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USSR Report

CONSTRUCTION AND EQUIPMENT

(FOUO 3/81)

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USSR REPORT

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CONSTRUCTION

PRODUCTION CAPACITIES MATHEMATICALLY CALCULATED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 1, Jan 81 pp 50-53

[Article by N. V. Karpukhin, Candidate of Economics Sciences, and S. A. Alekseyev, engineer: "Economics and Management: Determining the Capacities of Construction Organizations"]

[Text] Insuring high, steady rates of expanded reproduction based on technological progress and further building up the country's production potential depend to a great degree on accomplishment of the capital construction program that has been prescribed. A most important condition for successful fulfillment of the capital construction plan is achievement of a balance between the volume of construction and installation projects being planned and the production capacities of construction and installation organizations.

The pressing nature of the problem of balancing the volume of construction and installation projects being planned with the production capacities of construction and installation organizations is evident from the fact that, due to the absence of commonly accepted accounting methods for production capacity and insufficient attention being devoted to determining and planning the capacities of construction organizations, many of their production capabilities are not fully utilized, or, on the contrary, quotas are established for construction and installation organizations that fail to take into account their production capacities, which leads to non-fulfillment of the plan for construction and installation work and failure to put projects into operation.

In accordance with the 12 July 1979 resolution of the CC CPSU and the USSR Council of Ministers "On Improving Planning and Increasing the Influence of the Economic Mechanism on Enhancement of Production Efficiency and Work Quality," beginning with the 11th Five-Year Plan, a stabile, five-year plan for capital construction (with annual quota distribution) will be prescribed for the USSR ministries and departments and for the union republic councils of ministers, which will have achieved a balance of material resources and technical and power engineering equipment with manpower and financial resources, and with the capacities of construction and installation organizations. USSR ministries and departments and union republic councils of ministers are obliged to work out measures aimed at speeding up realization of production capacities and the commissioning of projects for construction jobs already begun, and measures to effect a sharp drop in the number of renewed-construction projects, in order to get the volume of unfinished construction down to levels of established norms in the next few years.

Accordingly, a well-founded determination of the capacities of construction and installation organizations and sound planning with regard to these capacities today constitute an important undertaking which must be taken into account in developing plans for capital construction.

A great number of ways of calculating the production capacity of construction and installation organizations (1-4, bibliography) have lately been approved, but attempts to formulate common recommendations in making these calculations for various management levels (trust, association, main administration, etc.) have not as yet yielded the desired results.

In order to achieve this aim, specialized literature (bibliography entry 1 in particular) proposes developing a set of methods that would permit defining all types and varieties of construction and installation organizations and planning their progressive development independent of technical orientation or specialization. Only if this is accomplished will it be possible to insure that balance calculations of production capacities by oblast, region and area of concentrated construction conform to plans for capital investments. In this regard it is necessary to tie in the methods of defining and planning the production capacity of a construction and installation organization with the methods and practical aspects of planning the basic technical indicators of its production operations.

A body of specialists from the All-Union Institute for the Planning of Electric Power Projects is currently working on formulating and introducing systematic recommendations for determining and planning production capacities that take into account the volume of construction and installation projects being planned, resources, and the technical and economic indicators of construction and installation organizations.

The first step towards establishing common industrial methods for determining production capacities of construction and installation organizations of the USSR Ministry of Power Engineering was the drafting of recommendations for calculating production capacity of the construction and installation trust.

According to accepted concept, by production capacity of a general-construction organization that accomplishes construction and installation work and engages in diverse construction projects is meant the maximum volume per calendar period (year) of construction and installation work which can be accomplished by the organization on construction jobs included in the engineering support plan for projects underway. This assumes full utilization of what means of production and labor force the organization has at its disposal (including externally solicited) and also the use of advanced technology and the most efficient organization of production and labor. It follows from this definition that production capacity depends on the availability to the construction and installation organization of an active portion of construction-related fixed production capital (including production capital brought in from mechanization administrations and trusts, machine-rolling facilities, clients, and other outside organizations) as well as on the qualifications of the labor force.

The average annual production capacity for a construction and installation organization, $ПМ_{ст}$ (in thousands of rubles) may be calculated by one of the following formulas:

$$ПМ_{ст} = Ф^{а}_{ст} Е^{а}_{макс}; \quad (1)$$

$$ПМ_{ст} = В^{макс} Ч_{ст}, \quad (2)$$

where $Ф^{a}_{cr}$ represents the average annual cost of the active portion of construction-related fixed production capital in thousands of rubles; $E^{a}_{макс}$ is the computed index of maximum (upper limit) capital yield per ruble cost of the active portion of construction-related fixed production capital; $B^{макс}$ is the computed index of maximum (upper limit) average annual output per employee measured in rubles per person; $Ч_{cr}$ denotes the average annual number of employees.

One would agree with the opinion of the author of the first work (bibliography) that there are no fundamental differences in determining the production capacity of a construction organization according to formulas (1) and (2). The problem comes down to finding the variance in the output index (or in the yield index) which adequately reflects the actual influence of production factors on it. In our view, the second formula for calculating the production capacity of a construction and installation organization is preferable, since the factors that determine the index for a single worker's output, and the dynamics of its change in light of growth in the technological level of construction and improvement of the organization and management of the construction process have been studied in sufficient depth. There is a natural tendency for constant growth in the output index, a fact which illustrates the development of technological progress in construction. Being a generalizing indicator of the production economics of a construction and installation organization, the output index has long been applied in practical planning and can therefore be used in calculating and evaluating other technical and economic indicators. Along with output, the index for yield per ruble cost of fixed production capital is also a generalizing indicator of the production economics of a construction and installation organization, and reflects the degree of utilization of resources in this regard (both technological and manpower), but insufficient study has been conducted as to how this index varies.

The output index depends on the simultaneous influence of a great number of factors, all of which must be taken into account in its calculation.

In its general form, the dependence of the output index upon the factors that determine it is characterized by the expression

$$B=f(X_1, X_2, X_3, \ldots, X_n), \qquad (3)$$

where $X_1, X_2, X_3, \ldots, X_n$ represent the factors which determine level of output.

It follows from formula (3) that, with the help of the index for labor productivity (output), one may conduct a comparative analysis and appraisal of the production capacity of construction and installation organizations that accomplish various kinds of construction and installation projects and have different levels of labor mechanization.

In order to build an economic-mathematical model for the output index and calculate the production capacity of a construction and installation organization, one must know the nature and degree of influence of certain factors on this index.

In our opinion, all those factors which influence the production capacity of a construction and installation organization and their usage level may be conditionally broken down into groups that characterize the following:

(a) the technical level of production, the composition and structure of fixed production capital, the mechanization level of construction-related processes, the technical condition of means of production being utilized, and power availability per worker;

(b) the level of organization for construction production and labor, the utilization of construction machinery and equipment as related to time and productivity, the rhythm with which construction and installation projects are accomplished, the organization of labor and salaries of workers and other employees, the skill level of the labor force (workers and engineering and technical personnel), the diffusion of advanced labor techniques and methods;

(c) the pattern of construction being accomplished, the proportion by type of construction underway, the level of prefabrication in structures;

(d) the supply of resources (labor force, building materials, products, structural parts);

(e) geographical, climatic and hydrometeorological conditions under which construction takes place, the territorial distribution of projects, the concentration of construction production, the presence and condition of road networks.

The value of $B^{макс}$ in formula (2) is dependent on the maximum influence of these factors on the production capacity of a construction and installation organization.

$B^{макс}$ is determined from the base output B_0 and from the sum of the increments for each "i-th" factor $\sum_{i=0}^{n} \Delta B_i$ relative to the base year (fixed):

$$B^{макс} = B_0 + \sum_{i=1}^{n} \Delta B_i; \qquad (4)$$

$$\Delta B_i = B_i^{макс} - B_0, \qquad (5)$$

where $\Delta B_i^{макс}$ is the output from maximum effect of the "i-th" factor entered into the economic-mathematic model.

Substituting expression (5) into formula (4), we obtain:

$$B^{макс} = B_0 + \sum_{i=1}^{n} (B_i^{макс} - B_0)$$

or

$$B^{макс} = B_0 \left[1 + \sum_{i=1}^{n} \left(\frac{B_i^{макс} - B_0}{B_0} \right) \right]. \qquad (6)$$

If we use l_i to represent $(B_i^{\text{макс}} - B_0)/B_0$, then

$$B^{\text{макс}} = B_0\left(1 + \sum_{i=1}^{n} l_i\right), \qquad (7)$$

where i=1, 2, 3,..., n.

Substituting expression (7) into formula (2), we obtain:

$$ПМ_{\text{ст}} = \left[B_0\left(1 + \sum_{i=1}^{n} l_i\right)\right] Ч_{\text{ст}}. \qquad (8)$$

The base output is determined from reporting and accounting data under conditions of organization and management of construction production in existence for the given period; it is determined by building the multi-factor correlation model

$$B_0 = f(X_1, X_2, X_3, \ldots, X_i, \ldots, X_n).$$

To determine $B_i^{\text{макс}}$, correlation functions of output B_i for the "i-th" factor are formulated while eliminating the effect of the remaining factors. The extreme output value selected in the model which has been built will represent $B_i^{\text{макс}}$.

TABLE I

No.	Indicator	Information Source		
		Form	Line	Column
1	Number (average listing) of employees [rabotnik] engaged in construction and installation projects (CIP) and auxiliary production (AP)	3t [expansion unknown]	001	2
2	Number (average listing) of workers [rabochiy] engaged in CIP and AP	3t	002	2
3	Wage fund for workers engaged in CIP and AP (thousands of rubles)	3t	002	4
4	Number (average listing) of workers engaged in CIP	3t	033	2
5	Number of man-days worked by all CIP and AP workers	3t	100	-
6	CIP volume, taking into account projects not completed (thousands of rubles)	3t	102	2

TABLE I (cont'd)

No.	Indicator	Information Source		
		Form	Line	Column
7	Output per employee (rubles)	3t	104	2
8	Salary of workers who are on the lump wage payment system (thousands of rubles)	3t	392+393	-
9	Salary of workers who are on piece-rate valuation (thousands of rubles)	3t	502	-
10	Time rate wages by wage scale (thousands of rubles)	3t	504	-
11	Wage increment for workers in the extreme northern regions and areas that equate to them (thousands of rubles)	3t	512	-
12	Same as above by rayon coefficient (thousands of rubles)	3t	513	-
13	Volume of CIP accomplished by general contracting (thousands of rubles)	1ks [expansion unknown]	10	2
14	Volume of CIP accomplished by internal resources	1ks	30	2
15	Actual expenditures on basic materials (thousands of rubles)	2s [expansion unknown]	031	2
16	Actual expenditures for operation of machinery and equipment	2s	033	2-3
17	Total aggregate power capacity (at year's end) of all building machinery (kilowatts)	12s	39	-
18	Average annual cost of construction-related fixed production capital (thousands of rubles)	11s	080	2
19	Average annual cost of machines and equipment in operation (thousands of rubles)	11s	090	2

TABLE I (cont'd)

No.	Indicator	Information Source		
		Form	Line	Column
20	Value of power machinery and equipment at the beginning of the year (thousands of rubles)	11s	170	2
21	Value of power machinery and equipment at the end of the year	11s	170	2
22	Cost of auxiliary production output at wholesale prices (thousands of rubles)	3pp-p [expansion unknown]	conclusion	7
23	Time of operation for machines and equipment (machine-hours)	1pt or explanatory note	"	5
24	Number of machine-days (present in the economy)	same as above	"	2
25	Number of machine-days (operational)	"	"	3
26	Average percentage fulfillment of output norms	4t or explanatory note	01	6
27	Average worker pay grade	explanatory note	"Labor" section	-
28	Number of team workers (those working by the "N. Zlobin method")	same as above	same as above	-
29	Number of workers released by virtue of violation of labor discipline or of their own accord	3t or explanatory note	"Labor Force" section	-
30	Number of unauthorized or unexcused work absences (man-days)	same as above	120+119	-
31	CIP volume of industrial (power engineering) construction (thousands of rubles)	explanatory note	-	-
32	CIP volume of residential construction	same as above	-	-
33	CIP volume of social and cultural construction, everyday facilities	"	-	-
34	Capital repair, etc.	"	-	-
35	Number of trust subunits	"	-	-
36	Number of annual work days	"	-	-

TABLE II

Symbol	Factor	Formula for Calculation Using Initial Data
X_1	Power-to-worker ratio (kilowatts per person)	$\frac{\text{п. }17}{\text{п. }4}$
X_2	Mechanization-worker ratio (rubles per person)	$\frac{\text{п. }19+\frac{\text{п. }20+\text{п. }21}{2}}{\text{п. }4}$
X_3	Utilization of the inventory of building machinery and equipment with respect to time (%)	$\frac{\text{п. }23}{\text{п. }24\cdot 8{,}2}\,100$
X_4	Labor-intensiveness pattern (%)	$\frac{\text{п. }3\cdot 10^{-3}}{\text{п. }6}:\frac{\text{п. }9\cdot 100}{\text{п. }26}+\text{п. }10\cdot\text{п. }5\cdot 10^{-3}$
X_5	Materials-intensiveness pattern (%)	$\frac{\text{п. }15}{\text{п. }6}\,100$
X_6	Level of production concentration (millions of rubles)	$\frac{\text{п. }13\cdot 10^{-3}}{\text{п. }35}$
X_7	Time-at-work utilization (%)	$\frac{\text{п. }5\cdot 100}{\text{п. }2\cdot\text{п. }36}$
X_8	Labor force turnover (%)	$\frac{\text{п. }29}{\text{п. }2}\,100$
X_9	Application (%) of the lump wage payment (and bonus) system	$\frac{\text{п. }8}{\text{п. }9}\,100$
X_{10}	That proportion of the overall number of employees who are workers engaged in basic production (%)	$\frac{\text{п. }2}{\text{п. }1}\,100$
X_{11}	Time-at-work loss (%)	$\frac{\text{п. }30}{\text{п. }5}\,100$
X_{12}	Auxiliary production ratio (%)	$\frac{\text{п. }22}{\text{п. }6}\,100$
X_{13}	Expenditures for machinery and equipment operation per worker (rubles pe. person)	$\frac{\text{п. }16}{\text{п. }2}$
X_{14}	Level of specialization (%)	$\frac{\text{п. }13-\text{п. }14}{\text{п. }13}\,100$
X_{15}	That proportion of basic production workers who are engaged in auxiliary production (%)	$\frac{\text{п. }2-\text{п. }4}{\text{п. }2}\,100$
X_{16}	Ratio of industrial construction to overall volume of general-contracted CIP	$\frac{\text{п. }31}{\text{п. }13}\,100$
X_{17}	Ratio of residential construction to overall volume of general-contracted CIP	$\frac{(\text{п. }32+\text{п. }33)}{\text{п. }13}\,100$
X_{18}	Ratio of capital repair expenditures to overall volume of general-contracted CIP	$\frac{\text{п. }34}{\text{п. }13}\,100$

"П." in this col. denotes the corresponding indicator from TABLE I.

