Production Planning

Chairman: Mr W. S. GALLAGHER

Rapporteur: Professor A. M. STARFIELD

Papers:

Long-term mine production scheduling by G. C. S. Burne

An application of linear programming to investment analysis by A. Erlandsson

Optimizing medium-term operational plans for a group of copper mines by M. Splaine, D. C. Atkinson, W. Davison and L. Smith

The simulation of underground stoping and transport operations in gold mining by F. H. Touwen and N. C. Joughin

Production planning is a subject that lies at the interface between the computing centre and mine management. Discussion during this session was thus largely concerned, directly or indirectly, with communication between computing and mining personnel, and as such was relevant to the symposium as a whole.

Mr A. Weiss set the tone of this discussion by referring to 'user-orientated systems'. He congratulated Mr Burne in this regard, pointing out that his long-term production scheduling program, as a computer system, was similar in approach to the manual system it replaced, and was therefore easily understood by planning engineers. He asked whether the schedule engineer had his 'hands on' the system, to which Mr Burne replied that the engineer did in fact spend several days running alternative schemes through the computer. Mr Weiss commented on the advantage of having terminals on site for this sort of engineer-computer interaction. He also commented on the flexibility of Mr Burne's approach to scheduling and how preferable this was to a one-step optimization package. This was brought home by a question from Mr H. D. Small: Mr Burne's program sometimes found it necessary to temporarily halt an advancing face, and he asked whether the logic of the program could be altered to avoid this (e.g. by suitably slowing down the rate of face advance). Mr Burne replied that it was in fact easier for the planning engineer to sort this problem out manually. The way in which the computer results were presented made it particularly simple for the production engineer to see how to avoid or remedy a stopped face.

On the technical side, both Mr Weiss and Mr H. M. Wells questioned Mr Burne on the handling of grade control by his program. From answers by Mr Burne and his colleague Mr K. H. Thomson it emerged that a spot-check on grade every now and then was all that was necessary at Mufulira, and that the idea of actual grade *control* was more a question of short-term than of long-term planning.

User-orientation came up again in the presentation of the paper by Touwen and Joughin. Mr Touwen pointed out that his simulation program was designed specifically for mining personnel, with output in practical mining terms that 'could hardly be understood by computer men'. It was evident from the discussion that mining personnel were using the simulation program extensively, and as a result had further practical modifications to suggest. Thus Mr D. Saunderson suggested that the 'equipment failure' subroutine be modified to distinguish between minor and major failures, and Mr J. W. Wilson and Mr V. O. Steed both suggested extensions to the program which would enable it to simulate more general conditions.

Mr Wilson listed a few of the ways in which Touwen's simulation program was being used:

(i) to look at scraper sizes in relation to production and the proximity of support at the stope face;

(ii) to look at the implications of introducing new equipment (such as stope drilling rigs) underground; and

(iii) to investigate ways of maintaining production if a switch is made from a six- to a five-day working week.

Mr Steed described a successful application of Touwen's transport simulator. Seventeen locomotives and 131 six-ton hoppers had been in use on a certain level. Simulation studies showed that a 14 per cent increase in output could be expected if two locomotives were to be removed and if the hoppers per span were increased. Two locomotives and six hoppers were actually removed from the level, with a resulting 16 per cent increase in the number of hoppers tipped per day and an estimated capital saving of R23 000. Use of the transport simulator had convinced him of the need to collect more data and had indicated what sort of data (e.g. times spent waiting for blocked loading chutes to clear) to collect. He had also developed a way of presenting computer results in the form of nomographs which enabled one to establish quickly whether certain combinations of train loading and emptying times were feasible.

That 'user-orientation' is not the responsibility of the computer man alone was brought out by Dr K. Lieberknecht's description of how Mr Touwen's program had originally given poor answers at Stilfontein. Parameters had subsequently been adjusted in the light of mining experience and the simulator was now being used successfully.

Two other main points in the discussion were the relative advantages and disadvantages of simulation and linear programming, and the trade-off between sophistication and simplicity in the use of more complex optimization techniques. Prof E. P. Pfleider indicated that, in his experience, simulation nearly always proved to be a more flexible and useful approach than linear programming or optimization. He asked Mr A. Erlandsson whether simulation would not have been preferable to linear programming in his paper on investment analysis. It emerged from Mr Erlandsson's reply and further comments by Prof A. M. Starfield and Mr P. C. Pirow that the strength of Mr Erlandsson's paper lay in the way in which he had used

linear programming as a subroutine in an approach that was essentially one of simulation. He had in fact taken a classical linear programming problem in ore transportation and added to it a step-wise program to simulate different investment strategies. Mr Pirow mentioned some straightforward and successful applications of linear programming to transport problems from the point of breaking to the mill, allocation problems to mills and reduction works, and problems involving the strategy to be followed in determining which tonnages to mine from which areas. He emphasized the difficulty of finding, in practice, the facts for the linear programming model.

Mr A. H. Munro, with reference to the paper by Touwen and Joughin, mentioned that his experience of simulation included both successes and disasters, and that care had to be taken in the choice of simulation applications. Both he and Mr J. W. Wilson questioned the use of simulation where performance was strongly influenced by human behaviour, e.g. the many personal human factors which affect the performance of individual stoping contractors. It is a pity that this contention was not more closely defined in the discussion, as it is this rapporteur's opinion that, depending of course on the purpose of the simulation, it is precisely in areas strongly influenced by human behaviour that simulation could prove to be most useful.

Dr B. Joffe raised the question of more sophisticated optimization techniques. For instance, he asked Mr Erlandsson why he had not used integer programming techniques to obtain a true optimum rather than a possible sub-optimum in his investment analysis. Integer programming could be used to represent the presence or absence of a plant or concentrator. Mr Erlandsson replied that his approach was more flexible and that the number of practical alternatives was relatively small. It was easier to investigate these alternatives one by one than to find a true optimum which might then be invalidated on practical grounds. Dr Joffe also questioned Mr Splaine's use of Rosenbrock's method of finding an optimum rather than a quadratically-convergent method such as that of Powell. Mr Splaine answered that in a problem as complex as his, he preferred to use a conservative but reliable optimizing algorithm rather than a more complex method that might well be faster, but might well also prove troublesome. There is much to be said for a 'slow and/or simple but safe' approach to computer algorithms for complex problems. However, this does not mean that the operations research man working on mining problems should automatically disregard the more sophisticated tools of his trade. It was in this spirit that Dr D. M. Hawkins, in a written contribution, suggested that Touwen and Joughin might have used variance reduction techniques, such as antithetic variables and parallel running, to sharpen their estimates of improvements in systems operation. Dr Hawkins believed that in any attempt to optimize the underground system, sophisticated methods of experimental design (e.g. response surface analysis and evolutionary operation) would be required to keep experimental simulations to a minimum.

The production planning session and the discussion that followed it established solid guidelines for at least one aspect of the intelligent and practical use of computers in the mining industry. A more careful look at the papers presented in this session might have tempered the alacrity with which members of the panel, during the concluding panel discussion, agreed to the suggestion that progress in the application of computers to the minerals industry had been disappointing.