High gradient magnetic separators

HGMS cyclic

The Metso High Gradient Magnetic Separators (HGMS) are used in many magnetic separation applications. Among these are the processing of more strongly magnetic minerals of Fe, Co and Ni as well as less magnetic minerals such as rare earths which normally are not regarded as treatable by magnetic processes. Even weakly, para-magnetic materials can be processed by the HGMS including separation of galena, chalcopyrite and sphalerite; and cleaning of refractory materials, coal and phos-phate concentrates.

Advantages

- Broad range of applications
- Wide range of equipment sizes and capabilities
- High separation efficiencies
- Fine particle processing
- Simple reliable design with no moving parts
- Easy flushing of magnetics
- Low specific power consumption
- Low maintenance cost
- Long component life
- Automatic operation – minimal equipment supervision

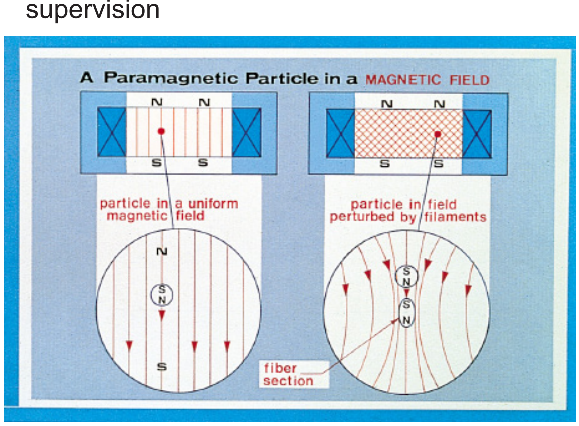

Fig. 1

Operating principle

The simplified equation for the magnetic attrac-tion force on particles is

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

S = particle volum

χ = particle magnetic susceptibility

B = magnetizing field

$\frac{dB}{dx}$ = magnetizing field gradient

From the above equation it is evident that in a homogenous magnetic field $\frac{dB}{dx}$ there is no resultant attraction force on the particles. This is illustrated in Fig.1 where the left part shows the undisturbed field and the right part shows a disturbed field. Field gradient is shown here by the varying distance between the field lines.

Any sharp edges of small dimensions will cause such a field distortion, and, hence, an increased gradient.

A familiar illustration of this phenomenon is an ordinary permanent horseshoe magnet attract-ing iron shavings. The shavings will stick mostly to the edges of the poles due to the increased gradient.

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The Metso HGMS design uses a hollow copper solenoid which surrounds a stainless steel matrix enclosed in a non-magnetic steel canister. The solenoid is enclosed in an iron return frame, as shown in Fig. 2.

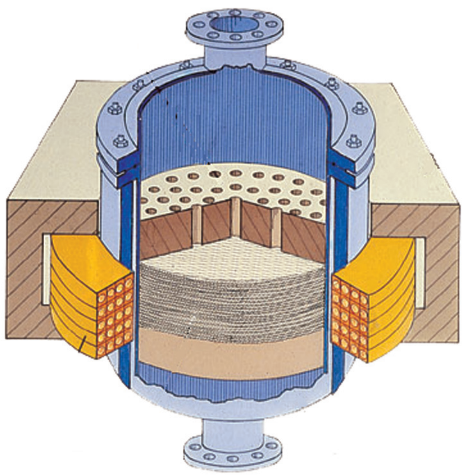

Fig. 2

This solenoid design overcomes many of the limitations of working within the air gap of a conventional horseshoe magnetic shape design. The most important advantage of the solenoid design is that the return frame cross-section can be increased to cope with higher field strengths without saturation.

The resulting homogenous magnetic field within the solenoid volume is then manipulated by inserting varying types of matrices into the canister.

The matrix grade depends largely on feed particle size. For coarser particles (up to 1 mm) a grid of expanded metal is used, for finer particles, layers of steel wool are used. Matrix material is usually manufactured from ferromagnetic grade of stainless steel, see fig. 3.