A most important element in making a true calculation of the value of production capacity for a construction and installation organization is the determination of those factors on which the values of B_{i} and $B_{i}^{макс}$ depend.

It must be noted that computer programming of the problem of determining production capacity for construction and installation organizations would permit the building of multi-factor, predictive models for labor productivity (output) and provide a basis for long-range calculations of production capacities.[1] In reaching a decision for the period under planning, long-range development trends are determined for the technical and economic indicators of an organization, objective principles for measuring the indicators come to light that took shape over the previous period, tendencies for change in the factors are ascertained, and calculated values of the capacity indicator are substantiated for the future period.

With this in consideration, the fo mula for calculating future [subscript П] production capacity of a construction and installation organization will look like this:

$$ПМ_{п} = B_{п}^{макс} Ч_{п}, \qquad (9)$$

where $B_{п}^{макс}$ and $Ч_{п}$ represent the planning values for maximum (upper limit) output per employee, and number of workers engaged in basic and auxiliary production, respectively.

$B_{п}^{макс}$ is determined in the same manner as $B^{макс}$. However, here the tendency for change in the value of each "i-th" factor that enters the predictive output model is taken into account, i.e., we have an approximation function which reflects the economic essence of the phenomenon and the principles of its development in time.

The methods that have been developed have become the basis for building a static report balance of production capacities for construction and installation project volumes of a number of trusts in the USSR Ministry of Power Engineering for 1979. This balance should be an important element in developing a program for contract work, and should reflect a link between production capacities and the CIP program. It should also show the level of utilization of resources (capacity) both according to the plan and in actuality. The final result of compiling a report balance of production capacities will be reaching objective decisions as to the advisability of redistributing the capacities of construction and installation organizations and contract work programs being planned. In this regard, the program for construction and installation projects should not exceed an organization's production capacity.

As a check of the methods used in calculating CIP production capacities and compiling a static report balance of production capacities for the 1979 CIP volumes, 36 technical and economic indicators (Table I) were collected and processed. These reflected data pertaining to 98 trusts of 11 main construction and installation administrations in the USSR Ministry of Power Engineering. Included in the initial data were only those statistical reporting indicators that were in effect over the seven-year period 1970 through 1977. The factors listed in Table II, which hypothetically influence the production capacity of contracting organizations, were calculated based on these indicators.

1. Such a computer program has been developed at the Odessa branch of the All-Union Institute for the Planning of Electric Power Projects under the directorship of V. Ya. Braverman.

Predictive models for output were built using methods of economic and mathematical modeling, based on which production capacities of trusts were calculated according to formula (9). Factors entered into the models were those that were most influential. 1977 was taken as the base year.

Using the values calculated, a static report balance was compiled for production capacities with CIP volumes for contracting organizations (98 trusts) of the USSR Ministry of Power Engineering for 1979.

Results of the theoretical calculations agree favorably with the true data for trust capacities. It should be stressed that deviation from calculated capacities in planning will sharply increase the probability of failure to meet plan quotas. For example, a program was established for the Northern Power Engineering Construction Trust in 1979 for projects to be accomplished using their internal assets. The program exceeded the organization's calculated capacity by three million rubles, a factor that turned out to be one of the reasons for non-fulfillment of the 1979 plan (87.5 percent). For the Central Power Engineering Construction Trust, the 1979 program exceeded the trust's capacity by 3.5 million rubles; as a result the plan was fulfilled only to the extent of 93.1 percent.

Naturally, the methods being proposed require more rigorous analysis and further study, but the results already achieved are indicative of their viability.

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CONSTRUCTION MACHINERY

NEW APPROACHES TO ORGANIZING CONSTRUCTION RECOMMENDED

Moscow VOPROSY EKONOMIKI in Russian No 1, 1981 pp 23-33

[Article by P. Podshivalenko: "Ways to Reduce the Cost of Construction"]

Text] The CPSU Central Committee's draft for the 26th congress, "The Main Directions for the Economic and Social Development of the USSR During 1981-1985 and During the Period up to 1990," set tasks for improving design and budget-estimating matters and for executing construction in accordance with more progressive and economical designs; for requiring increased capital-investment effectiveness in designs, based upon use of the achievements of scientific and technical progress and advanced experience and a saving of material and labor expenditures; for reducing costs for constructing buildings and structures; and for reducing specific capital investment per unit of capacity introduced into operation.

Many large facilities that meet the highest requirements for scientific and technical progress have been built according to designs by Soviet specialists. Thus, the assembly complex of the Plant imeni I. A. Likhachev and the diesel building of the Bryansk Machinebuilding Plant, which were introduced ahead of schedule, greatly raised the capacity of these enterprises. Labor intensiveness of vehicle assembly was reduced one-third to one-half below the industry average. Comprehensive reconstruction of the rolling mills of the Pervoural'sk New-Pipe Plant enabled their capacity to be increased by 200,000 tons of steel pipe per year. The reconstruction cost 25 million rubles but 100 million rubles would have been required to build a new shop of the same capacity.

The creation of the Takhiatash hydraulic-engineering complex on the Amu-Dar'ya River enabled more than 1.5 million hectares of arid land to be used effectively. After it was put into operation the water supply of the river's lower courses improved considerably, and yields of cotton and rice--the principal agricultural crops of Central Asia--rose. As a result, annual state income was increased by more than 50 million rubles. Construction of the hydraulic engineering complex enabled elimination of mechanized water intakes and, correspondingly, expenditures (up to 35 million rubles per year) for regulatory work on the riverbed and for cleaning settling tanks. The costs were recouped in 3 years.

At the same time there are still deficiencies in the work of design organizations, primarily the long time taken to make up designs and low design quality. For example, the cost of a blast furnace that was built at Lipetsk in 1973 turned out to be 13.4 million rubles more than initially planned. The volume and production area of oxygen-converter departments designed by Gipromez [State All-Union Institute for the Design of Metallurgical Plants] of USSR Minchermet [Ministry of Ferrous Metallurgy] exceed 1.5-fold to 2-fold those of departments built in some other countries. This leads to delays in and greater costs for construction.

Design institutes often develop and send to construction organizations documentation that is based on solutions that are far from being the most progressive from the scientific, technical and industrial standpoints. Thus, seven blast furnaces that were introduced during the Ninth Five-Year Plan were not equipped with integrated automation systems. Even designs for rural construction projects often provoke rebukes. Modern machinery cannot be used at many livestock buildings. As a result, manual labor is retained where the work could have been mechanized.

The proportions that now exist between the budget-estimated cost of all the facilities that are under construction (it exceeds 4-5 annual plans) the time spent erecting them (5.7 years versus the standard of 3.5) and the amounts of uncompleted construction (91 percent of the annual amount of capital investment instead of the approximate 65 percent under the norms) are irrational. All this is the consequence of the dispersion of capital investment over numerous jobs, the number of which now reaches 300,000 (for facilities for production purposes). However, a decrease in the number of jobs under construction does not in and of itself completely solve the problem of reducing construction time.

The interdependence of the prolongation of construction time and increase in construction costs is traced in the data of an analysis that embraces about 50 percent (by annual amount of capital investment) of construction projects for production purposes (in percent of the total):[1]

	Full budget-estimated cost	Residue of budget-estimated cost at the start of 1975	Capital investment plan, 1975
Construction projects started:			
Prior to 1966..................	46	34	29
1966-1970......................	25	24	23
1971-1975......................	29	42	48
Total.................	100	100	100

Fifty-two percent of the total capital investment, 71 percent of the total budget-estimated cost and 58 percent of the residue of the budget-estimated ceilings were at facilities started prior to 1971, with construction periods of 6 to 10 years or more. At the same time, 48 percent of the total capital investment, 29 percent of the total cost, and 42 percent of the residue of the budget-estimated ceiling were at facilities that were started in 1971 or later.

The budget-estimated cost of construction during the period being analyzed rose by more than 20 percent. In so doing, 77 percent of the total increase in budget estimated cost was at facilities whose construction was undertaken prior to 1966,

1. See "Faktor vremeni v planovoy ekonomike" [The Time Factor in a Planned Economy]. Izdatel'stvo "Ekonomika", 1978, page 86.

21 percent at facilities included in the 1966-1970 plan, and about 2 percent at facilities started during the Ninth Five-Year Plan.

Consequently, as the time spent erecting facilities increases, construction becomes costlier. As a result, the annual growth in capital investment goes mainly to making up the difference in the budget-estimated cost, which causes a shortage of resources for carrying out the program for facilities due for startup. In 1976-1979 the increase in construction costs was about 40 billion rubles.

It must be noted that sometimes the press advances arguments to the effect that a reduction in construction time makes construction work cheaper, which should compensate construction organizations. It is true that recently the defenders of this concept have been remarking that this refers to compensation not for all actual expenditures but only for the "socially normal" ones that are needed for reducing construction time. Obviously, they have in mind "new principles and relationships" that are in the background, outside the sphere of economic analysis. These include, for example, nonuniformity in the workload of construction organizations, especially when their work program is reduced; structural shifts in the program, including changes in the ratios between the total amount of the work and the introduction of fixed capital; the connection of the contractors' capacity with previously started jobs, and so on[2]. In our opinion, none of this has any foundation in principle but is just a consequence of miscalculations in plans and in deployment of construction organizations, violations of proportions in the development of their capacity, and so on. Therefore, it is necessary to eliminate deficiencies in planning, to improve economic activity, to intensify the influence of the economic mechanism on the work results of construction organizations, and to refrain from planning, as has been suggested, for compensation for construction becoming costlier.

Some economists in the USSR and abroad observe that the optimal norm for the construction of average-sized enterprises is 12 months. In Japan, for example, it is considered that it is unsuitable to build most facilities over a period of more than 2 years because of the rapid obsolescence of equipment and technology.

In accordance with the decree of the CPSU Central Committee and the USSR Council of Ministers of 12 July 1979, design-and-survey, design-development and other organizations of a similar type are being converted to full cost accounting. They should plan the output of a finished product; they will obtain funds for a finished design and prior to this they will use bank credit; they will be granted the right to form economic incentive funds through profit.[3] This will undoubtedly

2. For example, R. M. Merkin, "Ekonomicheskiye problemy sokrashcheniya prodolzhitel'nosti stroitel'stva" [Economic Problems of Reducing Construction Time] (Izdatel'stvo "Ekonomika", 1978); and "Problemy sovershenstvovaniya planirovaniya tekhniko-ekonomicheskikh pokazateley stroitel'nogo proizvodstva" [Problems of Improving Planning of the Technical and Economic Indicators of Construction Work], (STROITEL'STVO I ARKHITEKTURA [Construction and Architecture], No 10, 1980).
3. The decree called for settlements between clients and design and survey organizations for designs that are completely finished and accepted by the client. In accordance with the Standard Practice Instructions of USSR Gosplan on Planning for Design and Survey Work (1980), designs for which the client has made no comments in 45 days, that is, independently of approval of the design, are

create a basis for restructuring work in the areas of the design of construction and the development of equipment and in seeking out and using reserves for reducing construction time and costs.

According to the indicated decree, USSR ministries and agencies and Union-republic councils of ministers are obligated to design and build new enterprises and to expand and rebuild existing enterprises on the basis of highly effective technology for production and the use of new equipment that will provide at the newly introduced capacities for the output of products that will correspond in their technical level and quality to the best domestic and foreign models or will exceed them. It is important here to increase the share of the active portion of fixed productive capital, for the growth of capacity of any enterprise depends upon the degree to which it has been provided with modern machinery and equipment.

For example, the installation of high-powered turbines at new electric-power stations decreases the specific cost of the construction of thermal electric-power stations by an estimated 25-30 percent per kilowatt of power generated. Growth in the capacity of installations that produce low-density polyethylene from 50,000 tons in 1975 to 70,000-75,000 tons in 1980 provides for a reduction in specific capital investment by 50 percent, metals intensiveness by 40-50 percent and prime cost by 10 percent, and for a 1.4-fold to 1.5-fold increase in labor productivity.[4]

The use of more machinery and equipment of higher capacity or power improves the technological structure of capital investment and, as a rule, does not lead to an expansion of production space, reduces the time required for introducing capacity into operation, and yields great national-economic benefit. Meanwhile, the November 1978 CPSU Central Committee Plenum noted a definite lag of machinebuilding behind the national economy's requirements. In confirmation of this is the fact that the average period for creating new models of machines, equipment, apparatus and instruments during the Ninth Five-Year Plan was 2.6 years, while for 21 percent of the models the average was more than 4 years. In particular, a modern complex of machines with an annual output of 1.6 million tons of I-beams was planned for the start of the Ninth Five-Year Plan but was put into operation at the end of 1977. The long delay in introducing the complex at the Nizhnyy Tagil Metallurgical Combine led to an overconsumption of almost half a million tons of expensive metal in the national economy.[5]

Obsolete machinery is still being produced, modern machinery is being manufactured slowly, and equipment (including serially produced equipment) is being delivered to construction sites without preliminary adjustment and testing, and at times the equipment has not been fully outfitted. As a result, construction takes longer and becomes costlier, the technical and economic indicators of the enterprises and facilities being introduced are degraded, and there is obsolescence of the new equipment.

