ISBN : 81-87053-53-4
Processing of Fines (2)
Eds. : P. Bhattacharyya, R. Singh and N. G. Goswami
© NML Jamshedpur-831 007, India, 2000, pp. 188-198

Designing flotation process for lead-zinc ore from Nepal

R. SINGH[1], S. K. SENGUPTA[1], P. N. PATHAK[1], S. N. PRASAD[1], J. P. SRIVASTAVA[1], B. BANERJEE[1], A CHATTOPADHYAY[1], D. S. RAO[1], S. C. MAULIK[1] and C. K. CHAKRABARTI[2]

[1]*National Metallurgical Laboratory, Jamshedpur 831 007, India*
[2]*Nepal Metal Company Ltd., Kathmandu, Nepal*

ABSTRACT

The paper deals with the development of a process based on froth flotation for the concentration of a lead-zinc ore from Ganesh-Himal region of Nepal. A detailed characterisation and flotation studies were carried out under the varying process conditions. The ore was predomionantly made up of sphalerite and pyrite in association with sub-ordinate amount of galena, minor amount of pyrrhotite and chalcopyrite with dolomite as the major gangue. Under the optimum process conditions the rougher lead and zinc recovery were 96.3% and 90.8% respectively. Regrinding followed by three stage cleaning of the lead rougher concentrate resulted in cleaner concentrate assaying 79.11% Pb with 83.4% recovery. Similarly two stage cleaning of the zinc rougher concentrate produced cleaner concentrate analysing 60.08% Zn with 80.4% recovery. Based on the studies undertaken a process flow-sheet for the concentration of the ore to individual lead and zinc concentrates has been recommended.

Key words : *Froth flotation, Lead-zinc ore, Process flow-sheet, Characterisation*

INTRODUCTION

A rich mineralisation of lead and zinc is located in the Ganesh-Himal region of Nepal. There are six rich mineralisation of lead and zinc sulphides in an area of 5 sq.km. between 4,050 and 4,900 m above mean sea level. From the recent exploration the mineable ore reserves are estimated to be 1 million tonne containing 2.06% lead and 13.30% zinc. The in situ ore grade is about 19% as combined lead and zinc and the possible ore reserves are more than 2 million tonne[1].

M/s Nepal Metal Company Limited (NMCL), Kathmandu has been interested in developing Ganesh-Himal lead-zinc deposit. In this connection studies on beneficiation of the ore and extraction of zinc, from the concentrate produced, were carried out at National Metallurgical Laboratory (NML), Jamshedpur. Initially a handpicked ore sample was received at NML for the preliminary beneficiation, preparation of concentrate and zinc extraction studies. Bench scale flotation studies carried out on the handpicked sample resulted in poor selectivity and higher losses of lead in the tailings. This was attributed to the surface oxidation of galena due to long exposure to environment at the mines head[2]. But in this case efforts were directed to prepare zinc concentrate adopting a gravity-cum-flotation route for hydrometallurgical extraction of metal by the process developed at NML[3]. The zinc concentrate produced resulted in recovering over 80% of zinc and sulphur in the leach solution[4].

Encouraged with the above studies, a detailed bench scale beneficiation studies were carried our on the representative sample from the Ganesh-Himal deposit to design the process for concentration of lead-zinc ore. This paper presents a part of the results of the flotation studies carried out in the second phase, on the representative lead-zinc ore sample.

EXPERIMENTAL

Ore Sample

The representative lead-zinc ore sample from Ganesh-Himal deposit was used for this study. The as received ore sample consisted of lumps ranging from 7.5 cm down to fines. The sample assayed 2.47% Pb and 13.63% Zn with 16.64% CaO and 11.89% MgO. The silica and alumina contents of the sample were low i.e. 0.56% and 0.97% respectively. The mineralogical and liberation characteristics of the sample were determined and are presented in the subsequent paragraph.

