Technical Planning and Control

Chairman: Professor J. de V. LAMBRECHTS

Rapporteur: Mr R. HEMP

Papers:

Computer-aided design of a flash smelting installation by M. A. T. Cocquerel, R. T. Gates and L. A. Green

Planning of mine ventilation by E. U. Reuther and A. Dohmen

Coal mine ventilation systems in the U.S.A. by R. Stefanko and R. V. Ramani

Heat flow models in ventilation planning by A. J. Dickson and A. M. Starfield

The first of the papers in the session dealt with a flash smelter installation, while the remaining three papers dealt with mine ventilation. In view of this the Chairman proposed that the paper on flash smelting be introduced and discussed first, after which the remaining three papers would be introduced followed by discussion on all three.

Dr Cocquerel, who presented the first paper, used some typical flow diagrams to illustrate the process and stated that the program considered only steady-state operations and did not take into account the dynamical changes. Subjective judgment was necessary for the preparation of input data and some degree of user appreciation was required.

Dr Cocquerel said that no work had yet been done on an optimization program, but that this was being considered. Such a program would require a large amount of physical and chemical data which were not yet available. The variables to be optimized were the energy and material consumptions and the loss of metal in the slag.

The Chairman opened the discussion by asking Dr Cocquerel if he could give a brief description of the flash smelting process for the benefit of those not familiar with the subject. Dr Coquerel replied that in the Outokumpu process concentrates were injected directly into the furnace, and that the process was somewhat analogous to flash distillation or evaporation processes, but was perhaps closer to the burning of pulverized fuel.

The process had two distinct advantages. First, the heat evolved in the smelting reaction was used to heat the furnace, which resulted in less fuel consumption, and, second, the effluent gases were cheaper to treat than the effluent gases from other pyrometallurgical processes. This was important particularly in view of the current interest in pollution problems.

Mr P. Marais thought that the authors had done themselves an injustice by not including details of the very complex processes taking place in the furnace.

Mr Marais asked three questions. The first was whether the computer program could be used for the prediction and computation of the metal or metal compound content of the slag as a function of the slag and matte compositions. Dr Cocquerel replied that the values for metal content were based on operating experience, and simple interpolation techniques were used. He said that they were interested in building a model to relate slag metal losses to the chemical composition and viscosity of the slag; optimization of the process would not be possible unless this was done. In reply to Mr Marais' second question, Dr Cocquerel confirmed that the program took into account the heat of reaction of the liquid phase reactions in the heat balance.

Mr Marais, in his third question, stated that the chemical reactions taking place, the end products of the slag phase, and the heats of reaction depended upon the ratio of concentrate to flux added to the smelter, and asked whether the program made allowance for these.

Dr Cocquerel explained that the flash smelting process produced a controlled degree of oxidation in the furnace. As a result of this, iron oxide was produced and in many cases there was no need for fluxing with lime. The theoretical objective was to produce a fayalite slag, but in some instances this was unsatisfactory and the program allowed some parameters to be altered so that to some extent slag composition could be controlled towards the desired composition.

Mr. A. Weiss asked several questions. He asked first for the sulphur dioxide concentration resulting from the flash smelting process. Dr Cocquerel replied that this depended upon the heat balance. If the process was autogenous the sulphur dioxide content was normally between 12 and 15 per cent, while if fuel had to be added the sulphur dioxide content could fall to 8 per cent. This level was still high enough for economic acid production, although not high enough for the production of elemental sulphur.

Mr Weiss then asked whether a continuous smelting process such as the Noranda process would be preferable to the discontinuous flash smelting process. Dr. Cocquerel said that the metal loss in the slag in a continuous process was higher than in the flash process, although there is a tendency to increase the grade of the matte in the flash process, which resulted in high metal losses in the slag.

Mr Weiss asked finally whether the authors were working on the use of the computer for process control. Dr Cocquerel said that in the case of the Botswana project the client wished to use a conventional control system, and was not at present considering on-line computer control. He said that once the Botswana smelter was in operation it could be used to validate the computer model. The computer model could then be used to develop an operating strategy for the smelter.

Professor Reuther introduced the first paper on ventilation. He gave a short description of current coal mining practice in Germany, and described the development and use of the computer program dealing with ventilation networks.

The second paper was introduced by Dr Ramani. He described some of the changes brought about in coal mine ventilation in the United States by the recently enacted Federal Coal Mine Health and Safety Act of 1969, and described some typical ventilation systems. Dr Ramani emphasized how important it was that computer programs should be applied, and felt that it was vital for each program to be well described in readable operating manuals.

