The use of large OK-16 flotation machines at the concentrators of Outokumpu Oy

by O. KORHONEN* and T. LESKINEN* (Visitors)

SYNOPSIS

The development of the OK–16 flotation machine is described briefly, and an account is given of its use at various concentration plants in Finland. The benefits arising from the use of larger flotation machines are listed, and the technical specification of the OK–16 machine is detailed in an appendix.

SAMEVATTING

Die ontwikkeling van die OK–16 flottasietoestel word kortliks beskryf en daar word verslag gedoen oor die gebruik daarvan by verskillende konsentrasie-aanlegginge in Finland. Die voordele wat voortspruit uit die gebruik van groter flottasietoestelle word opgenoem en die tegniese spesifikasie van die OK–16-toestel word in 'n aanhangsel uiteengesit.

INTRODUCTION

In the 1960s, when large flotation machines appeared on the market, this was a part of a world-wide trend towards the use of ever-larger machine units. One factor that has played a decisive part in this development is the increase in the amounts of ore that have to be handled as the exploitation of ever-poorer ores becomes necessary. The application of instrumentation and automation has increased in the same way.

In 1970, a working group was set up within Outokumpu Oy for the development of flotation machines. The principal task of the group was the design and development of

— a new type of rotor of increased efficiency, especially for the dispersion of large amounts of air, and
— a mechanical–pneumatic flotation machine that would be substantially larger than the existing plant.

This development project required an extensive programme of theoretical investigation and experimental studies at several concentration plants of the company.

The commonest flotation machine at present used in the concentration plants of Outokumpu Oy is the VK 3. It is of the mechanical–pneumatic type, and the volume of its cell tanks is 2,5 m³ per shaft. This machine was developed within the company, and its first development phase is represented by the OKKO 3, which was built for the Kotalahti concentrator in 1959. It was comparable in volume with the largest machines then in use anywhere in the world.

The object in the design of a large flotation machine was the achievement of a flotation yield for the combined tank volume that would be at least equal to that attained by smaller machine units. As the cell tank becomes larger, the main difficulties encountered are in keeping the pulp in suspension and providing sufficient aeration of the pulp. Accordingly, the first task was to develop a new agitating mechanism that would be more efficient than the existing mechanisms.

The design of the new rotor is based on a physical theory that describes the conditions in which large amounts of air can be dispersed into the whole volume of the flotation machine. The exceptional feature of the design is that the dispersion of air takes place on the whole surface of the rotor slots rather than from a narrow zone.

In addition, a mathematical model has been developed to assist in the dimensioning of the drive mechanisms for flotation machines having different sizes of cell tanks.

The rotor is of such a design that it produces, in addition to good air dispersion, a vigorous internal circulation of the slurry with moderate speeds of rotation. The power consumption of the rotor depends on its rotational speed and on the circulation of slurry produced. When there is no circulation of slurry at all, the power is proportional to the square of the rate of rotation; on the other hand, the power required to circulate the pulp is proportional to the amount of circulating pulp. Thus, a large quantity of pulp can be circulated with relatively low speeds of rotation. The air feed and the amount of air in the cell can be increased with increasing circulation.

The studies for the testing and comparison of different types of rotor were conducted on a flotation machine with glass walls. The finishing touches were put to the new design while the machine was operating in normal flotation service at the concentration plants.

EXPERIENCE AT OUTOKUMPU OY

The use of OK–16 flotation machines by Outokumpu Oy is summarized in Table I. At Keretti, a test run was conducted on a factory scale in the spring of 1972. The results obtained were used in the finalization of the technical details of the OK–16 flotation machines for the Hammaslahti concentration plant, which was started up in March 1973. Further OK–16 flotation machines were installed at the Lahnaslampi talc concentrator of Suomen Talkki Oy, Finland, in March 1974, at the Vuonos and Vihanti concentrators in August and October 1974, at the Hitura concentrator in November 1974, and at the Pyhäsalmi concentrator in February 1975.

The Keretti Test Run

The prototype machine under test comprised four 16 m³ cell tanks, and it was used for both the roughing and the scavenging flotation of copper, replacing Fagergren

*Outokumpu Oy, Tapiola, Finland.