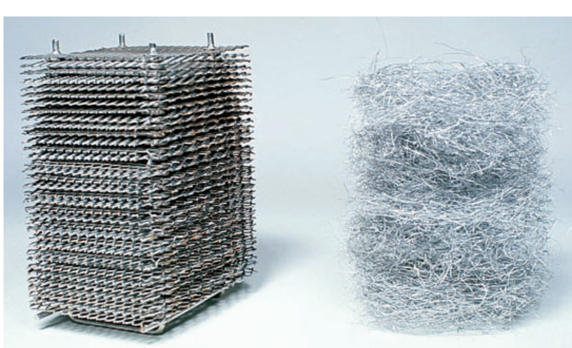

Fig. 3

This design allows for field strengths, field gradients, and matrix flow-through capabilities to be optimized for each separation process.

The magnetic separator shown in Fig. 2 is a cyclic type, since the procedure must be stopped and the matrix demagnetized for flushing out the trapped magnetic particles. Its use is therefore limited to feeds with magnetic material contents low enough to permit acceptable cycle times.

Application

The capacity of the Metso HGMS varies with application and the parameters for selection of a suitable HGMS unit for a specific process is normally established by proper testing of the material in a laboratory unit.
The operating parameters sought are matrix loading, superficial pulp flow velocity, magnetic strength and matrix grade. The test data are then used to select the canister diameter and to determine the cycle time.
Sometimes the sizing process reveals that a cyclic machine may not be a practical or economical selection.
This is typical when the magnetic product is around five percent of the feed tonnage.
On such occasions a continuous machine may prove to be a more suitable selection.

Designation

Since the Metso HGMS cyclic is available in many sizes and ratings to suit the largest possible range of applications the following designation system is used.

Example:

The model Metso HGMS **107-15-20** includes the following information:

107 – canister (process vessel) OD (outer diameter) in cm
– models available from 10 to 305 cm

15 – matrix height in cm – three heights are available:
178 mm, 300 mm, and a special 500 mm

20 – magnetic rating in kGauss
– ratings from 3 to 20 kGauss (2 Tesla) are available

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Operation

The Metso HGMS magnetises the filamentary matrix bed contained within the process vessel. When the slurry flows through the matrix bed, the magnetic particulates are captured and held magnetically in the matrix until the magnet is turned off and the separator is back-flushed.

The HGMS matrix filament cross- section must be small enough to create the high magnetic field gradient and filament area required to capture the weakly magnetic particles.

The HGMS (cyclic) matrix bed has a void volume of 80 to 90 percent depending on the selected matrix grade.

This open void volume creates a large holding capacity for magnetically captured material.

During actual operation, the pressure drop over the matrix varies with matrix grade and pulp velocity and finer matrices may at times limit the holding capacity of the unit. Also, a higher field strength applied to the the matrix may sometimes increase the pressure drop over the matrix bed.

The operation is “cyclic” which means that the feed to the separator operating time is shut off for a certain fraction of the operating time to allow for the backflush to occur.

The feed slurry is either pumped or gravity fed into the process vessel. At the end of the feed cycle when the pressure drop across the matrix shows that the matrix is optimally loaded, the feed to the separator is stopped and the rinse cycle occurs.

The rinse cycle allows for clean water to pass through the matrix, the separator vessel, and piping to remove non-magnetic particulates. The rinse cycle comprises shut-off of feed and setting of the valves to allow rinse water to be correctly routed. The rinse stage may with certain applications be omitted.

At the end of the rinse cycle the rinse water is shut off, the process valves are reset, the power to the magnet is shut off and the flush water valve opened to back flush the magnetically trapped material. When the flush cycle is finished the flush water is shut off, the power turned back on to energise the magnet system, the valves are readjusted and the feed slurry turned back on.

