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Optimal Planning of Main Petroleum—Product Transportation

More than 2,3 thousand milion tons of petroleum, are consumed yearly, all over the world, in the most cases for the driving of transport means.

Let us not forget, that this huge quantity, before beeing used for transport, needs itself to be transported.

The liquid petroleum-product volume, which was planned to be conveyed by railroad in 1970, amounts to about 13 million tons, for which railroad-transportation costs of over 825 million lei were planned.

The problem of supplying petroleum products with minimal transportation costs represented a permanent concern of the experts of the Petroleum Ministry and of the Central for Conditioning, Delivery and Transportation of Petroleum Products. Nevertheless, as a result of the lack of modern computation means, methods with approximate solutions were used for planning transports.

Beginning with the year 1970, the optimization of the main petroleum-product transportation plans, laid out by year, quarters and months, is carried out by means of electronic computers, as a result of the co-operation between the experts of the Centre of Economic Computation and Economic Cybernetics in the Academy of Economic Studies, and the experts of the Central for Conditioning, Delivery and Transportation of Petroleum Products.

From a range of over hundred products, in a first run, the following petroleum products were selected, which represent about 48% of the total volume of the products range:

Motor gasoline CO75
Motor gasoline CO90
Kerosene
Regular-grade gas-oil

Mazout
Type A petroleum fuel oil

The criteria which lay at the basis of the selection of these products were as follows: the high quantitative weight, as against the total of products to be conveyed, the spreading level of consumers throughout the country, the high volume of the rolling stock, necessary to convey these products, and the high economic efficiency assured by the transportation optimization in this case, as a result of the existence of several dispatching bases (refineries) and a very high number of consumers.

1. TRANSPORTATION MODEL

In order to draw up optimal supply plans, the classical transportation model was selected, where the economic function is not represented by the total transportation cost, but by the product of quantity and distance; distance was preferred instead of transportation unit cost, on the one hand, due to the direct-proportionality relation between them, and, on the other hand, due to the simplifying of solving the problem.

The transportation model, in the present case, is tridimensional. According to [2], we have to solve a T-2A-ab-type biaxial transportation problem; this solving is carried out by decomposing problem T-2A-ab in usual bidimensional transportation problems.

We shall denote, in the following relations, the specified products by $P_k(k = 1, ..., p)$, the dispatching centres (refineries) by $R_i(i = 1, ..., m)$ and the beneficiaries by $B_j(j = 1, ..., n)$.

We shall use following notations:

a_{ik} — quantity, in tons, of product P_k, available in refinery R_i
b_{jk} — quantity of product P_k, needed by beneficiary B_j
d_{ij} — distance, in km, between refinery R_i and beneficiary B_j
x_{ijk} — quantity of product P_k, transported from refinery R_i to beneficiary B_j

Between the quantities available in the refineries and the quantities needed by beneficiaries, there exists the relation:

$$\sum_{i=1}^{m} a_{ik} = \sum_{j=1}^{n} b_{jk} = c_k \qquad (k = 1, ..., p)$$

The problem requires to determine quantities $x_{ijk}(i = 1, ..., m; j = 1, ..., n$ $k = 1, ..., p)$ such as

$$\sum_{j=1}^{n} x_{ijk} = a_{ik}$$

$$\sum_{i=1}^{m} x_{ijk} = b_{jk}$$

$$x_{ijk} \geqslant 0$$

minimizing the functions:

$$F_k = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{ij} x_{ijk} \qquad (k = k, \ldots, p)$$

The problem is schematically presented in table I.

Table I

	B_1		B_2		.....	B_n		Available
R_1	x_{111} x_{112} ⋮ x_{11p}	d_{11}	x_{121} x_{122} ⋮ x_{12p}	d_{12}	....	x_{1n1} x_{1n1} ⋮ x_{1np}	d_{1n}	a_{11} a_{12} ⋮ a_{1p}
R_2	x_{211} x_{212} ⋮ x_{21p}	d_{21}	x_{221} x_{222} ⋮ x_{22p}	d_{22}	....	x_{2n1} x_{2n2} ⋮ x_{2np}	d_{2n}	a_{21} a_{22} ⋮ a_{2p}
. . .	. . .		. . .		....	. . .		. . .
R_m	x_{m11} x_{m12} ⋮ x_{m1p}	d_{m1}	x_{m21} x_{m22} ⋮ x_{m2p}	d_{m2}	....	x_{mn1} x_{mn2} ⋮ x_{mnp}	d_{mn}	a_{m1} a_{m2} ⋮ a_{mp}
NEEDS	b_{11} b_{12} ⋮ b_{1p}		b_{21} b_{22} ⋮ b_{2p}		....	b_{n1} b_{n2} ⋮ b_{np}		c_1 c_2 ⋮ c_p

