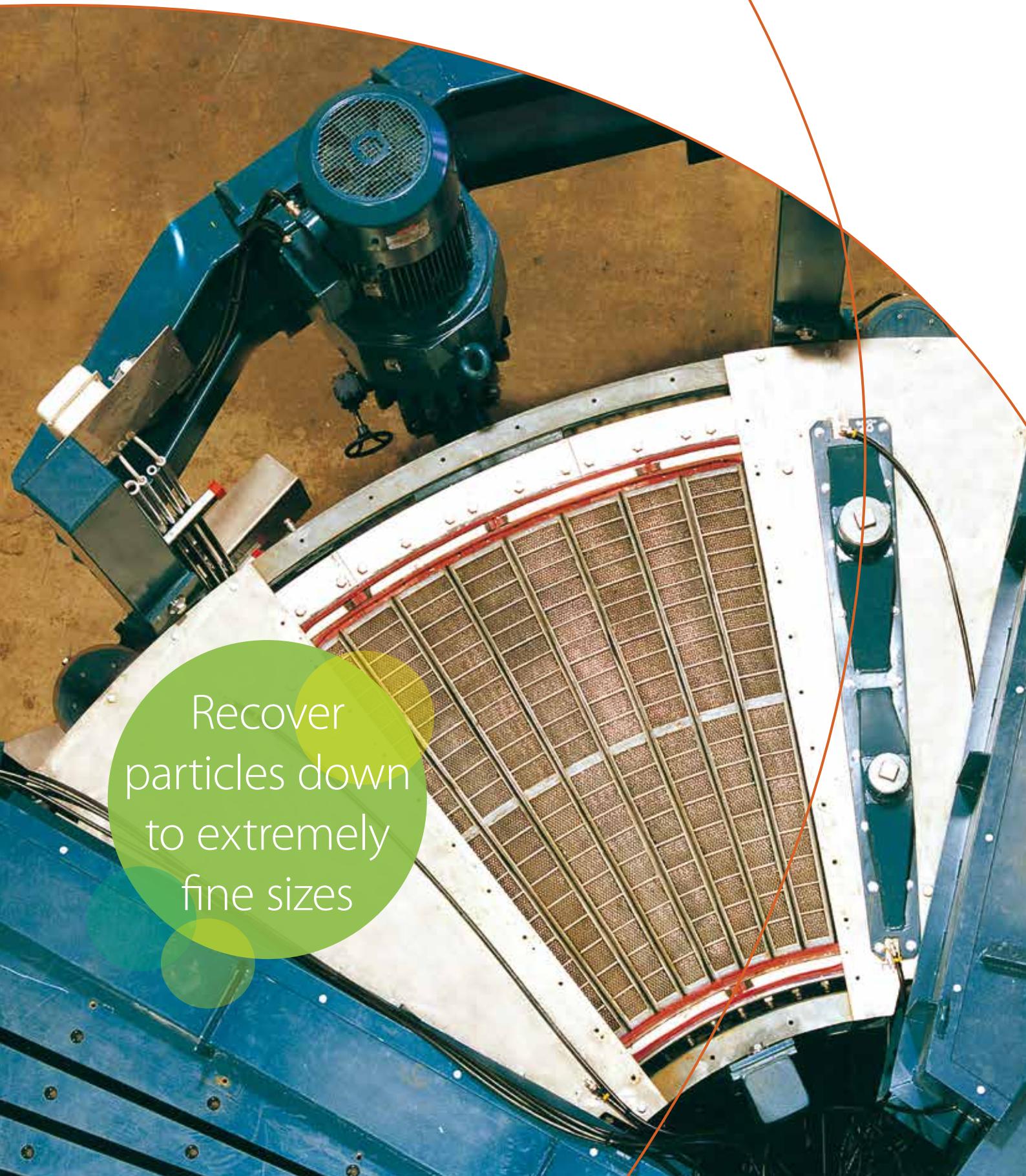


High gradient magnetic separators  
Continuous HGMS



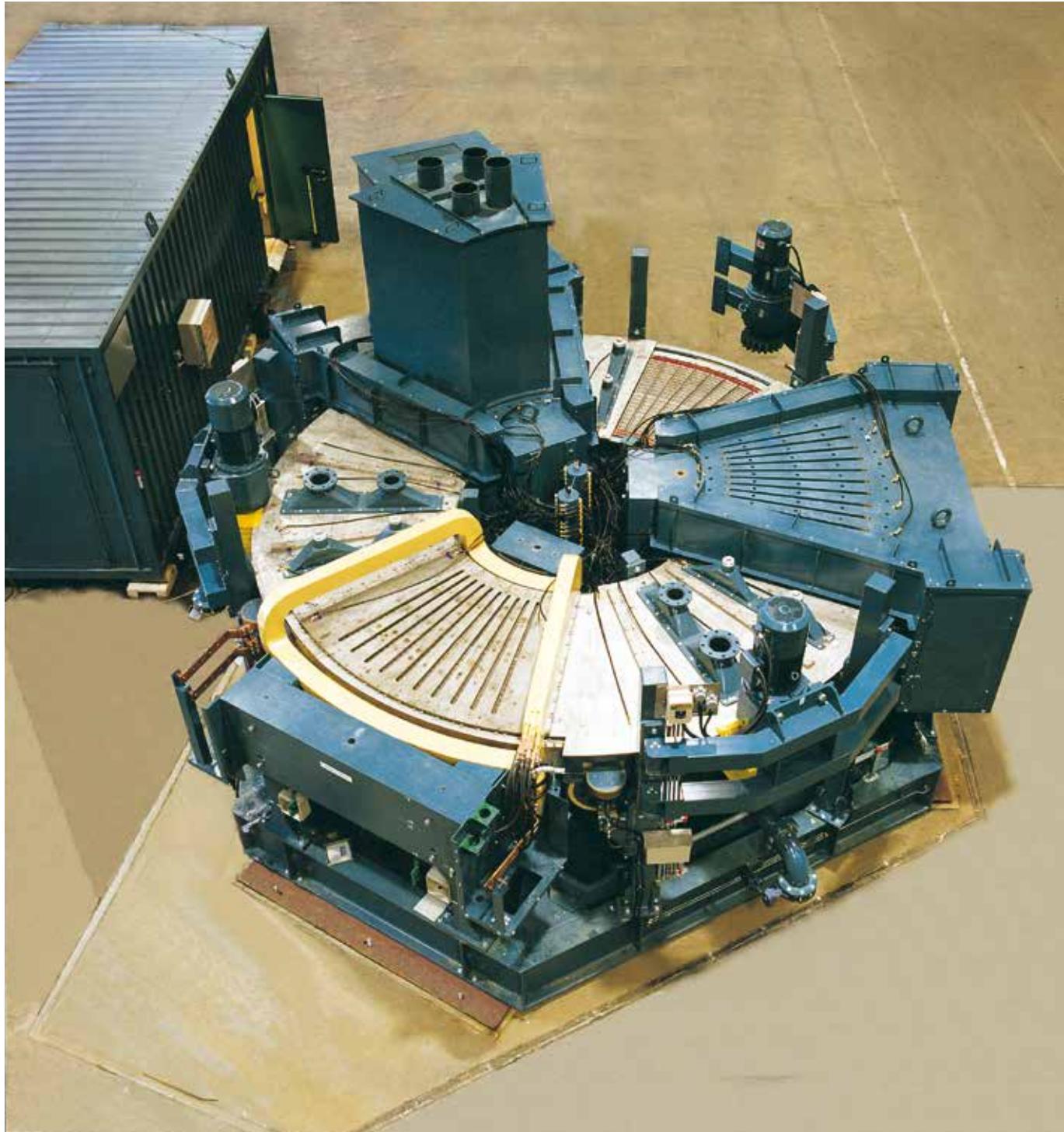
Recover  
particles down  
to extremely  
fine sizes

## High gradient magnetic separation

# Continuous HGMS

Metso (as Sala Maskinfabrik AB, later Sala International AB) has a long tradition in magnetic separation. Already in the end of the 19<sup>th</sup> century "SALA" built its first electromagnetic separator. The High Gradient Magnetic Separation, HGMS, dates

back to early 1970's when "SALA" acquired MEA, Magnetics Engineering Associates, in Cambridge, Massachusetts USA and founded Sala Magnetics Inc.



