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The Use of Linear Parametric Programming in view of Optimizing Production in a Combed Wool Spinning Mill

The purpose of the present paper is to provide the management of spinning mills with a mathematical tool, capable of readily pointing out the correct policy to be assumed any moment, towards each type of manufacturing line, in order to minimize the overall production costs.

The investment projects of outstanding importance, directed towards the continuous industrial development, in order to build up new factories and plants and modernize the existing ones, claim on the part of each and every enterprise to increase its production and working organization, so as to meet the requirements of modern production processes.

The achievement of a full agreement between the level of technical equipment, on the one hand, and production and working organization on the other, is one of the essential approaches to the problem of developing the efficiency of economic activities, of rational use of production capacities and manpower, which are fundamental for the continuous increase of the labour productivity, the reduction of costs and the improvement of products quality.

Scientific organization, based on scientific research, in turn, has a strong influence on the pace and rate of technical development.

The evolution of technical progress in general, and particularly the advent of the synthetic fibres, have allowed, among other things, the modernization of the preparation lines in the combed wool spinning mills. At the present time, in these spinning mills there are numerous preparation systems, illustrating the technical development in the course of time, as well as a great number of mixtures, resulting from the development of the raw material supplies.

Under such circumstances, the planning activity becomes increasingly complex; the distribution of mixtures into assortments according to the technical conditions and the economic profitableness of individual assortments require a basic technological analysis and the application of mathematical methods of operational research to the activity of the industrial unit.

The technological analysis — a first step in scientific programming of production — may be performed on the basis of the investigation of the influence, in accordance with the mixture, of each separate piece of machinery, on the unevenness of half-finished products. The industrial units working in this area are mostly equipped with the uster devices, allowing optimum adjustments, by means of spectrograms. By comparing the uster unevenness data, obtained for each mixture, with various preparation systems of the spinning mill, the most appropriate system of preparation for the processing of a specific mixture is found out.

However, in alloting the mixtures to the preparation systems, one must take into account not only the qualitative considerations, but also the necessity of optimally resolving the problem from the economic point of view.

Since the costs express the overall expenses of the industrial unit in view of achieving production, the investigation of elements that affect this complex index is necessary, in order to obtain a system of distributing the mixtures in assortments so as to minimize the total level of production costs. Consequently, a problem of this kind must take into account numerous factors; the complex inclusion of these manifold factors, in order to obtain an optimum solution to the problem, implies the solving of a system of equations with a relatively great number of unknowns.

The use of electronic computers for the purposes of processing information derived from the economic models of processes and economic phenomena that take place objectively in an industrial unit minimizes the time required for the performance of these computations and, at the same time, ensures their accuracy.

In the economic computation with the aid of mathematical methods and electronic computers an important part is played by linear programming, one of the methods of operational research widely used in the scientific management of economic organizations.

The first step of the scientific organization of the activities in industrial enterprises is the designing stage. It is, undoubtedly, a highly complex problem, as the organizational design has to include all the fields of activity in the enterprise. Such a project may significantly contribute towards the progress of the welfare of the industrial unit, at the same time being an important means of hastening the accomplishment of the designed parameters. On the other hand, under the modern technical conditions, the task of the designer estimating production capacities is not restricted to the use of classical methods, but, already in this stage, he also has to find out the optimum ways for availof all the existent means.

Starting from these preliminary arguments, we are giving below an example, including the solution of a problem frequently encountered both in the designing and in the current activities of effective planning, and even in long term planning.

In the application of the parametric linear programming method, while taking into account certain indexes pertaining to the production, and bearing in mind certain limitations, we wanted to obtain the optimum distribution of mixtures among preparation systems for an existing spinning mill, or for one to be built, with a view to realizing production at minimum costs.

For illustration purposes, we assumed a combed wool spinning mill that would be equipped with three preparation lines, namely:

— Type 1 — preparation system with flyer-frame
— Type 2 — preparation system with finisher
— Type 3 — classical system, modernized.

