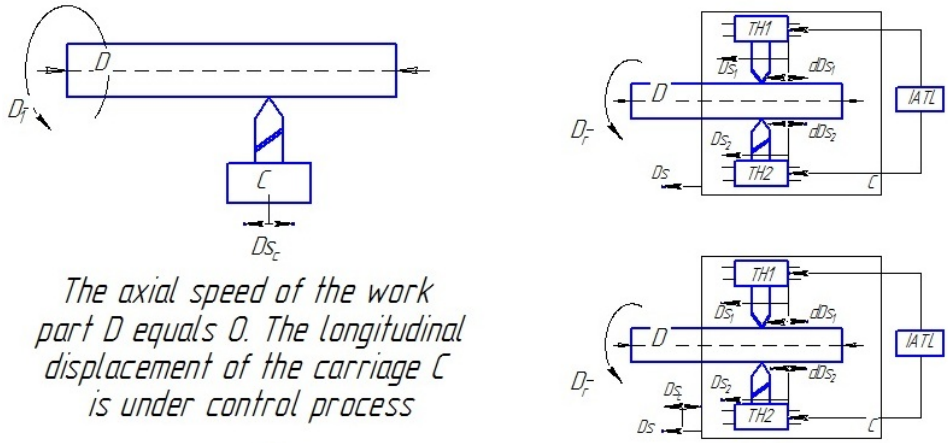

Fig.1. Comparison of structural and kinematic schemes of chip breaking in a case when the axial speed of work piece equals 0

In a first case (fig. 1) the work part in the process of machining is non movable in the axial direction and the forced oscillations *Dsc* are imposed on the lathe slide carriage steady motion *Ds*. Such integrated motion allows periodically cutting tool stopping and as a result chip cutting off. The scheme of adaptive discrete cutting is of different kind from the given one. It provides the chip breaking using only the interlinked oscillation motions ∂Ds_1 and ∂Ds_2 of cutting tool holders (THi, i=1,2) as a result of the inter-tool adaptive type link (IATL) operation as well as the combining the movement *Dsc* with vibrations and oscillations dDs_1 and dDs_2.

Some kinematic methods of chip breaking in the process of turning are used in a case of the constant feed speed value as a result of the controlled work part axial displacements (fig. 2). As an alternative to the given one the scheme of the chip breaking using inter-tool adaptive links can be discussed. In this case the working part is oscillated in the axial direction as well. It is easily can be noted that not taking into consideration the motion *Dsd* the proposed scheme is transferred to the similar scheme at the fig. 1.

The chip breaking in non-adaptive single tool machining can be also achieved by simultaneous velocities changing both axial displacements of the carriage and work part (fig. 3). This combination can be applied to the case of multi edge turning in the process of machining with inter-tool adaptive type links using.

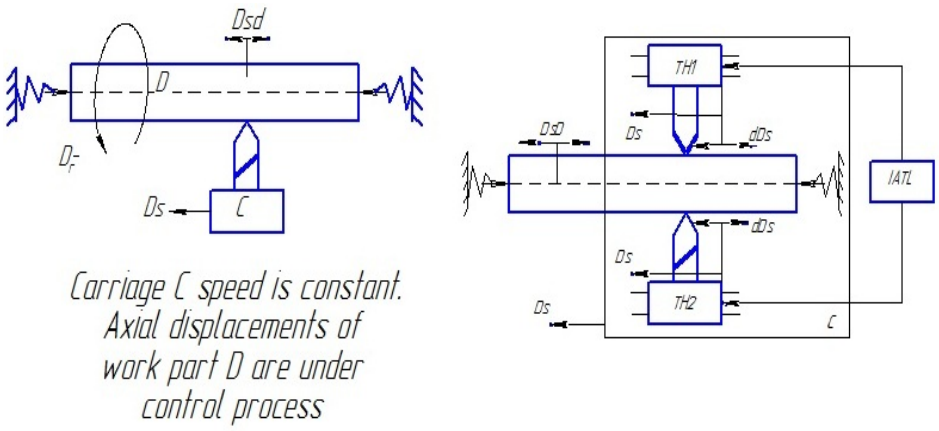

Fig. 2. Comparison of structural and kinematic schemes of chip breaking in a case when the carriage speed is constant

