CLASSIFICATION OF CHEMICAL EQUIPMENT AND PLANT SPECIALIZATION

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Mass production contrasts with custom-tailored production and with job-lot production, as we know, in the continuity with which parts of the same model and dimensions are fabricated over a protracted time period, or in the strict reproducibility of the technological process in all phases of production. This continuity becomes a practical possibility only in factories having a limited assortment of parts to be produced,combined with an enormous production volume. The continuity in output assures the stability of the production process and steady flow of stock to the work sites. This is turn opens the way for narrow specialization of jobs, to the point of assigning one part, one operation, or even one distinct step in an operation to one job. This specialization contributes to a marked improvement in the technological equipment serving job operations, to the use of specialized technological, transportation, and control equipment, and is a prerequisite for the acceptance of complex mechanization and automation of production processes.

The presently accepted point of departure in determining the type of production in machine shops, for example, is the load factor of the equipment in an operation, i.e., the degree of specialization of jobs. Two indices are employed to rate the degree of specialization: K_1 the number of operations per unit equipment, and K_2 the ratio of average operational time t_{av} to the production rate r of the part in question. Approximate values of coefficients K_1 and K_2 appear in Table 1, for machine shops.*

Coefficient K_2 may also be used in volume calculations of the capacity of a shop (or department), since it indicates the number of units of equipment needed to complete a particular operation.†

Under mass-production conditions, the limited range of items manufactured and the concentration on production of those few items contributes to specialization of one or several pieces of equipment in each operation in the production process. In that case the calculation of the plant-average coefficient characterizing the mode of production will not be difficult. Under unit manufacturing conditions and small job lot production conditions, it is barely possible at all to calculate these indices in any practical way because of the broad range of parts and items manufactured and the low production volume of each item.

* E. A. Satel' et al. Organization, planning, and economics of the main departments of machinery plants. Moscow, Mashgiz, 1963 [in Russian].

† $r = \frac{\phi}{N}$, where ϕ is the equipment operating time allotment in the planning period; N is the program of production in the planning period. Consequently, $K_2 = t_{av}N/\phi$.

TABLE 1

Index	Production characteristics			
	mass	quantity	batch	small lots
K_1	1	<10	10—20	>20
K_2	⩾1	0,2—0,5	0,05—0,1	<0,05

We now suppose that the range of items manufactured and the production volume are optimized for the particular plant, i.e. are so arranged that the available plant equipment and the material and labor resources at hand will be utilized to the full in the most efficient manner. Then the problem of characterizing the mode of production is greatly simplified. It reduces to one of determining to what extent the national economy requires products from the particular branch of industry involving the use of the particular types of machinery.

In 1962, the Gipropribor institute worked out a schedule of optimum plant output of chemical machinery in the production of the basic groups of chemical equipment to cover the subsequent planning period.

We made a classification of chemical process equipment scheduled for production in 1970 on the basis of an expanded list of production items to match the list of equipment categories adopted at the conference of member nations of the Council for Economic Mutual Aid [COMECON] in 1963 in Moscow.*

Table 2 gives figures on structural shifts in the production of equipment and the number of specialized plants of optimum productive capacity needed, according to our calculations, to meet the 1970 production targets in chemical process equipment. The tabulated figures also indicate that well-defined specialization of plants and shops engaged in the production of chemical machinery and optimization of operations in those plants would enable nine plants to fulfill the 1963 program assigned to 16 specialized plants and six specialized shops. There is hardly any need to argue that the productivity of labor in this branch of industry would be greatly increased by improvements in quality, or that net production costs would be brought far below 1963 levels thereby. 28 to 30 specialized plants with optimized production capacities, or 42 plants taking consumers into account, will be needed to satisfy 1970 needs for chemical and petrochemical process equipment. It is also proposed that the use of a certain number of plants in other branches of industry for production of chemical process equipment be continued on to 1970, since the volume of capital investments set aside for the development of chemical machinery production and the rates of construction and introduction of new productive capacity will not be fulfilled by specialized plants alone in this time.

The level of specialized production in some leading categories of chemical equipment in 1970 will be far beyond the 1963 level. This is assured by the continually expanding and intensifying process of integration of chemical advances in all branches of the national economy. For example, while the production of equipment in the first three groups (categories in Table 2) may be organized on a short run production basis at present, or at best on medium production runs, there is a distinct possibility of achieving quantity production of these items by 1970.

The number of plants specializing in the production of tank type equipment with fixed internal structure of heat exchangers and evaporator plants will be tripled; plants manufacturing column equipment will be more than tripled. The situation in other categories is much the same. By 1970, for example, item specialization in the chemical machinery industry will far surpass the 1963 level.

The number of specialized plants required to do the job can be successfully narrowed down only by rational allocations of chemical machinery production over the period ahead.