Reagents

A combination of laboratory grade sodium cyanide and zinc sulphate from M/s BDH India Ltd, Bombay was used as depressant and copper sulphate as activator for zinc bearing minerals. Commercial grade potassium ethyl xanthate (KEX) from M/s Suyog Chemical Pvt. Ltd., Nagpur was used as collector and laboratory grade methyl iso-butyl carbinol as frother for lead and zinc minerals. Commercial grade lime was used as pH regulator and depressant for pyrite.

Methods

Bench scale flotation experiments were carried out in standard Wemco Fagergren Laboratory Flotation Cell while large batch flotation was performed in Denver D12 Unit Cell. For this purpose 0.5 kg -10 mesh sample, crushed in stages in jaw and roll crushers, was wet ground in laboratory rod mill at 66% pulp density and floated, after conditioning, at a pulp density of 22%. All the products from the flotation experiments were assayed for %Pb and %Zn by standard wet chemical method and material balance was computed.

RESULTS AND DISCUSSION

A detailed characterisation and froth flotation studies were carried out on the sample. The salient results are discussed below :

Mineralogical Characteristics of the Sample

Mineralogical characterisation of the sample indicated that the ore was predominantly made up of sphalerite and pyrite in association with subordinate amounts of galena, minor amounts of pyrrhotite and chalcopyrite. Dolomite was the main gangue. The other accessory minerals and mineral impurities namely, mica, cerussite, smithsonite, quartz, garnet, rutile, magnetite, goethite/limonite were in minor to trace amounts. The ore minerals were widely varying in size from 1.4 cm to less than 5 micron but the bulk of sulphide mineral was 148 micron and above in size. Pyrites were mostly euhedral while other sulphides were anhedral to subhedral in shape. The sulphide minerals showed replacement, exsolution textures and triple junction points. As observed by the electron probe microanalysis (EPMA) study, the constant presence of iron in all grains of sphalerite could be due to structural substitution. While out of the three grains of galena analysed only one grain showed the presence of zinc. X-ray diffraction (Fig. 1a) study carried out on the head sample also corroborated the peterographic findings.

The modal analysis (Figs. 2 & 3) showed the probability of fair liberation of sulphides from gangue around 60 mesh but the locking of galena with sphalerite and other sulphides continued to finer sizes. This indicated the need of fine grinding below 150 mesh for liberation of galena and sphalerite from rest of the sulphides.

Flotation Studies

The basic flotation scheme consisted of differential flotation separation by depression of zinc bearing minerals using a combination of sodium cyanide and zinc sulphate as depressant and flotation of lead minerals using potassium ethyl xanthate (KEX) as collector and metyl iso-butyl carbinol (MIBC) as frother. Lime was used as pH regulator and this also helped in depression of pyrite. Subsequently zinc was floated using copper sulphate as activator and xanthate and MIBC as collector and frother respectively at a higher pH. The effects of various process parameters were studied and results are discussed below :