Mr Dickson introduced the third paper and described briefly the stages followed in the development of heat flow models and in addition gave some interesting examples of the application of the computer programs.

The discussion on these three papers was started by Mr P. Niskanen. In his first question he asked Prof Reuther whether a special computer program was available for investigating the stability of mine ventilation networks. This question was answered by Mr A. Dohmen, who replied that stability of a mine ventilation system was required by law, and that the network program was used at the planning stage to ensure stability. During the operation of a colliery the effect of a fire or of the collapse of workings could be investigated by changing the resistance values used in the program.

In his second question, Mr Niskanen asked Dr Ramani to list the most serious problems which arose in the automation of coal mine ventilation. Dr Ramani replied that methane and dust posed the most serious problems. Continuous methane monitoring was required at coal cutter heads. Dr Ramani mentioned that the United States Bureau of Mines had recently made a substantial grant for the development of a ventilation monitoring system.

Dr A. Whillier made some general comments on the value of symposia such as the present one, and expressed the view that there would be great advantages in the exchange of computer programs. He mentioned in particular some difficulties which were being experienced with a network program. These views were supported by both Prof Reuther and Dr Ramani who were both willing to co-operate in exchanging computer programs. Dr Whillier described briefly the ventilation training system operated by the Chamber of Mines and mentioned how valuable this was in introducing ventilation officials from the mines to the operation of the computer and the use of various programs.

In reply to a question by Dr Whillier, Prof Reuther confirmed that their heat flow program did allow for the heat emitted by the broken coal.

Mr W. L. le Roux asked Dr Ramani what air velocities were typically used in longwall faces. Dr Ramani replied that these velocities were 300 ft/min or less, which implied an air quantity per face of about 10 000 cu ft/min.

Both Mr le Roux and Dr A. E. Hall raised several points in connection with the velocity limit of 250 ft/min laid down for trolley haulages, which had been mentioned by Dr Ramani. Dr Ramani confirmed that the reason for this limit was the fire hazard, but mentioned that it did lead to other problems, particularly those associated with methane layering, and he said that this regulation might be challenged.

Dr Hall asked whether it would be preferable to devise effective fire extinguishing methods rather than to limit the air velocity. Dr Ramani agreed that work was necessary in this matter and confirmed that fire extinguishers had to be carried on locomotives.

Mr V. O. Steed subsequently submitted to Dr Ramani two questions dealing with coal mine ventilation costs and typical air requirements in the United States. Dr Stefanko replied as follows:

'Cost figures are very difficult to obtain from the industry because of the concern for releasing proprietary information. Also, accounting principles vary from one mine to another to make comparisons less meaningful. For example, even for major capital items that are normally capitalized, some companies today will expense them. However, as a typical figure for a group of mines, operating costs are 14c per ton and capital costs 25c per ton. This total ventilation cost of 39c per ton would be on approximately $7 per ton FOB coal representing 2 per cent and 3.6 per cent for the operating and capital cost, respectively, or 5.6 per cent total ventilation costs.

The second question asks for an average cfm ventilation figure for mines in the U.S.A. The weighted figure is unknown and really has no significance. There are approximately 1 600 coal mines in the United States, some ranging from 100 tons per day operation to 22 000 tons per day for the largest. The largest utilizes seven large exhaust fans and produces about 2 400 000 cfm of air. This mine represents the upper range and also is one with a severe ventilation problem. Generally, in a modern coal mine, for each ton of coal produced each day, 4 to 6 tons of air are circulated in the mine.

An "average" condition in the United States might be considered a mine with a flow of 600 000 cfm operating at seven inches of water gauge. This figure is not a weighted average but represents a known group of mines that are rather typical.'

Mr le Roux, referring to Dickson and Starfield's paper, said that empirical work on heat flow, such as had been carried out by Lambrechts, had been of great value, and had in fact been used by the present authors to validate their work. He asked what steps were taken to keep the programs up to date, and said that he thought that it was still necessary to carry out a scientific validation of the method. Mr Dickson replied that it was intended that the programs should be kept up to date by means of feed-back from users in industry. He thought that a scientific validation would be extremely difficult, particularly in stopes.

Prof Starfield emphasized the value of empirical work but said that such work could not be expected to apply under conditions different from those under which the data were collected. He therefore thought that the computer model would generally give better results when extrapolation was required.

Prof Starfield said that two requirements for a computer program were necessary to make it acceptable to the user. The first was that the program should be in conversation mode, and the second was that the program should give results in a very short time.

The Chairman, in closing the session, thanked both authors and contributors, and said that for a closing remark he would like to quote Dr Stefanko and Dr Ramani, to the effect that the output of a computer program could be only as good as the input data.