The HGMS is often indiscreetly referred to as WHIMS (wet high intensity magnetic separator). However there are a lot of differences, which places the Metso HGMS in a separate category:

- Unlike to the WHIMS, HGMS is capable of handling and recovering particles down to extremely fine sizes due to the possibility to choose a suitable matrix grade with large collection area and to control the slurry velocity during the separation process.
- The flushing sequence takes place outside the magnetic zone and this makes the Metso HGMS less sensitive to the content of ferromagnetic material such as magnetite.
- Due to the magnetization direction, the HGMS is also less vulnerable for blocking of the matrix due to bridging over.
- The capacity increases with approximately the square of the diameter of the equipment while the capacity of the WHIMS normally is proportional to the diameter of its rotor.
- The stray magnetic field is a considerably lower around the Metso HGMS compared with the WHIMS for similar duty.
- The wear of the HGMS matrix is extremely low and replacement is normally due after eight to ten years in operation and sometimes even longer.

## Applications

As a lot of minerals are magnetic to some degree and others are associated with minerals that are ferromagnetic or paramagnetic, High Gradient Magnetic Separation can often be used in separation processes where normally difficulties are experienced with other processes. The paramagnetic minerals at the higher end of the list are normally easy to recover. Many low susceptibility minerals are associated with other minerals or have extra Fe in the crystals, and are hence often possible to separate.

As examples of HGMS applications can be mentioned:

- Hematite recovery
- Pyrrhotite extraction
- Chromite fines recovery and / or upgrading
- Ilmenite fines recovery
- Wollastonite upgrading
- Kyanite recovery
- Apatite upgrading
- Sulphide ore recovery and separation

## Principle of separation

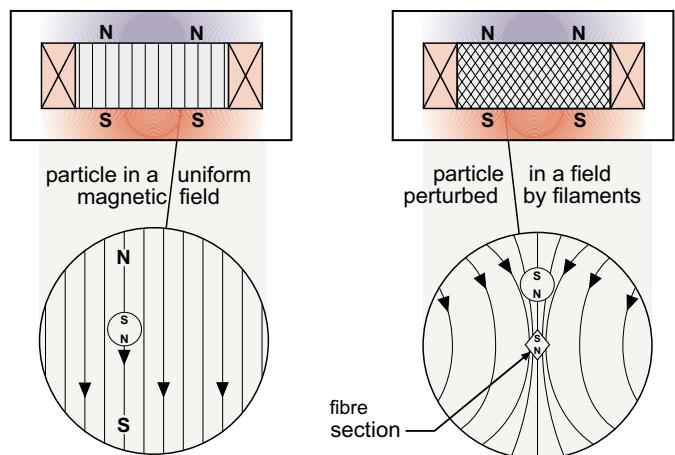
The success of any magnetic separation process is governed by the property of the material to be collected and the structure of the separator to carry out the process. This can be expressed in the relationship between on one side the competing forces and the magnetic force on the other. The magnetic force itself can be expressed as

$$F_m \propto d^3 \cdot \chi \cdot B \cdot \frac{dB}{dx}$$

The above relationship indicates that the magnetizing field, B, and the magnetic field gradient,  $\frac{dB}{dx}$ , are equally important in the

process. The mineral parameters, like the particle "diameter" d, and the apparent susceptibility,  $\chi$ , are as important. The balancing forces in the HGMS process are mainly the hydraulic drag and, to a lesser degree, the gravity force.

The magnetic system of the Metso HGMS produces a uniform magnetic field in the process area. To generate the necessary magnetic field gradient, a matrix of magnetic material with a structure such as expanded metal or steel wool is inserted. A high magnetic field gradient is hereby created around the filament of the matrix. The sharp edges of the matrix material enhance the gradient magnitude.



