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EVOLUTION AND GENETIC FORECASTING OF MULTISPINDLE AUTOMATIC LATHE DEVELOPMENT

Classifications based on various design and technological parameters of multispindle automatic and semiautomatic lathes from various manufacturers are analyzed, as elate evolution of their development base don productivity as defined by spindle RPM, and specific metal consumption as the lathe weight to main drive power capacity ratio. The genetic forecast has been made for new generations of multispindle automatic lathes, their units and mechanisms, including replacement mechanical systems with the electromechanical ones.

Keywords: multispindle automatic lathe, classification, productivity, specific metal consumption, evolution, genetic forecast

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ЕВОЛЮЦІЯ І ГЕНЕТИЧНЕ ПРОГНОЗУВАННЯ РОЗВИТКУ БАГАТОШПИНДЕЛЬНИХ ТОКАРНИХ АВТОМАТІВ

Проаналізовано конструктивні і технологічні параметри багатошпіндельних токарних автоматів і напівавтоматів різних виробників.

Визначено шляхи еволюції багатошпиндельних токарних верстатів в основу розвитку яких покладено не швидкість обертання шпинделю, а металоємність по відношенню до потужності приводу. Зроблено генетичний прогноз розвитку нових поколінь багатошпиндельних токарних автоматів, їх вузлів і механізмів, включаючи заміну механічних систем на електромеханічні і близькі до них приводи.

Ключові слова: багатошпиндельні токарні автомати , класифікація, продуктивність, металоємність, еволюція, генетичне прогнозування

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ЭВОЛЮЦИЯ И ГЕНЕТИЧЕСКОЕ ПРОГНОЗИРОВАНИЕ РАЗВИТИЯ МНОГОШПИНДЕЛЬНЫХ ТОКАРНЫХ АВТОМАТОВ

Проанализированы конструктивные и технологические параметры многошпиндельных токарных автоматов и полуавтоматов различных производителей. Определены пути эволюции многошпиндельных токарных станков в основу развития которых лежит не скорость вращения шпинделя, а металлоемкость по отношению к мощности привода. Сделано генетический прогноз развития новых поколений многошпиндельных токарных автоматов, их узлов и механизмов, включая замену механических систем на электромеханические и близкие к ним приводы.

Ключевые слова: многошпиндельные токарные автоматы, классификация, производительность, металлоемкость, эволюция, генетический прогноз

Problem statement

The world production tends to flexible automated manufacturing as a result of rapidly changing product range, thus increasing the share of small-batch production. Still, there are such products and individual parts, which are produced in thousands and millions (accessories, fasteners, bearings, plumbing hardware, etc.). Such products and parts are manufactured by means of large-batch and mass production techniques at high-productivity cutting machines, including multispindle automatic (MAL) and semiautomatic lathes (MSAL) processing bar stock, pipe stock, and piece blanks (fig. 1) [2,10 - 13, 17].

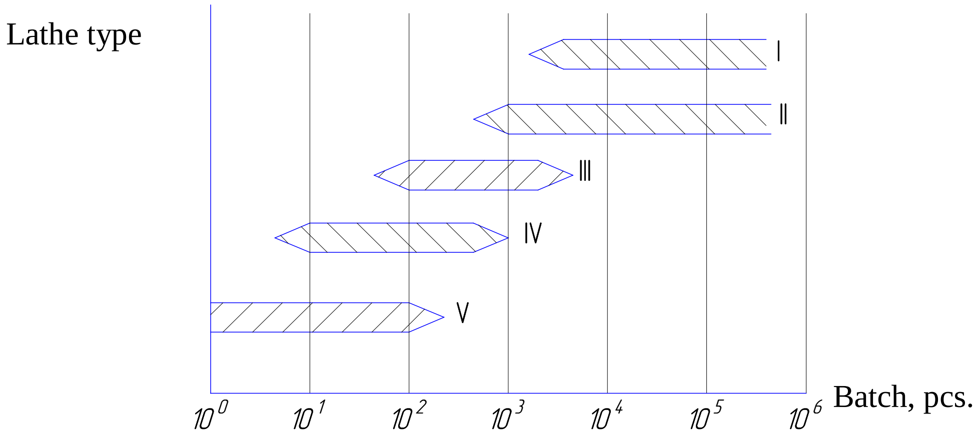

Fig. 1. Applicationareasfordifferentlathesandpartbatches: 1 –drum (rotary) automatic lathe; 2 –multispindleautomaticlathe; 3 –single-spindle automatic lathe; 4 –turret lathe; 5 –CNC lathe

Analysis of the previous researches and publications

The first bar-fed MAL ever with rotary spindle carrier (SC) was developed by NationalAcmeCo., Cleveland, USbased on patentNo. 530180 in 1894 [12,16].