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considered to be adopted. Such a design can scarcely be considered complete and accepted. It cannot be transmitted to the builders for implementation. Obviously, the USSR Gosplan instructions need revision.

4. See PLANOVOYE KHOZYAYSTVO No 4, 1977, pp 93-103.
5. See IZVESTIYA, 17 October 1978.

Equipment and machinery that are being supplied by new or existing enterprises should be distinguished not only by innovation and high productivity but also by a reduction in the costs of acquiring them. K. Marx wrote: "The production of machines by machines reduces their cost in comparison with their sizes and their performance."[6] He further emphasized that "the purpose of introducing machines is... to reduce the costs and, therefore, also the price of a commodity, making it less costly, that is, to reduce the work time necessary for producing a unit of the commodity...."[7]

The studies of a number of economists indicate that equipment is becoming more expensive. In order to evaluate the dynamics of the capital intensiveness of construction of hot-rolling plate mills, a comparison was made of the "1700" mills of the Karaganda Metallurgical Combine (introduced in 1967) and the Metallurgical Plant imeni Il'ich (introduced in 1960), and of the "2000" mills of the Novolipetsk Metallurgical Plant (introduced into operation in 1970) and the Cherepovets Metallurgical Plant (the first phase was turned over for operation in 1975). The comparison indicated that capital intensiveness per ton of the designed annual capacity of the wide-strip mill of the Plant imeni Il'ich was 15.1 rubles, while for the nearly similar mill of the Karaganda combine it was 21.8 rubles, that is, it had risen 44 percent; correspondingly, the weight of the industrial equipment had increased from an estimated 5,600 tons per 1,000 tons of design capacity to 9,500 tons, that is, almost 1.7-fold. The increase in cost per ton of design capacity of the Cherepovets Plant in comparison with that of Novolipetsk was 11 percent, the cost of the industrial equipment was 32 percent higher, and the cost of the elevating and transporting equipment was 43 percent higher. Capital intensiveness per unit of production capacity for specific departments was about 8-10 rubles per ton in 1966-1970, but it rose to 14-16 rubles per ton in 1971-1975.[8]

According to existing computations, during the Eighth and Ninth five-year plans the average cost per unit of capacity of power-engineering equipment (boilers and turbines of all types) rose by 25 percent, while the cost per kilowatt of the capacity of electrical-engineering equipment rose by 27 percent.[9] Similar computations for 1976-1978 indicated that the rate of increase in cost per unit of capacity of this equipment during the Tenth Five-Year Plan not only did not decrease but it increased.[10]

Computational data testifies that growth in individual productivity or capacity of new machines by 1 percent over the old, previously mastered machinery causes the upper limit of the price of machine-tool equipment, for example, to increase by 14-15 percent (on the average). Design developments cannot be considered as effective if they yield an insignificant growth in productivity (or capacity) but cost much more as a result of the improvement of various operating parameters of a given group of equipment for some sphere of its application.

6. Karl Marx and F. Engels. Soch. [Works], Vol 23, page 401.
7. Ibid., Vol 47, page 351.
8. See P. A. Shiryayev and V. A. Shtanskiy, "Effektivnost' kapital'nykh vlozheniy v chernoy metallurgiya" [Effectiveness of Capital Investment in Ferrous Metallurgy]. Izdatel'stvo Metallurgiya, pages 184-185.
9. See VOPROSY EKONOMIKI [Questions of Economics] No 3, 1979, page 28.
10. See V. Fal'tsman, "The Capacity Equivalent of Fixed Capital" (VOPROSY EKONOMIKI, No 8, 1980).

An analysis of comparable parameters of useful effect of new machine-tool equipment and of production facilities assimilated in recent years indicates that, on the average, the share of growth in the equipment's productivity is only about 30 percent. Other operational improvements make up the remaining part of the useful effect. For example, the total service life of various machine tools is being raised to 10 years or more, while the time taken to become obsolete becomes substantially shorter.

Thus, the problem of computing the obsolescence of machinery remains unsolved. In determining the norms for amortization of the tools of labor, it must be considered that, given today's service lives for them, the requirement for overhaul disappears completely or is greatly restricted. It follows from this that an artificial lengthening of the service lives of machines, including obsolete ones, increases the prime cost of the output and stimulates the necessity for costly and poorly effective overhaul. The repair of machines often costs two to three times as much as new machines. In industry, amortization for overhaul is 20-22 percent greater than the entire total of capital investment in machinebuilding. In many cases reconstruction, reequipping and the replacement of obsolete equipment by new equipment is performed instead of overhaul. It can be said that "violations" of such a nature reflect the process of replacing moribund methods of rejuvenation and, partly, the modernization of equipment by other, more rational and economically advantageous methods.

In budget estimates for construction, equipment prices are often established according to calculations of the supplier plants, and they exceed the budget-estimated assumptions. Meanwhile, machinebuilding plants, using their weakest capabilities and deviating from the standard terms adopted in the price lists, strive to increase the cost of the equipment. The more so since equipment prices called for by the price lists often are oriented to equipment already being manufactured and do not cover new equipment which is required in the modern era of scientific and technical progress. From 20 to 70 percent (in terms of cost) of the equipment is manufactured in accordance with individual orders in some industries. All this emphasizes the importance of the principles advanced in the draft of the "Main Directions" about raising the unit capacity or power of machines and equipment in the optimal amount with a simultaneous decrease in their dimensions, metals intensiveness and energy consumption and a reduction in cost per unit of final useful benefit.

The specific share of outlays for transportation in the final cost of cement is 14.4 percent, wall materials 30.1 percent, refractories 10.7 percent, of other materials 37.7 percent, and of sand, gravel, crushed rock and other quarried materials more than 70 percent. The hauling distance for wall materials was 731 km in 1978 and 751 km in 1979, for brick it was 352 and 364 km, respectively, and for prefabricated reinforced-concrete structure it was, respectively, 679 and 727 km.

A similar situation also prevails in relation to other resources. For example, reinforced-concrete output is widely developed in the USSR. In some oblasts, krays and Union republics there is even a surplus. About 1 million tons of reinforced concrete are exported over the Northern Railroad and simultaneously almost 2 million tons of the same products from other cities arrive in regions served by this railroad. In this case, materials and articles of the very same products mix, with identical characteristics, are imported and exported. Thus, nonpressure reinforced-concrete pipe, wall panels, ceiling floors and so on, are transported to

Central Asia. Similar products go from Central Asia to the Nonchernozem Zone [of the RSFSR]. All this results from the fact that all construction ministries and agencies, and also local organs, have their own reinforced-concrete production facilities.

One of the most important reserves for reducing construction time and costs is that of causing the service lives of facilities that are being erected for the siting of equipment to be coincident with the service lives of the equipment. Not so long ago the service lives of industrial equipment was 20-25 years. Right now, because of the more rapid obsolescence that occurs because of scientific and technical progress, it has been cut by one-half or two-thirds. At the same time, the tradition of creating production facilities often in the form of large monumental buildings of several stories or with 1.5 to 2 rows of windows, which require the corresponding architectural shaping and which are intended, as a rule for 80-100 years of service, still has not been overcome. It is considered that there should be a reserve of area and loads on such buildings. The retention of this tradition causes high capital investment, mainly for construction and installing work.

Placing new machinery in such buildings inevitably necessitates, after the machinery has served out its previously established service life, the reconstruction and construction of buildings and structures. This requires time and considerable additional expenditure. For the national economy as a whole, only 9 percent of the total amount of capital investment aimed at reconstruction and expansion is for reconstruction without the construction of buildings and structures.[11] Therefore, over a number of years, the reconstruction and expansion of many existing enterprises does not yield the desired growth in the share of equipment in the technological structure of capital investment. Thus, according to a USSR Stroybank check of jobs included in the capital construction plan for 1976, the share of expenditures for equipment in the total budget-estimated cost was 28.7 percent, including 25.9 percent for new construction projects, but only 31.2 percent for existing enterprises.[12]

In the USA, during 1955-1973, the cost of machinery and equipment in the total volume of capital investment in the processing industries was at least 71-72 percent, in motor-vehicle plants 84 percent, in the chemical industry 86 percent, and in the building-materials industry 75 percent. At leading USSR enterprises, the share of equipment in the capital investment structure after technical reequipping was 50-60 percent.

The current stage of the scientific and technical revolution is marked by conversion to the erection of lightweight, inexpensive, rapidly disassembled buildings, and, in some cases, movable buildings, primarily one-story. Domestic and foreign experience indicate the high effectiveness of such an approach to the creation of production space.

The consolidation of production cannot be endless, and it does not always promote improvement in technical and economic indicators. As the volume of production grows at individual enterprises, the share of capital investment and the prime cost

11. See V. K. Faltsman, "Intensification of the Development of Production Equipment" (VOPROSY EKONOMIKI, No 1, 1978).
12. See M. S. Zotov, "The Effectiveness of Capital Investment and Credit Relationships in Construction (VOPROSY EKONOMIKI, No 4, 1977).

of the product are increased. One of the causes of this is the increased cost of raw materials and of the processing thereof as a result of the decrease in the proportion of the useful element. The extraction of raw material requires increasingly larger expenditures (for example, because of the depth of deposits), and transport expenditures rise because of the need to import raw materials and other resources from distant regions. All this requires additional expenditures for the beneficiation of raw material, the construction of underground and strip mines, oil and gas wells, railroads, highways, and so on. As a result, specific capital investment, both at a given enterprise and at interdependent branches of the economy, is raised.

Growth in specific capital investment and the prime cost of output at enterprises that operate on nature's raw material is often explained as an inevitable consequence of scientific and technical progress. Meanwhile, a rise in the productivity of machinery often occurs through a reduction in the sizes and weights of assemblies and machines. The use of high-strength, plastic and durable materials, which possess the necessary electrical, magnetic and other properties and which require small outlays for production, changes the structure of the raw materials and of the items made from them.

In some countries basically new solutions have appeared that change the nature of the mutual coexistence of large and small plants. Thus, along with modern metallurgical giants, plants that possess a small fraction of their capacity (in production volume) become completely profitable.

In 1976 about 240 miniplants that produced more than 36 million tons of steel per year were operating in 38 countries of the world. The miniplants were designed and built in 14-18 months. This reduces by far the potential of their obsolescence during introduction into operation. The profits of the miniplants (per unit of output) are higher than for the large enterprises, by virtue of the insignificant capital intensiveness, simplicity of the production process, small transport costs, optimal use of highly productive modern equipment, and flexibility of industrial schemes.

In considering the main factors that make the construction of small-capacity metallurgical conversion plants desirable, it can be affirmed that in some parts of the Soviet Union (the Volga Region, Central Asia, Siberia, the Far East, the North of the European portion of the country, Belorussia, the Baltic, Moldavia and the Western Ukraine) the construction of such plants will be extremely effective.[13]

In the Soviet Union preparations are now being made to convert metallurgical output as a whole to the manufacture only of high-quality steels. The replacement of ordinary structural steel by high-quality steel will enable metal consumption to be cut 5-fold to 10-fold. Apparatus for ore preparation, for smelting steel and for manufacturing rolled steel are being created for this purpose. It is planned to automate the whole industrial process completely. The capacity of an installation will be 50,000-100,000 tons of metal products per year.

Designs for miniplants at which all industrial operations will be carried out by one unit are being developed. A movable plant also is being designed: either on wheels or on a barge, or on a ground-effects ship.

13. See V. Zimin, "Prospects for the Construction of Small Movable Metallurgical Plants" (PLANOVOYE KHOZYAYSTVO No 12, 1978).

In recent years, industrial production associations that are located in large centers have been striving to create branches in small towns and urban-type settlements (for example, the Tutayev Branch of the Yaroslavl' Motor Plant). The transfer of production to a satellite town has enabled the supplying of products to customers of the nearest oblasts to be greatly improved at minimal capital expense.

The organization of collapsible movable enterprises can yield a major saving of time. In the construction industry, mobile collapsible plants for housing construction that are easily assembled and disassembled (the framework consists of knockdown arches) have already appeared. They can be hauled by rail to any part of the country.[14] This trend is also being spread to other producing industries. For example, movable installations for the primary processing of agricultural products have been established. Unfortunately, not enough attention is being paid yet to the open placement of equipment or to the installation thereof under lightweight broach roofs. Meanwhile, such a procedure for siting it will enable construction costs to be reduced by 10-25 percent. Of course we are not speaking of converting everywhere to the erection only of small or movable enterprises. They must be established where it is technically justified and economically feasible.

Experience indicates that constructional structure, semifinished items and other articles should be lightweight, inexpensive, without unnecessary strength reserves, interchangeable, and, to a certain extent, collapsible, for use at other facilities. As for heavy products made of concrete and reinforced concrete, metal and stone, they can be used only where this is dictated by the technical norms and the rules for erecting production buildings.

Rationalization of the structure and a rise in the quality of building materials will enable the weight thereof per unit of operations to be reduced by about 25-30 percent, and, therefore, the weight of buildings to be decreased. A reduction in the weight of materials per unit of operations, even on such a comparatively small scale, will affect considerably the duration, labor intensiveness and cost of construction. Reduction of the weight of buildings in turn enables the mechanization of construction operations and the quality thereof to be increased and the organization of construction work to be improved. As a result, labor productivity grows sharply, and the consumption of material resources and of monetary resources per unit of increase in capacity is reduced.

