IMHOFLOT

ADVANCED REACTOR FLOTATION

MAELGWYN

WHAT IS PNEUMATIC FLOTATION?

Pneumatic flotation is the **generation** and **attachment** of fine bubbles to particles using the laws of **differential pressure.**

TWO METHODS:

1. **LOW ENERGY** – Air is pumped through porous materials and **fine bubbles** shear off. Fine bubble size but **low-energy** bubble attachment.
2. **MEDIUM – HIGH ENERGY** – Uses the hydrodynamic cavitation caused by passing slurry at high velocities through an aspirated venturi. The higher the venturi energy the finer the bubble size. This gives **ultrafine bubbles** and **high-energy** bubble attachment.

THE SECRET TO SUCESSFUL FINE PARTICLE FLOTATION:

1. **YOUNG BUBBLES** – Fine bubbles alone are **not** enough to float fine particles. Fine bubbles **coalesce** rapidly into larger bubbles. This can be slowed by frother addition, but the key is to achieve bubble-particle attachment when the bubbles are still **"young"** and small.
2. **CLEAN BUBBLES** – Bubble surfaces are rapidly **contaminated** with **fine gangue**, this reduces selectivity for mineral adhesion. Bubble-particle attachment selectivity is correlated with **short times** between bubble formation and attachment.

THE NEED FOR PNEUMATIC FLOTATION

01

HIGH BUBBLE ATTACHMENT ENERGY

The energy of the pump is focused at the point of the venturi aperture. This increases bubble-attachment energy and allows fine bubbles to attach to ultrafine particles without repulsion.

02

IMPROVED METAL RECOVERY

Most metal losses are in the fine fractions. Imhoflot is often fitted as a Scavenger unit to improve fine mineral particle recoveries. As future deposits become more fine-grained and complex, Imhoflot offers a way to maintain recoveries.

03

FASTER FLOTATION KINETICS

Because bubble attachment is optimized and uses high energy, the flotation kinetics are accelerated.
Slow floating mineral particles require less residence time to report to concentrate. Imhoflot circuits have smaller physical footprints, saving on plant capex and infrastructure costs.

04

INCREASED MINERAL SELECTIVITY

Bubble-particle attachment occurs with "young" bubbles soon after they are formed and when they remain "clean" from fine gangue contamination. Mineral selectivity is optimized."

REACTOR FLOTATION DESIGN PHILOSOPHY

Aim: The isolation and then **individual optimisation** of each step of the flotation process.

Conventional mechanical flotation cells combine many steps into the same vessel where the performance is limited by **counteracting forces.**