TABLE I

OK–16 FLOTATION MACHINES AT OUTOKUMPU OY

Concentrator	Annual Capacity t	Grade of ore	Grind %–200 mesh	Feed of air m^3	No. of cell tanks	Use
Keretti (test run)					4	Roughing and scavenging
Hammaslahti	400 000	1 % Cu	50	20	2×4	Roughing and scavenging*
Vuonos		0,18 % Ni	40	10–20	4 4 4	Roughing Middling Scavenging
Vihanti	500 000	(1) 0,5 % Cu 0,5 % Pb 6 % Zn (2) Dissem-inated Cu ore	55–60	<5	4 4 4 4	Cu–Pb bulk roughing Cu–Pb bulk scavenging Zn roughing Zn scavenging
Hitura	300 000	0,6 % Ni	65–70		8 8	Roughing Scavenging
Pyhäsalmi		0,7 % Cu 2 % Zn 32 % S	65–70		8 8	Zn roughing Zn scavenging

*The rough concentrate is cleaned in two four-section VK 3 flotation machines.

machines with cell tanks of 2,5 m^3.

The experiments proved that the flotation under all conditions was at least as good as that obtained during regular operation. On the basis of these trial runs, improved selectivity and successful flotation of extremely fine grain sizes were found to be typical features of the OK–16 flotation machine.

The Hammaslahti Concentrator

The Hammaslahti concentration plant treats 400 000 t of copper ore annually. The ore has a copper content of about 1 per cent. The roughing and scavenging stages are each equipped with one four-section OK–16 flotation machine. Cleaning of the rough concentrate is carried out in two four-section VK 3 flotation machines, the scavenger concentrate and the tailings from the cleaning stage both being returned to the beginning of the roughing stage (Figs. 1 and 2). The copper content of the final concentrate is about 25 per cent and the copper recovery is more than 96 per cent.

The operation of the OK–16 flotation machines was smooth and trouble-free from the start, both mechanically and from the control point of view. During the two years the cells have been operating, no wear in the rotor, stator, or the machine itself has been noticed. The feed of flotation air into the OK–16 cells has been about 20 m^3 per cell and is very abrasive. The host rock is quartzite (over 90 per cent of the ore), and the degree of grinding is only 50 per cent minus 200 mesh. Automatic level control is used on both machines, being based on pressure measurement and a control valve with a pneumatic actuator.

The Vuonos Concentrator

At the Vuonos nickel concentrator, a comparative test was carried out in the autumn of 1973 using the prototype machine, as well as the VK 3 flotation machines, for rough flotation.

The consumption of energy was reduced by 25 per cent, and the nickel recovery was increased by 11 per cent (Table II). On this basis, the OK–16 flotation machine was selected to replace the VR 3 flotation machines in nickel rougher and scavenger flotation.

The circuit consists of

4 cells in nickel rougher flotation
4 cells in nickel middling flotation
4 cells in nickel scavenger flotation.

The circuit today handles 140 t/h (new feed) of ore having a nickel content of 0,18 per cent. The degree of grinding is only 40 per cent minus 200 mesh (30 per cent plus 65 mesh),

TABLE II

COMPARATIVE RESULTS OF ROUGHER FLOTATION MACHINES AT VUONOS NICKEL CONCENTRATOR

Data	Flotation machine	
	OK–16	VK 3
Feed rate, t/h	100	
Units, no.	1	6
Total cell volume, m^3	60	
Energy, kWh/t	1,5	2,0
Nickel in ore, %	0,17	
Nickel in concentrate, %	2,5	1,7
Nickel in tailings, %	0,07	0,09

and the mineral-dressing characteristics are very difficult. However, the results compare favourably with the results from a parallel circuit of VK 3 machines treating 'easy handling' ore.

The feed of flotation air has varied from 10 to 20 m^3 per cell.

The Vihanti Concentrator

The Vihanti concentrator treats two types of ore: copper–lead–zinc ore and disseminated copper ore. The copper–lead–zinc ore contains 0,5 per cent copper, 0,5 per cent lead, and 6 per cent zinc, and the annual capacity is 500 000 t of ore. The degree of grinding is 55 to 60 per cent minus 200 mesh.