Overhead costs in construction are still great. Their share in the structure of expenditures for construction and installing work was 15.9 percent in 1965, 16.2 percent in 1970, 16.3 percent in 1975 and 17.1 percent in 1979. Some of the causes: a multiplicity of control levels, the existence of a large number of small subunits, and inadequate attention to the introduction of new and more progressive forms for organizing construction.

The CPSU Central Committee and the USSR Council of Ministers decree of 12 July 1979 requires ministries and agencies to work out and to take measures to improve the management of capital construction and to convert to the two-level or three-level system of control. The basic cost-accounting elements of construction operations are the production construction and installing associations, and, only in certain

14. Minenergo [Ministry of Power and Electrification], which first created such a plant, did not succeed, however, in propagating such a useful experience.

cases, the trusts. The draft of the "Main Directions" orients the construction industry to completing the conversion of the middle link of construction management to cost accounting in the near future.

Experience has been gained that indicates that production associations do up to 75-80 million rubles' worth of construction and installing work per year, far more than the trusts of the highest capacity. Nowadays, the value of the minimal annual amount of contracting work for associations has been set at 50 million rubles, while the maximum amount can reach 150 million rubles. The associations include construction and installing subunits, mechanization trusts, motor-vehicle transport pools, trusts and administrations for operational-equipment outfitting, and other units.

The CPSU Central Committee and USSR Council of Ministers decree of 12 July 1979 pointed out that the assembly of outfitting equipment can be carried out by the machinebuilding supplier plants. This will provide for acceleration of the introduction of equipment into operation, a reduction in expenditures for assembly, and increased supplier responsibility for equipment quality. It is known that the elimination of deficiencies in manufactured equipment engenders additional expenditures which, as a rule, occur not at the machinebuilding plants but during construction and installing operations.

The plant-construction combines that were established at one time produced constructional structure and parts for a facility as a whole, transported the output to the construction site, and assembled it, creating finished production space. Now they have all been transformed into reinfored-concrete products plants. Meanwhile, combining their work to prepare space with the work of general suppliers of the equipment to execute the delivery of complete sets of equipment and the assembly thereof reduces construction time and construction costs.

Modular construction is an effective method. An association organized in Tyumen' by Minneftegazstroy [Ministry of Construction of Petroleum and Gas Industry Enterprises] produces modules, assembles the equipment in them and delivers them to the construction site, assembles the finished product and turns it over to the client. The time spent erecting the facilities is reduced by 25-30 percent, labor expenditures at the construction site are cut to half or two-fifths, and the weight of the building materials is two-thirds to three-fourths less.[15] For more than 15 years this association has been the only one in the country. The creation of design-and-construction organizations, which combine design, construction, installing and other subunits in their makeup and turn their output over turnkey style, helps to reduce construction time and costs. The CPSU Central Committee's draft pointed out the desirability of building facilities more widely through bank credit, which is granted to construction organizations in the full amount of the budgeted cost of the enterprise until it is introduced into operation. It is proposed to create conditions for spreading everywhere the start-to-finish flow-line brigade contract. The introduction of more progressive organizational forms for construction will reduce its expensiveness by at least 10 percent.

15. See N. Shcherbina, "Industrialized Methods for Fuel-Industry Facilities" (PLANOVOYE KHOZYAYSTVO No 3, 1980). The author remarks that the total sum of the national economic effect from introducing the modular method of construction during the period 1973-1978 exceeded 500 million rubles.

The term "assimilation" of capacity introduced into operation usually means the achievement primarily of the design capacity, and, later, other technical and economic indicators. Effectiveness in creating fixed productive capital is manifested mainly in the ratio between the yield from the growth of labor productivity achieved and what has been spent on it, and in indicators that mark the relationships of yield on capital and capital intensiveness. As a consequence of the lengthy periods of design, construction and assimilation of enterprises introduced into operation and of a low shiftwork utilization factor, the time of productive use of the capacity that has been created is reduced, innovation in the machinery and technology is lost, and construction becomes more expensive (exceeding the standard construction time by 10 percent raises costs by at least 1 percent). The average period of assimilation of new enterprises and capacity according to the norms is 1.5-2 years, but actually it reaches 3-4 years, and often more than 5.

The lengthy assimilation of capacity, as sometimes proves to be the case, is caused by unfinished construction and installing work. The results of an investigation of enterprises turned over for operation indicate that during the assimilation period more than half of them (in percents of the total number of enterprises) experience shortages of raw materials, electricity, water and other material resources, 29 percent lack skilled-worker personnel, 19 percent of them are eliminating design errors, 22 are eliminating equipment defects, and 21 percent are eliminating mismatching of capacity (or throughput) of departments and facilities and of some groups (or lines) of machines and equipment that process identical parts or carry out the very same operation.

Because of the indicated factors, yield on capital during the Ninth Five-Year Plan was reduced 5.2 percent. Out of 200 billion rubles in growth of national income during the five-year plan, about 100 billion rubles were used to compensate for a reduction in yield on capital (that is, mainly through additional capital investment).[16] In 1978 yield on capital in industry was 11 kopecks less than in 1975. If the yield on capital achieved in 1975 had been maintained in 1978, the national economy could have obtained about 55 billion rubles' worth of additional output.

The question arises: How smoothly was the "assimilation" stage introduced in the investment cycle? World practice indicates that only a brief startup period is required, which, as a rule, is contemporaneous with completion of the construction stage. The causes of lengthy assimilation of capacity enumerated above deny the necessity for an "assimilation" stage, corroborating the fact that deficiencies exist in design, construction, the manufacture of equipment, and preparation for production (providing a work force, raw materials and other items, and so on), which in and of themselves are impermissible. These cannot be the subjects of either design or planning. On the contrary, the problem consists in stopping their appearance.

The thoughts presented enable the conclusion to be drawn that it is obviously necessary to define the scale of introduction of the newest types of equipment, structure and materials and of the expansion of their production; to convert to the erection of lightweight, modern types of industrial buildings, to the wide use of experience in building miniplants and mobile enterprises and installations, to the

16. V. Krasovskiy, "Economic Problems of Yield on Capital" (VOPROSY EKONOMIKI [Questions of Economics], No 1, 1980). About 30 percent of the production capital of industry still does not yield the designed output (PLANOVOYE KHOZYAYSTVO [The Planning Activity], No 4, 1978).

outdoor placement of production facilities, providing thereby the prerequisites for improving the technological structure of capital investment and of the organic structure of fixed productive capital; to create, in addition to construction and installing production associations, design-and-construction, plant-construction, and housing-construction associations and enterprises; and to transfer the assembly of equipment to the supplying plants, organizing specialized installing subunits that are subordinated to them. It is required that design-organization activity be restructured and that design norms be refined, as is now called for in the case of budget-estimating norms.

In our opinion, it is desirable to dispense with the so-called period of "assimilation." It is important that new organizational forms of construction be more effective in the sense of achieving the final result (the introduction of capacity and facilities into operation). Right now the client, that is, the organ for which the newly created capacity was built (or rebuilt, expanded or reequipped) turns the capacity over for operation (to state commissions). Obviously, this should be done by the executors--the producing construction and installing associations, design-and-construction associations, plant-construction combines, equipment suppliers, and other organizations that take on the role of contractors, with the obligatory participation of the clients.

A steady rise in yield on capital and reduction in expenditures for producing the tools of labor make up the natural process of growth in the productivity of machines and equipment that outpaces the growth in their cost. Therefore, plans for economic and social development should assign tasks for raising yield on capital to ministries, agencies and production associations (or enterprises). Recommendations for reducing prices for machinery per estimated unit of capacity or other useful effect should be worked out, as well as a scale that determines the effectiveness of increase in the capacity of a unit of equipment and, correspondingly, of the price, with an obligatory and simultaneous reduction of the price per estimated unit of capacity.

It is just as important to solve the question of regularizing transport schemes for hauling building materials, providing construction projects with local materials and eliminating the long-outdated practice of creating so-called in-house construction-industry bases, paying greater attention to developing the building-materials industry and guiding its efforts toward organizing in each economic region the production of materials in the amount required for supplying the construction projects located in a given region with the basic building materials. Contractors should have only the most necessary implements, systems, accessories and mobile installations.

The task of restructuring the formation and organizing the use of the amortization fund is imperative. The allocation of a portion of it for renovation and overhaul loses its meaning. Right now it is authorized that this fund be used to modernize equipment, acquire new machinery and execute technical reequipping (by entering a portion of the amortization fund into the production development fund). The amortization fund should be a single fund and, obviously, of small size (at present it exceeds 67.7 billion rubles). Overhaul must gradually be replaced by merely an exchange of worn parts of equipment; it must be permitted only in various cases for certain types of fixed productive capital, and the overhaul bases transformed into enterprises that supply spare parts.

Norms for construction time should be worked out in conjunction with the norms that define periods of development, and consultation for approval of design and budget-estimating papers should be worked out with an eye to a reduction of these periods and mutual coordination (or integration) of norms. Because of the recomputation of the budget-estimated cost of construction in accordance with the new budget-estimating norms that are forthcoming in 1984, it is desirable to give thought also to the considerations that have been examined above with a view to providing for a substantial reduction in the cost both of carryover and of newly started construction.

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CONSTRUCTION MACHINERY

MANAGERIAL, ORGANIZATIONAL STEPS TO REDUCE MATERIALS INTENSIVENESS ANALYZED

Moscow VOPROSY EKONOMIKI in Russian No 12, 1980 pp 38-48

[Article by A. Polyak: "Ways to Reduce Materials Intensiveness"]

[Text] L. I. Brezhnev stated at the July 1980 CPSU Central Committee Plenum: "We have set ourselves such a fundamental task as raising production effectiveness and work quality. It should be kept in mind constantly." The CPSU Central Committee and USSR Council of Ministers decree of 12 July 1979 called for the introduction of an indicator for standard net product. One of its basic purposes is to provide the best conditions for reducing the materials intensiveness of production work. The significance of reducing materials intensiveness with a view to raising the effectiveness of social production is occasioned by the rising share of the expenditure of embodied labor in overall production inputs and by the increasing production and consumption of material resources. The share of material expenditure (raw materials, basic and auxiliary materials, and fuel and energy) in industrial production expenses rose almost 30 percent during 1930-1980.

Outwardly it seems that a net output indicator that is completely "clean" of materials expenditures will not cause a change in materials intensiveness. But it is this which is its most important feature: by not stimulating an artificial overstating of material expenditures, it thereby "works" in the direction of reducing them, since, on the one hand, where the given indicator is used, an increase in materials intensiveness of articles does not allow an increase in the output of production work, and, on the other hand, the expenditure of materials that are funded and for which norms are set increases, which is unprofitable for enterprises and associations.

Wide introduction of the standard net output indicator into economic practice prevents the use of total material production expenditures in gross social output for purposes of evaluating trends in the materials intensiveness of the national economy. The indicator of the national economy's materials intensiveness, which is defined as the ratio of material production expenditures to the amount of the gross social product or of national income, is easily computed. It could answer its purpose if the repeat counting of material expenditures that is introduced into the gross product, primarily by such industries as machinebuilding, light industry and others, were not included.[1] An increase in repeat counting is inevitable as the

1. We do not examine the influence of structural shifts in the economy's branch structure and of the value factor on the materials intensiveness of the gross

division of social labor, which is reflected in the development of specialization and cooperation in production work, intensifies. An expansion in cooperation can also lead to distortion of the actual indicators of production activity in some industries if they are determined by gross (commodity) output indicators, with the inclusion therein of the cost of the outfitting articles and semifinished goods obtained outside.

Criticism of the gross output indicator as a basis for computing production work, labor productivity, yield on capital and other basic economic indicators also is a criticism of the "gross" method of determining materials intensiveness--through the whole sum of material expenditures in gross social output, which often includes the repeatedly iterated cost of subjects of labor that are actually manufactured once.

For a full evaluation of trends in materials intensiveness in the national economy, a system of indicators that reflect the use of metal, fuel, energy, chemicals, building materials, wood and certain other most important material resources must be used. At the same time, the annual consumption of the main types of raw materials (primary materials), fuel and energy, which are applied to an increase in net output (or national income) can, from our point of view, be an important indicator of the materials intensiveness of social production work. The numerator of the given formula should include the annual consumption of iron ore, nonferrous metal ores, fuel of all types, nuclear energy and water power computed in standard fuel equivalents, the main building materials, wood, and chemical raw materials.

In a first approximation this amount can be transformed into the total consumption of finished metal output of ferrous (finished rolled products plus pig iron and steel castings, plus forgings and pipe made of steel ingots) and of nonferrous metals (rolled products plus castings), fuel and energy resources in standard fuel equivalents, logged wood (commercial timber), cement (used for building mortar), building brick, prefabricated and monolithic concrete, plastics, synthetic fiber, mineral fertilizers, sulfuric acid, varnishes, paints, soda and a number of other chemical products. Products of animal and vegetative origin (except for wood and certain industrial materials) should not be included in the final sum of primary material resources (that is, raw materials that undergo initial stages of processing) and fuel and energy, appropriate consumption indicators being computed individually for them, since consumption of these material resources is not proportional to change in the amounts of social production but depends directly upon the population's requirements. The growth of the people's requirements for subjects of consumption should not be reflected in an increase of the total indicator of the materials intensiveness of social production. Total consumption of the indicated primary material resources should be adjusted by the amount of the foreign-trade balance of these resources.

The indicator for materials intensiveness of net output that is obtained in accordance with this method is used to compare various time periods in the economy of a country with a comparatively stable structure of primary-materials consumption. However, the tentative nature of the indicator being examined should be kept in mind. In the first place, a different amount of labor is included in a unit of equal weight for each of the primary materials. Therefore, it is possible to

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social product, considering that this effect can be eliminated at least theoretically by change of the appropriate indexes and adjustments.

convert from an in-kind computation of the numerator of this materials intensiveness indicator to a cost computation (in prices). Although existing defects in price-setting also affect the precision of the computations, an indicator determined in accordance with the proposed procedure is, on the whole, free from the main deficiency: the repeat counting of material expenditures.

