Calculate countercurrent washing efficiency with dirty wash solution

R. B. Stein, Bechtel Corporation, San Francisco, California

ABSTRACT

Countercurrent decantation circuits (CCD) are often employed in hydrometallurgy to effect solids-liquid separation in combination with a barren solution wash to reduce losses of valuable solution component(s) from the tails. Bechtel Corporation uses its BEMSIM flowsheet-modelling PC computer program to simulate a CCD circuit where the "dirty" wash solution contains significant amounts of soluble components. An algorithm successfully models this condition and is simplified to a single expression when the wash solution is a "clean" solution containing no solubles. The CCD calculation module is compared to operating data from uranium and nickel-cobalt CCD circuits.

Introduction

Hydrometallurgical process schemes have often relied on countercurrent washing methods to reduce soluble losses of valuable product in the tails. Commonly used equipment to effect this operation is a CCD circuit of N thickeners in series, where a slurry is fed to thickener 1 and a wash solution to thickener N; clear pregnant solution overflows thickener 1 and washed tails exit as underflow from thickener N. CCD circuits of this type are typically employed when the solids tend to slime heavily and where a filter is not economic.

A typical CCD circuit usually employs from two to five thickeners and can employ either a "clean" washing solution of, say, pure water or else the hydrometallurgical circuit may generate a "dirty" barren solution containing an appreciable amount of soluble component which may be advantageously returned to the process as CCD wash solution. Various authors have treated the case for clean washing solutions (Svarkovsky 1977, Merritt 1970). For the case of dirty wash solutions, an algorithm has been developed to enable efficient modelling by the BEMSIM computer program, because the need for an accurate method to calculate soluble losses is required when performing an economic trade-off analysis of the value of product lost in the tails as a function of the number of thickeners.

Keywords: Countercurrent decantation circuits, Hydrometallurgy, Computer applications.

Paper reviewed and approved for publication by The Metallurgical Society of CIM.

Dr. R.B. Stein was born in Hollywood, California. He studied chemical and metallurgical engineering at the University of California and at Oregon State and received the Dipl. Dr.-Ing. from the Graduate School of Electrochemistry and Electrometallurgy of the University of Grenoble, France. His career of 25 years in industry includes extensive work in simulation modelling and flowsheet programs for petrochemical, hydrometallurgical and smelting processes. He is currently in the Technology Department of the Mining and Metals Operations of Bechtel where he sponsors use of their BEMSIM computer program.

Technical Background

The steps involved in developing a calculation method start from the basic description of one thickener in a CCD circuit shown schematically in Figure 1. (In actual practice the two feed streams can be mixed together in a launder, feed well, pump sump or externally agitated mix tank.) Reference to Figure 1 shows two feed streams 1 and 2, two product streams 3 and 4, and two paths for stage inefficiency due, respectively, to solution by-pass and to imperfect mixing. In the former case, feed pulp solution travels directly to the thickener exit stream 3 without undergoing displacement washing, and in the latter case the mixing of the two feed streams is non-uniform.

For thickener terminology, the over-all liquid phase volumetric flowrates of each of the two input and the two output streams is designated V1, V2, V3 and V4. For an individual stage, a subscript is added to indicate the stage number n. The mass flowrate of soluble component(s) in the stage n solutions is designed by subscript j for $1 \leq j \leq m$ soluble components, such as $C1_{j,n-1}$ for the feed pulp.

Stage-to-stage calculations for mass flows use the following assumptions, assuming for a first iteration that underflow pulp per cent solids are identical from each stage:

- Overflow volume from each stage is uniform except for $n = 1$.

$$V4_n = V2_{n+1} \qquad 2 \leq n \leq N \quad (1)$$

$$V4_1 = V1_{n-1} + V2_{n+1} - V3_1 \qquad n = 1 \quad (2)$$

- Underflow volume of solution from each stage is uniform, fixed by the volume per cent solids.

$$V3_n = V3_{n+1} \qquad 1 \leq n \leq N \quad (3)$$

- Underflow solids undergo no change in volume nor is there any leaching of soluble components during residence time in the CCD circuit. Solids volume is ignored in the calculations.
- Except for flow quantities due to stage inefficiency, the mixing of the remaining quantities of pulp and wash solution assumes ideal mixing.