At Vihanti, the OK–16 flotation machines are used as follows:

4 cells in copper–lead bulk rougher flotation

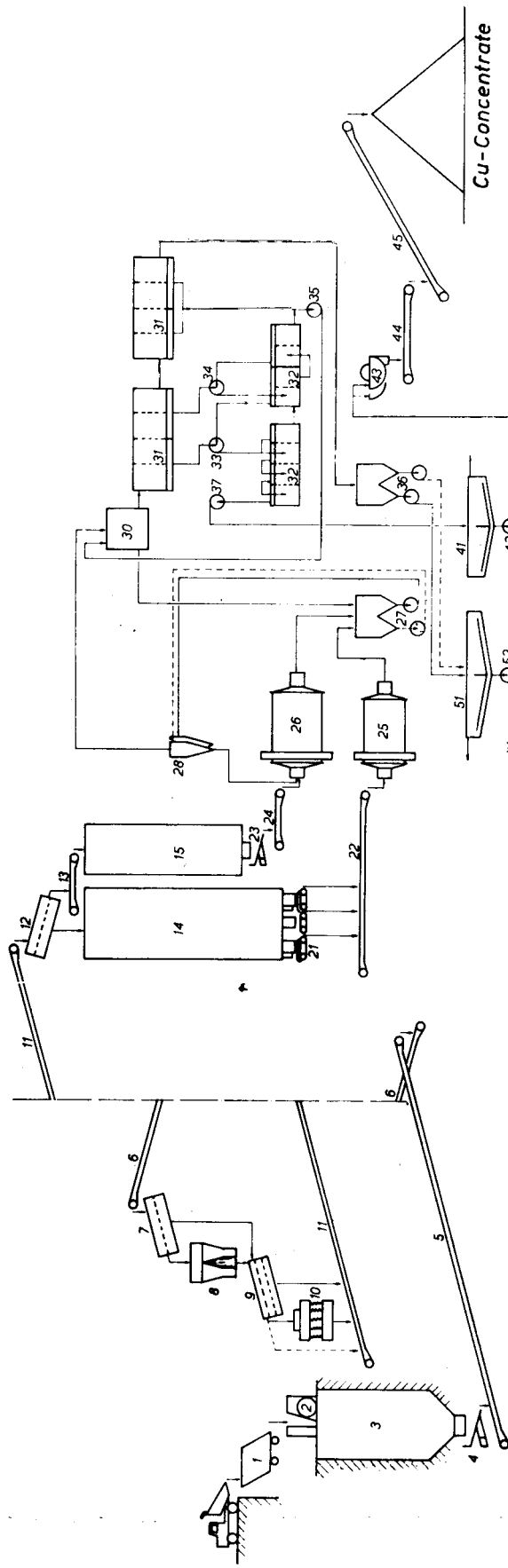

Fig. 1—The flowsheet for the Hammaslahti mill. No. 31 represents two OK-16 four-cell flotation machines for rougher and scavenger flotation, and 32 represents two OK-3 four-cell flotation machines for cleaner and recleaner flotation.

4 cells in copper–lead bulk scavenger flotation
4 cells in zinc rougher flotation
6 cells in zinc scavenger flotation.

In the short operating period, the feed of flotation air has been very low, only up to 5 m³. Larger amounts decreased the content of valuable metals in the bulk rougher concentrate.

The Hitura and Pyhäsalmi Concentrators

The Hitura concentrator annually treats 300 000 t of ore having a nickel content of 0,6 per cent. The degree of grinding is 65 to 70 per cent minus 200 mesh.

The OK–16 machines at Hitura are used as follows:

8 cells in nickel rougher flotation
8 cells in nickel scavenger flotation.

The corresponding figures for the Pyhäsalmi concentrator are:

8 cells in zinc rougher flotation
8 cells in zinc scavenger flotation.

The above circuit handles 140 t of new feed of ore. The contents are 0,7 per cent copper, 2 per cent zinc, and 32 per cent sulphur. The degree of grinding is 65 to 70 per cent minus 200 mesh.