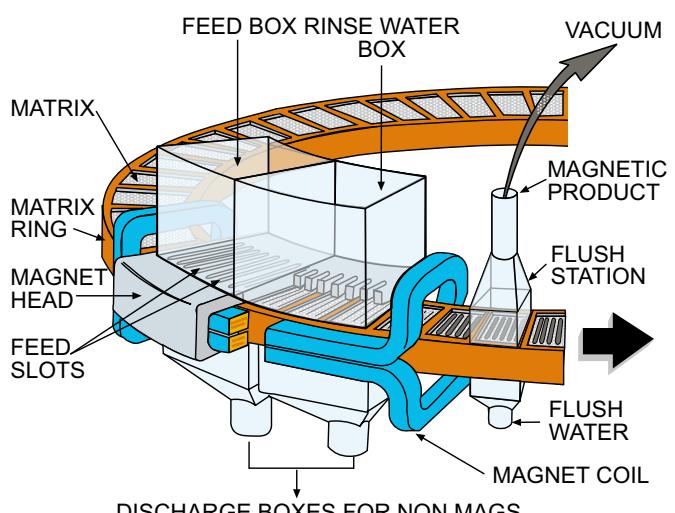
A magnetic particle in a magnetic field

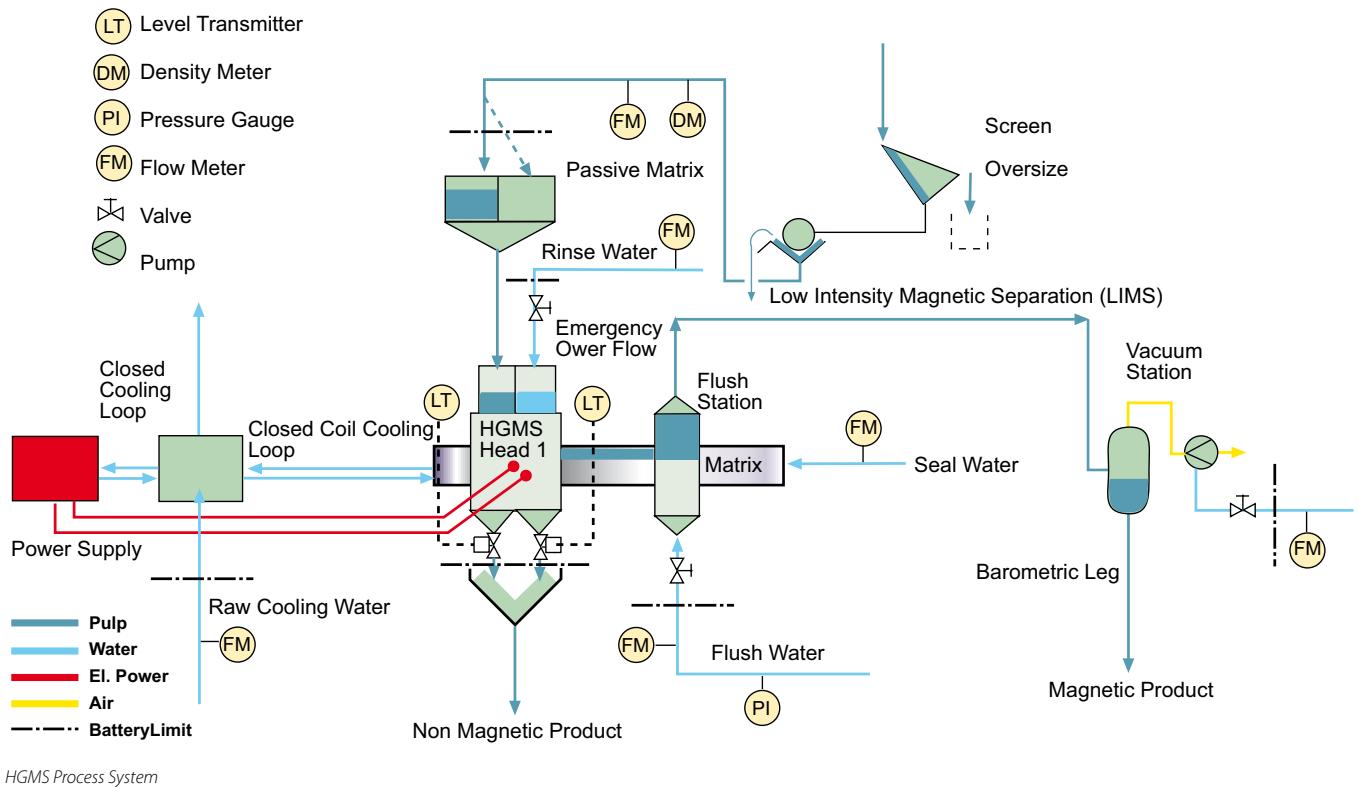
## Magnet system

The HGMS comprises a solenoid surrounding a non-magnetic process vessel. An iron return frame surrounds the coil itself. The solenoid design overcomes many of the limitations of working within the air gap of a conventional horseshoe shaped magnet.

The most important advantage of the design is that the return frame cross section can be increased to cope with higher field strengths without magnetic saturation.

A second advantage is that the direction of the magnetization becomes parallel with the pulp flow and a third is the reduction of stray field around the machine when in operation.





## Metso HGMS unit

The main unit consists of a heavy frame, one to three magnetic heads, and a matrix ring with matrix cassettes. The magnet head(s) are open on two sides to allow the matrix ring to travel continuously through the same during operation. On top of each magnet head are feed and rinse water boxes mounted for feeding and rinsing the matrix by gravity through slots in the magnetic return steel. Below the magnet head(s) discharge boxes collect the non-magnetic product.

The magnetic product is flushed away from the matrix at the flush station by means of low-pressure water and vacuum. Steel plates at top and bottom enclose the entire matrix ring. In the magnetic heads the plates are made from special magnetic steel and outside the heads stainless steel is used.

The matrix ring is divided into a number of compartments and each compartment is isolated by rubber lip seals on all sides on top and on bottom.

The ring is driven at the periphery by a ring gear and two or three gear motors.

## Auxiliary equipment

The HGMS requires auxiliary equipment for efficient operation.