Stage Efficiency

The key to calculation of soluble component(s) loss is the definition of stage efficiency. Figure 1 shows the two major sources of stage efficiency which can be identified as E_1 and E_2. It is improbable that the user of the computer model will know E_1 separately from E_2 and, what is more, the values of both can vary appreciably from stage to stage (Emmett 1981). As a simplification, the two efficiency parameters E_1 and E_2 can be lumped together into a single stage efficiency E_1, which is equated to the percentage of solution $V1_{n-1}$ which reports directly to $V3_n$ without having been subjected to a mixing or washing effect. Using CCD circuit operating data, it is possible to replace stagewise variations of E_1 with

TABLE 1. CCD circuit at 3.3:1 wash ratio with dirty wash solution

Feed pulp Stream 1		Dirty wash Stream 2		Tailings solution Stream 3		Pregnant liquid Stream 4
Liq. Flow m^3/h	U_3O_8 in Solution mg/L	Liq. Flow m^3/h	U_3O_8 in Solution mg/L	Liq. Flow m^3/h	U_3O_8 in Solution mg/L	Liq. Flow m^3/h
112.0	170.6	325	4.9	98.5	7.9	333.8

a global stage efficiency value, which can be backed-fitted when concentration values $C_{j,n}$ are not known for each stage. Then, one can establish the following relations when E_1 is the global efficiency (by-pass plus mixing inefficiency for incoming solution in the stage n pulp feed); $B3V_n$ is the volume of feed pulp solution to stage n which bypasses and reports to tails, and $B3C_{j,n}$ is the mass flow of soluble component j in the bypass solution B3V:

$$B3V_n = (1 - E_1/100)*V1_{n-1} \quad (4)$$

$$B3C_{j,n} = (B3V_n/V1_{n-1})*C1_{j,n-1} \quad (5)$$

$$C3_{j,n} = B3C_{j,n} + [(V3_n - BV3_n)/(V1_{nl} + V2_{n+1})]* (C1_{j,n-1} + C2_{j,n+1} - BC3_{j,n}) \quad (6)$$

If the per cent soluble loss of a component is defined as PSL_j, then

$$PSL_j = 100*[C3_{j,N}/C1_{j,0}] \quad (7)$$

and the total per cent soluble loss for all soluble components is

$$(PSL)_{total} = \sum_{j=1}^{m} PSL_j \quad (8)$$

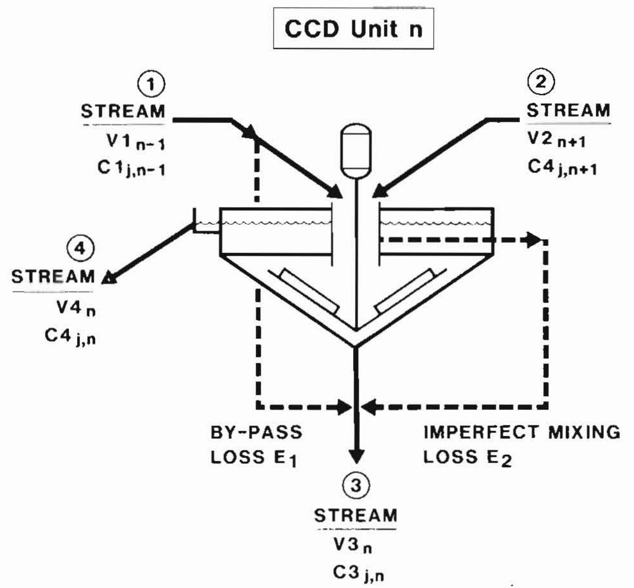

FIGURE 1. Washing thickener unit.