The cyclic effect of the operation is normally eased by installation of an intermediate slurry-mixer which allows feed slurry to be stored during the “off” cycle.

Alternatively, two or more Metso HGMS separators operating in parallel can reduce the cycling effect and allow for almost continuous flow.

Laboratory equipment

The Metso HGMS Model 10-15-20 with 10 cm bore is used for most laboratory investigations for applications of high gradient magnetic separation.

The test results obtained from applying the HGMS Model 10-15-20 on representative samples are such that it is normally possible to scale up to commerciallysized process machines. However, in order to determine long time results often pilot plant tests are often recommended.

Laboratory and pilot plant testing

The tests performed with the HGMS in the laboratory are exploratory tests and more detailed tests are required. These exploratory tests are performed to determine whether the HGMS is applicable and pilot plant tests are required to obtain the ultimate performance data necessary for sizing of the equipment. Experienced personnel from Metso normally perform both of these tests.

Metso has two units of the HGMS Model 10-15-20 available for testing in the laboratory of Metso (Sweden) AB, Sala.

HGMS carousels and HGMF units are available for renting for testing on site.

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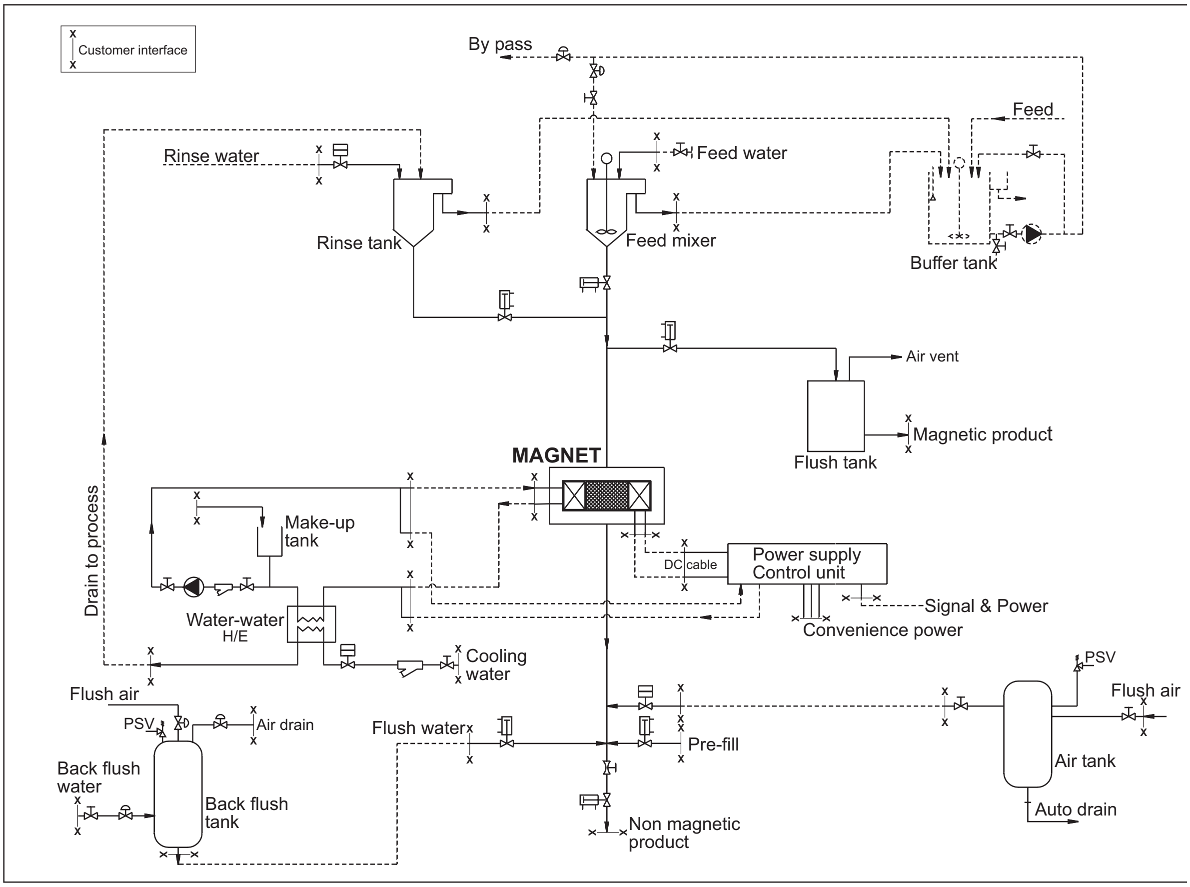