In the second place, in computing materials intensiveness according to the consumption of primary materials (but not raw materials), the in-kind consumption of some resources, primarily metals, differs sharply from the amount of original ore mined. Thus, the annual consumption of finished metal output of 126 million tons corresponds to the total consumption of about 1 billion tons of the original ore and the scrap and waste of ferrous and nonferrous metals (the expenditures for ore and scrap and waste are apportioned in the ration of 9:1). The consumption of original raw materials in nonferrous metallurgy is higher. For example, more than 3,000 tons of ore are required to obtain 1 ton of vanadium, more than 300 tons of ore per ton of tin, about 200 tons of ore per ton of nickel, and 100 tons of ore per ton of copper.

The labor method can be used to obtain theoretically "pure" data about the comparative amount of various material resources in the economy. It permits comparison of the materials-intensiveness level of heterogenous products in accordance with labor expenditures, that is, according to the amount of labor embodied in the original material resources, plus the expenditures of live labor in the production itself of this output. For example, the full labor intensiveness of production (including expenditures for raw materials, fuel, energy, transport and in-house blast-furnace conversion) is, for 1 ton of pig iron, about 38 man-hours, in which the labor expenditure for the iron-ore part of the charge (agglomerate) is about 19 man-hours; for coke and natural gas 9 man-hours; and, consequently, the materials intensiveness of the basic material elements for 1 ton of pig iron is 28 man-hours. The labor used for 1 ton of steel averages about 48 man-hours; for comparison, let us point out that the labor intensiveness for 1 ton of such structural plastics as polystyrene and polyethylene averages 250 man-hours. It is true that in this case there is an excess of labor intensiveness of plastics over steel, which is caused not so much by differences in the levels of materials intensiveness of the original products as by the higher labor expenditure for the production of the plastic itself. But, as a rule, materials intensiveness levels in the consumption of the original raw materials are reflected directly in the labor-intensiveness indicators. Thus, in the copper industry, where ores that average 0.7-1 percent of the main component are processed, the labor intensiveness for 1 ton of original raw material is about 5 man-hours, while the labor intensiveness for 1 ton of refined copper is about 500 man-hours (or more than 100-fold). In the aluminum industry, which processes raw material with up to 40 percent content of the useful component--alumina, labor consumption for 1 ton of the original raw materials (bauxites) is equal to 15 man-hours, but for 1 ton of aluminum it is about 300 man-hours (that is, the gap is much less).

The promise of the labor method for measuring materials intensiveness and the availability of the baseline information should be noted. The data on start-to-finish labor expenditure for producing output exist right now for most of the main industries and types of products. At the same time, this method still is not being used practically at all. Therefore, in our opinion, its introduction as a supplementary indicator, and in some cases, even the main indicator, for measuring materials-intensiveness levels of diverse products is an important and urgent task.

The CPSU Central Committee and USSR Council of Ministers decree of 12 July 1979 recorded some specific measures that are aimed at raising the level of planning work in the national economy. These measures have a direct relationship with purposeful action to reduce the materials intensiveness of production work. The development of an integrated program of scientific and technical progress for 20 years (by five-year periods) will enable both the near-term and the more remote consequences of introducing the achievements of scientific and technical progress in the area of changing materials intensiveness to be foreseen and will enable these achievements to be considered in long-range planning.

Because of this, it is necessary to intensify the scientific approach to the solution of economic problems in the use of materials and to make computations to substantiate the economically effective interchange of material resources, especially within the framework of the production and use of structural materials. Such computations are still being conducted tentatively, for they are based upon full data about the production of comparable materials, on partial data about their processing into articles, and on the most approximate data about the economic indicators of the operation of the finished articles. Meanwhile, the stages of operation are, in many cases (the introduction of aluminum instead of ferrous metals, the replacement of steel pipe by plastic pipe, and others), decisive for an integrated economic assessment of the effectiveness of using the materials being compared.

For example, the prime cost of 1 ton of flat rolled aluminum is 7-fold to 8-fold that of steel, but its capital intensiveness (considering the investment in power-engineering) is 6-fold higher. In particular, the start-to-finish specific consumption of electricity for producing 1 ton of rolled electric steel is about 600 kw-hr and for 1 ton of flat rolled aluminum it is 15,000-20,000 kw-hr. Nevertheless, the use of rolled aluminum sheet instead of steel in the national economy, when it is technologically possible, provides an annual economic benefit of about 500 rubles per ton, precisely through savings of operating expenditures during the service life of the corresponding articles.

The indicated decree notes that responsibility for satisfying the national economy's and the populace's needs for output of the necessary variety and quality rests upon the ministry that is the head ministry for production of the given product. This situation has special importance for products that are marked by universality and wideness of demand. Thus, for ferrous metals, which are used by practically all branches of the economy, it has been recommended repeatedly that long-range demand be determined by the efforts of some sort of interagency organ under USSR Gosplan, USSR Gossnab or the Academy of Sciences. It is obvious now that this task should be solved within the USSR Ministry of Ferrous Metallurgy system, on the basis of all the needed data, which are transmitted to it by central planning organs. Specialized Minchermet [Ministry of Ferrous Metallurgy] organs will get a real opportunity to intensify and deepen work on the scientific validity of the national economy's requirements for metal products.

Thus, the indicator for gross output of machinebuilding, purged of repeat counting (the final product), was used back in the 1960's as a method for the consolidated long-term determination of demand for ferrous metals. However, this indicator was calculated extremely roughly, on the basis of the consolidated assessments of planning organs. Now, while reviewing indicators of the economic activity of machinebuilding and while computing standard net output, the amount of repeat counting of the cost of semifinished articles and of outfitting items within material expenditures is refined for various branches of machinebuilding production. This will enable precision in the consolidated determination of requirements of the most important customers for metals--branches of machinebuilding and metalworking--to be increased.

With improvement of the economic mechanism, improvement of the system of in-kind indicators for accounting for and planning the output of material resources is of special significance in reducing materials intensiveness. The decree calls for introduction of the necessary changes to the system of in-kind measures for the output produced (for metallurgy, machinebuilding and other branches of industry) and conversion to planning of the production of equipment according to an expanded products list in units of measurement that reflect more completely the equipment's productivity and other customer characteristics.

A number of indicators that have more limited application than net output can nevertheless effectively influence the reduction of materials intensiveness. Such indicators, which replace or supplement in some cases the indicator of in-kind tonnage, are theoretical weight, adjusted (by coefficients of difficulty or labor intensiveness of production) tonnage, meterage (linear, square or cubic), and so on.

In machinebuilding, where metal output is turned over according to theoretical weight, expenditures are saved by reducing the formation of shavings. The metallurgists record output produced in terms of weight, which is determined in accordance with the nominal size of the rolled product, without detriment to plan fulfillment. Accounting for the output of a number of types of metallurgical output in meters will stimulate a reduction of their materials intensiveness. This relates primarily to reporting the production of various types of flat rolled products, especially sheet iron.

The output of steel pipe is now counted in tons and linear meters. The latter indicator can reflect the final national-economic results and the actual results of the production activity of the collectives more objectively. The Volzhskiy Pipe Plant is among the country's leading enterprises. It produces lightweight pipe of reduced wall thickness. However, in so doing, certain of the enterprise's most important economic indicators, for example, yield on capital, when it was accounted for in actual tons in-kind or commodity output (at the existing price levels), were degraded. Measuring production output in meters will in this case enable a more correct reflection of the effects of progressive shifts in the variety of output produced and in the metals intensiveness of production on the yield on capital. For the Ninth Five-Year Plan as a whole, yield on capital at the Volzhskiy Pipe Plant, when it was measured by tons in-kind and commodity output, was reduced, and it was raised only with reporting of product output in meters, which corresponded with the growth of effectiveness that actually occurred in the plant's work. Another possibility for correct reflection of progressive shifts in a plant's work is associated with the perfecting of prices for what it produces.

In metallurgical machinebuilding, planning and reporting of the output of equipment in tons in-kind have promoted an overstating of the weight and an increase in the weight of the units produced. Upon conversion, at the suggestion of VNIImetmash [All-Union Scientific-Research and Design-Development Institute for Metallurgical Machinebuilding] and the Elektrostal' Heavy Machinebuilding Plant, to a system of reporting the output of equipment for individual units in components, sets and pieces, and in terms of cost for the whole subbranch of metallurgical machinebuilding, the metals intensiveness of the articles produced was cut.

Improvement of the economic mechanism presupposes an examination of the problems of reducing materials intensiveness within the framework of appropriate complexes of metallurgical machinebuilding, fuel and power engineering, agricultural industry and others. Of interest in this connection, in our opinion, is an analysis of the existing level of and reserves for raising metal utilization coefficients within the framework of one of the main national-economic complexes--metallurgical machinebuilding.

In recent years, a trend toward raising the metal utilization coefficient of production processes has been noted in ferrous metallurgy. However, the pace of this increase has been insignificant. Thus, the yield of annual output of metallurgical production (including castings) was 70.9 percent in 1958, 71.9 percent in 1970 and 72.2 percent in 1975. The start-to-finish coefficient of the consumption of ingots and of cast billets for 1 ton of finished rolled metal in rolling departments improved slowly: 1.30 tons in 1965, 1.29 tons in 1970, 1.28 tons in 1975 and 1.27 tons (planned) in 1980.

Improvement of the indicated coefficient, despite conduct of the appropriate measures in ferrous metallurgy, was slowed by the following factors:

--the necessity for a subsequent rise in the share of flat-rolled steel, including cold-rolled, in the assortment of finished rolled products, in the interests of the metal-consuming branches of the national economy. During the 1965-1980 period the share of flat-rolled products increased from 37 to 41-42 percent. At the same time, the start-to-finish consumption coefficient for ingots for 1 ton of finished carbon bar section was 1.2-1.24 tons, for 1 ton of thick plate 1.3 tons, and for 1 ton of thin structural plate about 1.35-1.38 tons;

--a constant rise in the degree of alloying of the assortment. In so doing, consumption coefficients for the production of alloyed plate were much higher than for the rolling of carbon metal; and

--the necessity for including new shapes and sizes in the assortment of rolled products, in order that the rolled products might approximate the configuration of the finished articles and parts, which also is associated with an additional expenditure of metal in the production process.

The use of machines for flame scarfing metal in the flow line exerted a definite influence on increase in the consumption coefficient. Under these circumstances, the priority directions for improving the start-to-finish coefficient of metal consumption are: substantial expanded use of the highly effective process of the continuous casting of steel (its share is now 10-11 percent of all the metal poured); on the average, the use of machines for the continuous casting of billets (MNLZ) will enable at least 0.12 ton of metal to be saved per 1 ton of rolled metal (from 0.1 to 0.25 tons/ton); expansion of the use of semikilled steel instead of killed steel, which provides an average reduction of 0.08 ton in metal consumption per 1 ton of rolled metal (the amount of production of semikilled metal instead of killed can reach 20 million tons in the modern era); an increase in the amount of steel cast in ingot molds with the use of exothermic impurities, which raises the yield of annual rolling output by 1-5 percent; chemical plugging of rimmed steel during casting, with an increase in yield of annual rolling by an average of 2 percent; the introduction of low-oxidizing, high-frequency and induction electrical heating of rolled metal, which enables a reduction in metal losses; the introduction of systems for wastefree layout of rolled metal with the use of a computer; and the expansion noted above of the production of rolled metal with negative allowances, turned over according to the theoretical weight, bringing the output of rolled metal with negative allowances and narrow tolerances up to 40-42 million tons, saves about 800,000 tons of metal in absolute terms.

Along with the above-enumerated basic areas for saving metal in metallurgical conversions by the USSR's ferrous metallurgy, there are great reserves in the iron-ore industry for reducing losses of iron by improving the designs for concentrating and lumping (pelletizing) the raw material. Development of the concentrating processes has been linked with the later need to raise the iron content in technical-grade ore (from 55 percent in 1950 to 60 percent in 1980), while its raw material content was dropping (from 51 percent to 35 percent over the same time period).

There are substantial reserves in machinebuilding and metalworking for increasing metal-utilization coefficients. This is obvious from data about the use of finished output made of ferrous metals--by type, by branch and by areas of processing (see table on page 44).

Level of Metal Utilization in Machinebuilding and Metalworking
by Type, Industry and Area of Processing

Types of metal output and area of use of the metal	Metal utilization coefficient
Production of parts made from forgings and hot stampings made from rolled products	0.55
In forging and pressworking departments	0.82
In machining	0.68
Production of parts made of steel ingots	0.3
Forgings made from steel ingots	0.6
Direct machining of rod metal:	
Ordinary rolling	0.8--0.82
Structural rolling	0.68--0.7
Tool stock and stainless stock	0.58--0.67
Processing of sized stock	0.8
Stamping of articles made of flat rolled products:	
Ordinary	0.75--0.77
Structural, hot-rolled	0.69--0.7
Structural, cold-rolled	0.67--0.68
Stainless	0.7
Tool	0.56
Dynamo	0.5
Transformer	0.75
Working of pig iron and steel castings	0.8
Working of steel pipe	0.77
Working of molded section	0.92
Average utilization coefficient of metal output for machinebuilding and metalworking	0.76--0.78
For rolled steel products	0.72

In machinebuilding the utilization coefficient for all types of metal products is only 0.76-0.78, while for rolled steel it is 0.72. Many types of metal products that come to machinebuilding are subject to almost no processing. In some billet-processing facilities, the coefficient is still lower: in the production of parts made from steel ingots it is 0.3, in the production of parts made from forgings and of hot stampings made from rolled products it is about 0.55. For machine-building and metalworking as a whole, the metal utilization coefficient has not risen for a long time. In the modern era increasing it by 0.01 would save about 600,000 tons of metal. With respect to nonferrous metals, the utilization coefficient of rolled brass products is about 0.6, for rolled bronze it is about 0.7 (in automaking, heavy machine building and machine toolmaking), for wire made of tungsten-rhenium alloys it is 0.26-0.36 (in the electrical-equipment industry), and for gallium semiconductor junctions it is 0.2-02 [sic].