Acme system has been adopted by Gilde meister&Co. andA. Schuette for their MALs. The next one was Gridley system with four-spindle automatic machine produced by K. Hasse&Wrede (Berlin), then thefive-spindles Davenport system, the six-spindle New-Britain system, and the three-spindle Lister system (by Davies Saving &Co., Dayton, US) followed. Prent is system MSAL swere two-sided (Prentis&Co., New Haven, US) and one-sided (K. Hasse&Wrede, New-Britain). Wan near system differs significantly from the others in its vertical configuration and has 8 spindles located around the column (this MAL appeared first at Brussels World Exhibition, but has never been seen again since then). The same principle was employed in Bullard system MSALs for machining large parts.

Main material

There are several classifications for MAL sand MSALs [2, 10-13, 16-18]. Taking into account the accumulated experience and information, work piece types, drives, mechanisms, and machining techniques used, the most comprehensive of the mist he one proposed by Prof. G. Spur [10, 17] (fig. 2), in which all MALs and MSALs are classified based on the main design feature—application of the SC.

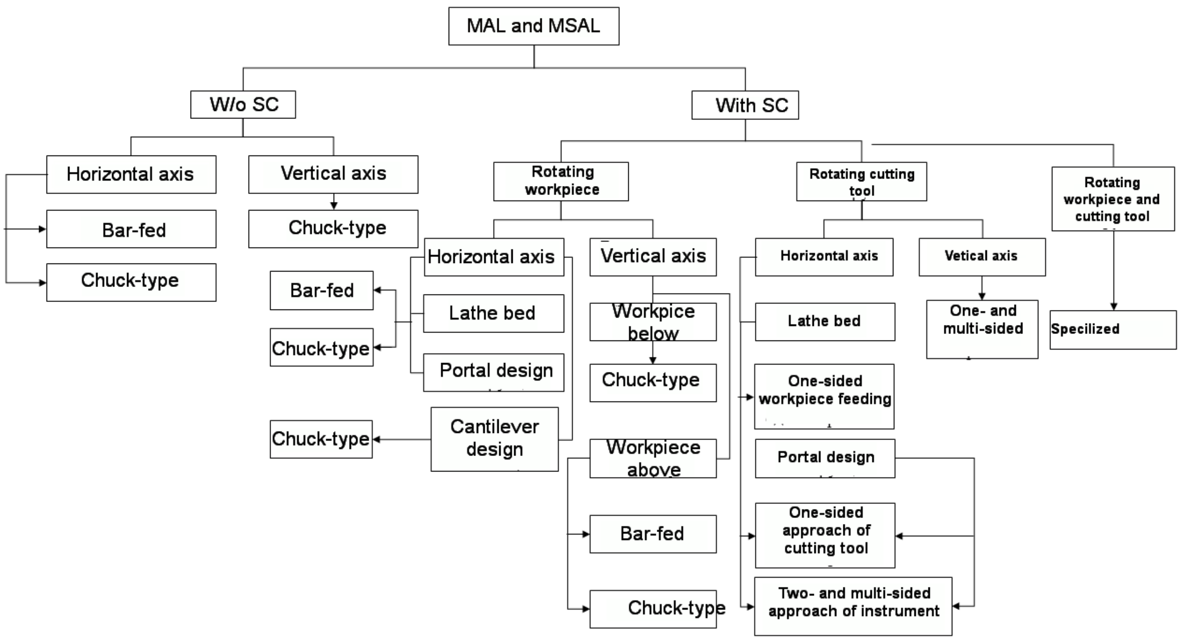

Fig. 2. Classification of MALs and MSALs based on design features [14]

However, this classification does not include MALs and MSAL switch inclined axis, bar-fed-chuck-type, cantilever-type, and others, which emerged with the introduction of CNC [3, 4 ,6]. Hereinafter, MAL also assumes MSAL.