A numerical example for a single soluble component is illustrated in Figure 2 for an assumed stage efficiency of 85% and for a single stage of CCD washing with a dirty wash solution at a wash ratio of 3:1, where the wash ratio is defined as the volume of wash solution per volume of solution in the final tails.

$$B3V_1 = (1.0 - 0.85)*200 = 30 \text{ L} \quad (9)$$

TABLE 2. Results from the uranium CCD circuit simulation

```
Bechtel M&M Operations:     BEMSIM Simulator Program                              [13:59   9/ 4/1990]      Page  1
-------------------------------------------------------------------------------------------------------------------
                              Uranium Leach Solids/Liquid CCD Circuit - Blyvooruitzicht Mill, RSA
                              5-Stage Counter-Current Decantation Washing @ 75.5% Stage Efficiency
                              Reference: CIM Bulletin, May 1979, pages 127-134
                              Authors: D.W. Boydell, P.A. Paxen, D.W. Bosch, W.G. Craig
                              Material Balance from Table 5, pg 137, Day -2.
-------------------------------------------------------------------------------------------------------------------
CD100   :  CCD CIRCUIT        [CCD    :  11]    [MASS BALANCE CLOSURE          .0000]   [ENERGY BALANCE CLOSURE         .00]

        [OUTLET TEMP OF U/FLOW    =      .0]  [OUTLET TEMP OF PREG.    =       .0]  [HEAT LOSS FACTOR        =        .0]
        [NUMBER OF STAGES (1-7)   =      5.]  [UNDERFLOW SOLIDS, %     =    55.90]  [OVERFLOW SOLIDS, PPM    =       .00]
        [STAGE EFFICIENCY, %      =   75.50]                                         [PCT SOLUBLE LOSS        =     3.856]
-------------------------------------------------------------------------------------------------------------------

                              ==========INPUT  STREAMS========= ==========OUTPUT STREAMS=========

                              1                2                3                4
                              PULP FEED TO CCD BARREN WASH      TAILS PULP       PREG LIQUOR
                              ---------------- ---------------- ---------------- ----------------

LIQUID PHASE

  LIQUID MASS FLOW  - t/h     114.9000         325.0000         101.0592         338.8408
  LIQUID VOL FLOW   - m3/h       112.0   gpl      325.0   gpl       98.5   gpl      338.8   gpl
  LIQUID S.G.       -            1.026 ======     1.000 ======     1.026 ======     1.000 ======
  U308              - t/h       .01910  .1706    .00160  .0049    .00080  .0081    .01990  .0587
  H2O               - t/h     114.8809 1025.83 324.9984 999.995 101.0584 1025.99 338.8209 999.941

SOLID PHASE

  SOLID MASS FLOW   - t/h     128.1000 Wt Pct     .0000 Wt Pct 128.1000 Wt Pct      .0000 Wt Pct
  SOLID S.G.        -            2.600 ======      .000 ======     2.600 ======     2.600 ======
  LEACHED ORE       - t/h     128.1000 100.00     .0000     .00 128.1000 100.00     .0000    .00

TOTAL STREAM

  TOTAL MASS FLOW   - t/h     243.0000         325.0000         229.1592         338.8408
  TOTAL VOL FLOW    - m3/h       161.3            325.0            147.8            338.8
  WT. PCT. SOLIDS   - PERCENT    52.72              .00            55.90              .00
  TOTAL S.G.        -            1.507            1.000            1.551            1.000
```

TABLE 3. Results from the Ni-Co circuit simulation

Bechtel M&M Operations: BEMSIM Simulator Program [14:37 9/ 4/1990] Page 1

Nickel-Cobalt Leach Solids/Liquid CCD Circuit - Pilot Plant Data
5-Stages of CCD Washing with "Dirty" Wash Solution
Uses 98% Stage Efficiency Computes Heat Balance

CCD : CCD CIRCUIT [CCD : 11] [MASS BALANCE CLOSURE .0001] [ENERGY BALANCE CLOSURE .00]

[OUTLET TEMP OF U/FLOW =	63.6]	[OUTLET TEMP OF PREG. =	42.1]	[HEAT LOSS FACTOR =	48.7]
[NUMBER OF STAGES (1-7) =	5.]	[UNDERFLOW SOLIDS, % =	47.00]	[OVERFLOW SOLIDS, PPM =	.00]
[STAGE EFFICIENCY, % =	98.00]			[PCT SOLUBLE LOSS =	12.895]
[HEAT OF REACTION =	.00]	[EXTERNAL HEAT ADDED =	.00]	[AMBIENT HEAT LOSS =	77704.01]