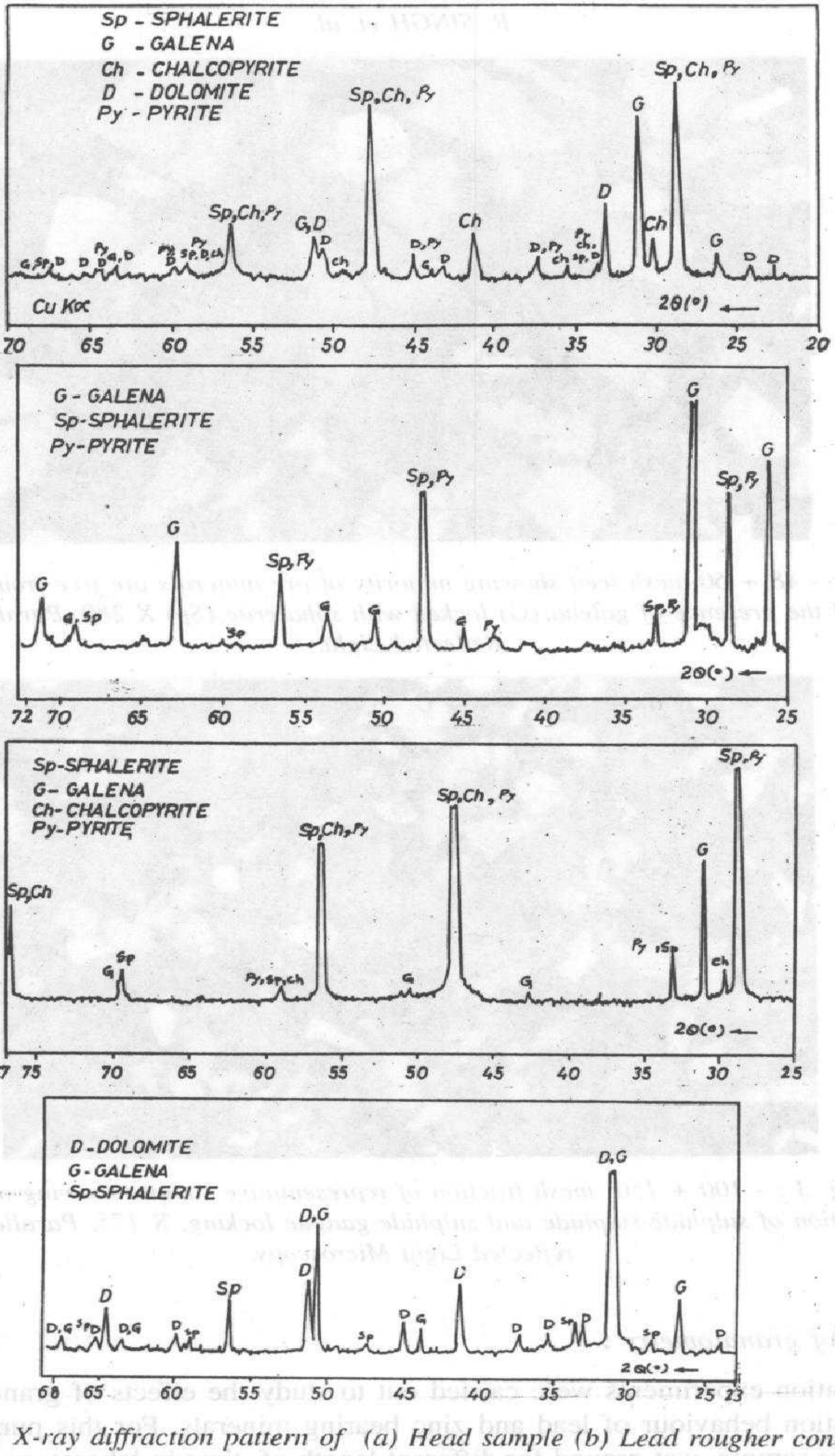

Fig. 1 : X-ray diffraction pattern of (a) Head sample (b) Lead rougher concentrate (b) Zinc rougher concentrate (c) Primary tailings.

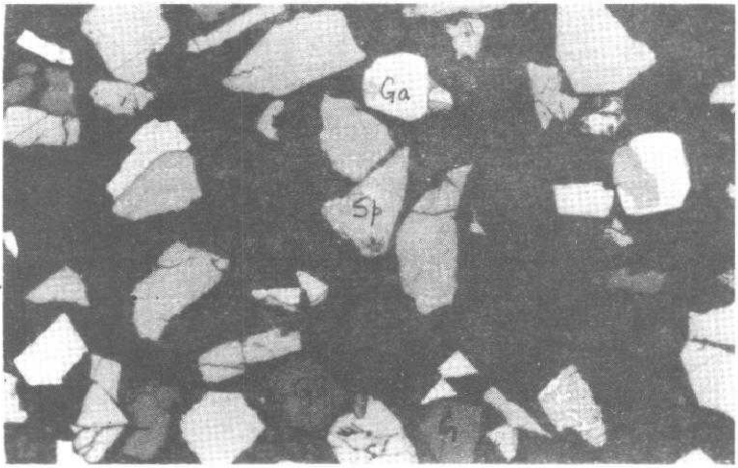

Fig. 2 : - 48 + 60 mesh feed showing majority of ore minerals are free from gangue (G) and the presence of galena (G) locked with sphalerite (Sp) X 280, Parallel Light, Reflected Light.