The main technical and cost parameter for MAL determining its development level is its machining productivity, which is greatly influenced by the main drive - spindle RPM. DevelopmentofMALsbythiscriterionhadbeenforecastwithsomecredibilityuntil 2000 by R. A. Sklyarovunder the supervision of the author of [5], using patent data available at that timein Special Design Bureau for Multispindle Automatic Lathes (SKBMA) at Kyiv Machine Tool Plant.

Anothertechnicalandcostparameterformachiningequipmentandothermachinesofvariouspurposesistheratioofitsweight G topowercapacity N ofthemaindrivesourcecharacterizing its specific metal consumption, which also is an indication of progressive development, particularly, taking into account the advancing metal deficit (mineral resources are being drastically exhausted): $M = \frac{G}{N}$.

A sofmid - 20th century, according to the in formation in[2], this parameter for six-spindle MALwith cyclic control by camshaft was at 400-800 kg\kW (fig. 3).

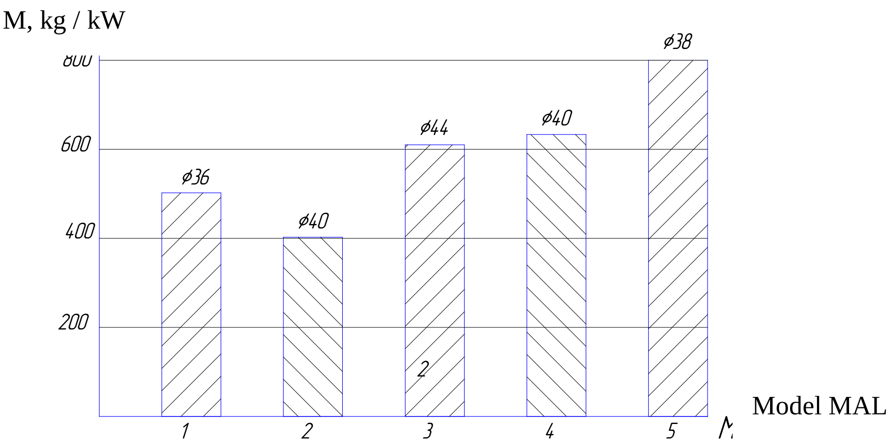

Fig. 3. Comparis on of metalconsumption efficiency for various models of MALs: 1—123; 2—1240-6; 3—Wickman; 4—Gildermeister; 5—KOH

By late-1970s the parameter M for Ukrainian MAL swith cam shaft control [11] decreased slightly and was 387-769 kg/kW (fig. 4).

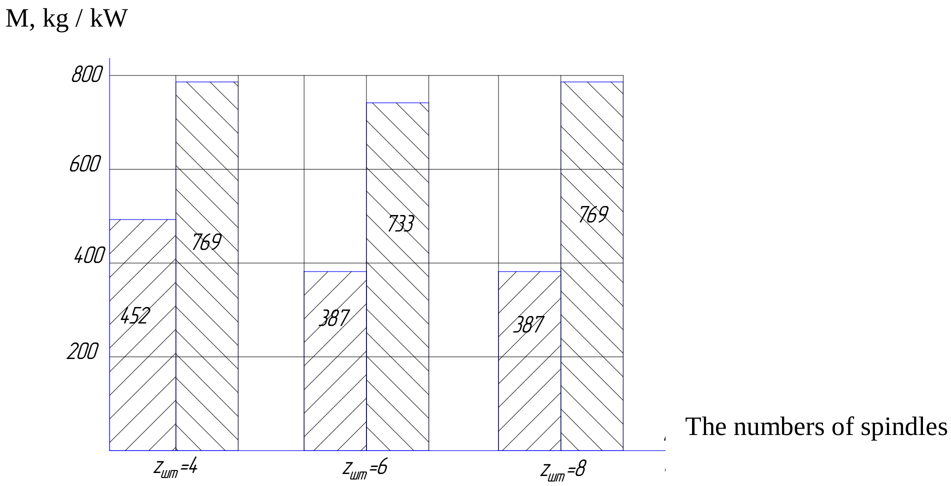

Fig. 4. Diagram of metal consumption efficiency for Ukrainian MAL switchy clic camshaft control for different numbers of spindles

It should be noticed, that according to [2, 11], for light and medium Ukrainian MAL spower lossatidle pass was 5.7-10.8 kW with cutting power of 15-42 kW, main drive power efficiency be in gat 0.6-0.8 and eventless (in some cases as little as 0.3), because of long driving trains (due to gearandbelttrains).