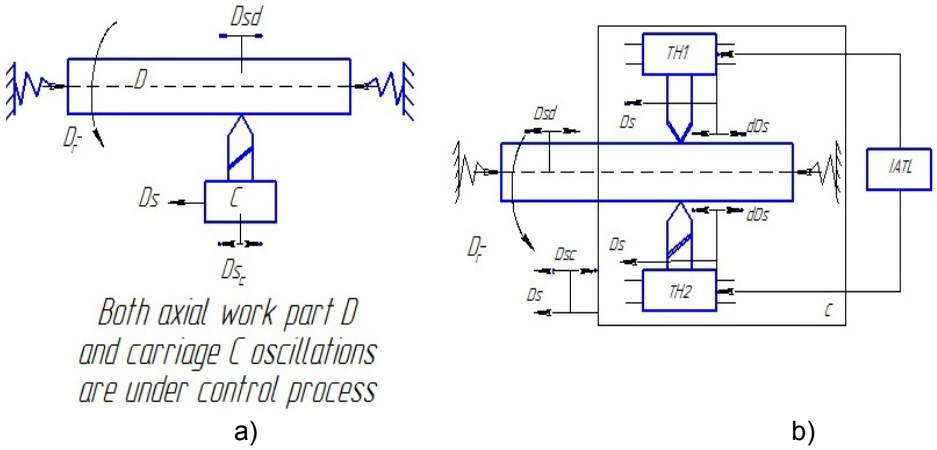

Fig. 3. Comparison of structural and kinematic schemes of chip breaking in a case when both work piece and carriage oscillations are under control process

Another variant of discrete machining process using two or more single point tools is possible. In this case the feed speed of one of the tools is constant and the additional carriage drive (drives) is used to produce the additional oscillations of the tool (tools) (fig. 4). In a case of multi tool cutting with adaptive links the chip breaking scheme can be proposed in which the feed speed of one of the cutting tools is of constant value($Ds_1 = const$), but the next part of the total feed is divided between another tools (motions ∂Ds_2, ∂Ds_3 etc.) in a process of adaptive links functioning.

The given schemes combining in the integrated one makes it possible to discuss their advantages and unsatisfactory features as well as prove the actuality of adaptive type links using in the chip breaking methods. It is also important to analyze the effectiveness of such techniques in combination with other motions of the machining system components.

The development of new schemes machineries for kinematic chip breaking using the links of adaptive type between separate cutting elements in the machining process of revolution surfaces is convenient to analyze in an easy-to-use form by means of morphological synthesis method.

To carry out this method let us differentiate the machinery's morphological characteristics. In this way let us take into account only the most fundamental ones that make the significant influence on the process of chip breaking. Besides that let us consider that the discussed synthesis deals with only the machining method of feed division because the feed division actually provides the inter-linked cutting elements oscillations in the process of adaptive type links functioning.

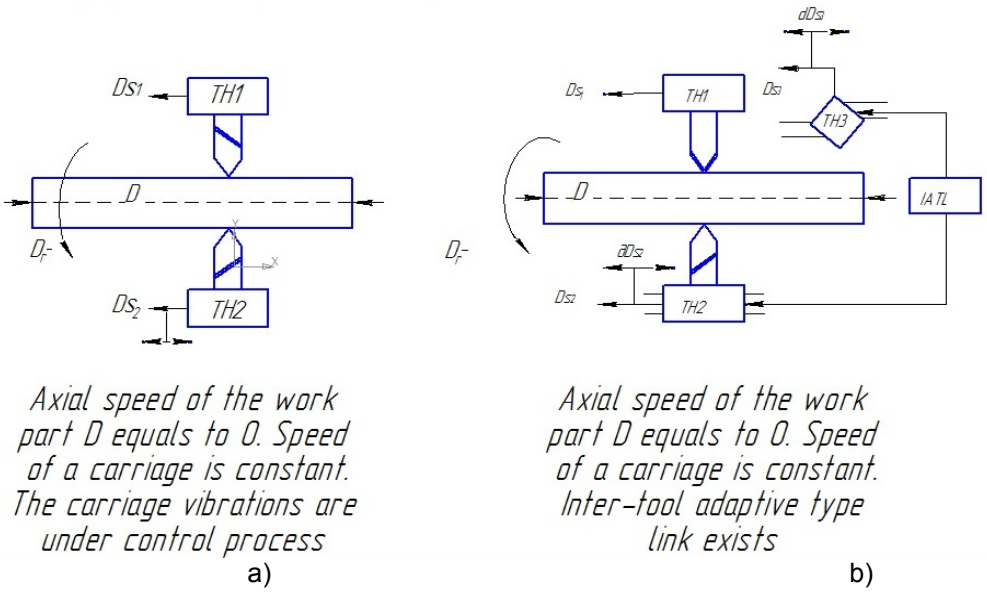

Fig. 4. Comparison of structural and kinematic schemes of chip breaking in a case when the axial speed of work piece equals 0 and the speed of the carriage is constant. The additional carriage vibrations are under control process

All the morphological features set of the chip breaking schemes with the adaptive links use it is convenient to distribute into 5 groups.

