OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

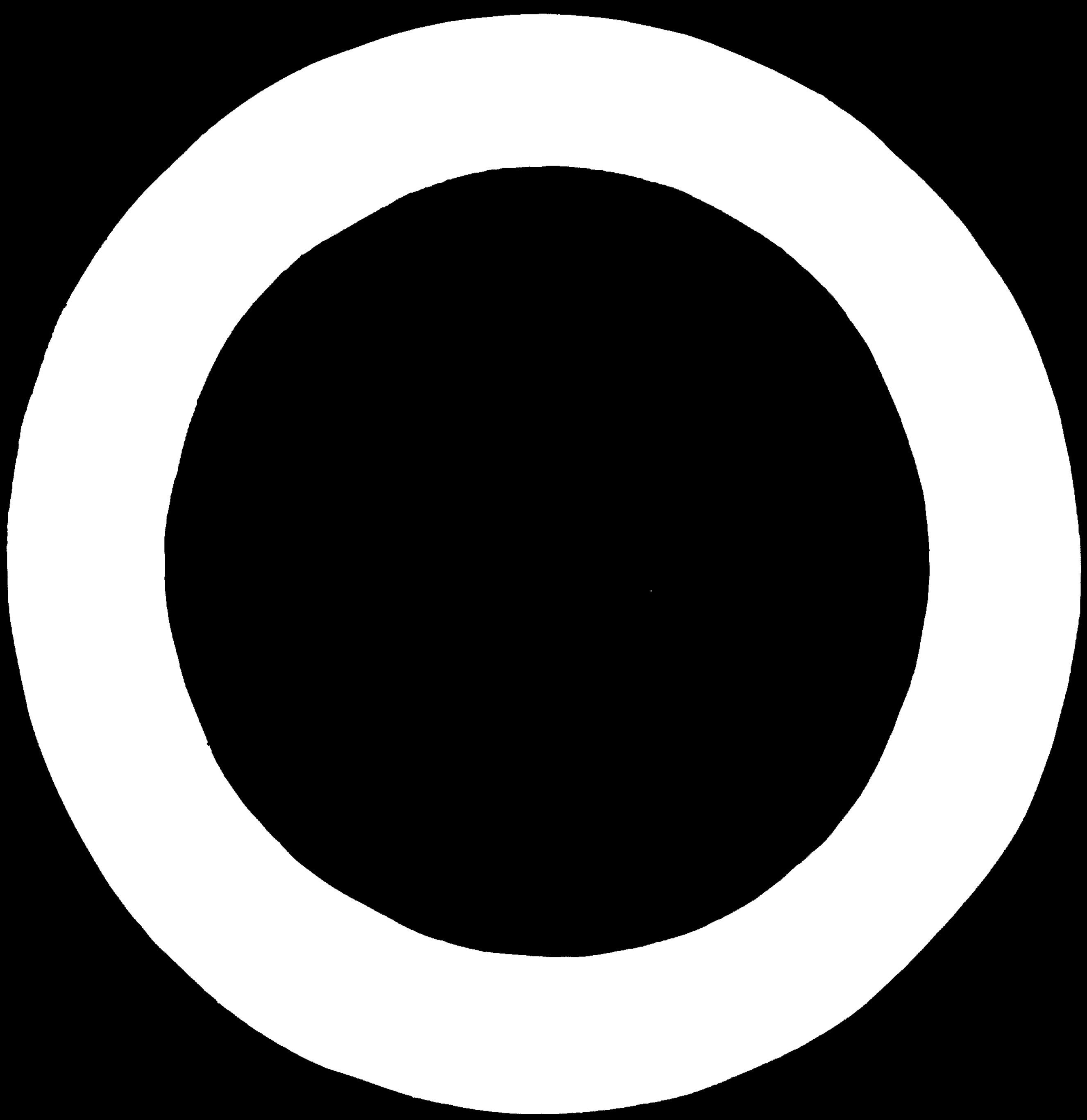
01132

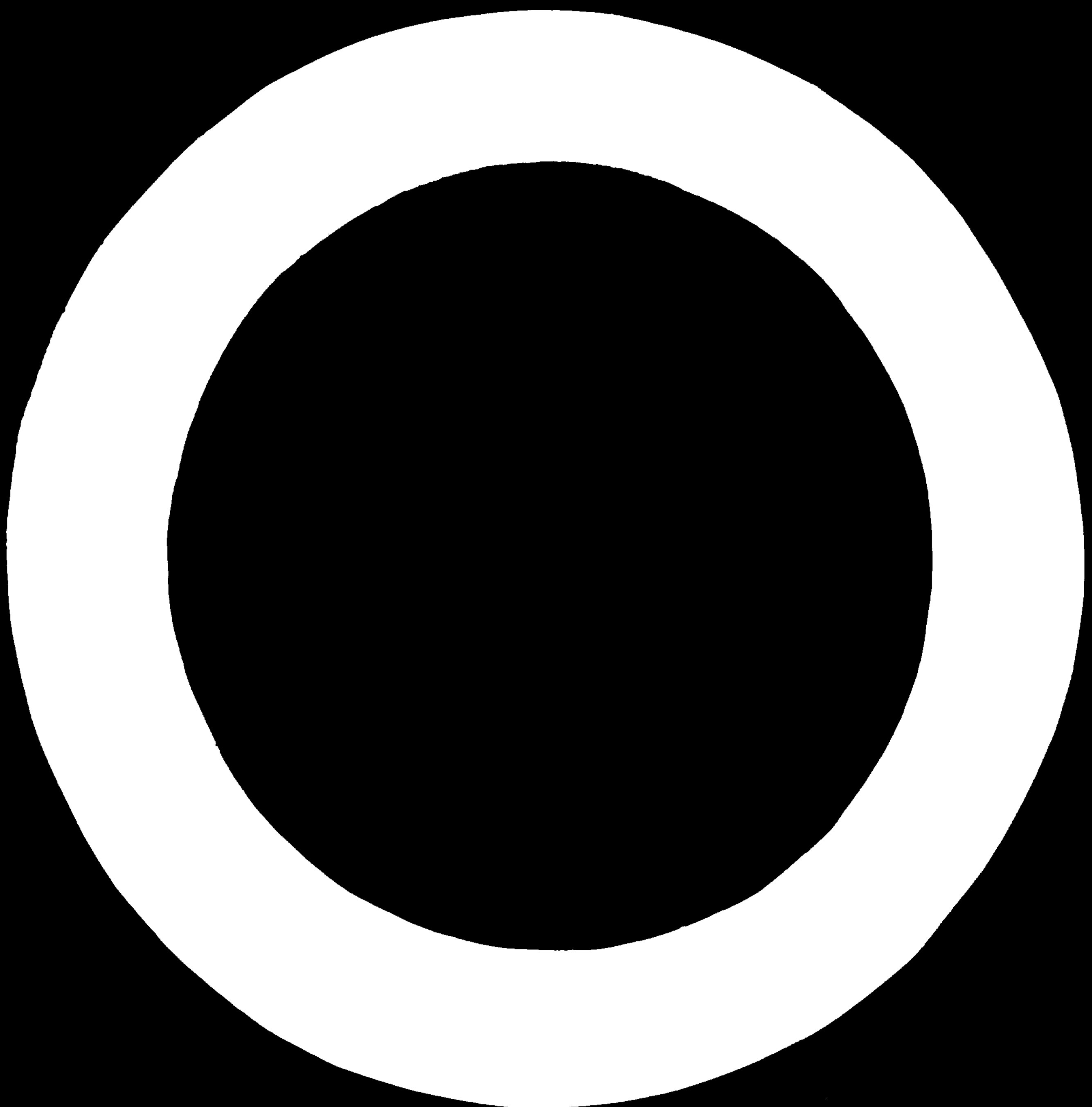
Development of Metalworking Industries in Developing Countries

Reports presented at the United Nations Interregional Symposium, Moscow 7 September—6 October 1966

Sales No.: E.69.II.B.2
ID/6

UNITED NATIONS
New York, 1969





D0118?

MACHINE-BUILDING TECHNOLOGY

A. E. Prokopovitch, Deputy Minister, Machine-Tool Industry, Union of Soviet Socialist Republics

TECHNICAL PROGRESS IN MACHINE BUILDING

Science and technology

Technological advances in the productive sectors of society are resulting in greater industrial and economic transformations than during all past stages of development put together, including the periods of discovery and industrial application of steam and electric power.

Rapid development of the so-called fundamental sciences, physical, technical, mathematical, chemical and natural, and the achievements of atomic physics and electronics have opened a new epoch in the development of technology, increasing the rates of industrial development.

The characteristic and distinguishing feature of the present stage of technological progress is a more rapid application of scientific discoveries into industrial production. If formerly tens and hundreds of years elapsed between scientific discoveries and wide-scale industrial application, now these periods are reduced to several years. Thus, for example, the discovery of the principle of generating focused beams of light (laser) took place slightly more than ten years ago. And at present laser methods have already obtained industrial application in communications, medicine and materials processing.

Especially vigorous development is taking place in the creation and industrial application of a wide range of synthetic materials.

Scientific discoveries radically changing the nature of industry and technology gave life to the appearance in the recent ten-year period of new branches of industry such as electronics and atomic energy.

Branches of industry producing household equipment and chiefly using the achievements of electrical engineering and chemistry are the most rapid in development.

As a rule, the industrial significance and economic effectiveness of all scientific discoveries and results of research is expressed mainly in new materials, new technological schemes and products possessing new and better qualities as compared with the old.

The rates of economic development of any country and especially of the developing ones depend, at present, on the speed with which scientific discoveries are transformed into actual schemes, technological processes and equipment and how widely they are employed in the country.

It is understood that scientific discoveries and technical achievements must be used for the development of productive forces and for making the life of the population more comfortable.

