CAPIRO AS

Calculations for CAPIRO Flotation Machine and Flotation Mechanisms scale-up and determination of Flotation retention time.

Scale-up of CAPIRO Flotation Machines and Mechanisms.

The scale-up factors for Flotation Machine sizes which have been used since 1930 upon today are in my opinion not correct any more.
These scale-up factors are based on scale-up from Laboratory Flotation Machines with a cell-box size of approximately 2 - 28 litre to plant size Flotation Machines.
The plant size Flotation Machines are today much bigger than the sizes which were used until the late 1980.
The old scale-up factors for the volumes necessary were approximately 2 X the laboratory test results.
For scale-up from Laboratory size Flotation Machines to Plant size Flotation Machine up to 5 m^3 the above scale-up table can be correct.
For scale-up factors from laboratory-sized flotation machines to plant-sized flotation machines with large flotation volumes, the aeration factor and froth surface area for large flotation cells will be an important issue.

Table 2: Comparison of optimum flotation times in the laboratory and in the plant (Metso, 2006)

Material Floating	Flotation Times in Industrial Rougher Flotation Cells, Minutes	Usual Laboratory Flotation Times, Minutes
Barite	8 – 10	4 – 5
Coal	3 – 5	2 – 3
Copper	13 – 16	6 – 8
Effluents	6 – 12	4 – 5
Fluorspar	8 – 10	4 – 5
Feldspar	8 – 10	3 – 4
Lead	6 – 8	3 – 5
Molybdenum	14 – 20	6 – 7
Nickel	10 – 14	6 – 7
Oil	4 – 6	2 – 3
Phosphate	4 – 6	2 – 3
Potash	4 – 6	2 – 3
Sand (impurities floated)	7 – 9	3 – 4
Silica (from iron ore)	8 – 10	3 – 5
Silica (from phosphate)	4 – 6	2 – 3
Tungsten	8 – 12	5 – 6
Zinc	8 - 12	5 – 6

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Model	Standard Drive (1)	Cell volume (2)		Connected motor (3)		Air requirements (4)			
		m3	ft3	kW	HP	Am3/min	kPag	Acfm	psig
RCS 3	VB	3	105	11	15	2	17	70	2,5
RCS 5	VB	5	175	15	20	3	19	110	2,8
RCS 10	VB	10	355	22	30	4	22	140	3,2
RCS 15	VB	15	530	30	40	6	25	210	3,6
RCS 20	VB	20	705	37	50	7	27	250	3,9
RCS 30	VB	30	1060	45	60	9	31	320	4,5
RCS 40	VB	40	1410	55	75	10	34	350	4,9
RCS 50	VB	50	1765	75	100	12	38	420	5,5
RCS 70	VB	70	2470	90	125	15	41	530	5,9
RCS 100	GB	100	3530	110	150	19	47	670	6,8
RCS 130	GB	130	4590	132	200	23	51	810	7,4
RCS 160	GB	160	5650	160	200/250	25	55	880	8,0
RCS 200	GB	200	7060	200	250	30	59	1060	8,6
RCS 300	GB	300	10595	250	335	38	67	1342	9,8
RCS 600	GB	600	21190	450	600§	50	85	1765	12,4

(1) VB - spindle bearing with V-belt drive GB - gearbox with direct drive
(2) Active flotation volume
(3) Per cell and applicable up to 1.35 slurry sg. If higher slurry sg, consult Metso
(4) Per cell and applicable up to 1.35 slurry sg. If higher slurry sg, consult Metso Air requirement is at flotation mechanism, pressure losses from blower to flotation bank should be considered when specifying blower

Air consumption Flotation		
m3	Air/m3/min	Aeration Factor
3	2	0.667
5	3	0.600
10	4	0.400
15	6	0.400
20	7	0.350
30	9	0.300
40	10	0.250
50	12	0.240
70	15	0.214
100	19	0.190
130	23	0.177
160	25	0.156
200	30	0.150
300	38	0.127
600	50	0.083

The picture on the left shown Metso-Outotec's information regarding the energy and air consumptions for different Flotation Cell sizes.

The Air Factor figures on the right showing the air consumption in Nm^3 per m^3 Cell volume.