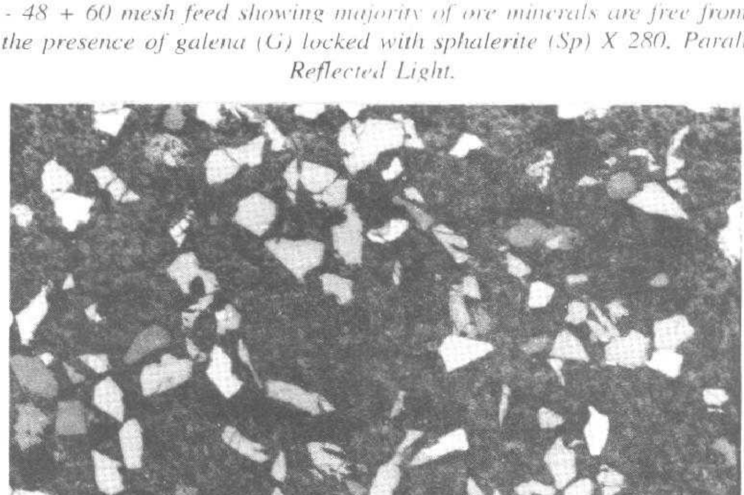

Fig. 3 : - 100 + 150 mesh fraction of representative sample showing minor proportion of sulphide-sulphide and sulphide-gangue locking. X 175, Parallel Light, reflected Light Microscopy.

Effects of granulometry :

Flotation experiments were carried out to study the effects of granulometry on flotation behaviour of lead and zinc bearing minerals. For this purpose -10 mesh ore sample, wet ground for different length of time in laboratory rod mill, was floated under fixed process conditions as pre-determinerd by trial experimentation[5]. The flotation results are shown in Fig. 4. We can see from this figure, due to better liberation an increase in -74 micron particles in flotation feed from 21.5% to 38.5% showed an improvement in lead and zinc recovery. It was also observed that overall flotation kinetics was better[5]. But a further increase in fineness of feed to 57% -74 micron did not show any favourable results rather it caused a loss in lead and zinc recovery. So a flotation feed consisting of 38.5% particles passing below 74 micron was considered suitable for rougher flotation of lead and zinc bearing minerals from the ore.

