PRACE NAUKOWE AKADEMII EKONOMICZNEJ WE WROCŁAWIU
Nr 1057 — 2005
Integracja procesów logistycznych

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ALGORITHM FOR OPTIMALIZATION OF LOADING GOODS ON THE VEHICLES

Authors of the paper are engaged in solving of problems with reference to optimalization of loading goods to the loading space of various vehicles. From methodical standpoint they can be solved as so called Cutting Stock Problems, which include bigger group of NP-hard problems. Review and classification of mentioned problems is possible to find for example in study Dyckhoff [1].

Approach to solution known up to now is possible to draw up in following way:

- Solution by linear programming suggested for example by Bannyj and Bannyj [2].
- Algorithms based on branch-and-bound method suggested by Christofides and Whitlock [3].
- Use of dynamic programming suggested by Gilmor and Gomory [4].
- Algorithm, suggested by Wang [5], outgoing form analysis of all possible combination.
- Application of intelligent search methodology suggested by Viswanathan and Bagchi [6].
- Application of genetic algorithms which are suggested for ex. Parada et al. [7].

1. Definition of the concrete type of the problem from practice

There were determined the bounds of the solution on the base of solving specific problem by following assumptions:

- Goods are loaded on palettes of various sizes.
- To each kind of goods correspond one dimensional type of palette.
- It's possible to put one or more pieces of the same goods on the one palette.
- It's possible to stack palettes if it can be put on a palette only one piece of good.

Information about number and kind of goods, which will be transport are input data for solving. For each kind of goods is defined:

- Size of palette corresponding to respective kind of goods.
- Number of pieces of the kind of goods it can be put on the one palette.
- Number of pieces of palette of the kind of goods, which a stack can be made from (it is given by the height of s loading space).
- Constraints referring to stacking of various dimensional types of palettes simultaneously.

Next it is known ground plan of loading space of the vehicle.

Target of solving of this problem is creating of an algorithm and its following transformation to a software tool form, which will optimalize allocation of palettes in the loading space of a vehicle so as the utilisation of the loading space was maximalized.

2. Solving algorithm

Algorithm proposed by author that enables achievement of the target can be summarized into following points:

1. Storage of goods on palettes

Storage of goods on pallets include dividing of the individual pieces of goods, which should be transported, on palettes according to maximum number of pieces that can be put on the palette.

It can be identified two groups of the goods from that point of view. The first group include goods where only one piece can be put on the palette. The second group include such goods where more than one piece can be put on the palette. In the first case number of pieces of goods is identical to the number of pieces of palettes, which will be loading next. In the second case number of palette is given by maximum number of pieces of goods that can be put on the palette. In association, the minimum number of pieces of goods, which have sense to storage on the palettes, is defined at this group. If number of pieces of goods on the palette decrease under the limit, storage on the palette will not be done. This goods is not reflected in next optimalization.

Output of storage of goods on palettes is total number of palettes for each of types of palette, which will be next loaded to the loading space.

2. Stacking

Stacking contains dividing palettes with goods to stacks according to maximum number of palettes, which can be, for given of type of palette, placed to the stack. Stacking is performed only in case of goods where it can be put only one piece.

In the first phase full stacks are created, i.e. stacks created from one type of palettes into the maximum possible height. In the second phase stacks from remaining, still not placed palettes are created (combined stacks). From available combinations are selected these, which minimalize resulting number of stacks and their ground area, of course at respecting of all constraints referring stacking of individual types of palettes.

Creating of combined stacks is possible to consider for the optimalization problem, which correspond to one-dimensional cutting stock problem. Authors solve this problem by means of linear programming. For creating of such model is necessary to generate comprehensive set of possible variants of combined stacks.

Output of stacking is total number of stacks (both full and combined) and their ground areas determined to the loading.

3. Layouting of palettes and stacks

Last step of that algorithm is layouting of palettes and stacks (that were obtained by application of the previous steps) to the loading space of the vehicle in order to its utilization was maximalized.

That optimalization problem correspond to two-dimensional cutting stock problem. Authors solve this problem by means of linear programming again. As in the previous case, creating of this mathematical model requires generation of comprehensive set of possible variant of layouting of palettes and stacks in loading space of vehicle. In view of huge number of available variants, their generating was reduced by prerequisite of sequential loading of individual palettes and stacks to the loading space in blocks („in rows"), which include one palette or stack or combination of two and three palettes and stacks together.