		==========INPUT	STREAMS=========			==========OUTPUT	STREAMS=========		
		7 CCD Feed		100 Total Wash		11 CCD Underflow		12 Preg. Solution	
Liquid Phase									
Liquid Mass Flow	kg/h	1217.91		800.09		379.23		1638.77	
Liquid S.G.		1.198		1.102		1.102		1.170	
Liquid Sp. Ht.	cal/g-C	.806	gpl	.866	gpl	.860	gpl	.806	gpl
Liquid Vol Flow	L/h	1016.6	======	726.0	======	344.1	======	1400.7	======
Ni	kg/h	8.56	8.42	.04	.06	.08	.23	8.52	6.08
Co	kg/h	.275	.27	.005	.01	.004	.01	.276	.20
Fe	kg/h	4.25	4.18	.13	.18	.09	.26	4.29	3.06
Mg	kg/h	25.36	24.95	16.80	23.14	7.96	23.13	34.20	24.42
Al	kg/h	3.01	2.96	1.48	2.04	.71	2.05	3.78	2.70
Mn	kg/h	1.74	1.71	1.13	1.56	.54	1.56	2.33	1.67
Cr	kg/h	.47	.46	.39	.54	.18	.53	.68	.48
SiO2	kg/h	25.44	25.02	8.42	11.60	4.08	11.85	29.78	21.26
Free Acid	kg/h	70.15	69.00	5.54	7.63	3.05	8.87	72.64	51.86
Sulfate	kg/h	157.55	154.98	74.36	102.42	35.55	103.31	196.36	140.19
Water	kg/h	921.10	906.05	691.80	952.84	326.99	950.20	1285.91	918.07
Solid Phase									
Solid Mass Flow	kg/h	336.30	Wt Pct	.00	Wt Pct	336.30	Wt Pct	.00	Wt Pct
Solid S.G.		3.400	======	.000	======	3.400	======	.000	======
Gangue	kg/h	336.300	100.00	.000	.00	336.300	100.00	.000	.00
Total Stream									
Total Mass Flow	kg/h	1554.21		800.09		715.53		1638.77	
Total Vol Flow	L/h	1115.5		726.0		443.0		1400.7	
Wt.Pct. Solids	PERCENT	21.64		.00		47.00		.00	
Stream S.G.		1.393		1.102		1.615		1.170	
Temperature	deg C	97.6		80.0		63.6		42.1	
Stream Sp.Ht.	cal/g-C	.686		.866		.573		.806	
Stream Enthalpy	kcal/h	104013.0		55430.6		26102.0		55637.5	

$$B3C_{1,1} = (30/200)*100 = 15 \text{ g} \quad (10)$$

$$C3_{1,1} = 15 + [(100 - 30)/(200 + 300)]*(100 + 51 - 15) = 34 \text{ g} \quad (11)$$

$$PSL_1 = 100*(34/100) = 34\% \quad (12)$$

Equations (1) through (7) were employed to construct an iterative procedure for the general case where $2 \leq N \leq 7$, $1 \leq j \leq 40$ and where stage n underflow pulps have different volume per cent solids. If warranted, this procedure can employ a different value of E_1 for each stage or varying values of E_1 and E_2 for each stage when their values are known.

TABLE 4. CCD circuit performance with dirty wash solution

	Stage 5 tails Stream 11		Stage 1 preg. liq. Stream 12	
	Measured	Calculated	Measured	Calculated
Temp., °C	65.0	63.6	41.7	42.1
Ni, kg/h	0.12	0.08	8.52	8.52
Co, kg/h	0.008	0.004	0.272	0.276
Fe, kg/h	0.22	0.09	4.16	4.29
Mg, kg/h	0.40	7.96	41.76	34.20
Al, kg/h	0.67	0.71	3.82	3.78
Mn, kg/h	0.64	0.54	2.23	2.33
Cr, kg/h	0.22	0.18	0.64	0.68
SiO_2, kg/h	5.18	4.08	28.68	29.78
Acid, kg/h	5.20	3.05	70.48	72.64

Examples

Two examples are given where the washing solution contains soluble components. The simpler Example 1 is a uranium washing circuit with only one soluble component. In Example 2 the wash solution contains 10 soluble components.