2. MODEL OF THE OPERATIVE TRANSPORTATION PLAN

In order to operatively utilize quantities x_{ijk}, determined by the condition of transportation-cost optimization, *operative transportation plans* must be laid out, for each refinery. These include various information, needed by those who use them, e.g.:

Information on the supplying refinery

— Denomination,
— Dispatcher's code,
— Dispatch-station code,
— Central higher body,
— Transfer-account number,

— District,
— District's code.

Information on the beneficiary

— Denomination,
— Beneficiary's code,
— Receiving station,
— Receiving-station code,
— Distance from the supplying refinery.

Information on the conveyed products

— Products denomination,
— Subgroups, assortments and tariff item,
— Traffic,
— Transported quantity, tons and mean waggon-weight units (20 tons. for a mean railway waggon),
— Type of waggon used for transport.

The operative transportation plans are drawn up for each refinery; hence, the optimal solutions, determined by solving the transportation model, are sorted on each refinery and— together with the above described information — make up the operative plan, printed according to the needs, both of the Transport Ministry, and of the refineries and enterprises belonging to the Central for Conditioning, Delivery and Transportation of Petroleum Products.

The operative transportation plans make up, hence, a reprocessing of the transportation-model optimal solutions, with a view to operatively using them, without manual interventions and systematization.

The optimum carried out by means of the two models is an optimum related to the petroleum-product transportation for the whole national economy.

3. INFORMATION ORGANIZATION AND PROCESSING-PROGRAM DESCRIPTION

The system of transportation-optimizing programs (SPOT), drawn up by the Centre of Computation of the Economic Cybernetic Department, has as main functions the solving of the transportation-optimizing problem, as presented in the previous paragraph, and the drawing up of operative transportation programs. The large majority of the information processed by the computer has a permanent character, and does not depend on the month in which processing is carried out. This information is organized under the form of files with permanent data, recorded on magnetic disks.

The permanent files, within which data are organized, are as follows:

— *Dispatchers file*, comprising the (previously exposed) main information for identifying and recording, necessary to the drawing up of operative plans;

— *Beneficiaries file*, comprising complete identifying and recording information on beneficiaries (code, denomination, receving station, a.s.o.);

— *Products file,* which comprises information on the conveyed products;
— *Receiving station file,* comprising distances from each refinery to each receiving station.

The permanent files are used for each processing; they are also updated, as often as some information is added or modified.

The only information requested by the programs for each processing regards the quantities available into the refineries (a_{ik}), accompanied by the refinery's code and the quantities needed by beneficiaries (b_{jk}), as well as the beneficiaries codes.

The tridimensional transportation problem, presented in the previous paragraph, consists in consecutively solving p bidimensional transportation problems (one problem for each product). This solving is carried out by one of the system SPOT programs — the OPTRA program — of optimization of transports, which lays down results in a temporary working area on the disk (provisional file for optimal solutions). The solving of the p transportation problems is done by the [1] potential method.

The necessary data for solving these problems are taken over by the OPTRA program, from another working area in the disk (provisional file for available amounts and provisional file for necessary amounts), where they were laid down by another program of the system, IVETRA — initial-data automatic verifying program — as a result of some correctness verifications and transforming of units of measure.

The existence of the IVETRA program is fully justified in processing high volumes of data, as in the present case, in which any error in data transmitted to the computer can have negative consequences. This program verifies the correctness of the beneficiary and refinery codes, signals the appearance of new beneficiaries and refineries, verifies every amount of petroleum products, if it is a multiple of the conveying-waggon capacity, transforms in tons the quantities in the waggons, and verifies the correspondence between available and necessary quantities. Transforming of the units of measure, concerning the quantities, is effected in order to avoid fractions of waggons in the optimal solution, a fact which reduces their optimization.

The optimal solutions, computed by the OPTRA program, are taken over from the disk by the editing program of the operative transportation plans — PLOP — which, with their help and by means of the data in the permanent files, draws up and prints the monthly, quarterly or yearly transportation plans, according to the user's option.