CONCLUSIONS

A change to larger machines generally results in a number of obvious advantages, the most important being the smaller number of machines, ancillaries and instruments, and the lower initial operating and maintenance costs. These, together with the main technical particulars of the OK–16 flotation machine, are listed in the Appendix.

The following are typical benefits from the use of OK–16 flotation machines:

— Low operational costs as a result of a low consumption of energy and negligible wear. In the experience of Outokumpu Oy, the consumption of energy has been only 14 to 25 kW per shaft. No replacement of any parts has been necessary during two years of operation.
— The machine can be started with a full load after a power failure at a plant, even if all the solid material has settled.
— The new rotor can disperse exceptionally large amounts of flotation air. Up to 25 m³ per shaft have been dispersed with a blower power of 5 to 10 kW per shaft.
— No sanding problems have been noticed.
— The closed structure of the machine has resulted in clean operating conditions at the concentrators.

The practical results obtained with a large flotation machine are so encouraging that the OK–16 will be the flotation machine mainly

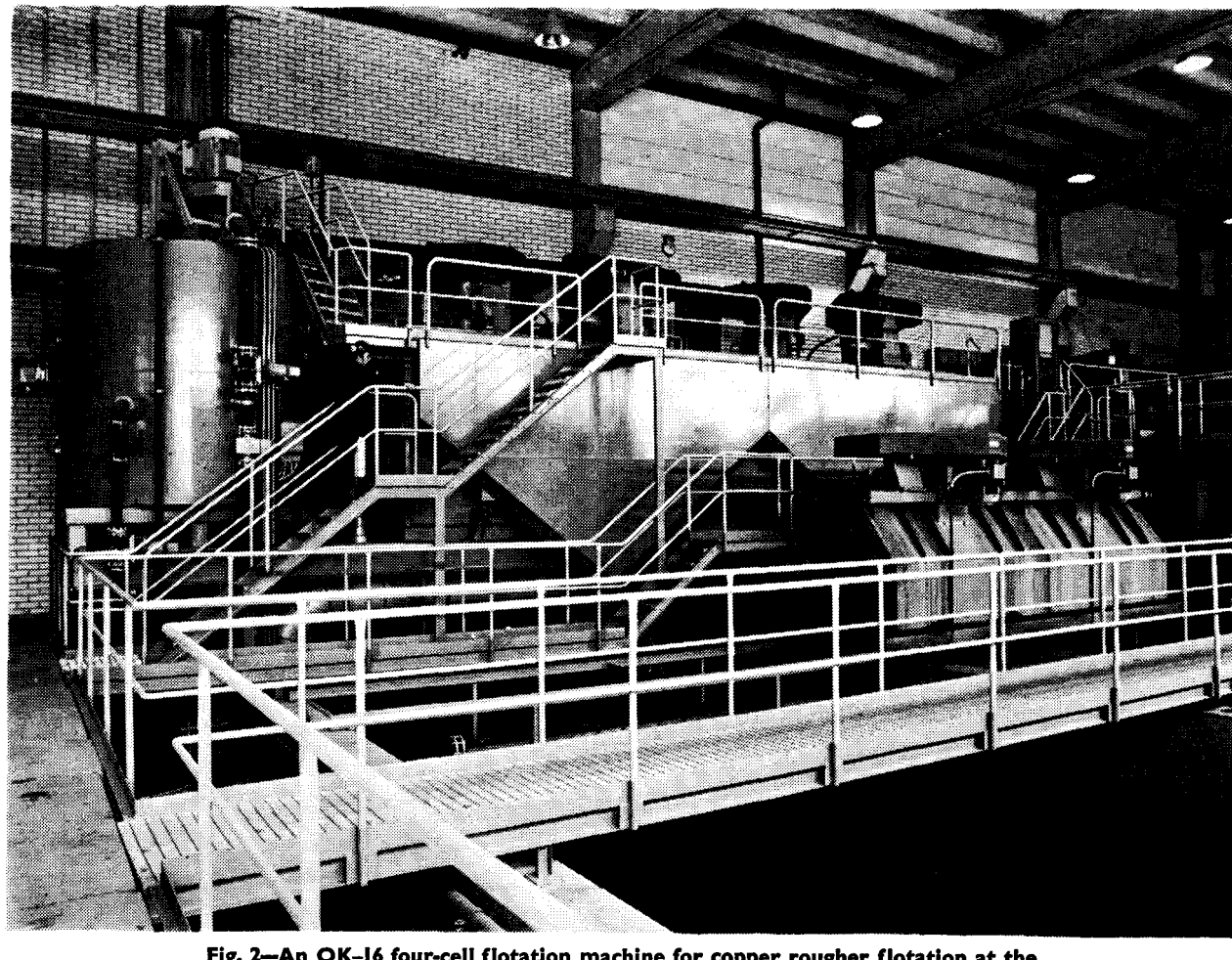

Fig. 2—An OK–16 four-cell flotation machine for copper rougher flotation at the Hammaslahti concentrator. The covers of the machine serve as walkways. Note the heavy-duty construction of the launders, which are used as pump sumps. An OK–3 four-cell flotation machine for cleaner flotation is seen in front.