Example 1 — Uranium Circuit

This example of CCD circuit from an operating uranium plant (Boydell, *et al.* 1979) is selected to illustrate the calculation method; it uses the data for washing at a wash ratio of 3.3:1. Operating data was modified in a minor way for internal compatibility and ignored any solubilization of uranium during CCD washing.

Data from Table 1 were used as input to the BEMSIM program at an over-all stage efficiency of 75.5%. Output is shown in Table 2, where it is seen that the calculated U_3O_8 loss in the tails solution of 8.1 mg/L is quite close to the value reported in Table 1. Soluble loss is calculated at 3.86%, compared to the reported value of 4.14%.

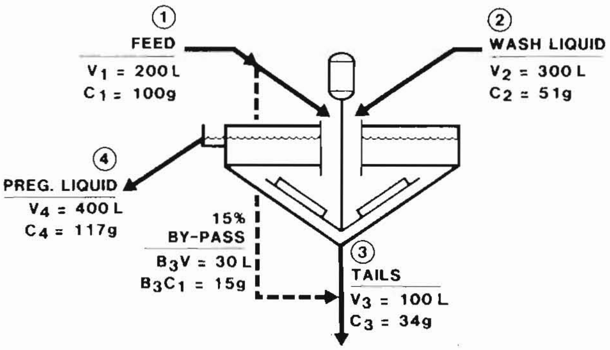

FIGURE 2. Numerical example of thickener at 85% stage efficiency and wash ratio of 3:1.

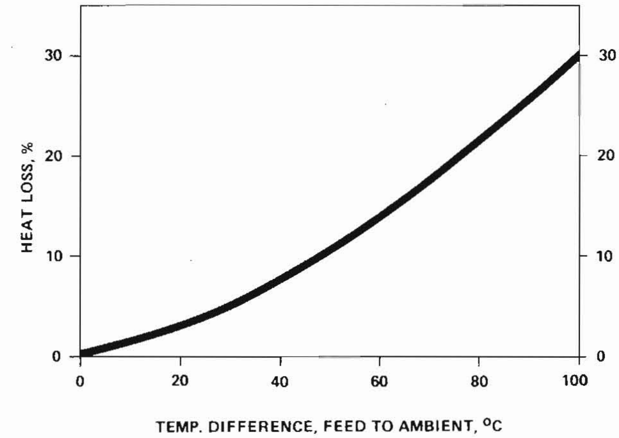

FIGURE 3. Heat loss from a single CCD stage as per cent of input enthalpy (feed + wash).

Example 2 — Nickel-Cobalt Circuit

This example of a five-stage CCD circuit came from operating data of a pilot plant. The feed slurry to the CCD at 97.6°C was the flash slurry from autoclave leaching of nickel-cobalt laterite, and contained 8.56 kg/h Ni^{++}, 0.275 kg/h Co^{++} and 25.36 kg/h Mg^{++}. The dirty wash solution at 80°C contained 0.04 kg/h Ni^{++}, 0.005 kg/h Co^{++} and 16.8 kg/h Mg^{++}.

This CCD circuit employed separate, agitated interstage mixers and oversize thickeners, and the computation results using 98% stage efficiency demonstrate the high efficiency of this configuration. Input and output data are shown in Table 3. Measured and experimental results are shown in Table 4.

The input value of 98% stage efficiency was selected to make the calculated loss for Ni^{++} equal to the measured value in the pregnant solution. At this value, the measured value for total soluble loss was 10.9%, compared to a calculated value of 12.9%.