Herewith the first group of characteristic features (typ) (see table 1) relates to the number of cutting elements (edges) that take a rate part in machining as well as to the links between these cutting elements

Table 1

Morphological characteristic features first group (typ) of chip breaking schemes

Characteristics of multi edge machining (typ)	
1. Number of cutting edges (tools) (no)	2. Links between cutting edges (lk)
1.1 One	2.1 Without
1.2 Double	2.2 Using adaptive links only
1.3 Three and more	2.3 One tool is rigidly fixed, adaptive links exist between others

The second group of factors (kin) (table 2) deals with the cumulative action of motions carrying out by elements of machine tool accessories (MTA) in chip cutting and breaking. The comparative analysis of the necessary motions and their correlation with the well-known kinematics of chip breakage was illustrated in figures 1-4. These motions realization can be provided by additional drive that gives the useful oscillation to the machining system. Such a vibration can be different in the shape mode being sinusoidal and harmonic or in the impulses shape of squire pulse, triangular or parabolic form.

The third group of characteristic features (sys) (table 3) relates to the manufacturing system breakage setting. Thus item is discussed because the cutting elements setting for machining can be different for various cases. For example the setting can be the same for different tools (edges). Alternatively the cutting edges can be set into different cut depths as well as with the height errors or non-uniformly of the work piece circumference. Besides that the work piece can be fixed with eccentricity as well as with an error when its longitudinal axis straddles with the spindle (tool) rotation axis.

The fourth features group (cut) (table 4) regards to the geometry of cutting edges taking into account the differences in major and minor cutting edges angles as well as in the face and clearance angles and in the cutting edge angle.

The fifth features group (mec) (table 5) discusses the construction design characteristics of the adaptive type mechanisms that fulfill the function of oscillations operation. They can include the control system but the control system can be off of the process of chip breaking. The mentioned characteristics can be exemplified with the leveling devices using lever mechanism, differences in screw kinematic pairs as well as in cone-ball or cone-pin type mechanisms or in hydraulic system of adaptive type.

Table 2

Second group (kin) of chip breaking schemes morphological factors

Breaking kinematics characteristics (kin)		
1. Oscillation motions in breaking (mo)	2. Additional drive (dr)	3. Shape of additional oscillations (os)
1.1 Motions are off	2.1 Without additional drive	3.1 Oscillations are off
1.2 Adaptive type mechanisms motion only	2.2 Using additional drive	3.2 Harmonic
1.3 Carriage slide motion (tool unit)		3.3 Impulse of squire pulse shape
1.4 Work piece motion		3.4 Impulse of triangular shape
1.5 Both carriage slide (tool unit) and work piece motion		3.5. Impulse of parabolic shape

Table 3

Third group (sys) of chip breaking schemes morphological features

System setting (sys)	
1. Tools setting (to)	2. Work piece setting (de)
1.1 Equal	2.1 Ideal
1.2 Different cut depths	2.2 With eccentricity
1.3 Errors in height	2.3 Straddles with the spindle axis

Table 4

Fourth group (sys) of chip breaking schemes morphological features

Cutting edges geometry characteristics (cut)	
1. Edges angles (an)	2. Cutting edges sharpening (sh)
1.1 Equal	2.1 The same
1.2 Different major or minor angles	2.2 Different point radius values
1.3 Different face angles	2.3 Different edges sharpening angles
1.4 Different cutting edges inclination	2.4. Other

Table 5

Fifth group (sys) of chip breaking schemes morphological features

Adaptive type link irregularities (mec)	
1. Control system is off (uc)	2. With control system (wc)
1.1 Symmetry of the inter-tool link	2.1 Control system with actuators
1.2 Different levers of the leveling system	2.2 Control of levers length
1.3 Different screws pitches	2.3 Control of rotating speed
1.4 Different characteristics of cone-ball and other mechanisms	2.4 Control of tools feed
1.5 Differences in hydraulic devices parameters	2.5. Control of system components rigidity
1.6 Other	2.6. Other

Integrating all these characteristics in a total system provides deriving the basic morphological model. Combinations of the model components develop the set of chip breaking schemes in multi-edge cutting with the adaptive type links using. The general logic function of the discrete cutting in chip breaking can be written as follows:

$$\tau = typ\Lambda kin\Lambda sys\Lambda cut\Lambda mec. \quad (1)$$

The connecting links between the characteristic features of different groups cannot be derived as single-valued. But the morphological matrix is developed in such a form that in a general case the following equalities can be obtained:

$$typ = no\Lambda lk\ ;\ kin = mo\Lambda dr\Lambda os\ ;\ sys = to\Lambda de\ ;\ cut = an\Lambda sh\ ;\ mec = uc\Lambda wc\ .$$

Correspondingly the general formula of the schemes is:

$$\tau = (no \Lambda lk) \Lambda (mo \Lambda dr \Lambda os) \Lambda (to \Lambda de) \Lambda (an \Lambda sh) \Lambda (uc \Lambda wc). \quad (2)$$

For the separate features groups it can be written also:

– Group typ:; $no = \overset{3}{\underset{j=1}{V}}(no_i)$; $lk = \overset{3}{\underset{k=1}{V}}(lk_k)$.