01 **Slurry conditioning**

02 **Bubble generation**

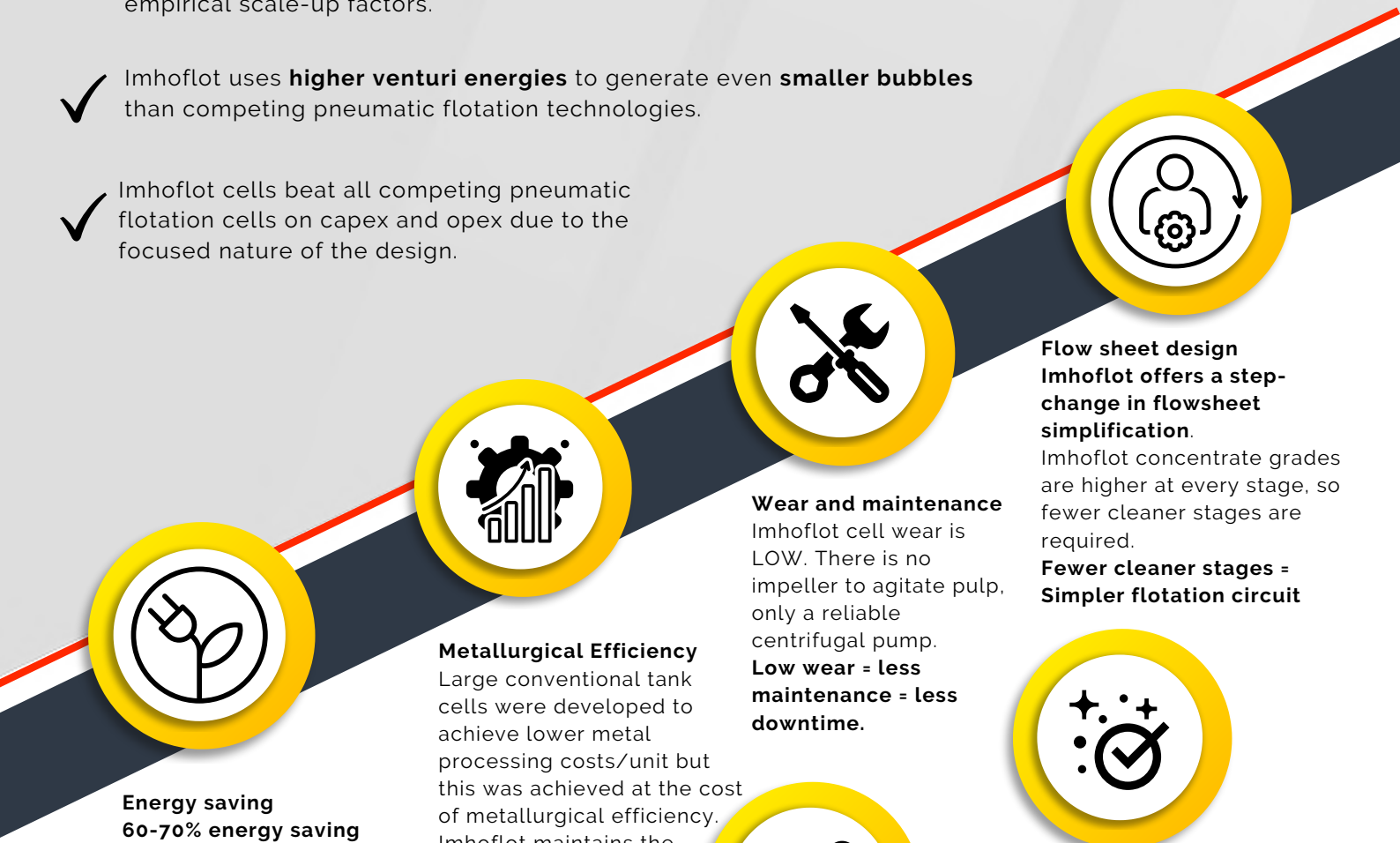
03 **Selective bubble-particle attachment**

04 **Mineralized froth collection**

05 **Tailings handling and/or recycling**

WHAT DIFFERENTIATES IMHOFLOT:

- Imhoflot USP is the **unique high-energy aerator** patented design.
- Imhoflot high-energy aerator achieves the **highest bubble-particle attachment energy** on the market. Over 90% of the pump energy is utilized in bubble attachment.
- Mechanical flotation requires large impellors to keep pulp solids suspended; this results in **increased bubble detachment** and **froth contamination** with fine gangue due to pulp turbulence.
- Imhoflot offers **superior Grade-Recovery** curves.
- Imhoflot test work protocol supports a **1:1 scale-up** ratio from a small pilot scale (200kg) to the industrial range. Imhoflot offers lower engineering risk compared to mechanical cells which apply empirical scale-up factors.
- Imhoflot uses **higher venturi energies** to generate even **smaller bubbles** than competing pneumatic flotation technologies.
- Imhoflot cells beat all competing pneumatic flotation cells on capex and opex due to the focused nature of the design.



Energy saving
60-70% energy saving vs mechanical tank cells. The "Energy Gap" increases even further as tank volume increases. Imhoflot cells have the **lowest CO2 footprint**/metal unit.

Metallurgical Efficiency
Large conventional tank cells were developed to achieve lower metal processing costs/unit but this was achieved at the cost of metallurgical efficiency. Imhoflot maintains the **grade-recovery curve** even at the highest throughputs.

Wear and maintenance
Imhoflot cell wear is LOW. There is no impeller to agitate pulp, only a reliable centrifugal pump.
Low wear = less maintenance = less downtime.