CCD Washing with Clean Wash Solution

For the special case when there is only one soluble component and the wash solution contains no soluble component, the set of iterative equations (4) through (6) is replaced by a simple expression for N stages. Let

N = Number of stages .... (13)

r_o = Feed ratio = V4/V1 .... (14)

r_1 = Wash ratio = V2/V3 .... (15)

$$A = \frac{r_1 + (1-E_1)}{(1-E_1)\, r_o + 1} \qquad (16)$$

TABLE 5. Results from uranium CCD circuit with clean wash

```
Bechtel M&M Operations:    BEMSIM Simulator Program                    [14:17  9/ 4/1990]     Page 1

                 Uranium Leach Solids/Liquid CCD Circuit - Petrotomics Mill
                 5-Stage Counter-Current Decantation @88.6% Stage Efficiency
                 Reference: "The Extractive Metallurgy of Uranium", pp.460-61
                 Author: R.C. Merritt                  CSMRI, Golden CO, 1970.

CCD100  :  CCD CIRCUIT     [CCD   :  11]   [MASS BALANCE CLOSURE        .0000]   [ENERGY BALANCE CLOSURE        .00]

      [OUTLET TEMP OF U/FLOW   =      .0]  [OUTLET TEMP OF PREG.   =      .0]  [HEAT LOSS FACTOR      =       .0]
      [NUMBER OF STAGES (1-7)  =      5.]  [UNDERFLOW SOLIDS, %    =   59.00]  [OVERFLOW SOLIDS, PPM  =   200.00]
      [STAGE EFFICIENCY, %     =   88.60]                                      [PCT SOLUBLE LOSS      =     .498]
```

		==========INPUT	STREAMS=========		==========OUTPUT	STREAMS=========			
		1 CCD FEED		2 WASH LIQUOR		3 TAILINGS		4 PREG SOLUTION	
LIQUID									
LIQUID MASS FLOW	- lb/h	92000.		250000.		69454.		272546.	
LIQUID VOL FLOW	- gpm	179.	gpl	500.	gpl	135.	gpl	545.	gpl
LIQUID S.G.	-	1.026	======	1.000	======	1.026	======	1.000	======
UO2SO4	- lb/h	268.00	2.989	.00	.000	1.33	.020	266.67	.978
H2O	- lb/h	91732.	1023.01	250000.	1000.00	69452.	1025.98	272280.	999.022
SOLIDS									
			Wt Pct		Wt Pct		Wt Pct		Wt Pct
SOLIDS MASS FLOW	- lb/h	100000.	======	0.	======	99945.	======	55.	======
LEACHED ORE	- lb/h	100000.	100.00	0.	.00	99945.	100.00	55.	100.00
TOTAL STREAM									
TOTAL MASS FLOW	- lb/h	192000.		250000.		169399.		272601.	
TOTAL VOL FLOW	- gpm	255.		500.		211.		545.	
WT PCT SOLIDS	- PERCENT	52.08		.00		59.00		.02	

$$B = \frac{r_1 + (1-E_1)}{(1-E_1)\, r_1 + 1} \qquad (17)$$

then,

$$PSL = 100 * \frac{r_o - 1}{r_o A B^{N-1} - 1} \qquad (18)$$

As an example to illustrate equation (18), the operating data from a uranium mill (Merritt 1970, pp. 460-461) were used as input to the BEMSIM program. The reported soluble loss of uranium of 0.5% was achieved when the stage efficiency of the 5-stage CCD circuit was set equal to 88.6%, as shown on the computer results in Table 5.

Heat Balance

For the case illustrated by Example 2, the CCD circuit feed was at or near boiling, and because the thickeners were uncovered there was appreciable heat loss due to evaporation from the surface of the thickeners. In fact, the 5-stage circuit lost an estimated 43.6% of its input enthalpy (in streams V1 and V2) to evaporation and only about 2.5% to 2.6% each to radiation and convection from the tank walls.