A **passive matrix** is normally furnished to ensure that the feed to the HGMS is not containing oversized material and / or any debris.

A **vacuum system** is provided to assist the upward flush of the magnetic product.

A **power supply unit with PLC** is included to supply proper current and monitor the process.

A **cooling station** is provided for cooling the magnet coils and the power supply container.

An **automatic lubrication system** is installed for all support and guide rollers bearings.

The **process control instrumentation** such as density and flow meters to monitor and control feed and product slurries is normally not provided by Metso. The feed should also be controlled with regards to flow and dilution (% solids by weight) and surges in flow.

## Passive matrix

To achieve an uninterrupted operation the feed to the separator must be controlled with respect to the feed particle top size, preferably by screening to make sure that the feed is suitable for the selected matrix grade. Any foreign debris such as wood sticks, metal fibres and plastic must be screened at high-level sensors for triggering the alarm and switching the feed to the stand by compartment when required.

## Vacuum system

The magnetic concentrate is flushed out of the matrix with water. To increase the pressure drop over matrix at the time of flushing the discharge is connected to a vacuum system consisting of a receiver tank and a vacuum pump.

In case of multi magnetic head applications one receiver tank per head is normally required while one common vacuum pump is used.

The vacuum system is furnished with high and low level switches and alarms.

## Cooling station

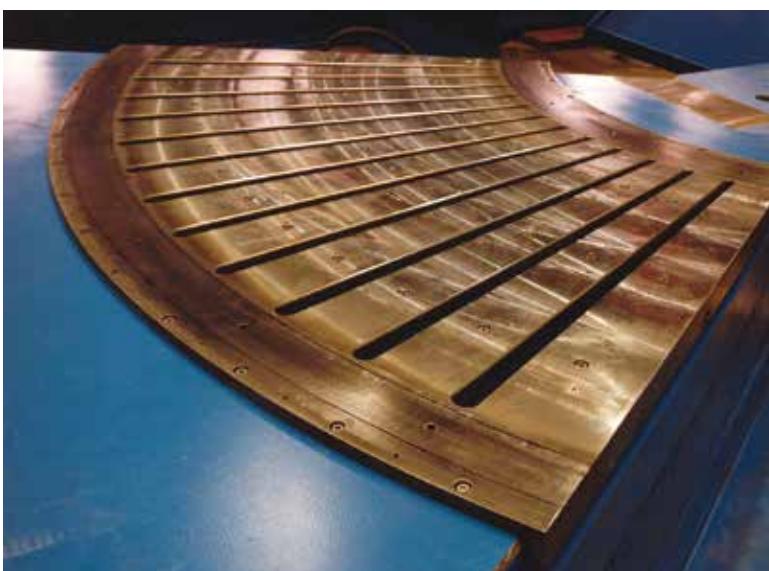
The magnet coils and the power supply with transformer and rectifiers require continuous cooling during operation. The cooling station provided with the system is selected with respect to the rated power consumption.