Individual variants of blocks and number of their usage that guarantee adequate (sub optimal) solution are output of solving of that problem.

3. Process of creation, verification and realization of the algorithm

The impulse for the definition of the problem and following creation of the algorithm for its solving was the particular problem from the practice, which involves four assortment groups of goods appointed to transport:

1. 99 kinds of goods, which is put on 16 dimensional types of palettes – there is a possibility to place more number of peaces of goods on palettes.

2. 99 kinds of goods, which is put on 11 dimensional types of palettes – only one piece of goods can be placed on the palettes and there is a possibility to perform their consequential stacking.

3. 28 kinds of goods, which is put on 5 dimensional types of palettes – there is a possibility to place more number of peaces of goods on palettes in case of 8 kinds of goods; only one piece of goods can be placed on palettes in case of the other kinds of goods but with the possibility of their stacking.

4. 50 kinds of goods, which is put on 7 dimensional types of palettes – there is a possibility to place more number of peaces of goods on palettes.

So, there are 276 kinds of goods appointed for transport in total, which are put on 39 dimensional types of palettes.

In view of extent of the problem it was simplified version comprising two groups of goods formulated for finding and verification of suitable algorithm:

1. 17 kinds of goods, which is put on 6 dimensional types of palettes – there is a possibility to place more number of peaces of goods on palettes.

2. 9 kinds of goods, which is put on 3 dimensional types of palettes – only one piece of goods can be placed on the palettes and there is a possibility to perform their consequential stacking.

There are 26 kinds of goods appointed for transport in total, which are put on 9 dimensional types of palettes.

For practical realization of the designed algorithm, thanks to his availability and universality, the spreadsheet MS EXCEL was applied. The solution of both optimization problems is performed by means of „Solver" tool.

4. Present state of implementation, methodological problems and possibilities of their solving

In present time there was a full functional application in spreadsheet MS EXCEL created, which is able to solve a simplified version of the problem successfully. That application requires just placing of number of individual kinds of goods, which is appointed for transport and running of „Solver" tool for the both optimalization problems.

Concurrently, the application, which is able to solve the initial real problem in full extent, is created.

On basis of existing experience with creation of said applications there is a possibility to identify the main methodological problems connected with implementation of the created algorithm and to define possibilities of their solving.

Particularly, generation of comprehensive set of possible variant of blocks of palettes and stacks and enormous accrual of number of variables in mathematical model for optimalization of layouting of palettes and stacks in loading space of vehicle in dependent on increase of number of dimensional types of palettes are problematic.

In present time the first problem is solved by creation of the additional application in MS EXCEL, which is used as base for creation of the mathematical model.

In the second case, however, at creation of mathematical model for initial real problem the increase of number of variables was so great that the possibilities of spreadsheet MS EXCEL was exceeded. Mentioned problem can be solved with using:

- Specialized software for the linear programming,
- Enlarged version of „Solver" tool made by Microsoft Company,
- Other approaches then linear programming.

Currently the effort is concentrated on two last possibilities. On the one hand there was bought Premium Solver Platform, which include enlarged version of „Solver" tool. On the other hand verification of possibilities for using of genetic algorithm for solving of mentioned optimalization problem is running.

References

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ALGORYTM OPTYMALIZACYJNY SŁUŻĄCY DO ROZMIESZCZENIA ŁADUNKU W SAMOCHODACH TRANSPORTOWYCH

Streszczenie

Autorzy artykułu pracują nad rozwiązywaniem problemów optymalizacji rozmieszczenia transportowanych dóbr w przestrzeni ładunkowej różnych pojazdów. Celem prac jest stworzenie algorytmu optymalizacyjnego i jego implementacja jako programu komputerowego służącego do optymalizacji problemu rozmieszczenia palet na ograniczonej przestrzeni ładunkowej samochodu tak, aby przestrzeń ta została maksymalnie wykorzystana. Algorytm zaproponowany przez autorów umożliwiający osiągnięcie wytyczonych celów można w skrócie ująć w następujących punktach: ustawienie towaru na paletach, układanie palet w stogi, rozmieszczenie i układ całego ładunku. Autorzy rozwiązują problem za pomocą programowania liniowego. W artykule zaprezentowany został również sposób tworzenia, weryfikacji oraz aktualny stan wdrożenia algorytmu. Wskazane zostały także problemy metodologiczne oraz możliwe sposoby ich rozwiązania.