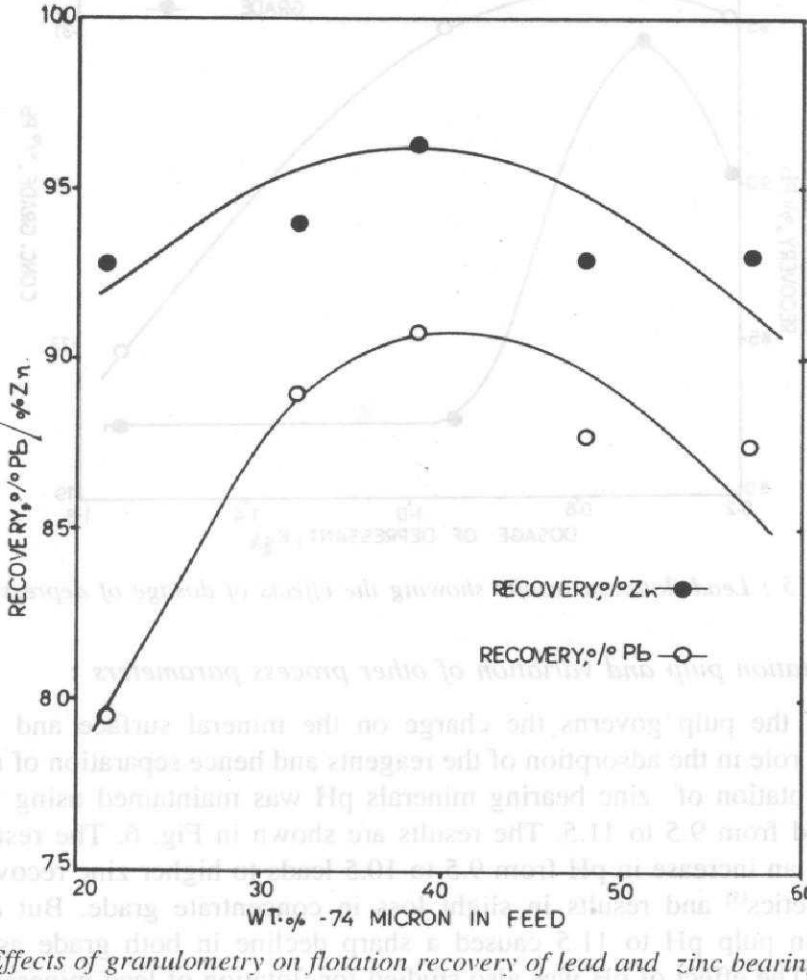

Fig. 4 : Effects of granulometry on flotation recovery of lead and zinc bearing minerals.

Depression of zinc bearing minerals :

As mentioned earlier, a combination of sodium cyanide and zinc sulphate was used as depressant for zinc and selective flotation of lead minerals. The dosage of the depressant was varied from 0.215 kg/t to 1.7 kg/t. The flotation results are graphically shown in Fig. 5. It is evident from the data shown in Fig. 4 that an increase in dosage of depressant from 0.215 kg/t to 0.425 kg/t resulted in improvement in recovery as well as grade of lead concentrate to 95.3% and 30.82% respectively. But a further increase in depressant dosage also caused depression of lead as shown by a sharp fall in grade and recovery of lead.

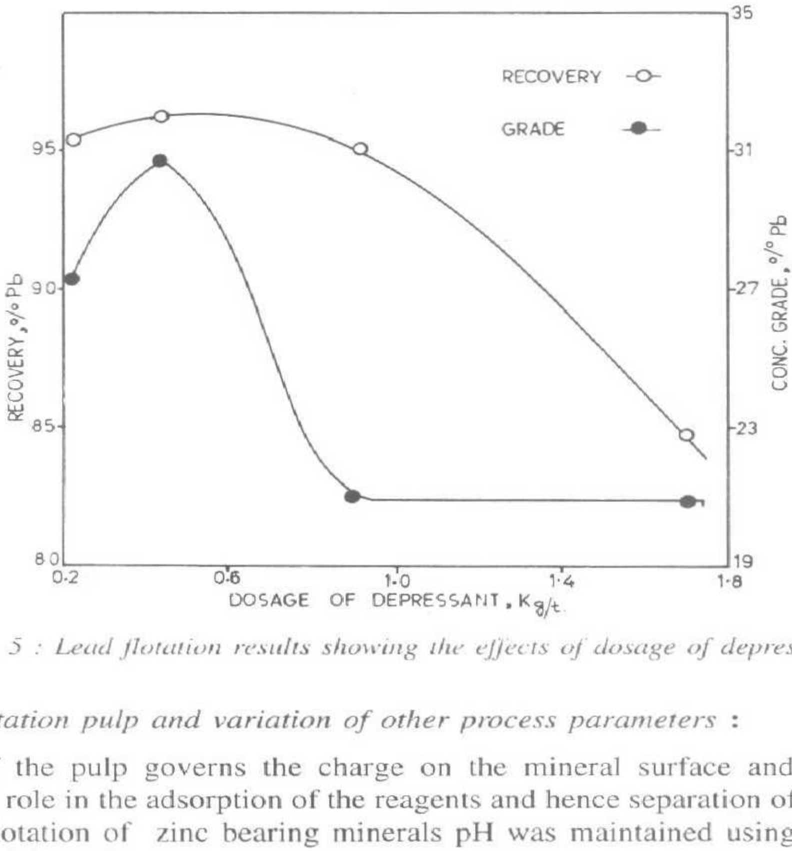

Fig. 5 : Lead flotation results showing the effects of dosage of depressant

pH of flotation pulp and variation of other process parameters :