The cooling station has closed loop with distilled water being circulated through the coils and the air conditioner in the power container. The hot return water is passed through the heat exchanger, cooled and pumped back through the coils.

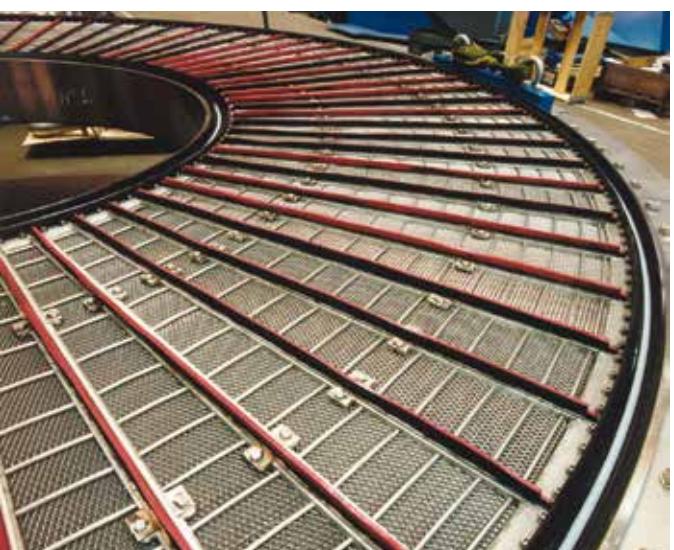
The cooling system is provided with temperature and flow switches for monitoring of the operation.



Passive matrix



Wear plate in magnet head



Web and ring seals around each matrix cassette noticeable near the periphery of the ring.

## **Power distribution unit and equipment supervisory control (PLC)**

The Metso HGMS requires direct current (DC) for energizing the magnet coils and hence a power transformer, and DC converters are provided. The DC converter also controls the current for the magnet coils. The power supply unit normally also provides for the power to the auxiliary equipment and a PLC is integrated in the system for control logics.

All components are installed in cabinets, which in turn are installed in a special totally enclosed container, which is prewired and tested together with the HGMS unit in shop.

The shop prewiring and testing ensure a fast installation on site and a safe operation.

The container and the components are protected by a system of sensors for overload, overheating etc.

The power supply can be designed for most low-tension three phase systems. In case of high voltage applications it is recommended that the power be brought down 400 to 500 volts for acceptance by the HGMS power supply unit.

## **Automatic lubrication**

The support roller and guide roller bearings are greased by centralized automatic lubrication system, which is controlled by the PLC system.



*Power distribution and control unit*

# **Establishing process parameters**

## **Laboratory testing**

The feasibility of applying the Metso HGMS process for a particular process must be tested in laboratory to establish dimensioning parameters as the properties of minerals vary considerably.

Many applications can be scaled up directly from laboratory tests; however it is often advisable to perform pilot plant tests in addition to the laboratory findings.

## **Establishing process parameters**

The Metso HGMS carousel Pilot Plant Unit can process 1 to 12 tons per hour at a maximum magnetic field strength of 1,5 T (1500 Gauss). As a part of Metso's processing services, the HGMS120 may be incorporated in a flowsheet that includes other equipment.

A HGMS120-10 (one magnetic head, 1T rating) or HGMS120-15-15 (two magnetic heads, 1,5T rating) may be rented for a period from the Metso laboratory for on site testing.