In order to reduce the structural metals intensiveness of machines, expansion of the use of thermal hardening and of low-alloy rolled products play major roles (at present almost no thermally treated rolled section comes to machinebuilding). Of the total amount of rolled metal subjected to thermal treatment in metallurgy in 1980, flat-rolled steel was 64 percent, rails 19 percent, railroad-car wheels 8 percent, and reinforcement steel and rolled section 9 percent. Meanwhile, as a result of raising the strength level of steel, the use of heat treatment yields a metal saving (according to domestic and foreign data) of 10-50 percent (15-20 percent on the average).

Right now the basic portion of rolled low-alloy steel (about 90 percent) is required in the production of pipe for oil and gas pipelines and of reinforcements for reinforced concrete and in shipbuilding. Only a little more than 10 percent of the total amount of low-alloy steel is sent to machinebuilding, about half of it to carmaking. Meanwhile, as experience indicates, the use of low-alloy metal yields great technical and economic benefit in many branches of machinebuilding, enabling an average of 20 percent of the metal to be saved.

Among the central areas for reducing the materials intensiveness of production are the reduction of waste and the nonproductive losses of output. The start-to-finish coefficient for the use of iron (from processing of the raw iron ore to the receipt of finished metal articles) is 0.43, and, taking into account repeat use in metallurgical production of a portion of the waste that is formed, it is 0.65. This is higher than the corresponding figure for certain industrially developed capitalist countries, but, nevertheless, in the USSR current metal waste and losses (not counting amortized scrap) consist of more than 70 million tons per year (or more than 50 percent). A part of this waste can be eliminated (for example, losses during the casting of metal, the forming of shavings, and so on have been reduced) by introducing new equipment and progressive technology, but as for the remaining portion, it must be collected to the maximum and utilized. Capital expenditures for the collection and preparation of 1 ton of scrap of ferrous metal is about one-tenth the capital intensiveness of 1 ton of newly poured pig iron.

Despite constant improvement of nonferrous metallurgy's operating processes, about 20 percent of the basic metal and a large amount of the accompanying components are lost irrevocably in ore beneficiating and the later metallurgical conversion. Increasing the integration of the processing of the raw material used remains one of the chief problems of nonferrous metallurgy. The significance of improving ore beneficiation in the USSR's nonferrous metallurgy is defined by the fact that right now more than 95 percent of all ore mined (about 85 percent in ferrous metallurgy) is subjected to beneficiation. New, effective technological processes for beneficiating nonferrous-metal ores enable the degree of metal extraction to be raised. In the metallurgy of heavy nonferrous metals, the use of autogenous processes, which enable, along with other advantages, the extraction of copper, nickel, lead and other metals to be increased, is being greatly expanded. The improvements in the pyrometallurgical treatment of widely distributed copper-sulfide and nickel ores, however, do not completely solve the problem of eliminating losses of the iron and sulfur that these ores contain. Hydraulic metallurgy, rationally combined with pyrometallurgical processes, will enable metal extraction to be increased and sulfur extraction to become practically complete, but in this case also the achievements of technology should be combined with an effective economic mechanism that is aimed at maximum elimination of losses.

The potential for reducing the formation of waste and for rationalizing its use can be illustrated in the example of such a promising structural material as titanium. Its useful-utilization coefficient now is 20-25 percent. About 75-80 percent of the titanium in the original titanium sponge gets into the waste. Only 30 percent of the waste is used effectively enough by return to the charge during ingot pouring. The remaining waste is used with poor effectiveness. According to available analyses, titanium waste can be reduced by at least one-third and its use in the charge raised to 50-60 percent by improving the technology for obtaining and processing titanium.

Problems of saving and utilizing heat and energy also are exceptionally important. In Common Market countries the efficiency factor of fuel and power resources averages 30 percent, while in the Soviet Union it is about 43 percent. However, in 1980, out of the 1.6 billion tons of standard fuel equivalent that the USSR allocated to production and operating needs, about 900 million tons were consumed nonproductively. More than one-third of the fuel and energy losses can be eliminated in the next 10 years, and the expenditures required for this will be repaid rapidly.[2]

The economy's major reserves for saving energy are associated with improvements of the fuel and energy balance. At present the share of oil and natural gas is about 70 percent of the total output of all types of fuel in the country. The accelerated development of oil and gas recovery was caused by growth in the national economy's requirements and by export shipments. The main growth in oil and gas recovery is achieved in the country's eastern regions. This requires increased capital investment and, later, the transmission of high-capacity streams of these energy bearers to the country's central regions. Under these circumstances, the structure of the fuel and energy balance should be further developed harmoniously, with an increase in the role of coal. In the European part of the country, growth in mining coal should be determined basically by the requirement for coal for coking: it is desirable that additional requirements for coal to generate heat and electricity be satisfied through the promotion of strip coal mining at deposits in the eastern part of the USSR. The prime cost for mining Kansk-Achinsk hydrogenous coal and Ekibastuz pit coal, including transport thereof to local power stations, is half that of Kuznetsk coal and one-fourth that of Donets coal. Specific capital investment in mining coal at these places is lower than that of Kuznetsk coal by about 40 percent, and it is about one-third that of Donets coal.

2. See G. Aleksyenko, L. Melent'yev and D. Vol'fberg, "Save Fuel and Energy," (PRAVDA, 26 May 1980).

Among the most important unused reserves for reducing energy consumption is the introduction of energy-saving technology. Using it to save fuel consumption is especially urgent in ferrous metallurgy for pouring pig iron, and, in the building-materials industry, for producing cement clinker, and so on. In order to save electricity, the improvement of technology opens up the greatest possibilities: in ferrous metallurgy, for smelting electric steel; in nonferrous metallurgy, for producing titanium, aluminum, magnesium and nickel, where specific consumption of electricity runs from 15,000 to 40,000 kw-hr/ton; and in the chemical industry, for obtaining ammonia (1,500-2,300 kw-hr/ton), synthetic rubber (2,500-3,000 kw-hr/ton), chlorine (2,700-3,000 kw-hr/ton) and phosphorus (15,000 kw-hr/ton).

It should be noted that a reduction in the materials intensiveness of production along the line of reducing the expenditure of raw and other materials simultaneously leads to corresponding savings in fuel and energy. Thus, a reduction of the consumption of rolled metal in machinebuilding by 1 million tons will enable about 1 million tons of standard fuel equivalent to be saved, and a reduction in cement consumption in construction work per 1 million tons will save 0.2-0.22 million tons of standard fuel equivalent.

Considerable reserves for saving energy are associated with expansion in the use of waste heat and with reduction of losses of heat and of electricity. The level of utilization of high-temperature waste heat in industry can be brought up to 55 percent in comparison with 30 percent at present. The development of a system of recovery installations requires specific capital investment which is three to six times less that of building enterprises to mine coal and to recover oil.

The main area for raising the utilization effectiveness of wood resources is expansion of the integrated processing of timber with maximum possible involvement in circulation of the waste that is formed. Nowadays no more than 20 percent of all wood waste is put to use, although 1 ton of wood waste or waste paper replaces 2-5 m^2 of commercial timber in the production of wood fiber, particleboard and pasteboard.

In the modern era, the importance of improving the use of material resources in construction is growing. Capital construction uses 80 percent of the cement, more than 20 percent of the rolled ferrous metal, about 30 percent of the timber, more than 50 percent of the steel pipe, and so on. An increase in factory manufacture of constructional structure and articles, a rise in the level of prefabrication of buildings and structures, and the mechanization of construction operations have helped to increase the share of the cost of materials in the structure of expenditures for construction and installing operations from 48.9 percent in 1940 to 53.8 percent in 1978. At the same time, the specific materials intensiveness of construction (estimated per unit of the physical volume of buildings and structures) has been reduced for the most important resources. However, the pace of this reduction can be increased by making structural shifts in the use of material resources.

For construction as a whole, the main area for reducing materials intensiveness is expansion of the use of structure made of lightweight concrete and of structures made with the use of economical rolled section and pipe. At present, the share of prefabricated reinforced-concrete structure made of lightweight concretes based on porous aggregates in the total amount of prefabricated reinforced-concrete structure and the share of constructional structure that uses economical metal shapes in the total amount of constructional structure is 20-25 percent.

In order to increase the pace in reducing metals intensiveness in construction, expansion of the introduction of high-strength reinforcement, H-beams, roll-formed section, thin-walled electrically welded pipe, thin-walled tubular shapes and roll-formed flooring with an anticorrosion coating is of great significance. Wider use of aluminum in construction, especially in the northern and eastern parts of the country, is extremely promising. The consumption of wood in construction is hampered by the wide extent of the use of reinforced concrete and the limited development of low-rise housing construction. At the same time, given the existing structure of construction work in the USSR, it is desirable to greatly increase the consumption of many progressive materials and articles made of wood, particularly glued-wood structure made at the factory, plywood, woodboard, and so on.

The use of plastic will enable the weight of constructional structure and the labor intensiveness of its manufacture to be reduced. Plastics are used effectively to manufacture enclosure structure, lightly loaded members of industrial and nonindustrial buildings and some sanitary-engineering products and small parts that are usually made of metal.

The broad program of industrializing construction in our country has occasioned a higher specific share of prefabricated reinforced concrete in total consumption of the main building materials than in some foreign countries. Monolithic reinforced concrete is used basically for various types of footings and underground structures, where water impermeability is to be provided and large amounts of concrete are to be placed, with the use of small amounts of formwork operations, and also for structure that contains a small number of prefabricated or repeatedly used members. However, as experience indicates, cast-in-place concrete can also be used effectively in other cases. Data that has appeared in recent years testifies to the effectiveness of increasing the share of building brick in the structure of wall materials, particularly for housing construction needs.

Improvement of the economic mechanism requires that planning organs give more complete consideration to material resources by region of the country and to compiling regional balances for the production and distribution of the most important types of output. These circumstances raise the role of regional development and research in saving material resources and in reducing the materials intensiveness of output.

Interesting experience in the conduct of organizational and technical measures aimed at saving metal has been gained by Belorussian SSR machinebuilding, which has worked systematically to reduce the materials intensiveness of the machines and equipment they produce. Improvement in the use of metal is achieved primarily at motor-vehicle enterprises and in the tractor industry and in machine toolmaking. In particular, at the Minsk Motor-Vehicle Plant the specific consumption of metal per 1 ton of load capacity is among the lowest in the country.

A factor analysis of possible metal savings is being made at Middle Urals machinebuilding enterprises. Strip-mining and walking excavators of Uralmashzavod [Urals Machinebuilding Plant], gas turbines of the Urals Turbomotor Plant, and some articles made by Uralkhimmashzavod [Urals Chemical Machinery Plant] have lower specific metals intensiveness than foreign and domestic models. As a whole, according to the data of Urals organizations, during the 10th Five-Year Plan 89 of 128, or 70 percent, of the most important machinebuilding articles of Mintyazhmash [Ministry of Heavy and Transport Machine Building], Minelektrotekhprom [Ministry of Electrical Equipment Industry] and Minkhimmash [Ministry of Chemical and Petroleum Machine

Building] enterprises that are located in the Middle Urals were marked by specific metals intensiveness that is lower than that of the best existing models. The use of some Urals enterprises' machines in the national economy enables substantial metal savings to be made. Thus, use of the Uralmash EKG-4.6B excavator, with a productivity of 1.85 million m^3, instead of the EKG-4.6A, with a productivity of 1 million m^3, in ore mining enables rock excavation to be increased by 75 million m^3 per year. An additional 75 EKG-4.6A excavators would have to be manufactured to excavate this much rock. When a certain increase in the absolute weight of the EKG-4.6B excavator is considered, its output and use saves the national economy more than 7,000 tons of ferrous metal each year.

The country has in recent years taken a number of steps that are aimed at improving norm-setting for the consumption of materials, which, while the economic mechanism is being improved, remains the main direction for purposeful control of material resources consumption. However, right now we should be concerned not only about improving "direct" norm-setting but also about developing comprehensive norms that coordinate jointly the national-economic consequences of realization of the three most important areas for intensifying production--the reduction of its intensiveness in materials, labor and capital. Deepening and development of the scarce scientific and practical developments that exist in this area should enable determination of the extent to which labor and fixed capital expenditures are being raised (or, in some cases, reduced) per unit of output produced in a given industry and in allied industries while materials intensiveness is being reduced. Later, this can serve as a base for the mutually correlated determination of trends in the intensiveness of materials and capital of production and of labor productivity, and for the establishment of agreed tasks and ceilings in the indicated spheres.

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CONSTRUCTION MACHINERY

SUGGESTIONS MADE FOR ASSESSING METAL SAVINGS IN METALLURGY, MACHINEBUILDING

Moscow VOPROSY EKONOMIKI in Russian No 12, 1980 pp 49-59

[Article by N. Morozov: "The Metals Intensiveness of Machines and the Norms"]

[Text] The modern scientific and technical revolution is stimulating an ever-increasing updating of machinery and an increase in its power, energy and speed characteristics, which make high demands on metal. The problem of the effective use of materials, primarily of ferrous metals, is acquiring ever greater urgency. The potential for satisfying the national economy's growing requirements for metal products is a function of many factors, primarily of radical qualitative changes in the output of such industries as metallurgy and machinebuilding.

Vast reserves for saving metal should be found during the design of machinery and during the development of the technology for creating it. Analysis has shown that the use of low-alloy steels, special types of rolled metal, lightweight alloys and plastics can reduce truck weight by 5-7 percent. At the annual output of the main units (about 600,000 of them), this is equivalent to increasing load capability by 200,000 tons or to using about 40,000 ZIL-130 trucks. Assimilation of the production of spring strips with parabolic edges alone yields about a 9-percent saving in metal. The use of welded bedplates and the manufacture of parts from precision castings greatly facilitates the design of machine tools. In 1981-1985 Minstankoprom [Ministry of Machine Tools and Tool Building] plans to reduce tolerances and allowances during machining by 10-15 percent through the use of precision forgings. Deficiencies in production technology and in tooling lead to great losses of metal and additional labor expenditure. According to the data of NIEI [Scientific-Research Institute of Economics] under UkSSR Gosplan, the removal of excess allowances makes up 50 to 90 percent of the overall labor intensiveness of machining, at a time when the share of finish machining is 4-12 percent in all.