pH of the pulp governs the charge on the mineral surface and plays an important role in the adsorption of the reagents and hence separation of minerals. For the flotation of zinc bearing minerals pH was maintained using lime and was varied from 9.5 to 11.5. The results are shown in Fig. 6. The results indicated that an increase in pH from 9.5 to 10.5 leads to higher zinc recovery with faster kinetics[5] and results in slight loss in concentrate grade. But a further increase in pulp pH to 11.5 caused a sharp decline in both grade as well as recovery. The effect of pH was also studied for flotation of lead minerals. A pH of 8.5 was considered suitable for effective flotation of lead minerals.

The effects of other process parameters like dosage of activator and collector for flotation of zinc and dosage of collector for lead were studied. The results are discussed elsewhere[5]. The typical lead and zinc rougher concentrates and primary tailings were analysed by X-ray diffraction technique. It is indicated from Fig. 1(b,c.d) and as expexted, the lead and zinc rougher concentrates showed dominance of galena and sphalerite respectively while tailings consisted of dolomite as the major mineral phase.

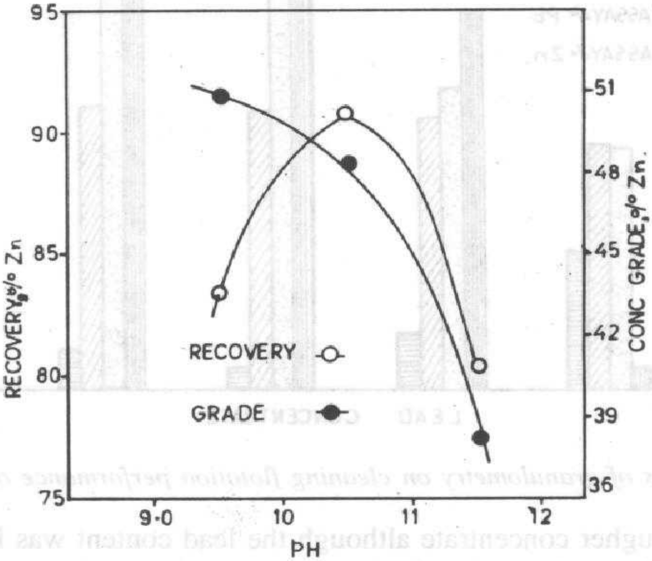

Fig. 6 : Results showing the variation of pH for the flotation of zinc minerals.

Improving grade of lead and zinc concentrates :

As indicated by the liberation data and the microscopic observation in particular, the high zinc content of the lead rougher concentrate was mainly due to locking problem. Hence experiments were carried out to improve the flotation selectivity by grinding rougher concentrate followed by cleaning flotation of the ground product. Cleaning flotation experiment was also carried out using rougher concentrate without regrinding. For flotation of lead the results are schematically shown in Fig. 7. As we can observe from Fig. 7 that two cleaning of the lead rougher concentrate, without grinding (33% -44 micron), resulted in cleaner concentrate with 60.32% Pb and 11.01% Zn. Grinding the lead rougher concentrate to 85.2% - 44 micron, improved the concentrate grade to 65.42% Pb with 5.26% Zn. The improvement in grade was mainly due to enhanced liberation of sulphides at finer particle sizes. However, with further grinding of lead rougher concentrate to 89.6% -44 micron, there was increase in lead content of the concentrate but zinc assay was slightly higher (6.24%). This may be attributed to the flotation of the finely ground zinc minerals due to entrainment and entrapment phenomena. Thus a regrinding size with 85% particles passing below 44 micron was considered suitable for cleaning flotation of lead rougher concentrate.