When bought Kyiv-made MALs, Japanese companies (according to SKBM Areports) used them at full capacity in creasing cutting (feed) speed and decreasing the duration of idle passes by increasing camshaft RPM. Upon decommissioningtheymadethreemachinesusingthemetalobtainedfromrecyclingtwoMALs.Later, with the gradual introduction of CNC systems and high-speed spindle units along with short driving trains, Japanese companies managed to make two MALs using one recycled Kyiv-made MAL. That means the specific metal consumption lowered first 1.5-fold (258-513 kg/kW), and later was halved (193-385 kg/kW). Thistendencyofloweringmetalconsumptioncanbeobservedinothercompaniesaswelldue to the utilization of modern CNC systems and short driving trains eliminating mechanical transmission and employing high-speed spindle units with CNC and continuous control in the form of motor-spindles [3, 4, 6, 19]. Examples include Multi swiss series CNC MAL [22] by Swiss company Torno with six work spindles and one counter-spindle, which had a specific metal consumption of 208 kg/kW.Other European and Asian companies have also reached this level with some accuracy. Along with adopting amodulardesigninMALdevelopment,theyalsoproviderepairandmaintenanceservices.

Thevaluesachievedarenotfinalandcanbeloweredmorebyintroducingelectromechanicalsystems, mechatronics, new load-bearing systems, and non-metallic materials, particularly, composites.

Forthepurposeofsolvingtheproblemsofproductivitygrowthandmetalconsumptionreduction, it is reasonable to use the approaches from evolutional and genetic synthesis theories [1, 7, 8 ,14, 15, 19], which are based on the laws of evolution and interdisciplinary sciences. Another representative of this group is genetics — an interdisciplinary knowledge do main studying the laws inheritance and structural changes in natural and anthropogenic systems developing in time.

With theintroductionofCNCinMALs,thedrivingtrainshavechangedfundamentally, electromechanical replaced mechanical, which initiated count for new MAL generations accounting for the evolution of main driving source (fig. 5) and SC rotation and fixing mechanisms (fig. 6). Abandonment of SC, the axis of which is the geometric axis of the lathe [3, 13], allows the most efficient implementation of modular design principle [4] and creating a number of CNC-equipped MALs with the help of systematic morphologic approach [6], increasing the number of spindles in order to raise the productivity.