These preparation lines have to handle monthly the following quantities:

Mixture A. (70 per cent PE + 30 per cent staple rayon) 10,200 kg yarn 54/2
Mixture B. (100 per cent wool assortment 70 S) 40,500 kg yarn 45/2
Mixture C. (45 per cent wool assortment 11 + 55 per cent PE) 27,100 kg yarn 60/2
Mixture D. (70 per cent wool assortment 70 S + 30 per cent staple rayon) 39,200 gk yarn 45/2

The planned mixtures may be processed in the following preparation lines:

Mixture *A* in the Type 1 preparation line;
mixture *B* in all of the three preparation lines;
mixture *C* in Types 1 and 2 preparation lines;
mixture *D* in all of the three preparation lines.

Moreover, it is assumed that the overall quantity of raw materials used and the total costs of production are homogeneous linear functions of the quantities of products obtained.

As a result of elaborating the spinning plans for each mixture, based on the preparation system applied and on the determination of the other data required for computation, the following results were obtained:

Table 1

Costs expressed in lei for one kg yarn

Preparation line	Mixture			
	A	*B*	*C*	*D*
1	150	355	331	249
2	—	358	335	253
3	—	360	—	255

Table 2

Preparation time for one kg yarn
(in tens of thousands minutes)

Preparation line	Mixture			
	A	*B*	*C*	*D*
1	4.50	5.00	4.75	4.85
2	—	5.00	4.75	4.85
3	—	17.00	—	16.49

Limiting capacities of the lines
(monthly available minutes)

Preparation line Type 1	216,000
Preparation line Type 2	252,000
Preparation line Type 3	396,000

Table 3

Monthly demand of yarn in kg

	Yarn *Nm* 54/2 70 per cent PE + 30 per staple rayon	Yarn *Nm* 54/2 100 per cent wool 70 S	Yarn *Nm* 60/2 45 per cent wool S 11 + 55 per cent PE	Yarn *Nm* 45/2 70 per cent wool 70 S + 30 per cent staple rayon
Total kg/month	10,200	40,500	27,100	39,200

The knowledge of production distribution in the various preparation lines is necessary, bearing in mind the quantities of yarn required, so as to minimize the economic function "total production costs", provided that the production costs of some preparation lines change linearly and independently as compared to those of other lines.

Hence, the problem is to successively parametrize production costs for each preparation line, in order to be able to substantiate the decisions regarding production distribution in each preparation line.

The solution of this problem was effected through the following three models:

Model 1

$$
\begin{aligned}
4{,}50x_{11} + 5{,}00x_{12} + 4{,}75x_{13} + 4{,}85x_{14} &\leqslant 216{,}000 \\
5{,}00x_{22} + 4{,}75x_{23} + 4{,}85x_{24} &\leqslant 252{,}000 \\
17{,}00x_{42} + 16{,}49x_{34} &\leqslant 396{,}000 \\
x_{11} &= 10{,}200 \\
x_{12} + x_{22} + x_{32} &= 40{,}500 \\
x_{13} + x_{23} &= 27{,}100 \\
x_{14} + x_{24} + x_{34} &= 39{,}200
\end{aligned}
$$

$$min\ Z_1 = 150\ (1+\lambda)x_{11} + [355(1+\lambda)x_{12} + 358x_{22} + 360x_{32}] +$$
$$+ [331(1+\lambda)x_{13} + 335x_{23}] + [249(1+\lambda)x_{14} + 253x_{24} + 255x_{34}].$$

Models 2 and 3 differ from model 1 only in the way of parametrizing the function objective. We have:

Model 2

$$min\ Z_2 = 150x_{11} + [355x_{12} + 358(1+\lambda)x_{22} + 360x_{32}] +$$
$$+ [331x_{13} + 335\ (1+\lambda)x_{23}] + [249x_{14} + 253(1+\lambda)x_{24} + 255x_{34}].$$

Model 3

$$min\ Z_3 = 150\ x_{11} + [355x_{12} + 358x_{22} + 360(1+\lambda)x_{32}] + [331x_{13} + 335x_{23}] +$$
$$+ [249x_{14} + 253x_{24} + 255(1+\lambda)x_{34}].$$

Each of the three above mentioned models parametrize the costs of the preparation lines Types 1, 2 and 3.

Computation was carried out by means of the electronic computer ECONOMIST CIFA 102, and the results obtained are systematically arranged in Tables 4 and 5.