This means that there will be approximately 8 times more air which will be used to float the minerals to the surface of a 3 m^3 cell compared with a 600 m^3 Flotation cell.

In addition to the different Aeration Factor for larger Flotation Cells the depts of the big Flotation machines have a big influence on the time for the air-bobbles to raise to the surface of the Flotation Cell.

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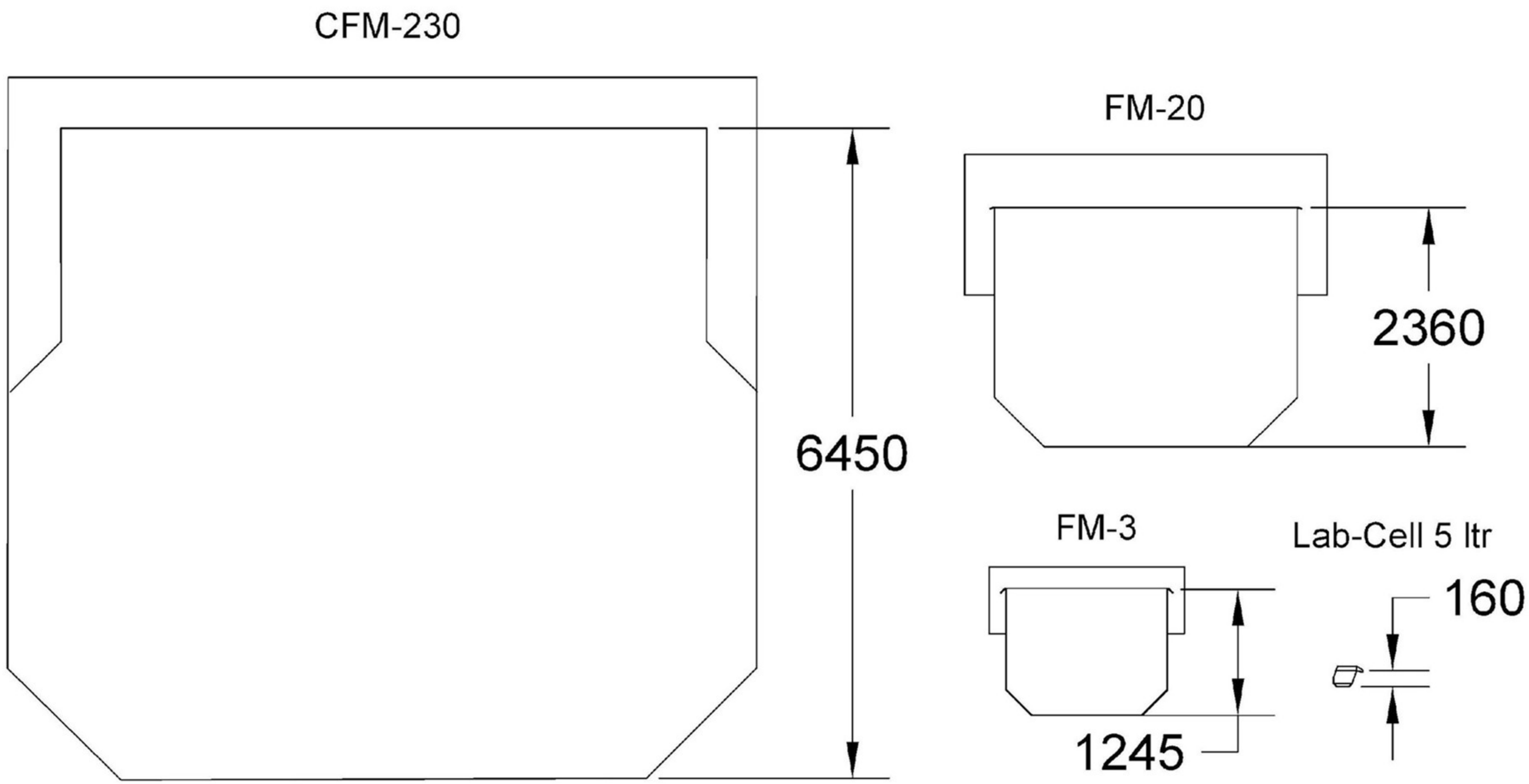

The average depth of a 1 –3 m^3 Flotation Cell is 1 meter and the dept of a 230 m^3 Flotation Cell is 6,45 meters.