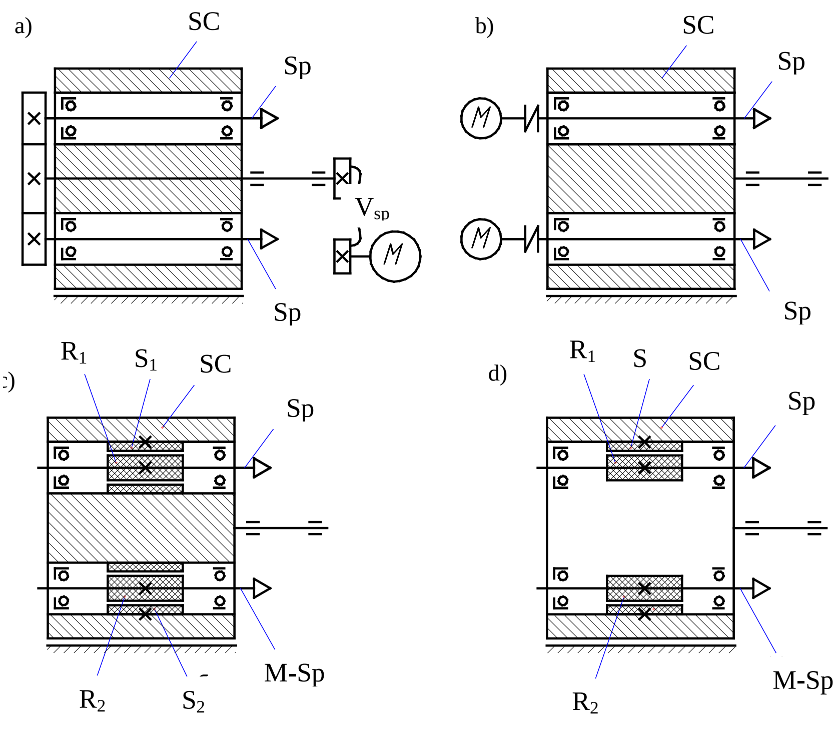

Fig. 5. Evolution of main drive development in MAL with rotary spindle carrier:
a—1st generation with mechanical transforming motor;
b—2ndgenerationwithoutmechanicaltrainswithindividualmotorsforeachspindle; c—3rd generation with motor-spindles; d—4th generation with motor-spindles and common stator (genetic forecast)

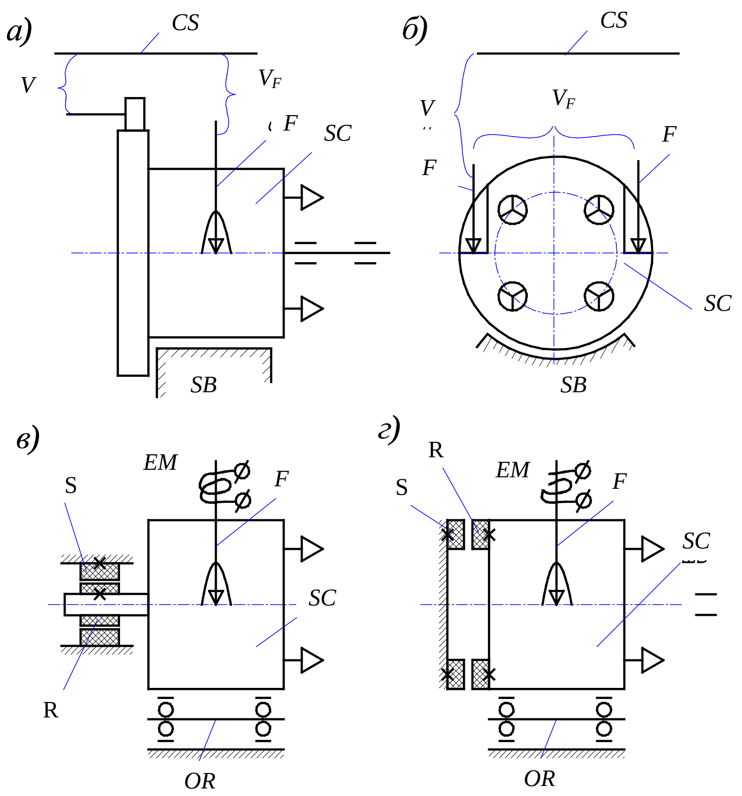

Fig. 6. Evolution of spindle carrier rotation and fixing mechanisms with cyclic control from camshaft with mechanical trains (a) and electromechanically systems and CNC—genetic for ecast (b, c): SC—spindlecarrier; CS—camshaft; F—fixator; EM—electromagnet; S—stator; R—rotor; SB—sleeve bearing; OR—rolling bearing

Conclusion

Based on the analysis of MAL evolution, 2 directions of enhancing them can forecast:

1. With SC and electromechanical systems of main drive, tool turret feed drive, chuck drive with geometric locking in loading-unloading position, bar feeding and fixing drive, rotation and fixing mechanisms of spindle carrier.

2. Without SC and with electromechanical systems of the main drive as a single module incorporating a motor-spindle and automatic chuck, tool turret feed drive, bar feeding and fixing drive.

In both cases hybrid driving systems for mechanisms and units will be utilized, as well as framework load-bearing systems widely employing non-metallic materials. The second direction with out rotary SC is the most promising, it implements parallel and parallel-serial machining techniques providing high productivity and machining quality along with maximum employment of modular principle and minimum consumption of materials and energy.

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