Table 4

Solution \ λ	—1	0	1
Model 1	$x_{11} = 10{,}200$ $x_{12} = 34{,}020$ $x_{13} = 0$ $x_{14} = 0$ $x_{22} = 0$ $x_{23} = 27{,}100$ $x_{24} = 25{,}417.52$ $x_{32} = 6{,}480$ $x_{34} = 13{,}782.47$	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 27{,}100$ $x_{14} = 8{,}530.925$ $x_{22} = 20{,}651$ $x_{23} = 0$ $x_{24} = 30{,}669.07$ $x_{32} = 19{,}849$ $x_{34} = 0$	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 0$ $x_{14} = 31{,}520.5$ $x_{22} = 17{,}205.88$ $x_{23} = 27{,}100$ $x_{24} = 7{,}679.494$ $x_{32} = 32{,}294.11$ $x_{34} = 0$
Model 2	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 16{,}678.94$ $x_{14} = 18{,}737.11$ $x_{22} = 40{,}500$ $x_{23} = 10{,}421.05$ $x_{24} = 0$ $x_{32} = 0$ $x_{34} = 20{,}462.88$	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 27{,}100$ $x_{14} = 8{,}530.925$ $x_{22} = 20{,}651$ $x_{23} = 0$ $x_{24} = 30{,}669.07$ $x_{32} = 19{,}848$ $x_{34} = 0$	$x_{11} = 10{,}200$ $x_{12} = 17{,}205.89$ $x_{13} = 17{,}699.06$ $x_{14} = 0$ $x_{22} = 0$ $x_{23} = 9{,}400.938$ $x_{24} = 39{,}200$ $x_{32} = 23{,}294.11$ $x_{34} = 0$
Model 3	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 27{,}100$ $x_{14} = 8{,}530.927$ $x_{22} = 17{,}205.88$ $x_{23} = 0$ $x_{24} = 30{,}669.07$ $x_{32} = 23{,}294.11$ $x_{34} = 0$	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 27{,}100$ $x_{14} = 8{,}530.925$ $x_{22} = 20{,}651$ $x_{23} = 0$ $x_{24} = 30{,}669.07$ $x_{32} = 19{,}849$ $x_{34} = 0$	$x_{11} = 10{,}200$ $x_{12} = 0$ $x_{13} = 27{,}100$ $x_{14} = 8{,}530.926$ $x_{22} = 40{,}500$ $x_{23} = 0$ $x_{24} = 10{,}206.18$ $x_{32} = 0$ $x_{34} = 20{,}462.88$

Table 5

minimum \ λ	—1	0	1
Z_1	21,356.460	34,922,270	44,324,210
Z_2	16,934.300	34,922,270	48,016,180
Z_3	26,543.280	34,922,270	40,141,530

In figure 1 are shown the plots of the functions Z_1, Z_2 and Z_3 for $\lambda = -1$; 0; 1, assuming that in the ranges (—1, 0) and (0, 1) these functions assume no critical values.