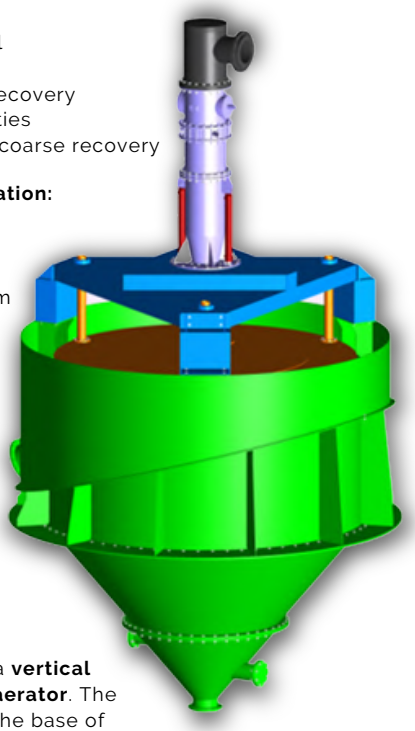
Flow sheet design
Imhoflot offers a step-change in flowsheet simplification.
Imhoflot concentrate grades are higher at every stage, so fewer cleaner stages are required.
Fewer cleaner stages = Simpler flotation circuit

Selective attachment
Bubble attachment occurs when bubbles are still **"young"** and clean of adhered fine gangue particles.

High-shear bubble attachment
Achieves **ultrafine particle-bubble** attachment in **high-shear** environment in the aerator.

Fine bubble generation
Optimized fine bubble generation using **venturi** hydrodynamic cavitation.

V-CELL



The V-Cell is the Imhoflot cell **optimized for:**

1. Superior fine (-38+20µm) recovery
2. High concentrate yield duties
3. Superior coarse and ultra-coarse recovery

Superior coarse particle flotation:

- Base metal = +200µm
- Coal = +500µm
- Potash = +800µm
- Cleaning stage up to 1.2mm

Commodities:

- Potash
- Coal
- Iron ore reverse flotation of silica
- Fluorspar, baryte, magnesite, phosphate

Automated control includes:

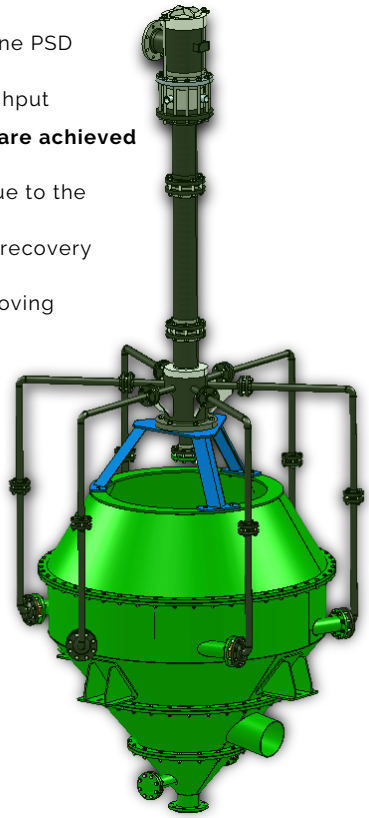
1. Overflow level control
2. Short-circuit prevention
3. Recycling load control

Pulp is fed centrally through a **vertical self-aspirating high-energy aerator**. The pulp distributor is located at the base of the separation zone.

The pulp distributor **spreads the pulp kinetic energy** over multiple nozzles to generate a **low turbulence** upwards flow that prevents gangue entrainment in the froth and keeps the **bubble-particle dissociation coefficient low.**

Froth washing may be added as a design option. A conical froth crowder **permits fine control of froth velocities**. Tailings discharge through a conical hopper which prevents cell "sanding-out"

G-CELL



The G-Cell is the Imhoflot cell **optimized for:**

1. Superior Concentrate Grade
2. Superior recovery of ultra-fine PSD (-20µm)
3. Increased volumetric throughput

Very **high-grade concentrates are achieved through**

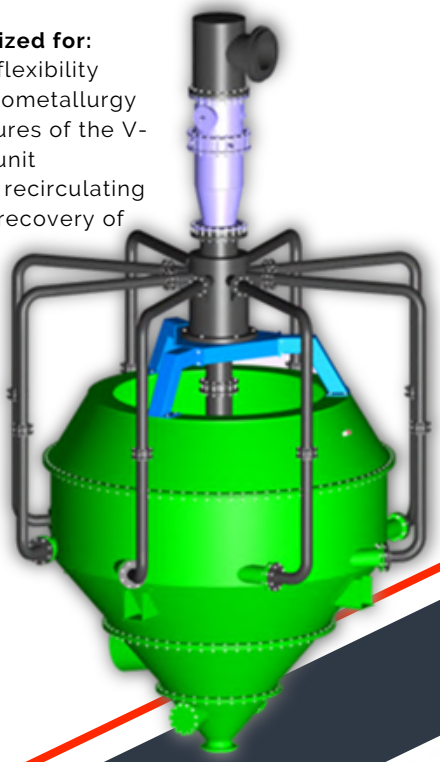
1. Improved fines selectivity due to the High-Energy Aerator
2. Increased ultra-fine mineral recovery (down to 5µm)
3. Improved froth draining removing entrained gangue

