J. Opl Res. Soc. Vol. 39, No. 1, pp. 109–113, 1988
Printed in Great Britain.
0160-5682/88 $3.00 + 0.00

Letters and Viewpoints

(Contributions to this section are invited but we reserve the right to edit at our discretion—Ed.)

PROGRAMMING IN TRANSFORMER DESIGN

A recent paper by Moores[1] proposes a dynamic programming (DP) approach to solving an interesting problem of transformer design. The author stresses the fact that DP is rarely a useful way of solving problems, but in this case it was. The author describes the solution procedure as of a non-combinatorial nature.

In essence the problem seems to me a combinatorial one with an optimum required. Integer programming (IP) is frequently slighted as being appropriate for formulating problems but not for solving them. It appears that this application might equally well have been tackled using IP, and the author could then have claimed to have found a practical use for IP.

The problem may be summarized as follows. Strips of steel of any of 14 widths between 10 and 140 cm (in 10 cm steps) have to be used to pack a semicircular section of a transformer of diameter 150 cm. The strips are 1 mm thick, and a typical solution might be to use 45 cm of 120 cm width followed by 10.9 cm of 100 cm width, which would pack 73% of the total area. In practice there is a restriction that at most five different widths can be used. An IP formulation would be the following:

$$\sum_{i=k}^{14} x_i \leqslant u_{k+1} + \delta_k(u_k - u_{k+1}) \quad (k = 1, \ldots, 13)$$

$$\sum_{i=1}^{14} \delta_i \leqslant 5$$

$$x_i \leqslant u_i\delta_i \quad (i = 1, \ldots, 14)$$

$$\text{maximize} \quad \sum_{i=1}^{14} ix_i,$$

where $\delta_i = 1$ if a strip of width $10i$ cm is used, 0 otherwise $(i = 1, \ldots, 14)$, x_i = quantity of strip of width $10i$ cm used $(i = 1, \ldots. 14)$, and $u_1, \ldots, u_{14}$ are, respectively, 74.8, 74.3, 73.4, 72.2, 70.7, 68.7, 66.3, 63.4, 60.0, 55.9, 50.9, 45.0, 27.9, 26.9 cm. (Note that u_7 is corrected from the original paper.)

The problem contains 28 variables, of which 14 are binary, and is thus fairly small. At the solution stage, standard IP software can be used to progress rapidly to a solution. From the continuous optimum, a sequence of integer solutions is generated until the optimum of $x_5 = 7.3$, $x_8 = 7.5$, $x_{10} = 10.9$, $x_{12} = 18.1$, $x_{14} = 26.9$ for the widths is obtained.

A variety of easy-to-use IP software is now available for microcomputers, e.g. LINDO.[2] Formulating the problem as an IP has the advantage that standard software can be used and there is no need for a program to be written. The model can be altered readily to accommodate changes in size specifications or to introduce further limitations, and so the IP approach appears to offer some advantages.

Department of Management Studies
Loughborough University
J. M. WILSON

REPLY

They do say that there is more than one way of skinning a cat, and I am delighted that Wilson has been able to formulate the transformer design problem in integer linear-programming terms. Doubtless, another practitioner would plump for a graph-theoretic-based approach. I should perhaps stress that the paper was not intended to be interpreted as a theoretical development, but