The fact that actually almost all the scientific and technical achievements in all branches of industry and agriculture are realized through machine equipment and instruments is a characteristic peculiar to technological progress.

This is the special role and significance of machine building, the basis for technically re-equipping the country's economy and the means for speeding up the technological reconstruction of industry and for increasing the national income.

General tendencies in development of machine building

Contemporary machine building is fulfilling, in general, two basic functions. First and foremost is the production of means of production, i.e. of equipment and instruments for production of various types of products. The nomenclature and the technical parameters of industrial equipment manufactured by individual countries are determined by the specific peculiarities of the economy and especially raw materials resources, by the size of the territory and the number of the population, by national traditions in trends of trade, and the existing and the prospective level of industrial development.

The second and the more increasing peculiarity of machine building is connected with the creation of so-called consumer equipment: radio and television sets, means of communication, refrigeration equipment and means which make household labour easier (vacuum cleaners, floor polishers, etc.).

If the first branch of machine building is developing in individual countries, in special channels, taking into account these peculiarities, then the second branch is of importance not only to the industrially developed countries but also to all others including the developing ones.

Under the current conditions of communication and association, the problems of supplying markets with sufficient quantities of cheap and high-quality consumer items are an urgent problem of every state. This acquires special importance for the developing countries which for a long historical period could not make full use of the achievements of contemporary society in improving the standards of living because of some economic and other reasons.

It is quite natural that the demands for, and the assortment of, consumer goods will be determined both by the economic and climatic conditions of each country.

But a considerable part of this variety is sold also in the world market.

When analysing this variety, it is necessary to estimate and weigh carefully the conditions in each country as well as the scale of development of machine building both for the industrial machinery and consumer equipment.

The assortment of modern machines and equipment is measured in millions. Technique is constantly developing and improving. The common characteristic of the development process anywhere is to increase the speed of production processes. This is expressed in continuous and sufficiently intensive growth of working speeds (in aviation, for example, speeds in the past twenty-five years have increased, excluding rocketry, from 200 300 km per hour to 1,000 3,000 km and more).

High-speed working processes and continuity of production processes became necessary and largely possible through automation and automatic control.

The tendencies of development of machines directly affect the technology of machine building which should create conditions making it possible to manufacture in sufficient quantity and variety with the least labour.

Thus, for example the application of electroerosion made it possible to manufacture curved and shaped holes and to meet design requirements for machines. The use of ultrasonic and laser techniques made it possible to produce materials with great precision and of practically any strength, thus creating the conditions for the use of new designs of machines.

Thus the development of machine building and instrument construction are closely related to the development of machine-building technology.

Peculiarities of machine-building development in developing countries

The industrial development of machine building and the use of equipment under contemporary conditions may be divided into three basic stages in the developing countries.

The first stage is the importation of machinery from more developed countries.

The second stage is the organization of maintenance and repair of the machinery.

The third stage is the organization of a country's production of machinery for its own use.

A developing country's decision on whether to import machines, produce its own, or some combination, must be based on its needs.

Today, not a single country, even the most developed one, can produce sufficient quantities and keep up the technical level of all the machines required: all are forced to import a considerable amount.

It is most probable that the economically expedient organization of production of industrial equipment in individual countries should be limited to those types of machines which are necessary for the development of the main branches of the economy and which draw on the country's natural resources. But there are many examples when some developing countries started to produce machinery from imported raw materials and successfully competed in the market. This is done to increase employment and national income.

International division of labour is already a fact and will increase as the economic relationships develop and become stronger, involving to an increasingly greater degree the industrially developed countries.

Technical and economic abilities of individual countries already show the advantages of producing certain types of machines more economically in one country than another. These peculiarities should be considered by the developing countries both at the first stage when solving the problems of import and especially at the third stage when organizing their own production.

The solution to the problems of the second stage, maintenance of machinery, is more complicated.

Practice shows that maintenance and repair of automobiles, refrigerators, radio and television sets and other equipment by the exporter may be acceptable at the first stage only. It is evident that in the course of development it is more economical to create national maintenance and repair facilities which will make it possible to render service both to the industry and to the public.

The third stage is the creation of national machine building, taking into account all ramifications.

Economic calculations prove the expediency, especially in the large developing countries, of creating in the shortest period national machine-building production of industrial equipment and consumer goods for its own use and for export.

It is very probable that within the next decade there will be all types of production scaled from mass to job work. Consequently, it is necessary to develop technology and to procure equipment bearing this in mind.

Effect of industrial development on machine-building technology

In what way does modern industrial development influence machine production?

First, in the change of raw materials to be processed. The variety of metals and alloys is continuously enlarging and these metals are stronger and more heat- and chemical-resistant.

Ceramics, hard minerals, plastics and other synthetics are more broadly used. However, based on all the factors, it is difficult to expect that in the next ten-year period the volume of plastics used in machine building will exceed 5 6 per cent of the total quantity of materials. Metals and their alloys will remain the basic construction materials for machine building.