Note that the functional purpose of the machinery or equipment in question is the decisive criterion in this classification. This does not allow complete utilization of this classification for specialization and cooperation in chemical machinery production. Standardization of manufacturing processes, and unitization of parts and subassemblies, and most important of all, expansion and intensification of specialization and cooperation in this branch of industry, requires a classification of chemical equipment based on design and process features of the machinery and equipment. Equipment similar in function often differ in design and format and in production technology. We can see this by comparing rotary dryers and desiccators, or by comparing shell-and-tube heat exchangers, coiled heat exchangers, and plate type heat exchangers. Conversely, equipment designed for different process functions may be quite similar in features of design or in the process used to manufacture them, e.g.: tubular contacting equipment and tubular heat exchangers, packed rectification towers and entrainment scrubbing towers. The similarity or dissimilarity of the equipment is determined in the first instance by the following factors: shape of the equipment predetermining the methods to be used in the major processing and machining operations; physico-mechanical properties of the constituent materials of parts and subassemblies and in turn predetermining the choice of productction techniques affecting almost every single operation in the manufacturing process; the nature and structure of

*The needs of the national economy in chemical process equipment over the 1966-1970 period were arrived at using a refined planning procedure for production of chemical equipment which was developed by the authors in 1964.

TABLE 2

Equipment category*	Category No.**	Specific weight of category in tonnage, %		Calculated number of plants involved		Specific weight of specialized plants, %	
		1963	1970	1963	1970	1963	1970
Tank equipment*** with or without fixed internal structures	8	22.3	30.0	1.9	7.2	20.8	26.0
Heat exchangers and evaporators	1; 2	18.86	17.24	1.9	6.3	20.8	24.0
Column equipment	3	18.97	20.9	1.6	5.0	17.6	19.3
Paint grinders	18	–	2.47	–	1.8	–	6.0
Agitator equipment	7	2.78	6.36	0.3	1.5	3.3	5.0
Filters	12	9.11	6.25	0.8	1.5	8.8	5.0
Furnaces	20	0.56	3.57	–	0.9	–	3.0
Rotating-drum equipment for firing, drying, crystallization	5	2.62	3.24	0.2	0.8	2.2	2.7
Dryers	4	5.6	2.13	0.5	0.7	5.6	2.3
Porcelain and enamel equipment	10	1; 8	2.1	0.2	0.5	2.2	1.7
Crystallizers	6	–	1.99	–	0.5	–	1.7
Electrolyzers	17	1.8	1.65	0.2	0.4	2.2	1.3
Centrifuges	11	1.9	0.6	0.2	0.3	2.2	1.0
Liquid-separators	13	0.5	0.92	–	0.2	–	0.7
Granulators	16	–	0.58	–	0.1	–	0.3
Miscellaneous		13.2	–	1.3	–	14.3	–
Total	–	100	100	9.1	27.7	100	100

* Categories of equipment are listed in the table in order of decreasing specific weight of plants specialized in the production of equipment in those categories.

** Number assigned to category by the COMECON classification. For more on the COMECON classification of chemical equipment, see the article by V. B. Nikolaev in Khimicheskoe mashinoestroenie, No. 1, 1959.

*** This category includes equipment with fairly simple fixed structures.

the principal manufacturing techniques required (boilermaking, forging or pressworking, machining, etc.); dimensions of the equipment. Using design and manufacturing-process criteria as a basis, we have completed a classification of 25% of the chemical process equipment required to equip chemical industry plants now under construction or undergoing expansion.

By grouping chemical process equipment in this manner, we can achieve increased production quantities and enhanced specialization levels in production. For example, the group "tubular equipment" formed on the basis of the group "heat exchangers and evaporators" sees an increase from 24% to 36.4% in the specific weight of specialized plants, with the tonnage subgroups ranging from 22.6% to 39.8%; the group "process equipment," with column type equipment as the major basis, shows the specific weight of specialized plants increasing from 16.6% to 23.4%, and the tonnage subgroups ranging from 0.2% to 28.8%; the group "tank equipment of minor or intermediate complexity" based on the first group (in Table 2) shows only a slight increase in the specific weight of specialized plants. This is because some of the equipment of considerable complexity in design and fabrication is reclassified from this group into the "process equipment" group.

The cost effect of specialization of mass production and quantity production depends primarily on increase in the utilization factor of the equipment. According to data reported in the literature, the productive operational use of all types of ordinary and semiautomatic metalworking equipment was increased 2 to 2.7 times by transition to mass production standards with a simultaneous decrease in losses for reasons of production organization and engineering advances.

In chemical machinery production the specific weight of machining operations at individual plants accounts for 20% or more of the total labor involved in the equipment manufactured. The most cautious estimates indicate that higher production runs in chemical equipment can cut machining labor costs by no less than one million standard man-hours, resulting in an all-round improvement in the total cost picture.

Further improvements, advances, and intensification in specialized production must proceed alongthe lines of a gradual transition from specialization in objects and groups of objects to specialization in models and standard equipment, where economically feasible; in centralization of the manufacture of standardized components and subassemblies which could be switched to mass production even today (bottoms and closures, nozzle holes, flanges, trays, column bubble caps). Current needs for closures, nozzle attachments, and flanges could be met at the present time by specialization of two plants. The centralized manufacture of components for column equipment can be organized at reasonable cost at those plants which are currently the chief suppliers of that line. The outlook, with the increasing demand for chemical process equipment in industry, is for concentration of the production of trays, bubble caps, and other standard components and subassemblies at a restricted number of specialized plants by simultaneously combining the manufacture of standardized components in narrowly specializedplants with assembly of chemical equipment at designated assembly plants located close to the chemical process plants ordering the final equipment.