– Group kin: $mo = \left[\overset{5}{\underset{l=1}{V}}(mo_1)\right] V \left[\overset{3}{\underset{r=1}{V}}(mo_2 \Lambda mo_{2+r})\right]$; $dr = dr_1 V dr_2$; $os = \overset{5}{\underset{m=1}{V}}(os_m)$.

– Group sys: $to = \left[\overset{5}{\underset{n=1}{V}}(to_n)\right] V \left[\overset{2}{\underset{s=1}{V}}(to_2 \Lambda to_{2+s})\right]$; $de = \left[\overset{4}{\underset{g=1}{V}}(de_g)\right] V \left[\overset{2}{\underset{p=1}{V}}(de_2 \Lambda de_{2+p})\right]$.

– Group cut: $an = \left[\overset{3}{\underset{t=1}{V}}(an_t)\right] V \left[\overset{3}{\underset{f=1}{V}}(an_2 \Lambda an_{2+f})\right]$; $sh = \left[\overset{3}{\underset{e=1}{V}}(sh_e)\right] V \left[(sh_2 \Lambda sh_3)\right]$.

– Group mec: $uc = \overset{5}{\underset{0=1}{V}}(uc_0)$; $wc = \overset{5}{\underset{v=1}{V}}(wc_v)$.

The analysis of tables 1-5 as well as of the given logical regularities shows that in the limits of the developed general formula some combinations are not real and they must be excluded. For example the drill has only two cutting edges, not more; the additional drive is off in any way when the oscillation motions are off and so on. Thus we can also write the logic limitations that are to be considered in the schemes developing, for example:

$$lk_1 \Lambda mo_2 = false;\ lk_2 \Lambda mo_1 = lk_2 \Lambda mo_3 ... lk_2 \Lambda mo_5 = false$$

$$lk_1 \Lambda mo_1 \Lambda dr_2 = false;\ uc_i \Lambda wc_j = false;\ (i = \overline{1,5};\ j = \overline{2,5});\ \text{etc.}$$

The variants with these limitations are to be excluded from consideration.

In this way the schemes variants set can be represented by formula

$$\tau_p = [true(\tau)]. \quad (3)$$

By the way it is clear that the given tables also represent the schemes that are functionally operative and effective but do not achieve the chip breaking. So according to the formulas

$$lk_1 \Lambda mo_1 \text{ or } lk_2 \Lambda mo_2 \Lambda dr_1 \Lambda os_1 \Lambda to_1 \Lambda de_1 \Lambda an_1 \Lambda sh_1 \Lambda uc_1 \Lambda wc_1,$$

the schemes set also cannot be discussed, because these schemes regard to the variants of single point or multi edge stable type cutting without adaptive links and kinematic oscillations.

Applying other additional limitations the morphological set is to be narrowed. Thus exemplifying the two edge lathe machining with adaptive links using the lever force leveling mechanism the following alternatives can be proposed:

$$\tau_T = no_2 \Lambda lk_2 \Lambda mo_2 \Lambda dr_1 \Lambda os_1 \Lambda (to_1 V to_2) \Lambda dr_1 \Lambda (an_1 V am_1) \Lambda sh_1 \Lambda (uc_1 V uc_2) \Lambda wc_1. \quad (4)$$

So in result we obtain in this case that the kinematic chip breaking comprises such schemes as: 1) lathe machining by equal tools being set for different dimensional allowances removal; 2) cutting tools machining with different major cutting angles; 3) different arm levers leveling mechanism using as an adaptive type link; 4) combination of these techniques.

Conclusions

1. As an investigation result of the various aspects of kinematic metal chips breaking techniques in multi edge machining the adaptive type machinery scheme synthesis is developed to clear the adaptive links role in the kinematic chip breaking process.

2. The morphological characteristics analysis of chips breaking schemes is performed. The represented logic operations with the morphological matrixes give the possibility to design the new principal equipment constructions for the chip cutting and breaking when using the adaptive links between the separate cutting elements. The results of the mentioned synthesis are gathered in the table form and are described in detail.

3. The given systematic approach makes it possible to develop the effective strategy for choosing a lot of functionally operative accessories for turning, drilling, boring machining followed by guaranteed continuous chip cutting and breaking. As a result of applying the additional limitations that exclude the contradictive and nonoperational variants the developed morphological set can be narrowed to the reasonable mathematical form. Thus the actually proposed variants of effective chip breaking in machining process comprise the ease methods of system setting and adjustment, as well as right tools geometry choosing.

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