The operating data for the CCD circuit in Example 2 indicated that a correlation can be established for heat loss from a single stage CCD thickener based on the temperature difference of the feed slurry and the ambient temperature. When temperatures are expressed in °C, then Figure 3 shows that the percentage heat loss $(PHL)_1$ is given by:

$$(PHL)_1 = 0.129\ \Delta t + 1.823*10^{-3}\ \Delta t^2 \qquad (19)$$

and the heat loss from N stages ($N \geq 2$) is then found from

$$(PHL)_N = (1.209)^N *(PHL)_1 \qquad (20)$$

When these equations were applied to Example 2, calculations of the pregnant liquor outlet temperature yielded 42.1°C against a measured value of 41.7°C, while the underflow temperature of 63.6°C is compared to a measured value of 65°C.

Conclusions

An iterative method is presented for computer calculation of CCD wash circuits when the wash solution contains soluble component(s) present in the feed slurry. A special case for a single soluble component and a clean wash solution results in a simplified expression.

Two examples of calculations using an in-house computer program show the application of the method to washing with dirty wash solutions at a wash ratio of 3.3:1 in an operating uranium plant and a wash ratio of 1.8:1 in a nickel-cobalt laterite pilot plant. In these examples the stage wash efficiencies were 75.5% and 98%, respectively, and the calculated losses of individual soluble component values is compared to measured values, as well as the total loss of soluble components.

An example of an operating uranium circuit with a clean wash solution was used to check the simplified expression in Equation (18). The results compared with the measured soluble loss at a stage efficiency of 88.6%.

When individual stage efficiency values are not known the method presented uses a single over-all value to represent the stage efficiency and gives reasonable good results and provides a method for calculations in the computer program.

A special case of hot or near-boiling feed was used to determine an empirical correlation to find the heat losses and do the CCD circuit heat balance for uncovered thickeners operating under this feed condition.

REFERENCES

1. BOYDELL, D. W., *et al.*, The New Uranium Recovery Circuit at Blyvooruitzicht; *CIM Bulletin, Vol. 72, No. 805, pp. 127-135, May 1979.*
2. EMMETT, R. C., Gravity Separation Methods in Hydrometallurgy; 11th Annual Hydrometallurgical Meeting of CIM, Oct. 1981.
3. MERRITT, R. C., The Extractive Metallurgy of Uranium, Colorado School of Mines Research Institute, Golden, Colorado, 1970.
4. SVAROVSKY, L., Solid-Liquid Separation, Butterworths, London 1977.

2nd Symposium on Application of Mathematical Methods and Computers in Geology, Mining and Metallurgy

The Yugoslav Committee for Application of Mathematical Methods and Computers in Geology, Mining and Metallurgy is organizing the Second Symposium to take place in Belgrade, Yugoslavia, from **October 21-25, 1991**. The symposium will provide the opportunity for the exchange of information, including recent developments in research and technology and education in the fields of geology, mining and metallurgy.

The symposium will include all fields of the application of mathematical methods and computer techniques in the field. The main topics are:

- development and application of engineering methods based on mathematical approaches and computer techniques (CAD — technique, modelling, simulation, planning, design, graphics etc.);
- operational researches (methods and application);
- geostatistics;
- information systems and data bases;
- application of computer techniques;
- artificial intelligence and expert systems; and
- education and specialists.

The official languages of the symposium are English and Russian, for both the presentation of papers and publication.

Authors interested in submitting papers should send three copies of short abstracts (up to 150 words) to the address given below no later than **January 15, 1991**. All accepted papers from registered delegates will be published in a proceedings volume which will be available to participants at the symposium. Papers not written in English will have extended English abstracts.

The registration fee is US$250 which includes access to the symposium and technological exhibition, all volumes of the proceedings, coffee breaks and cocktails.

A 4-day field trip, from October 26 to 29, is being organized. Included are guided tours of the Kostolac open pit coal mine; Bor copper mine; Madjanpek open pit copper mine; Rajko's Cave; Gamzigrad's Spa; Grza karstic spring; Djerdap hydropower plant. The field trip will also include visits to the Serbian medieval monasteries, Manasija and Ravanica. The cost of the field trip is US$350, and includes transportation, accommodation, meals, all tickets and a guide book.

For the submission of abstracts and further enquiries, contact: SITRGM — KPMR, II Symposium, Kneza Milosa 9/IV, Yugoslavia; Tel.: +38-11-334-357; Fax: +38-11-342-613.

CIM