This is also a factor which should be taken in consideration when scaling-up retention times.

The advantages of large flotation cells compared to smaller cells are extremely overrated. I have my doubts if the efficiency is as claimed. The only positive thing about Big Flotation Cells is smaller footprint and cheaper to produce 1 Big Cell compared to 4 or 8 smaller Flotation Cells. But what about the performance?

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RELATION BETWEEN SQUAR VS CIRCULAR FLOTATION TANK VOLUME AND FROTH AREA

SQUAR FLOTATION MACHINES VOLUME AND FROTH AREA

Tank Volume m3 (V)	1.00	5.00	10.00	20.00	50.00
Tank Depth % of Length	0.80	0.80	0.85	0.85	0.85
Tank Length and width (L)	1.0772	1.8420	2.2744	2.8655	3.8891
Tank Depth H in meter	0.8618	1.4736	1.9332	2.4357	3.3057
Froth Areal (A)	1.1604	3.3930	5.1727	8.2112	15.1252

CIRCULAR FLOTATION MACHINES VOLUME AND FROTH AREA

Tank Volume m3 (V)	1.00	5.00	10.00	20.00	50.00	100.00	200.00	300.00	600.00
Tank Depth % of Diameter	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
3.141592654	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
Tank Radius (r)	0.56	0.96	1.21	1.52	2.07	2.61	3.28	3.76	4.73
Tank Diameter (D)	1.12	1.92	2.42	3.05	4.14	5.21	6.56	7.52	9.47
Froth Area (A)	0.99	2.89	4.59	7.29	13.43	21.31	33.83	44.33	70.37

In addition to the aeration factor, the surface area of the flotation cell has influence on efficiency.
As can see on the calculations below the surface area for 1 m^3 cells is approximately 1 m^2 which is a surface area factor of 1.
For big volume cells like 50 m^3 this factor is only 0.3 for square cells and 0.27 and is even lower for 600 m^3 cells with a factor of 0.12.

The efficiency of a Flotation Cells depends on several factors, some of the main factors are:

- The creation of fine air bubbles.
- The aeration factor.
- Froth surface area.
- Active froth removal system.
- The surface tension of water which can be adjusted by using the right reagents.
- Efficient agitation.
- Froth-lip lengths.

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xlsx file: Determination of Flotation retention time.

Determination of Flotation Retention time.													
Sg Solids	Solids	Volume Slurry	Volume Solids	Volume Water	%Solids by Volume	%Solids by Weight	Sg Slurry	Laboratory retention time	Scale-up factor	Full plant retention time	Flotation Cell volume required	Cell size	Number of Cells
[t/m^3]	[Ton/hr]	[m^3/hr]	[m^3/hr]	[m^3/hr]	[%]	[%]	[T/m^3]	[min]		[min]	[m^3]	[m^3]	
2.96	47.0	83.51	15.88	67.63	19.01	41.00	1.3727	12	3.5	42	58.46	20	2.92

Determination of Flotation Retention time.													
Sg Solids	Solids	Volume Slurry	Volume Solids	Volume Water	%Solids by Volume	%Solids by Weight	Sg Slurry	Laboratory retention time	Scale-up factor	Full plant retention time	Flotation Cell volume required	Cell size	Number of Cells
[t/m^3]	[Ton/hr]	[m^3/hr]	[m^3/hr]	[m^3/hr]	[%]	[%]	[T/m^3]	[min]		[min]	[m^3]	[m^3]	
2.76	34.0	70.21	12.32	57.89	17.55	37.00	1.3088	12	3.5	42	49.15	10	4.91

Two samples for calculation of the retention time are shown.
This xlsx file will calculate the required retention time, flotation cell volume required and after selected the cell size it will calculate the number of cells for the system.

To be able to determinate the retention time for flotation of minerals we need to have the following information:

- Sg of the slurry.
- Feed rate.
- % of Solids by weight.
- The retention time which has been obtained with laboratory tests.
- Agree on a scale-up factor regarding the retention time.
- Cell size which will be most suitable for the process.