G-Cell throughput per cell diameter is limited by the rotational speed induced by the feed volume but can achieve **higher unit volume throughputs** than an equivalent diameter V-Cell.

A dynamic, centrifugal action **improves the mobility of rising air bubbles** which promotes gangue disengagement whilst reducing gangue entrainment in the froth by keeping the pulp-froth interface low in turbulence.

The **high volumetric throughput** of the G-Cell allows smaller footprint cells leading to **smaller flotation plant area and lower plant capex.**

H-CELL



The H-Cell is the cell **optimized for:**

1. Improved process plant flexibility response to changing geometallurgy
2. Combining the best features of the V- and G-Cell into a single unit
3. Facilitating an increased recirculating load, to further improve recovery of "slow floating minerals

Floats coarse and fine together that extends both ends of the **"elephant curve".**

Allows for **flotation circuit flexibility** throughout the mine life as mining progresses through the deposit. This de-risks the project development.

Superior froth handling properties.

"SIMPLE, STABLE, EFFICIENT IMHOFLOT OPERATION IS ACHIEVED BY FOCUSING THE PUMP ENERGY AT EXACTLY THE RIGHT MOMENT"

– DR. R IMHOF, IMHOFLOT INVENTOR.

Approximate flow for G(H)- Cells			
Type	Diameter in m	Min flow in m^3/h	Max flow in m^3/h
G-12	1.2	18	30
G-14	1.4	25	50
G-16	1.6	30	60
G-18	1.8	70	100
G-20	2.0	85	125
G-22	2.2	95	150
G-26	2.6	125	185
G-28	2.8	160	280
G-32	3.2	235	340
G-36	3.6	375	565
G-40	4.0	500	725
G-46	4.6	710	1050
G-50	5.0	900	1350
G-56	5.6	1150	1750
G-60	6.0	1400	2100
G-65	6.5	1700	2500

Approximate flow for V-cells			
Type	Diameter in m	Min flow in m^3/h	Max flow in m^3/h
V-12	1.2	15	25
V-16	1.6	25	40
V-18	1.8	50	80
V-21	2.1	70	110
V-25	2.5	145	210
V-30	3.0	225	300
V-35	3.5	330	450
V-38	3.8	420	600
V-41	4.1	510	730
V-45	4.5	660	950
V-52	5.2	920	1330
V-60	6.0	1300	1870
V-65	6.5	1600	2300

WHAT ARE FINE PARTICLES AND WHY ARE THEY IMPORTANT?

Imhoflot offers improved mineral recovery over mechanical flotation at: ultra-fine, fine, coarse, and ultra-coarse particle flotation.

SIZE	PARTICLE
-5 µm	Slimes
-20+5 µm	Ultra-fines
-38+20 µm	Fines
-105+38 µm	Medium
-250+105 µm	Coarse
+250 µm	Ultra-coarse

PATHWAY TO INSTALLATION

01

Initial Discussions with the local representative

02

Technical Discussions with the Maelgwyn Technical team.

- Define the current metal losses

03

Batch kinetics – Benchscale

- Batch kinetics flotation in Denver cells – 1 kg
- Define the reagent scheme

DIRECT TO PILOT-PLANT

04

Pneumatic flotation – Small Pilot-scale

- Batch flotation – 50 – 200 kg
- Generates a McCabe-Thiele decay curve
- McCabe-Thiele curve defines the flowsheet

05

On-site Pilot-Plant trial

- Multiple sizes of deployable
- pilot-plants from 20 – 450 m^3 /hr
- 3 month trial

06

Detailed Engineering Phase

- Engineers work integrated with client.
- Site visits from Project Delivery Team
- Analysis of impact on downstream processing