Second, this influence is reflected in the dimensions of machines. The tendency towards classification of equipment by size has become more important recently. There is also a tendency to increase sharply the sizes of machines in metallurgy and transport (railroad, aviation, freight and passenger) and to miniaturize machines used in electronics and medicine.

Machine-building technology now must be more flexible and be capable of producing items weighing several thousand tons and items whose weight is measured in thousandths of a gramme.

Third, what is increasingly attracting the attention of scientists and industrialists is the demand for higher quality precision, stability and reliability of production equipment.

One should expect that the demands for precision will grow with the increase in production capacity.

But already the physical barrier of precision is clearly visible. Thus, in the aviation, bearing and means of control industries, there is the necessity to manufacture individual parts with a precision measured by parts of a micron, that is, where permissible error approaches the size of a molecule.

Large expenditures of labour and means to ensure such high precision now become an obstacle for the further development of some designs of machines. That is why the clearly outlined tendency of moving from machines with large kinematic speeds and dynamic loads to units with rotating and quickly moving parts to stationary equipment distinguished by a complete absence of rotating and moving mechanical elements is a natural phenomenon. The evolution from propeller to jet engines, the direct generation of electricity by chemical or heat methods without the use of mechanisms, may be referred to such a tendency.

But if in the sphere of power supply, transport and some other types of machinery the transformation into stationary units may be expected within the next decade, then in the spheres of the basic means of control a considerable decrease of demand for precision is not yet observed.

That is why the most important problem in the development of machine-building and instrument-making technology is the problem of precision and reliability of operation.

This actually determines the special role and significance of the machine-tool building industry, the heart of machine building. The technical level and scope of development of the machine-tool industry determine the level and the pace of development of all machine-building and metal-processing industries and deeply affect the development of the country's economy as a whole.

BASIC DEVELOPMENTAL RULES OF MACHINE-BUILDING TECHNOLOGY

The technical level of machine-building technology is first of all determined by the quality of the material to be processed, dimensions and form, productivity, machinery and equipment and the scale of production (from piecework to mass).

Use of raw and semi-finished products

The cost of initial materials reaches 50–70 per cent and more of the cost of manufacture, particularly so in batch and mass production. Wages are 20–35 per cent, and in a number of branches (instruments, bearings) are only 10–15 per cent or less. That is why the materials factor is so important. This factor may be determined by:

$$K_m = \frac{Q_i}{Q_m}$$

where: K_m is the material factor
Q_i is the weight of the machine
Q_m is the weight of the initial materials.

Experience shows that the losses of metal at all stages of production constitute 20–30 per cent or more in mass production and 35–40 per cent or more in batch or piecework production.

There should be given greater attention to improving precision in initial operations so that there is less to do in final stages.

Experience shows that only 30–35 per cent of the initial weight of metals is delivered as finished parts to the assembly line.

Modern methods are only now beginning to be applied to improve this ratio. The level of consumption of materials should be increased soon to 80–85 per cent in the machine-building industry. This will make it possible to bring about 50–60 per cent of the original metal weight to the assembly line.

In the current world market, the cost of raw materials is low compared to the cost of manufactured parts. The analysis reveals that the established ratios of prices in a number of cases do not correspond to the actual expenditures of labour and are chiefly determined by the conditions of obtaining these types of products. There are cases when some raw materials produced in economically backward countries with low wages are priced unjustifiably low as compared to highly priced machinery from industrially developed countries with high wages.

It is probably wrong to be guided by the market prices, but the decision should be based on the analysis of exact cost of social labour both for obtaining the raw materials and the manufactured products.

Continuous processes

The ever-growing tendency of shifting from discrete to continuous processes is a peculiarity of the main trend in technology. The index of continuity may be estimated by the following equation:

$$K_c = \frac{T_w}{T_o}$$

where: T_w is the time of useful work of equipment
T_o is the total working time.

The estimation of these indices may be referred both to the working shift and to a long period (month, year) of work.

The total working time consists of the useful operation time, auxiliary time, manual time, adjustment time, idle time, etc.

The existence of discreteness, though the present objective conditions make it possible to fulfil many processes by theoretically continuous methods, is a characteristic of machine-building production at all stages. Especially unfavourable is the ratio of time of useful work to total time in press forging and metal cutting. The useful time of metal forming constitutes only 2–3 per cent of the entire cycle of the operation. On metal-cutting machine tools the useful time of cutting is 50–60 per cent of the entire cycle and for such types of equipment as turning lathes it does not exceed 20–40 per cent.

These unfavourable proportions prove that the main attention is paid to the problems of increasing productivity of the working process proper and not to increasing the degree of continuity when designing machines.

Possibilities of practical improvement of the index of the continuity degree may be illustrated by two examples: application of periodical rolling methods in which the degree of continuity of the working process may be brought to 70–80 per cent makes it possible to increase productivity 15–20 times as compared to presses of the same capacity; substitution of centre grinding processes by centreless grinding makes it possible to increase the continuity degree from 50–60 per cent to 85–95 per cent and the productivity of the process two to three times.