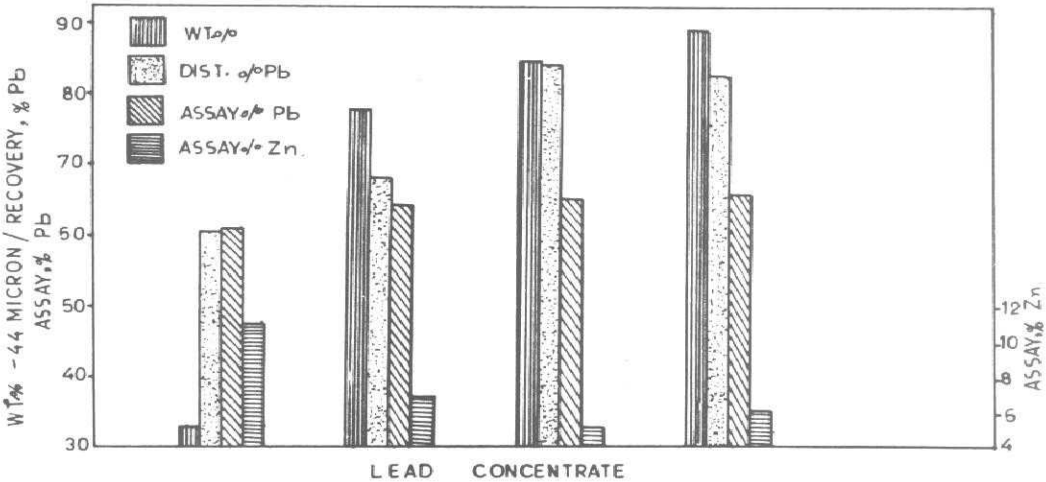

Fig. 7 : Effects of granulometry on cleaning flotation performance of lead minerals

For zinc rougher concentrate although the lead content was low but in order to study the effects of grinding for improving overall grade, regrinding-flotation experiments were carried out. But in this case regrinding of the rougher concentrate adversely affected the flotation performance. It seems due to undesirable activation of pyrite during regrinding, it floated alongwith the zinc minerals. So, for zinc circuit regrinding was not necessary.

Having established the conditions for rougher flotation and the granulometry for cleaning flotation, the next task was to improve the grade of the individual lead and zinc concentrates. Fot this purpose three stages of cleaning were performed for lead rougher concentrate ground to 85% - 44 micron. The final lead concentrate assayed 79.11% Pb with 4.23% Zn and with a lead recovery of 83.4%. The zinc rougher concentrate was subjected to two cleanings resulting in zinc cleaner concentrate analysing 60.08% Zn with 0.12% Pb with a zinc recovery of 80.4%. The metallurgical performance for the cleaning flotation is presented in Table 1.

PROCESS FLOW-SHEET

Based upon the studies undertaken a flotation based process was recommended for the concentration of lead-zinc ore sample under consideration. The schematic process flow-sheet is shown in Fig. 8. As required for the commissioning of the flotation plant, various data pertaining to physical, grinding, settling and filtration characteristics of the ore and concentrates were generated and are discussed elsewhere[5].

Table 1 : Metallurgical performance for cleaning flotation

Products	Wt. %	Assay, %		Dist., %	
		Pb	Zn	Pb	Zn
Pb Cl. Conc. III	2.7	79.11	4.23	83.4	0.8
Pb Cl. Tails III	0.2	33.40	22.47	2.6	0.3
Pb Cl. Tails II	0.4	16.08	21.50	2.5	0.6
Pb Cl. Tails I	3.2	3.92	20.45	4.9	4.8
Zn Cl. Conc. II	18.1	0.12	60.08	0.8	80.4
Zn Cl. Tails II	1.5	1.84	36.96	1.1	4.2
Zn Cl. Tails I	5.0	1.07	19.53	2.5	7.3
Pr. Tails	68.9	0.08	0.32	2.2	1.6
Head (Calc.)	100.0	2.56	13.53	100.0	100.0