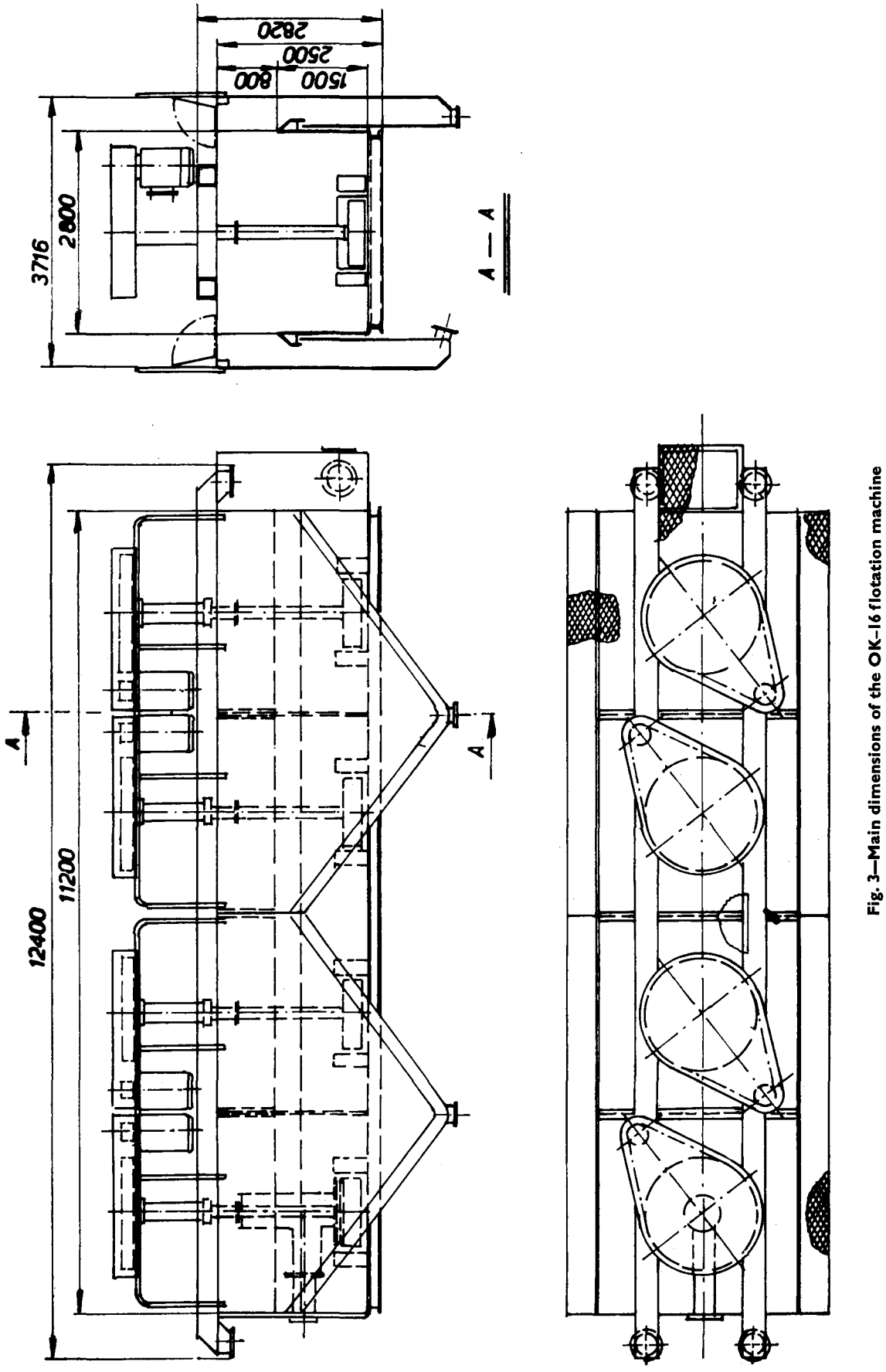

Fig. 3—Main dimensions of the OK-16 flotation machine

used in future concentration plants of the company. The present VK 3 machines will gradually be equipped with rotors of the new type discussed above, and their designation will then be OK–3. This machine will be manufactured for use mostly as a cleaning machine.

APPENDIX

TECHNICAL PARTICULARS OF THE OK–16 FLOTATION MACHINE

Main Dimensions (Fig. 3)

— Inner dimension of cell 2,8 by 2,8 m.
— Height of cell up to the cover 2,3 m.
— Height of cell up to the froth border normally 2,1 m (adjustable between 1,5 and 2,2 m).
— Volume per cell about 16 m^3, i.e., about 600 ft^3.
— The machines are normally made of units of 4 cells. When arranged one after another, the units should be located step by step at height differences of 0,5 m.

Weights and Power

— The weight of a complete unit of 4 cells with shafts, concentrate launders, and motors (but without slurry) about 32 t.
— The weight of the cell part of the above unit about 12,5 t (the heaviest individual component).
— The weight of a unit of 4 cells in operating conditions filled with slurry when the volume weight of slurry is taken at about 1,5 about 130 t.
— Motor power 30 to 45 kW per 1000 r/min, one motor for each cell. V-belt drive. The speed of the rotor is 150 to 170 r/min.
— Power consumption for each shaft (motor) in normal operation about 15 to 25 kW.
— Blower power for each shaft 5 to 10 kW.

Compressed Air for Flotation

— Air pressure needed about 0,2 atm. (2 m w.g.).
— Air consumption for each shaft in normal operating conditions about 10 to 25 m^3/min. Feed of even larger amounts of air and complete dispersion into the slurry are possible if needed.

Other Design Features