System

The Metso HGMS magnetic separator system consists of:

- Separator assembly
- Tanks for rinse and flush
- Frame-mounted when applicable
- Piping for slurry and water
- Associated valves
- DC power supply
- Instrumentation
- Automatic Process Control
- Magnet Coil Cooling System

The separator is fully assembled in the shop and tested as much as possible before delivery. Depending on transport

and other factors, the unit is either delivered fully assembled or partly assembled.

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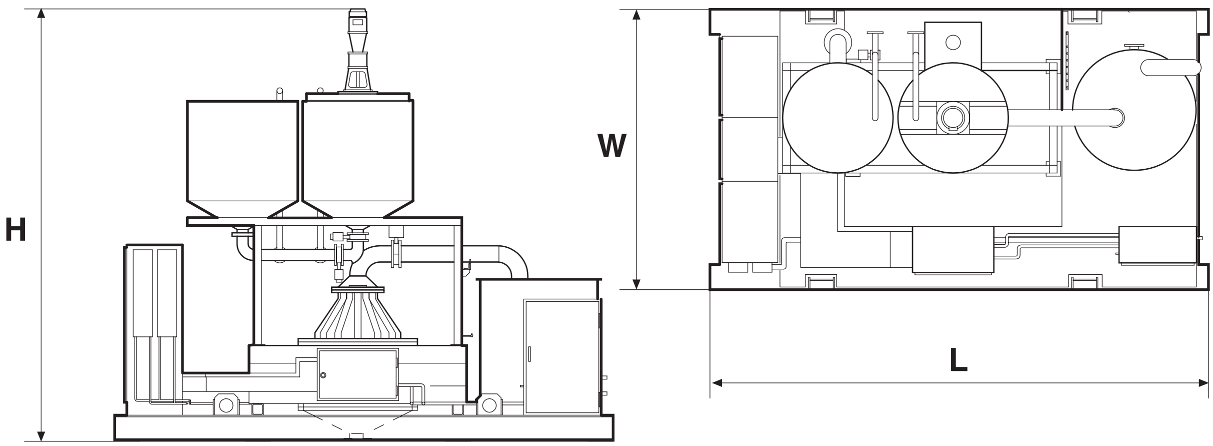
Dimensions



Model	H mm (ft)	L mm (ft)	W mm (ft) (magnet)	Power (empty) kW	Weight ton	Matrix area m² (ft²)
38-15-10*	4 000 (13)	3 800 (12)	2 450 (8)	40	10	0.11 (1.18)
56-15-10	4 100 (13)	4 000 (13)	2 450 (8)	46	13	0.19 (2.05)
76-15-10	4 100 (13)	4 200 (14)	2 450 (8)	53	14	0.43 (4.63)
107-15-10	4 380 (14)	5 150 (17)	2 900 (10)	63	26	0.85 (9.15)
152-15-10	**	**	**	80	46	1.75 (18.84)
214-15-10	**	**	**	103	**	3.42 (36.81)
305-15-10	**	**	**	-	**	7.30 (78.58)

*38-15-10= 38(Outer diameter in cm)-15(matrix height in cm)-10 (field rating in kGauss)

Magnetic field available 5,10,15 and 20 kGauss

** Site specific

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