Besides the three programs, briefly described above — IVETRA, OPTRA and PLOP — the SPOT programming system includes also programs for updating and editing permanent files.

4. ADVANTAGES OF DRAWING UP THE OPTIMAL PLAN WITH THE HELP OF THE ELECTRONIC COMPUTER

An accurate estimation of the savings, achieved in the railway transportation of the main liquid petroleum products, is difficult to carry out, due, on the one hand, to the high volume of necessary processings (it would be necessary to recalculate the supplying plans — with the help of the computer — for the year in which these plans were carried out by means of traditional

methods), and of their cost, and, on the other hand, due to other advantages, more difficult to estimate in values, derived from the applying of the optimizing method, which have as a result that the increased economic efficiency is found again in all economic and industrial fields, which are consuming petroleum products. Besides them, the very conditions of the problems changed as against the previous years (e. g., new refineries appeared, the beneficiaries number increased, a.s.o.).

Taking as a reference point the month of February 1970, when all supplying plans were computed both manually and by electronic computers, the savings in the year 1970 amount to the sum of 6.3 million lei. In the mean time, the transportation optimization leads to a diminishing of the mean transportation distance of every routing by about 5 km, which is equivalent to important availabilities of rolling stock, if we consider a number of over 2500 beneficiaries.

Another important advantage is represented by the reducing of a significant labour amount, both in the field of collecting, recording, checking and transmitting primary data in the information circuit, and the drawing-up proper of the plans. Keeping permanently a high amount of data in the external stores of the computer leads to the reduction of an important volume of transcriptions of beneficiary denominations, railway stations, a.s.o. With a view to reducing even more the manual-recording volume of primary data and their transmission, a very simple standard printed form was designed and worked out, in which the enterprises which deliver petroleum products fill in only the beneficiary codes and the requested amounts; this form is also adapted to the conditions of automatic data processing.

The substantial reduction of manual data recording and processing leads unavoidably to a considerable reduction of recording errors and to the quality increase of the drawing-up plans, respectively.

Another big advantage is represented by the fact that the operative transportation plans , edited by the computer, make up the final documents which do not require any manual intervention, as they are transmitted, under the form obtained from the computer, directly to the enterprises of the Central for Conditioning, Delivery and Transportation of Petroleum Products, and to the Romanian Railways.

In this way, the system of drawing-up optimal supplying plans has a high operativity and involves a minimal number of persons for its execution.

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At present, the system of drawing up optimal supplying plans — an outcome of the profitable co-operation between the experts of the Central for Conditioning, Delivery and Transportation of Petroleum Products and those of the Computation of the Economic-Cybernetics Department, is to be extended also for other petroleum products, and thus are valuably contributing to the achieving of a high economic efficiency.

REFERENCES

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LA PLANIFICATION OPTIME DES TRANSPORTS DES PRINCIPAUX PRODUITS PETROLIERS

Le volume total des produits pétroliers transporté au cours de 1970 par chemins de fer, a nécessité à-peu-près 825 milions de lei, frais de transport. Le problème de la réduction au minimum de ces frais a constitué l'objet d'une collaboration entre les spécialistes du Centre de calcul économique et cybernétique économique et ceux de la Centrale pour le conditionnement, la livraison et le transport des produits pétroliers.

Cette collaboration a eu pour résultat l'élaboration et l'application d'un système de programmes pour l'optimisation mensuelle, trimestrielle et annuelle des transports des produits pétroliers par voies ferrées, ainsi que pour l'élaboration des plans opératifs.

L'article décrit le modèle utilisé, le système de programmes appliqué, ainsi que les avantages de l'utilisation de ce système.

ОПТИМАЛЬНОЕ ПЛАНИРОВАНИЕ ПЕРЕВОЗОК ВАЖНЕЙШИХ НЕФТЕПРОДУКТОВ

В 1970 г. общий объем нефтепродуктов, перевозимых по железной дороге, потребовал транспортных расходов примерно в 825 млн. лей. Вопрос максимального снижения этих расходов явился предметом сотрудничества специалистов Центра экономического расчета и экономической кибернетики со специалистами Центрального управления кондиционирования, поставки и перевозки нефтепродуктов.

В результате этого сотрудничества была разработана и внедрена система программ месячной, квартальной и годовой оптимизации железнодорожных перевозок нефтепродуктов и разработки оперативных планов перевозок.

В статье описываются примененная модель, внедренная система программ, а также преимущества применения этой системы.