In general, the increase of the continuity degree may be achieved by an over-all speeding up of auxiliary movements of working parts of a machine, by the reduction of the number of consequent movement elements or by performing auxiliary movements with the working movements at the same time.

Experience shows that this combination is the most effective. The development of equipment and technology should ensure reduction of nonproductive expenditures of working time as compared to the reduction of time for accomplishment of useful work.

Degree of concentration

There are two ways to organize productive processes. One is differentiation based on the maximum division of complex technological processes into simple elements for which special equipment is designed. The other is concentration based on the maximum combination of technological operations to be performed in a single unit.

Differentiation of technological operation, which made it possible to apply comparatively simple equipment and less skilled personnel prevailed at the first stages of development of machine building and especially of mass production. But based on economic factors such as demand for a large amount of equipment, working site and personnel, differentiation gave way to more effective methods based on application of complex units in which the concentration of various technological operations is fulfilled to the maximum degree.

The ideal method of manufacturing machine parts, not considering technical and economic possibilities, is manufacturing the part on a single machine in one pass. In a considerable number of cases the expedient degree of concentration is practically achieved by multitool and multiposition machine tools and the continuous process. When estimating the practicality of such decisions it is also necessary to take into account that, in the conditions of identical expenditures of auxiliary time, their total value will be less if there will be more technological operations performed on one unit.

The degree of concentration is expressed as:

$$K_k = \frac{l}{n}$$

where: n is the number of consecutive operations in manufacturing of the part.

In machine building this coefficient is equal to 0.2–0.3, which means that the part is subjected to three to five operations.

It is a little more difficult to solve the problem of manufacturing precision parts, when the parts must undergo consecutive finishing operations.

Accelerating the working process

There is a trend to accelerate working processes by increasing machine speeds and pressures.

Mechanization and automation

Statistical analysis in a number of countries shows that only a third of the increase in labour productivity is related to the increase of machine productivity while two-thirds of the increase in labour productivity is related to automation.

A stronger and stronger tendency to use automated equipment and automated systems is noted in batch and mass production.

The degree of automation of individual operating machines may be defined by the following equation:

$$K_a = \frac{t_a}{t_o}$$

where: t_a is the time of automated operations
t_o is the total time of the cycle.

Wider use of electric and electrohydraulic controls is being applied along with traditional means of automation of operating machines through mechanical distribution devices (chiefly in automatic turning lathes). Development of numerical control systems is of a special significance for batch production.

The proportion of automated equipment in mass production is as high as 80–95 per cent and the further increase of such automation is connected to introduction of transfer machine lines and gradual transfer to complex automatic systems. The proportion of automated equipment in batch production is 20–30 per cent. Further increase in the degree of automation in batch production is connected with design of flexible, quickly readjusted automatic machines equipped with standardized, sufficiently universal devices for clamping, rotation and removal of machine parts.

Wide-scale introduction of grouped methods of treatment is of great significance for creating economic conditions for introduction of automatic equipment into batch production. Correct choice of similar technology, tools and sequences of operations make it possible to cut significantly the time for their resetting and to increase the size of the batch. The use of numerical control equipment is the best way to increase the degree of automation in small batch production and in heavy machine building.

When solving problems of labour efficiency in machine building it is also necessary to take into account the fact that along with the production workers there are many categories of workers indirectly involved such as transport and warehouse workers, inspectors, dispatchers and accounts, etc. In some cases this category of workers is as high as 30–40 per cent of the total number employed. Under modern conditions it is impossible to estimate the level of technology only through the degree of automation of the basic production equipment, but it is essential to consider this problem by taking into account all the people involved in the production.

This problem may be most effectively solved by creation of complex mechanized continuous lines in batch production and complex automatic lines and shops in mass production.

The development of computers and automatic control raise the problem of creating automatic systems of production in the industry.

The practical solution of these problems requires raising the numbers of skilled personnel.

Experience shows that the idea that the demands for skilled personnel will be decreasing with automation and the development of technology has been rejected by practice.

Highly skilled personnel possessing the necessary skills and knowledge to maintain complex equipment are necessary.

This problem is especially important for the developing countries. The opinion that developing countries should be chiefly orientated towards the simplest types of machinery because of the absence of well trained and skilled staffs is not confirmed by either the economic or the social aspect. It is evident that no less time is required for training a highly skilled turning or milling machine operator than for training a skilled mechanic. The difference in both cases is only in the general educational level.

Stability of processes

The most important qualities of technological equipment and processes are reliability, durability and stability in operation. Generally the stability index may be expressed by the following:

$$K_{st} = \frac{t_c}{t_o}$$

where: t_c is the continuous operation time
t_o is the total operation time.

It is necessary to maintain the stability of working parameters as long as possible during the operation. This is especially important for metal-cutting operations where the tool life is relatively not very high.

The most effective solution of this problem is through application of automatic control directly to the workpiece which is machined.

The second and the no less important problem is to insure high reliability of operation of all machine elements. To increase the reliability and durability of machines, the engineers are facing the problem of discovering objective means of rapid estimation of the preset durability and reliability of individual parts, separate mechanisms and of the whole machine.