— In normal construction, concentrate is skimmed from both sides of the cell. One-sided skimming is also possible if required.
— The flotation machine can be provided with a complete cover. The structure of the machine is closed.
— Suction can be arranged below the cover. In this way the dirty air that is liberated from the slurry can be prevented from spreading in the concentrator building. The covers are also used as walkways. The parts of the flotation machine that are subject to wear are rubber-lined. The cell can also be lined with rubber if desired.
— The machine is provided with automatic pulp-level control.
— It is not necessary to empty the machine of slurry when the operation is stopped. It can also be restarted easily after a sudden disturbance with a full load.
— The launders can be used as pump sumps.
— So far the flotation machine has been used for pulp flows of up to 8 m^3/min. This corresponds to a feed rate of about 160 t/h. Considerably larger amounts are possible if required. The parts connecting one 4-cell unit to the next are dimensioned according to the capacity range desired.

Advantages of Large Flotation Machines

— The number of flotation-machine units is lower.
— The number of necessary ancillaries (pumps, slurry distributors, samplers, feeders, chemicals, etc.) is lower.
— The floor area needed is smaller.
— The instrumentation of the flotation circuit is less expensive and the automatic control is easier when several parallel flotation machine rows in the same function are not needed.
— The power consumption per volume is lower.
— Less adjustment work is needed.
— Operating costs are lower.
— Capital costs are lower.
— Concentrating results are better. It is easier to use long flotation times when necessary.

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