07

Fabrication

- Fabrication in Germany under the supervision of Maelgwyn engineers

08

Installation and Commissioning

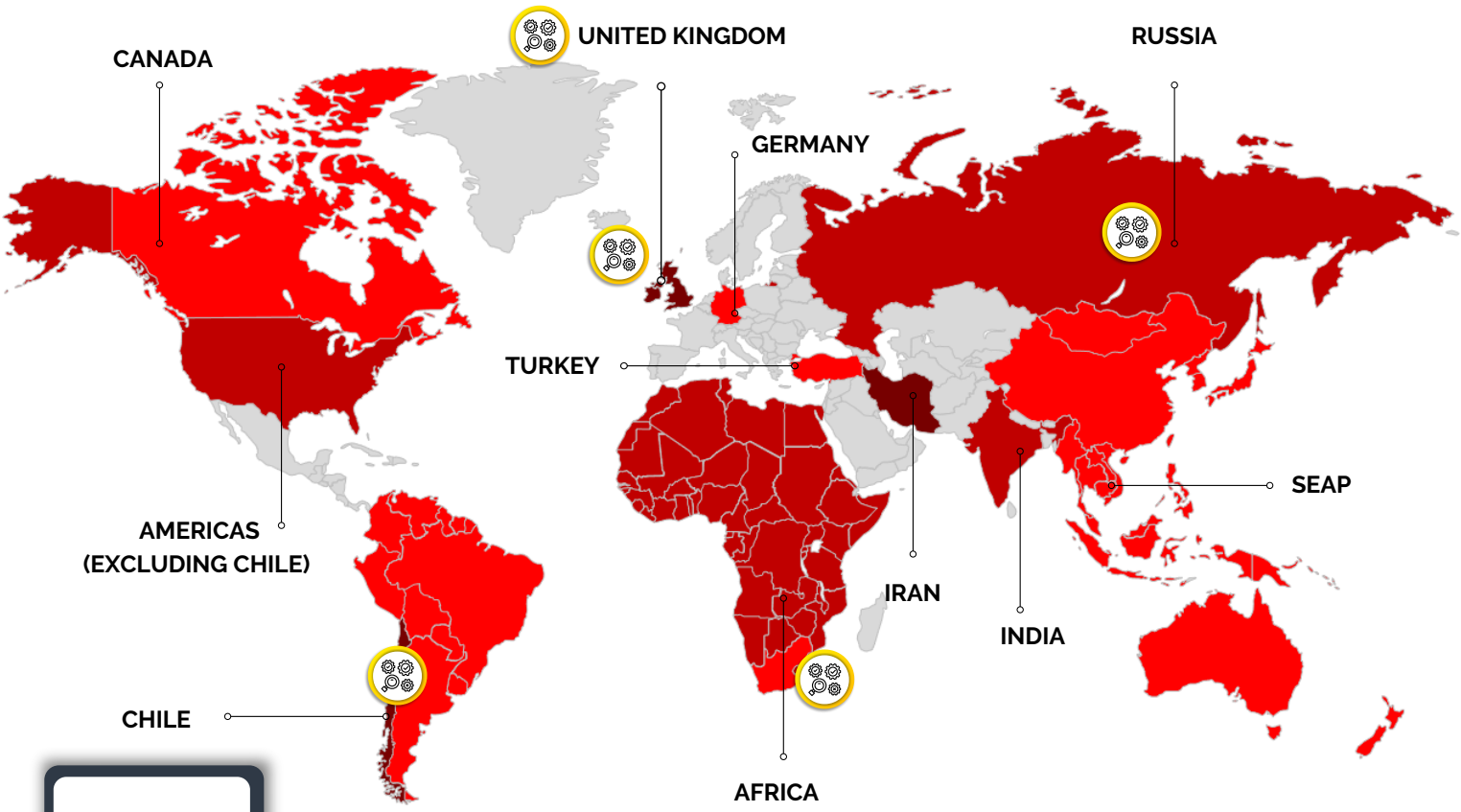
- Project Delivery Team deploy to site
- Commissioning is simple and keeps the Imhoflot installation off the project critical path

09

After-Sales support

- Technical support and advise throughout the life of the installation
- Remote monitoring is an optional extra by installing the Maelgwyn digitalization system

TESTING FACILITIES MAP



CERTIFIED TESTING FACILITIES

- UNITED KINGDOM: CORNWALL
- RUSSIA: TOMS
- AFRICA: JOHANNESBURG
- CHILE: SANTIAGO

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