It is necessary to analyse all factors, though in some cases one or several may be decisive, when solving engineering problems of machine building.

Some peculiarities of development of machine-building technology at basic process stages

Rolled stock

Rolled stock manufactured by metallurgical enterprises was, is and remains to be the basic construction material for machine building.

Rolled stock constitutes about 60 per cent of the entire amount of materials used in machine building.

It is necessary to mark, along with these facts concerning the assortment of materials for machine building caused by the peculiarities of technical development, the continuity in technical development. Various types of bent and shaped profiles of higher rigidity make it possible to make miscellaneous, comparatively complicated designs of machine parts; these are becoming more widely used along with the traditional rolled shapes. Application of such types of rolled metal makes it possible in a number of cases to do without any treatment of metal in machine building. The proportion of the rolled shapes and bent profiles should soon be 5–7 per cent of the total amount of rolled metal supplied for machine building, according to experts.

There is a recent tendency, based on the specific demands of machine building, to increase the manufacture of high precision types of shaped metal (with a precision of 5–10 microns) for manufacture of such parts as spline shafts. These precise profiles find wider and wider application in machine building in spite of the labour-consuming operations when rolling and pressing.

The general tendencies of changing to the continuous processes find their reflection in rolling of metal and fabrication of the volume blanks by continuous methods, by the so-called periodic method instead of forging or stamping. Such mass-produced parts include ploughshares and mouldboards, bearing rings, crankshafts and many other types of parts.

Though now the proportion of blanks manufactured by the periodic rolling method is comparatively small it is expected that this method will be developing very intensively in the near future and it is necessary to take it into account when solving the problem of blank supplies in machine building.

Bi-metallic rolled stock, in which the corrosion resistant layer is connected with usual cheap types of construction steel, and rolled stock with plastic coating are used more widely in a number of machine-building branches, and first of all in those where there is a demand for corrosion-resistant equipment. The application of bi-metallic rolled stock and the rolled stock with plastic coating makes it possible to use cheaper materials and to reduce finishing expenses in machine building.

A more intensive shift from sheets to rolled stock in coils is characteristic of new developments in machine building. The rolled stock in coils varies in thickness from several microns to 3–5 and more millimetres. Application of rolled stock in coils instead of sheets makes it possible to lay it out more rationally and to solve the problem of automated methods of metal forming.

Welding

Welding is the most progressive technique in machine building.

Achievements in very effective linking of parts by welding in combination with the increasing assortment of rolled stock supplied for machine building lead to a continuous increase in the use of welded constructions.

In the total volume of blanks the welded constructions constitute 25–30 per cent.

Carbon dioxide welding which makes it possible to automate the process quite easily and ensures the welding speed up to 180–200 and more metres per hour is being more widely used for welding frame-type constructions. High mechanical strength is achieved when using carbon dioxide welding and in the majority of cases there is no need for thermal treatment.

Application of molten slag arcless electric welding has great prospects.

Wide application of friction welding is noted for joining different and difficult-to-weld parts. Friction welding for joining comparatively large surfaces (6,000 by 10,000 mm and larger) is now possible. Friction welding is most widely used in tool, car and tractor industries. Experiments in creating methods to weld practically unweldable materials by any other methods (for example, ceramics, wood with metal) are now being successfully carried out. Welding in vacuum by means of electronic beams is being applied in instrument making. In such branches of industry as instrument making, electronics and electrovacuum equipment may facilitate welding various kinds of hard-to-weld materials.

Creation of high-quality synthetic glues makes it possible to use glued and glued-and-welded constructions instead of the welded ones on a sufficiently wide industrial scale. The wide use of glued-and-welded constructions is observed in a railroad car building (for projection-spot welding), when welding tubes (projection-roller welding), and in the automotive and aviation industries (spot welding).

Impulse methods connected with the use of high energies find application in the sphere of welding (chiefly the explosion method), for example, for facing large surfaces in a single operation. This method also may find application for facing hydroturbine blades, when making bi-metallic blanks and in chemical machine building.

Metal forming

Metal forming is one of the basic methods in machine building for manufacture of blanks. About 30–40 per cent of the entire volume of processed material is pressed and forged.

The most widely used method of cutting blanks is cutting them with disc saws and hacksaws, leading to considerable losses of metal reaching more than 15–20 per cent. That is why the development of the so-called loss-free or low-loss methods of cutting blanks by chopping them on presses, or cutting them with thin abrasive discs mechanically or electromechanically is a characteristic trend in improving the technology of blank cutting.

The second trend in decreasing the unjustified losses of metals is the attempt to obtain blanks approaching as close as possible to the weight of stamped and forged parts.

The problem of so-called seamless stamping which specialists of many countries are trying to solve depends much on the precision in weighing the material to be stamped. This problem may be solved by using, for chopping and cutting blanks, numerical control making it possible to weigh the material precisely.