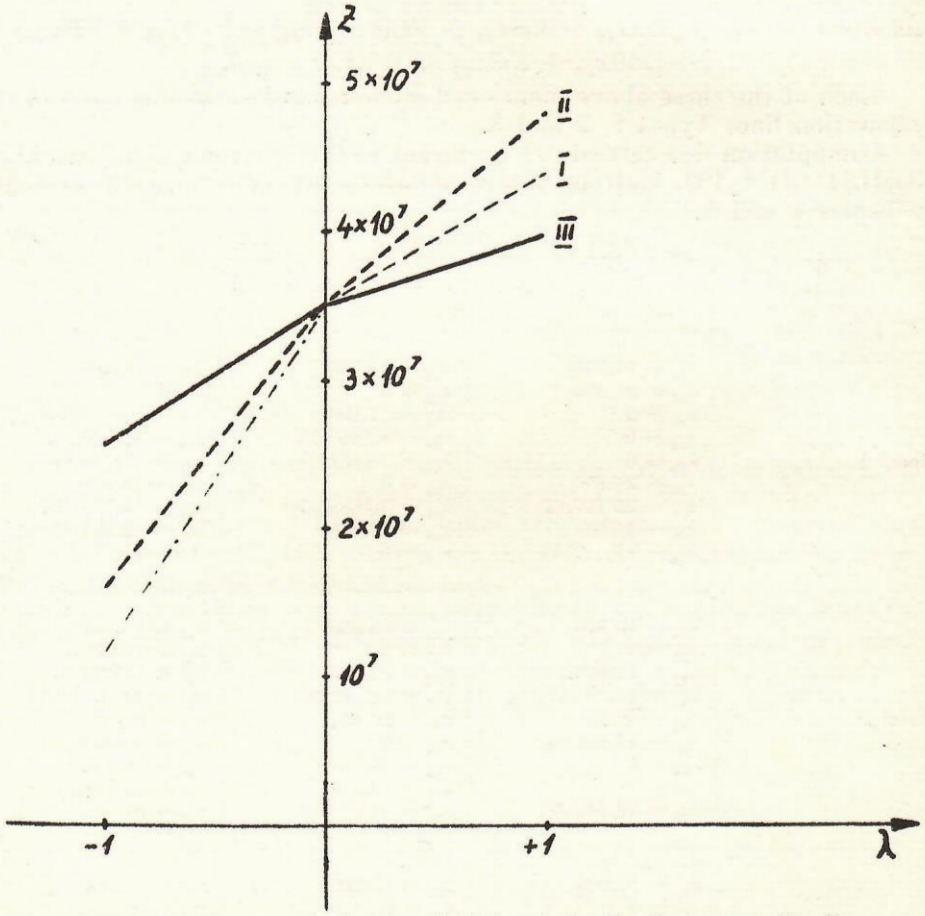

Fig. 1 Variation of the economic function of total costs for the three preparation lines.

The graphs representing the variation of the functions Z_1 (λ), Z_2 (λ), and Z_3(λ) provide the management with a rapid guide in the policy to be assumed any time, towards each type of manufacturing line, in view of the accomplishment of the target set.

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APPLICATION DE LA PROGRAMMATION LINEAIRE PARAMETRIQUE A L'OPTIMISATION DE LA PRODUCTION DANS UNE FILATURE DE LAINE PEIGNEE

L'analyse de la répartition des mélanges par qualités, dans les filatures de laine peignée est un problème ayant d'importantes applications pratiques et une grande portée économique.

La modernisation des lignes de préparation des filatures de laine peignée, ainsi que l'agrandissement continuel de la gamme des fibres synthétiques, ont mené à l'existence d'un grand nombre de systèmes de préparation dans ces filatures et à l'élaboration de nombreux mélanges.

L'article démontre que l'établissment des mélanges par qualités, par rapport aux conditions techniques et à la rentabilité de chaque qualité, séparément, impose une analyse technologique, de même que l'utilisation des méthodes de l'optimisation dans la planification de la production.

La solution du problème — c'est-à-dire la minimisation de la fonction économique — prix de revient total de la production, est représentée par la paramétrisation successive des coûts de production de chaque ligne de préparation, ayant pour but de fonder les décisions concernant la répartition de la production entre chaque ligne de préparation.

Les calculs ont été effectués à l'aide de l'ordinateur économique du type «Economist CIFA 102». Le modèle mathématique élaboré peut être appliqué dans les filatures de laine peignée.

ИСПОЛЬЗОВАНИЕ ПАРАМЕТРИЧЕСКОГО ЛИНЕЙНОГО ПРОГРАММИРОВАНИЯ ДЛЯ ОПТИМИЗАЦИИ ПРОИЗВОДСТВА НА КОМВОЛЬНЫХ ПРЯДИЛЬНЫХ ФАБРИКАХ

Анализ распределения смесей по сортам на комвольных прядильных фабриках представляет задачу с практическим применением и значительным экономическим эффектом.

Модернизация производственных потоков на комвольных прядильных фабриках, а также постоянное расширение гаммы синтетической пряжи привели к наличию большого числа производственных систем на этих прядильных фабриках и к обработке большого числа смесей.

В работе показано, что установление смесей по сортам, в зависимости от технических условий и рентабельности каждого сорта в отдельности, требует как технологического анализа, так и использования методов оптимизации в планировании производства.

Решение задачи — минимизация экономической функции — общая цена производства состоит в постепенной параметризации цен производства каждой производственной линии с целью обоснования решений о распределении производства по каждой производственной линии.

Расчеты были сделаны на экономической вычислительной машине Economist CIFA 102 и эта математическая модель может быть эффективно использована на комвольных прядильных комбинатах.