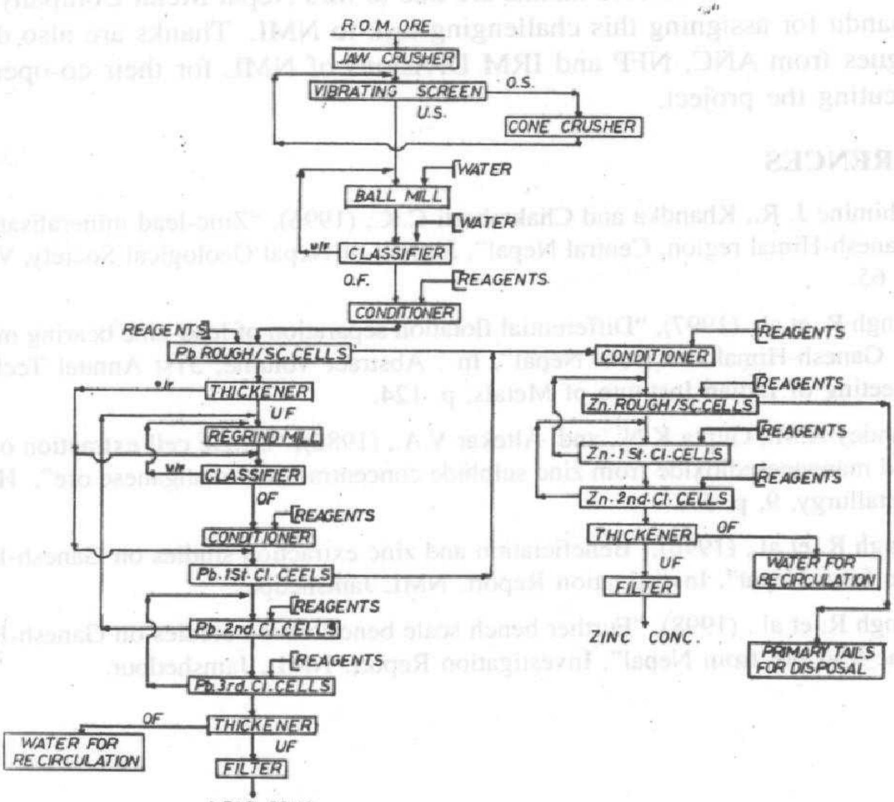

Fig. 8 : Process flow-sheet recommended by NML for concentration of Ganesh-Himal lead-zinc ore from Nepal.

CONCLUSION

Characterisation and flotation studies were carried out on a lead-zinc ore from Ganesh-Himal region of Nepal with a view to design a suitable flotation process for concentration of the sample.

Under the optimum process conditions the lead rougher and zinc flotation recovery were 96.3% and 90% respectively. Multistage cleaning of the rougher concentrates proved helpful in improving the concentrate grade, meeting the required specifications. Based upon the studies undertaken, a differential flotation process was developed for the concentration of the ore to individual lead and zinc concentrates.

ACKNOWLEDGEMENTS

The authors wish to express their sincere thanks to Prof. P. Ramachandra Rao, Director, National Metallurgical Laboratory, Jamshedpur for his keen interest in the work. Their sincere thanks are due to M/s Nepal Metal Company Ltd., Kathmandu for assigning this challenging task to NML. Thanks are also due to colleagues from ANC, NFP and IRM Divisions of NML for their co-operation in executing the project.

REFERENCES

1. Ghimine J. R., Khandka and Chakrabarti C.K., (1996), "Zinc-lead mineralisation in Ganesh-Himal region, Central Nepal", Journal of Nepal Geological Society, Vol 14, p. 65.
2. Singh R. et.al, (1997), "Differential flotation separation of lead-zinc bearing minrals in Ganesh-Himal ore from Nepal", In : Abstract Volume, 51st Annual Technical Meeting of Indian Institute of Metals, p. 124.
3. Pandey A.M., Gupta K.N., and Altekar V.A., (1982), "Single cell extraction of zinc and manganesedioxide from zinc sulphide concentrate and manganese ore", Hydrometallurgy, 9, p. 57.
4. Singh R. et al., (1996), "Beneficiation and zinc extraction studies on Ganesh-Himal ore from Nepal", Investigation Report, NML Jamshedpur.
5. Singh R. et al., (1998), "Further bench scale beneficiation studies on Ganesh-Himal zinc-lead ore from Nepal", Investigation Report, NML, Jamshedpur.