Reduction of metal losses caused by the heating of blanks is achieved through acid-free heating and through rapid heating by high-frequency currents. In some cases the method of rapid heating makes it possible to combine in one unit the processes of heating and plastic deformation.

Fabrication of blanks by free forging is the most widely used method. In spite of all the advantages of free forging, this method also has some disadvantages. Besides the low productivity, the precision of fabrication of blanks is extremely low and does not exceed for average sized forgings 2–3 mm and that is why, when processing the blanks fabricated by the free forging method, the losses of metal are as high as 40 per cent and higher. The solution of the problem of obtaining by the free forging method high precision blanks, will be accomplished through numerically controlled hammers which make it possible to make the forging with a precision up to 0.1 mm.

Thus, this ancient method may find new life in the manufacture of accurate blanks. So only its own disadvantage remains: comparatively low productivity.

Higher precision of blanks manufactured by stamping and pressing methods is first of all achieved through effective methods of fabrication of accurate dies and press forms and methods of press form restoration and also through dies and press forms made of durable materials. Electrocorrosion and electrochemical treatments for these purposes make it possible to change radically the character of technology of die fabrication, to restore them rapidly and to use dies of very strong materials including a wide assortment of hard alloys.

It is also necessary to note the second tendency in the development of volume forging: an attempt to shift from the methods of plastics deformation connected with previously heated blanks to the methods of manufacture of volume cold blanks. Application of these processes makes it possible to avoid losses caused by heating of materials and the expenses of heating.

The problem of obtaining very accurate blanks including those manufactured by methods of cold plastic deformation may be successfully solved through use of impulse methods connected with application of energy at high speeds and pressure.

Magnetic and explosion forming, electrohydraulic effects for plastic deformation and other methods are being widely used in a number of machine-building branches of many countries.

Many efforts are being made to find effective fabrication methods of such things as gears and spline shafts by rolling.

The problem of cold knurling of accurate gears with a module of up to 1.5 mm, and of spline shafts without any finish required as well as rough treatment by hot knurling of large module gears is practically solved today.

Rotation forging for making axle parts (crankshafts, etc.) is more widely used in batch production.

The shift from monoposition machines to the multi-position ones which make it possible to fabricate complex parts by a sufficiently productive method without intermediate annealing is a characteristic tendency in sheet stamping.

Methods of thin plastic deformation instead of the grinding effect are more widely applied along with the above-mentioned methods of knurling, threading and worming.

In addition, the methods which are widely used include: generating processes; rolling by means of rollers and balls; arbour pressing; vibration knurling of inner and outer cylindrical and flat surfaces and riveting.

Accurate blanks of comparatively small sizes for large batches and mass production are more economically fabricated from powder by pressing and caking. Application of metaloceramics makes it impossible to manufacture parts from compositions which it is difficult or impossible to obtain as alloys.

Automation in regard to feeding or removal of blanks, use of automatic control systems for heat treatment or machining itself is common in metalworking processes.

Castings

The proportion of castings made from ferrous and nonferrous materials constitutes 30–35 per cent including pig iron casting, 15–20 per cent; steel casting, 70 per cent; and nonferrous metal casting up to 5 per cent.

Tendencies to reduce the share of pig iron casting noted in the past ten years have slowed down.

This is explained by the cheap raw materials and by the creation of new effective methods of manufacturing accurate cast blanks and means which made it possible to mechanize and automate these processes.

The method of fabricating rods and castings by using liquid mixtures is a comparatively new method which became popular in a short time. This method is used along with the older methods of fabrication of accurate blanks in shell forms. This method makes it possible to fabricate sufficiently accurate blanks, makes simpler the technological process of preparing the moulds and does not require complex equipment.

The proportion of accurate castings in machine building constitutes at present about a third of the total production, including the castings manufactured by precision methods, 10 per cent of production.

The common disadvantage of the existing technology of casting is the disproportion between the technical level of technology and foundry equipment.

Problems of effective manufacture of precise moulds are the centre of attention of casting specialists. But as is known, the complex of casting production involves such labour-consuming processes as preparation of mixture and mould materials, preparation of liquid metal and its casting, cleaning and chipping of castings, thermal processing and painting of castings. Underestimation of the complexity of casting moulds leads to too much heavy manual labour. This is especially true for chopping and cleaning of castings. That is why efforts are directed to finding effective methods for solving these problems.

Ultrasonic and electrohydraulic methods of cleaning castings are being used along with the widely employed methods of hydraulic and shot-blasting processes. Plasma cutting, cutting by means of thin and very strong abrasive discs, etc., is being widely used to remove sink-heads, chiefly from steel castings. In batch and mass production this problem is most effectively solved by construction of complexes of mechanized and automated systems for all technological stages of casting.

The fact that the technology and production methods of casting are chiefly determined by their weight and volumes of production and to a smaller degree depend on the actual construction forms is an objective and favourable factor of successful development of casting. This makes it possible to create highly mechanized enterprises with application of up-to-date technology in highly mechanized plants. It is quite natural that the most effective solution may be achieved in conditions of specialized production based on optimal capacities.