Many NII's [scientific-research institutes], KB's [design bureaus], enterprises and associations do systematic work to improve machinery design and to rationalize production. Thus, the metals intensiveness of KhPT-type pipe units that were developed by the Elektrostal' Heavy Machinebuilding Plant's KB over a period of 30 years has been cut almost to one-fourth (from an estimated 0.07 to 0.027 per ton of output). The MTZ-142 general-purpose row-crop tractor of the Minsk Tractor Plant surpasses in materials intensiveness (26.7 kg per 1 hp) the American-made John Deere 4630 counterpart (44.5 kg per 1 hp). As a whole, the share of savings of rolled ferrous metal products in machinebuilding by using improved-quality rolled metal and substitutes is constantly increasing: it was 21.6 percent during the Eighth Five-Year Plan, 40.8 percent during the Ninth and 44.6 percent during the 10th.

However, along with these achievements, there are significant deficiencies. Thus, waste of metal in machinebuilding exceeds the annual saving of rolled metal severalfold. Five-year plan tasks for the production of economical section are not being met: out of 140 effective types of rolled metal, little more than half of them are being produced, and only 60 percent of the planned metal saving through improvement of metal quality is being provided for. Certain types of rolled metal, particularly grade 09G2S flat rolled steel 50-160 mm thick, which is used in making bridges for heavy cranes, is delivered with a large number of internal discontinuities, forcing large thicknesses of plate to be incorporated in designs. Many types of machines (load-carrying, road-construction and others) are not up to the best domestic and foreign counterparts in weight characteristics.

Metal losses are often caused by the fact that, because of unfinished design work, new models are not put into production for a long time, and the discontinuance of heavy models is hindered. Thus, the service life to overhaul of the DP-22 bulldozer-ripper, which has been produced since 1965 by the Bryansk Road Machinery Plant imeni 50-Letiya Velikogo Oktyabrya, is half that of its counterparts, it is 20 percent less productive, and it weighs 15 percent more. A new bulldozer-ripper still has not been placed into production, since it has some design defects. Such miscalculations are especially sensitive when the production of a new item is being mastered, since it often leads to a lowering of its engineering level. For example, the SKGD-6 Kolos rice-harvesting combines and the VPS-2.8 planting and transplanting machines, which were first produced in 1980 by Minsel'khozmash [Ministry of Tractor and Agricultural Machine Building], are 7-12 percent higher in specific metals intensiveness, respectively, than their counterparts of identical productivity.

The output volume of metal products and their qualitative indicators and the potential for saving metal are determined to a great extent by the technology of modern machine production and the structure of fixed capital. The level of metallurgical production technology is evaluated on the basis of the consumption coefficient, which reflects steel consumption per ton of rolled metal. In machinebuilding and metalworking the metal utilization coefficient (K_{im}), which is computed as the ratio of the weight of the part to the weight of the material or blank, is used. The actual values of the consumption coefficient and the metal utilization coefficient for many ministries of machinebuilding and metallurgy do not meet modern demands. According to the data of the 11 machinebuilding branches, the K_{im} averages 0.735, in the automotive industry it is 0.68, and in machine toolmaking it is 0.61.

When evaluating metal output, mainly individual technical parameters are considered, with orientation, as a rule, not to the concrete requirement but to the requirement "in general." USSR Gossnab centers often issue material without considering the assortment and multiplying factor. Enterprises turn over for scrap flat-rolled metal that is up to 0.5 meter wide and more than a meter long. Until recently not only rolled metal but also certain types of equipment were planned and calculated in tons, without breakdowns by assortment and products mix. Such a method is a simplification that does not meet the goals for saving labor and materials.

Analysis of the factors and conditions that affect metal savings has shown that economic factors are not given the consideration due them. The existing practices of planning the output of metal products from the level achieved and also on the basis of the metal utilization coefficient do not meet modern demands. A new method that incorporates the multiple-factor nature of the causes (technological and production factors, design-associated factors, and others) and the diversity of evaluations and relationships is needed. A system of norms and standards that would enable the choice of metal and methods for processing it to be optimized at minimal cost per unit of useful effect should be developed.

The CPSU Central Committee decree, "On the Work of Metallurgy, Machinebuilding and the Construction Ministries to Raise the Quality of Metal Products and the Effective Use of Metal Based upon the Introduction of Low-Waste Technology, in Light of the Requirements of the November 1979 CPSU Central Committee Plenum," pointed out deficiencies in the production, planning and use of metal products. It follows from the decree that the forming of the new conception signifies the development of a system of scientifically substantiated technical and economic norms and standards by type of operation and by expenditures for labor, raw and other materials, and the conversion to the planning and distribution of metal on the basis of standards.

State standards are the engineering-standards base of production. They define the indicators of the technical level and quality of production work, they establish indicators for the technical level and quality of the output, and they regulate the industrial processes. Their further improvement, as defined by the decree, is associated continuously with the development and introduction of a system of scientifically substantiated technical and economic norms, including those on the rational use of metal. Weight indicators were included in the standards even earlier but they often did not correspond with the best achievements.

Advanced economic methods are being disseminated increasingly, and enterprises and branches of machinebuilding are discovering and using reserves and eliminating existing deficiencies on the basis of them. Thus the ZIL [Moscow Motor-Vehicle Plant imeni I. A. Likhachev] Production Association, in executing a long-term program for saving metal, plans to prevent waste almost completely by introducing progressive industrial processes, scientifically substantiated standards and an effective incentive system. During the 10th Five-Year Plan the rolled-metal utilization coefficient will rise from 0.7 to 0.83. Laboring collectives are adopting increased socialist commitments in response to the decisions of the July 1980 CPSU Central Committee Plenum. Thus the workers of the Cherepovets Metallurgical Plant imeni 50-Letiya SSSR, in competing for a worthy greeting to the 26th party congress, have committed themselves to the manufacture in 1980 of about 4,000 tons of high-quality metal above the task, including the first batch of rolled steel processed with varnish. Metallurgists of Liyepaya's Sarkanays Metalurgs plant have adopted a commitment to produce 1.5-fold more rolled metal above the task than had been planned at the start of the year, and one-third of this output is to be manufactured from metal that has been saved. Having mounted a shockwork drive, the collective of the Minsk Refrigerator Plant in August 1980 completed realization of a five-year program for the mechanization and automation of production with the startup of a line for cutting coiled steel, which cuts the metal into strips of strictly determined size. Enough metal is saved in a year now to produce almost 2,000 refrigerators.

However, not by far is this work systematic in nature, nor is it marked by high effectiveness. The causes are varied: deficiencies in planning, the overstatement of norms, an absence of economic incentives to reduce materials consumption, a low level of technical equipping for production work, and so on. As indicated by checks of consumption norms of the basic materials used in the production of household refrigerators which was conducted by the NII for Planning and Standards of USSR Gosplan and the VNII [All-Union Scientific-Research Institute] for Normalization in Machinebuilding under Gosstandart [State Committee for Standards], enterprises and manufacturing ministries overstate consumption norms. Thus the Armelektromash association of Minelektrotekhprom [Ministry of Electrical Equipment Industry], in producing the KSh-200 Aist model refrigerator, uses a compressor of obsolete design that is heavier than its counterparts by 4.38 kg, which is 7.7 percent of the refrigerator's total weight. As a result of deficiencies in the industrial process, the metal utilization coefficient in this association is overstated by 3.5 percent, and in recomputing and converting to volume of refrigerator output, metal loss per year is more than 1,000 tons. The norms for rolling ferrous metals in this association were overstated by 6.4 percent, for seamless light-walled tubing by 37.5 percent, and for rolled and drawn stock by 80 percent. The data cited raises valid questions: what kind of norms are these, and how are they established? We shall try to answer these questions, relying upon the facts.

Planning for the level achieved covers up many mistakes and sets a formal approach to the development of metal consumption norms. The consequences of such a practice is well known. Factual data by branch of machinebuilding and metalworking indicate that in most cases the norms are overstated by far and it is through this that the metal "savings" are basically achieved. Such a technique is intended, as a rule, for filling out reports and, in essence, bypasses solution of the problem. It should be added that the situation is intensified by nonobservance of the requirements of the standards and specifications. A check made by Gosstandart in 1979 found that an average of 8-20 percent of the grinding and boring machine tools were manufactured in violation of various standard norms for precision of machining, degree of automation and equipping, noise characteristics, reliability of the various units, and weight.

Most technical characteristics of machines and equipment are directly or indirectly associated with a saving or, on the contrary, an overexpenditure of materials and labor resources, which, in the final analysis, affects the economic indicators.

In order to bring out the effect of the various factors on saving metal, let us examine generalized data for the 11 machinebuilding ministries for 1976-1980:

Metal Savings (in Percent)

Use of economical types of rolled metal products.......	15-40
Improvement of technology............................	25-60
Improvement of design................................	15-50
Use of substitutes...................................	5-15

As we see, the most savings are provided by the use of progressive industrial processes. But the significance of design parameters is manifested fully only in operation. According to the experts' assessments, losses of metal in the area of equipment use exceeds losses in production severalfold. Therefore, it is necessary to develop indicators of the materials intensiveness of output by means of which it would be possible to take the operational characteristics of the articles into account.

In order to validate appropriate norms for consuming metal, experience indicates that it is desirable to unite into one system the indicators that characterize the progressiveness of industrial processes (low-waste technology) and the indicators that relate to the design development of products (specific metals intensiveness). Consequently, norms must be further regularized by the multiple-factor method, based upon consideration of technological materials intensiveness and design and operational factors, and on the basis of standardization.

Standardized norms are adopted as the bases for organizing production work and control and are called upon to regularize the circulation of metal in the national economy, including the use of secondary metals at all stages--from design to operation. Ferrous metallurgy products are affected by 1,150 GOST's [State All-Union Standards], in accordance with which about 90 percent of its mass production for machinebuilding is produced. A comparison of domestic and foreign standards for metal and of methods for testing it indicate that identical amounts and levels of normed characteristics are established, as a rule, for metal products for definite purposes. The requirements of the GOST's for chemical composition, harmful impurity content, composition range of the main elements, and specifications of mechanical properties correspond basically to the indicators shown in standards of the USA, the FRG and Japan for similar grades of steel. As for the assortment of rolled products, our standards contain a lesser number of lightweight, light-walled shapes and, especially, complicated intricate-shape section. Thus, the fractional breakdown interval for the assortment is specified as 0.2 mm for rounds and squares, while in the USA the figure is 1.6 mm. The USA's standards indicate more rigid tolerances for beams and channels (maximum deviation in width and height), and a smaller minimum thickness for flat-rolled steel is called for.

In order to reduce metals intensiveness in machinebuilding output and to raise effectiveness in the use of supply and equipment resources, it is necessary, in our view, when developing new standards and specifications, or when reviewing existing ones for metal output, to consider both engineering and economic factors. An increase in the precision of rolled products is a substantial reserve for saving metal: on continuous cold-rolling strip mills it is about 5 percent, and on continuous hot-rolling strip mills it is 3 percent. Calculations indicate that capital expenditures for introducing into operation new capacity for producing thin sheet is recouped in 3 years through savings in operating expenditures.

The structure of the standards and of the mix of quality indicators for metal products, machines and equipment should be improved by introducing into the standards and specifications indicators and norms that characterize customer properties more adequately. The use of a method for differentiating metal strength and other operating properties can yield a substantial reserve for saving metal. Arranging for rolled products with guaranteed characteristics enables an increase in the reliability of metal structure, and a reduction in the cross-section of the rolled products used provides for a saving of metal that averages 2.85 percent for killed and semikilled steel.

In machinebuilding and instrument making the standardization system consists of five groups of engineering-standards documents that regulate: 1) development of and arrangements for the production of output; 2) industrial preparation for production; 3) production work; 4) the conduct of testing; and 5) certification of the product as to quality category and control of the product's quality. Depending upon the purpose of the articles, the grade composition of metals and alloys and the assortment of metal products are established in the standards, which set norms for the sizes and tolerances during machining, indicators of the strength of parts and structure, the reliability and service lives of articles in operation, approves requirements for anticorrosion treatment and for protection against corrosion, and introduces restrictions on weight. Production facilities have at their disposal a set of standard methods and means for computing and setting norms for the basic and auxiliary materials. Requirements for the design development of articles and for their technological design and manufacture are made up to take the economical use of materials into account.

In their structure, construction and level of indicators, state standards correspond in the main to the standards of industrially developed nations. However, the standardizing part of the state standards are to be developed and strengthened, the norms and requirements of the GOST's and of specifications (TU's) are to be more closely coordinated with each other, the requirements for the final product are to reflect more fully the technical standards documentation, and economic justification of newly introduced norms and requirements is to be improved.

Economic factors are decisive in developing standards and specifications. Along with the well-mastered method--restricting the lower limit of the values of the various parameters--new methods are coming into their own with increasing persistence--the establishment of degrees of quality and the development of programs for comprehensive standardization. The existence of degrees of quality and the incorporation of a priority in programs for the final output will enable the correlation of technical level indicators with prices and the introduction of parametric methods into price-setting on the basis of which price levels are set as a definite function of the levels of the engineering parameters and product quality. Such an approach will help to expand the scale of and to improve standards methods, and it will make the conduct of calculations, including those for indicators of metals intensiveness for standard production conditions, more realistic.