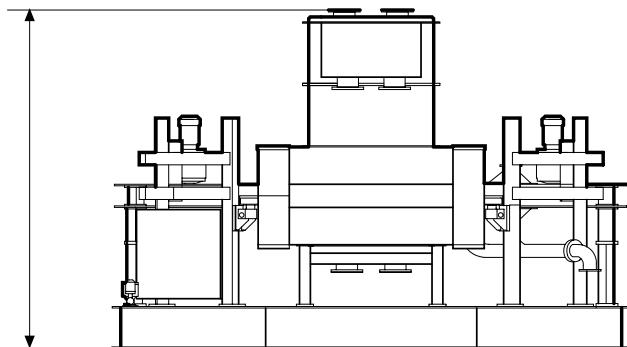
# **Operation and maintenance**

Despite the complex appearance the operation of the Metso HGMS is simple as every function is controlled and/or monitored by the integrated control system. Examples of functions, which are manually set and automatically monitored and/or controlled by the supplied control system, are:

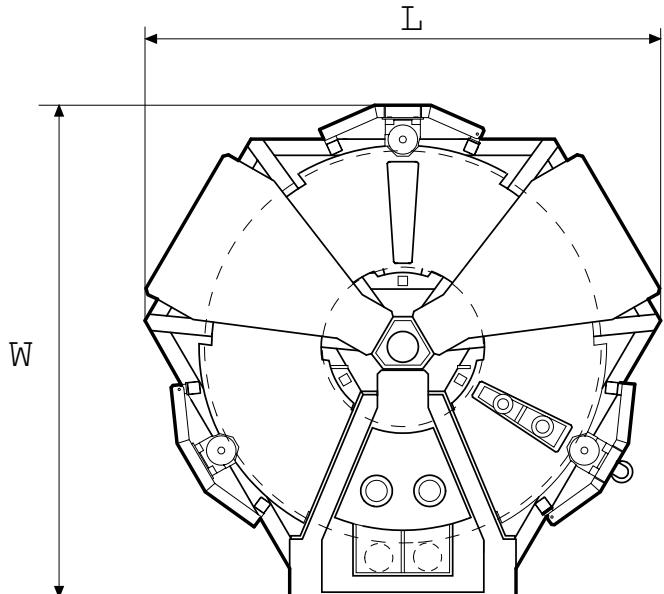
- Pulp level in the feed boxes
- Pulp level in passive matrix
- Pulp level in vacuum receiver
- Speed of matrix ring
- Magnetic field adjustment
- Flow of raw and closed loop water in the cooling system
- Bearing lubrication system
- Temperature in magnet coils
- Water to vacuum system

On request many functions, which are not standard, may optionally be included in the Metso HGMS control system. One such added function might be control of the feed density and flow; another could be automatic control of the rinse water flow and the matrix condition.

## Dimensions



The maintenance of the Metso HGMS is normally limited to changing of the seals around the matrix ring. The life of the seals vary considerably from application to application.



Model	L (mm)	W (mm)	H (mm)	Max. no. magnetic Heads	Field rating (kGauss)	Power/ head (kW)	Basic weight (ton)	Add. weight per head (ton)	Nom. cap./ head* (ton/h)
120	2600	2200	2800	2	10	75	4	4	6
120	2600	2200	2800	2	15	175	4	6	6
185	4100	3700	4100	2	7	65	9	13	36
185	4100	3700	4100	2	10	85	9	19	36
185	4100	3700	4100	2	15	200	9	33	36
250	6300	5100	4600	2	5	40	20	22	107
250	6300	5100	4600	2	7	75	20	32	107
250	6300	5100	4600	2	10	120	20	54	107
250	6300	5100	5600	2	15	260	20	95	107
350	7000	7200	4600	3	5	78	40	26	150
350	7000	7200	4600	3	7	136	40	37	150
350	7000	7500	4600	3	10	165	40	66	150

\*Based on hematite-separation

### Notes

- Model 120, 185 and 250 are available with one or two heads; Model 350 is available with one to three heads. Heads in the same unit can work in parallel or in series and can be built for the same or different magnetic field intensities.
- Metso reserves the right to change these specifications.
- Machine weight is basic weight + additional weight of magnetic heads.
- For lower field ratings or between ratings nearest larger size is used.

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