Metal cutting

No tendency to reduce the proportion of metal cutting is observed in spite of intensive development of fabrication of precision blanks by plastic deformation or casting. This is explained first of all by the fact that some reduction of expenses connected with the removal of excessive metal during rough operations is compensated by the necessity to involve new operations to achieve the ever-growing demands for precision of fabricated parts. That is why the primary attention is given to the problems of development of metal cutting which finally determines the quality of products.

Increasing cutting speeds is mainly related to materials and cutting tools. An assortment of various hard alloys makes it possible to increase speeds up to more than 300 m a minute.

Application of multiedged hard alloy inserts for cutting tools, milling cutters and reaming instruments makes it possible to cut down cost of production.

The standard wolfram high-speed steels recently became less used than cutting steels based on cobalt, vanadium and molybdenum. These new types of tool materials are 1.2–2 times more resistant than the standard wolfram types and make it possible to operate at higher speeds: up to 120 m per minute instead of 25–40.

New types of materials and first of all diamonds are being widely used along with the perfected links and materials of abrasive tools which make it possible to polish at a speed of 50–100 m per second, chiefly in finishing operations, because of industrial applications of synthetic diamonds.

An expert estimation reveals that the efficiency of the cutting process through a combination of speed, load and the length of the contact for almost all kinds of technological equipment, may soon be doubled or more. This requires special attention when designing metal-cutting equipment and when solving problems connected with the increase of the degree to continuity of processes as the analysis of the operation cycles of the last models of many metal-cutting machine tools reveals tendencies to decrease the useful operation time within the limits of the cycle leading to a considerable decrease in the efficiency of the production process.

The problem of ensuring the necessary accuracy of metal-cutting treatment by more economic methods is basic to compiling and estimating a technological process.

Recent research has revealed the common rules of alteration of accuracy and has determined the basic trends which will make it possible to control the accuracy.

The scope of factors determining metal-cutting accuracy consists of the precision of fabrication, rigidity and vibration resistance of machine tools and durability of elements determining the kinematic accuracy of the tool position with respect to work.

Other factors are: change of conditions in the process of treatment, thermal deformations, errors in measuring and changes of dimensions of cutting tools caused by wear.

The practical solution of this problem is to create durable, high-quality, strong machine and cutting tools.

But the complete solution of this problem and especially for high-precision operations (5–10 microns and less) is creation of systems of adjustment which affect all elements: machine tool, clamp, cutting tool and work.

Taking into account the entire complex of factors connected with obtaining the necessary accuracy throughout a continuous period of operation, it is necessary to regard positively the attempt of many companies to create the necessary tolerances, i.e. to fabricate equipment with considerably less error for this type of treatment.

The safety margin of the tolerances makes it possible to obtain the pieces with required accuracy for a long period of time.

Taking into account the conditions of unautomated production characteristic of the present stage of machine building in many developing countries, the wide application of active control for all finishing operations will be of a limited nature and it is necessary to envisage the up-to-date means of control to measure the parts after machining.

Multimeasuring fixtures are very effective for batch production. It is necessary to use instruments which will make it possible to test in a complex the entire scope of basic parameters.

Electrophysical and electrochemical machining

Electrophysical and electrochemical methods of machining are being more widely used for both rough and especially accurate finishing operations.

Basic disadvantages of electrospark machine tools, intensive wear of tools and low efficiency, have been eliminated in a comparatively short time.

The efficiency of the latest models of electrodischarge machines is as high as 15,000 mm^3 a minute and the wear of the electrode is reduced to a fraction of 1 per cent. The efficiency of ultrasonic and electrochemical machine tools has increased manyfold. The tendency to combine diamond treatment with electrochemical and chemical treatment is especially fruitful.

The peculiarity of chemical treatment methods, which makes it possible to remove very thin layers of metal, makes them very good prospects for precise treatment of flat and shaped surfaces. Studies in light beam and electron beam technology are very promising for the progress of machine building.

Conclusions

The achievements of science and technology are increasing machine-building productivity.

In the course of establishing machine-building plants in developing countries, it is extremely necessary to use all modern achievements and practice.

The methods and means of production accepted for practical use should be based on deep economic analysis and the perspectives of development should be taken into account.

Methods and equipment for machine-building production are determined by objective technical and economic laws governing the development based on the product design and the scale of production.

More profound studies and development of specialized production and particularly production of blanks and standard parts are the most effective initial means of development.

When studying and determining the nature of machine-building and metal-treating branches of industry planned for developing countries, it is expedient to study machine-building branches dealing with the production and processing of the most efficient types of domestic raw materials and the assortment of machine-building products for everyday life.

The problems of employment in the developing countries, increase of national income and well-being of the people may be solved effectively on the basis of highly efficient methods, equipment and production organization, not through the use of low-output machines.

Successful introduction and development of up-to-date machine building in the developing countries depends much on the rates of training of engineers and technicians possessing the necessary knowledge of modern technology, and skilled workers who are required to operate the up-to-date equipment.

74.10.17