The technical level of new output is determined to a great extent by scientific research and experimental design developments. GOST 15.001-73, which was introduced into design practice for the development and placement of output into production, establishes a precise procedure for the development and approval of experimental engineering tasks, the conduct of expert review of design, the testing of experimental models, the issuance of authorization for assimilating the production of new types of output, and the conduct of monitoring tests of serial output. Output that is subject to development, assimilation and placement into production should correspond to the highest quality category at the time its production is assimilated. At the stage when output is being placed into production, a final evaluation of the design in accordance with the criteria is conducted: for correspondence with the highest quality category, the cost of manufacture, the cost of operation, and consideration of the requirements of work-safety practices and preservation of the environment.

An important role in saving metal has been assigned to methods for analyzing the design of machines, for assuring strength uniformity of all parts, for reducing dimensions, and for using new structural materials, particularly welded parts. All this requires new design decisions and principles for building machines. Creating a rational design for a product and imparting a desirable shape to it should be combined with assurance of optimal reliability and durability. The reliability of machines, units, instruments and complexes is one of the main criteria of their perfection.

The realization of ideas invested in designs and the embodiment of design-development solutions are part of the task of industrial preparation for production. The technology of modern machinery production and the structure of fixed capital determine to a great extent the output volume of metal products and their qualitative indicators. In singling out the universality of its effect, technology exerts influence not just on the final product but also on the development of the supporting production operations, including metallurgical. Thus, the design of the equipment for castings and forgings production facilities of machinebuilding and metalworking, where metal-cutting tools predominate, determines to a great extent the variety of ferrous metals. Many processes associated with setting norms for materials intensiveness are performed on the basis of standards that are included in the Unified System of Industrial Preparation for Production (ESTPP), which includes the following list: development of the design of articles on the basis of manufacturability, choice of manufacturability indicators, computation of the norms for materials consumption, and choice of the main parameters for computing materials intensiveness.

However, a number of indicators for materials intensiveness and materials utilization that have been standardized do not have accurate definition and are inadequately systematized, so their use is not always effective. Thus, a draft of a standard for wheeled tractors recommended that materials intensiveness within the 41-64 kg/watt range be established. The introduction of a "bracket" with such a spread is unacceptable, the more so since a new modification of the tractor has a 32 kg/watt level for this indicator. But the main thing is that basic criteria for the different types of machines and industrial processes have not been established.

Much work is being done now to introduce order into norms and standards. In accordance with the CPSU Central Committee and USSR Council of Ministers decree, "On the Improvement of Planning and Strengthening of the Influence of the Economic Mechanism on Increasing Production Efficiency and Work Quality," USSR Gosplan has approved a system of progressive technical and economic norms and standards by type of operation and expenditure (or saving) of labor, raw and other materials, and fuel and energy resources and of standards for the use of production capacity and specific capital investment and norms and standards for determining the requirement for equipment and cable articles (the procedure for their development and approval). The system calls for the establishment of norms and standards for consumption and reserves of raw and other materials for each product being manufactured. This will pave the way for comparing expenditures for the production of articles and the technology of their production for the set of resources being used.

In state plans for economic and social development, a running total in percents of the level of norms of the base year (the last year of the five-year plan that precedes the plan period) will be approved for tasks for USSR and Union-republic ministries and agencies for the average reduction of norms for the consumption of raw and other materials during the period being planned. Consumption of the normed type of raw and other materials for the production of a unit of output is established on the basis of individual norms in units of weight or volume and so on. Grouped norms are figured as the weighted average amounts of the consumption of raw and other materials for the products mix of the industry, for the planned amounts of production of like types of output or of operations, by USSR and Union-republic ministry and department, and, when, necessary by association and enterprise.

Standards and indicators for the use of raw and other materials which have been recommended for use now include: the specific consumption of material resources per unit of weight, area, volume and length during the execution of production processes (forging and pressworking, machining, welding and so on), and the amounts of industrial waste and losses of material resources by type of production process.

The effectiveness of use of material resources and the progressiveness of consumption norms are evaluated by means of indicators. A coefficient of materials utilization in production--the ratio of useful consumption (theoretical weight of consumption) to the norm for the consumption of material--has been established. The consumption of materials per unit of the article's specifications is established by the application of the appropriate consumption norms per unit of the article to the chosen parameter. The yield of output (or semifinished item) is determined as the ratio of the output (or semifinished item) produced to the amount of raw and materials actually expended.

The procedure for the development and approval of norms for the consumption of raw and other materials, which is approved by USSR Gosplan, is common for ministries and associations (or enterprises) of all branches of industry and for the construction industry, but it does not completely consider the specifics of each of them. A differentiated approach that takes into account the operational properties of the items and progressive trends in the development of equipment and production technology is required for machinebuilding and instrumentmaking.

Gosstandart and the machinebuilding and instrumentmaking ministries are required to review existing standards and to develop new standards and specifications for raw materials, stock, outfitting articles and final articles, after scientifically sound norms for weight, reliability and durability have been established.

It is necessary, in our view, to establish standards for specific metals intensiveness in in-kind indicators per unit of technical parameter of the output that characterize more fully the output's consumer properties. The coefficient of specific materials intensiveness (K_{um}), which characterizes the technical perfection of the output, as well as its economic merits at the stages of design, production and operation, and, consequently, determines decisively not only the articles engineering and economic level but also the acceleration of scientific and technical progress, can be adopted in machinebuilding as the basic indicator. This coefficient is determined by the formula:

$$K_{um} = \frac{M \cdot Z}{P \cdot T},$$

where M is the weight of the article; P is the value of the article's main technical parameter (power or capacity, productivity, bucket capacity of an excavator, height of centers of a machine tool, and so on); Z is the material expenditure for servicing and spare parts; and T is the service life of the article and its reliability.

The multiple-factor method for determining specific metals intensiveness (taking into account material expenditures in production and operation, and applying them to the values of the main technical parameters) is used in analytical work in many branches of machinebuilding, although the calculation does not always include indicators of reliability and longevity or expenditures for servicing. For example, the specific metals intensiveness of a machine for centrifugal casting is calculated as the ratio of the machine's weight to the product of the basic size indicator of the casting (the largest external diameter and the length of the casting) and of the machine's maximum productivity (in items per hour). The exclusion of a reliability indicator from the normative indicators simplifies the operation. However, this, in our view, is anomalous. Service life expresses an important functional property of the output: an increase in service life to optimal values is equivalent to a corresponding release of material resources necessary for the reproduction or renovation of machines withdrawn from use.

The improvement of methods for computing metal savings should be organically correlated with scientifically substantiated methods for the design development of machines. The large amount of work that is being conducted now in this area should be noted. Thus the State Scientific-Research Institute for Machine Science imeni Akademik A. A. Blagonravov has developed a method for multiple-criteria optimization of machinery parameters. It will enable determination of rational parameters for objects being designed, including weight, dimensions and strength and dynamic characteristics. The development of standardizing documents, in which optimal methods for computing standard machine members, such as bars, plates and covers, has been started. They include standard programs for the computation on computers of stresses, deformations, oscillations, stability and longevity. Standardization of these standards documents makes them accessible to a large number of developers of machinery and mechanisms.

An indispensable prerequisite and element for the development, production and use of economical types of materials is the use of standards methods of tests and methods of optimal design. It has now become necessary to standardize more completely requirements not only for serial output, but also for model indicators of quality and for evaluating them during research, for the development of designs, testing, and the selection of material. The development of standards in the area of mechanical, instrument-engineering and corrosion tests has been recommended.

The scientific substantiation of a system of technical and economic norms and standards should be a starting standard-practice principle in developing measures to save metal. In so doing, it is desirable to create a system that includes indicators of specific materials consumption per unit of output and indicators of specific metals intensiveness applied per unit of technical parameter. Tasks should also be developed for average reduction of the norms for materials consumption, and they should be coordinated with tasks on the overall specific consumption of materials for the products mix being examined.

Norms for materials-intensive processes should possess universality and cover all types of material-production requirements (raw materials, billets and blanks, semifinished items, basic and auxiliary materials and outfitting articles), be convenient to use, characterize the design development of the article and the technology of its manufacture, and reflect more fully the customer properties of the output and the interests of the national economy. Material consumption norms in production work is the sum of the standard values of the weights of the initial material or billets, so a consolidation and accurate determination of them is possible. The value of standard weight, indicated in the drawings (M_n) and the material utilization coefficient (K_{im}) are used in a consolidated analysis. A precise determination of material consumption norms is based upon analysis and substantiation of the amount of waste of materials (M_0) by type of production work for each industrial operation associated with change in a part's weight. In so doing, a permissible amount of waste can be adopted for computation, based upon the condition for reducing it in comparison with the achieved level (at an entrprise and in a branch of industry) in the form of stages: for waste-free technology within the 0-3 percent range, for low-waste technology within the 5-15 percent range (roughly speaking).

In order to set norms for metals intensiveness with the use of a set of indicators, including those that characterize the article's reliability, by means of the coefficient (K_{um}), much work is required. The fact is that reliability itself is viewed as a comprehensive concept, which includes the properties of dependability, longevity, reparability and so on. Earnest research probably will have to be performed to establish the values of the reliability indicator for articles of a definite type, and a mix of indicators will have to be standardized to get comparable results of the computations and tests of reliability.

The diversity of existing and newly proposed indicators that characterize materials utilization need systematization and validation of the use of each of them in their various combinations in order to insure objectivity and comparability of individual and comprehensive evaluations. For example, in motor-vehicle manufacturing the specific metals intensiveness of trucks was reduced in the past 10 years by 19.8 percent (by raising axle loadings). However, this was not accompanied by a saving of metal in production; the K_{im} was reduced at this time from 0.70 to 0.68, and during the past 3 years the enterprises overexpended about 250,000 tons of rolled products (80 percent of the total overexpenditure in machinebuilding). Mintyazhmash [Ministry of Heavy and Transport Machine Building] approached the choice of criteria for metal utilization somewhat differently. In order to increase the load capacity of freight cars, weak components were strengthened. As a result of this work, the cars became much stronger and more durable, and it was possible to haul not 63 tons but 70 tons in each of them, in accordance with the standards. The increase in load capacity of the cars was equivalent to an annual saving of 33,000 tons of rolled products. Along with this, the norms were made more rigid here. It is intended to reduce metal waste by 15-35 percent during the 11th Five-Year Plan.

The set of basic engineering standards indicators is shown in the table in systematized form:

Title of engineering standards documentation	Indicators
1. GOST's [State All-Union Standards], general and technical, for specific types of output........................	K_{um}*, M_n
2. OST's [Industry Standards] and TU's [specifications].....	K_{um}*, M_n
3. TZ's [technical tasks], detailed designs and drawings....	M_n, K_{um}*
4. Charts of the technical level............................	K_{um}*, M_n
5. Technology, process charts..............................	M_n, M_m, M_0* K_{pm}, $K_{raskhoda}$, N_r* (1)

[Table (continued)]

Title of engineering-standards documentation	Indicators
6. Catalog of materials, orders and warrants, and plan tasks	M_m, N_r*

*Newly proposed indicators: K_{um}--coefficient of specific materials investment; M_0--weight of the waste; and N_r--norms for materials consumption.

Key:

1. $K_{raskhoda}$. Consumption coefficient.

Items 1, 2, 3 and 4 of the table relate to the development of a large set of engineering-standards documentation that defines the technical level and quality of machinebuilding and instrumentmaking articles, and it is directly associated with specific metals intensiveness. Item 5 shows the connection of the technological documentation with the norms for low-waste and wastefree technology, which can be used when making up catalogs, orders and warrants, and plan tasks and when forming funds for supplying materials and equipment (item 6). The symbol N_r signifies consumption norms, which can be calculated in two ways, proceeding 1) from the nominal or standard values for weights and totals of minimized waste of material which are indicated in the drawings; and 2) from the terms $N_r \leqslant M_\Phi - Z_s$ (M_Φ is the actual weight for the preceding period, and Z_s is the task for reducing materials consumption). In this case, preference should be accorded the calculations carried out under the first variant, since they are based upon technically and economically substantiated norms that correspond to the level of advanced technology and production organization.

Among organizational measures, the certification of output for the State Emblem of Quality has an important role. Certifying commissions should consider materials-intensiveness indicators along with the main ones that characterize the technical level and quality of output. The development of systems of quality control and effectiveness also are directly associated with the rational use of material resources.

Much procedural work must be done in substantiation of the use and the combining of indicators and coefficients, especially the newly proposed ones, for various types and models of articles and types of production work. However, it is difficult to overestimate the results of such work. A unified standards approach to the distribution of material resources and a unified assessment of the activity of design organizations and of enterprises, based upon technically substantiated norms for materials consumption and materials intensiveness, will enable the existing practice of planning the consumption of metal and of billets from the achieved level to be reviewed. The actual requirement for them will be determined, taking into account a reduction in the metals intensiveness of the articles and the introduction of low-waste technology. In our opinion, a regularization of standards will also enable the introduction of state accounting and reporting about actually achieved indicators in metal utilization by branch of industry and in construction, and also about the yield in service life for the most important types of machines, based upon a single computations base. A comparison and analysis of reporting data will help to improve the use of material resources.

A system of scientifically substantiated technical and economic norms and standards for consumption and for the use of raw and other materials, as the most important component part of specific integrated scientific and technical programs, will enable correlation of these programs with the appropriate main divisions of the state plan and with material and financial resources, and they will help in the successful fulfillment of national economic tasks. The existence of the appropriate technical and economic indicators will create realistic possibilities for creating material reserves (necessary for proportional and balanced development of the economy) and for introducing reporting of the effectiveness, economical distribution and integrated use of materials resources on the basis of precise calculations.

An intensification of the savings regime and elimination of losses in the national economy is inseparably connected with an improvement in cost-accounting relationships and the forming of economic incentive funds. Where there are comprehensively substantiated and stable standards, the activity of scientific-research, design development, and design organization and industrial enterprises can be evaluated according to their contribution to the final result, and, depending upon the total saving of material, a system for awarding bonuses constructed.

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