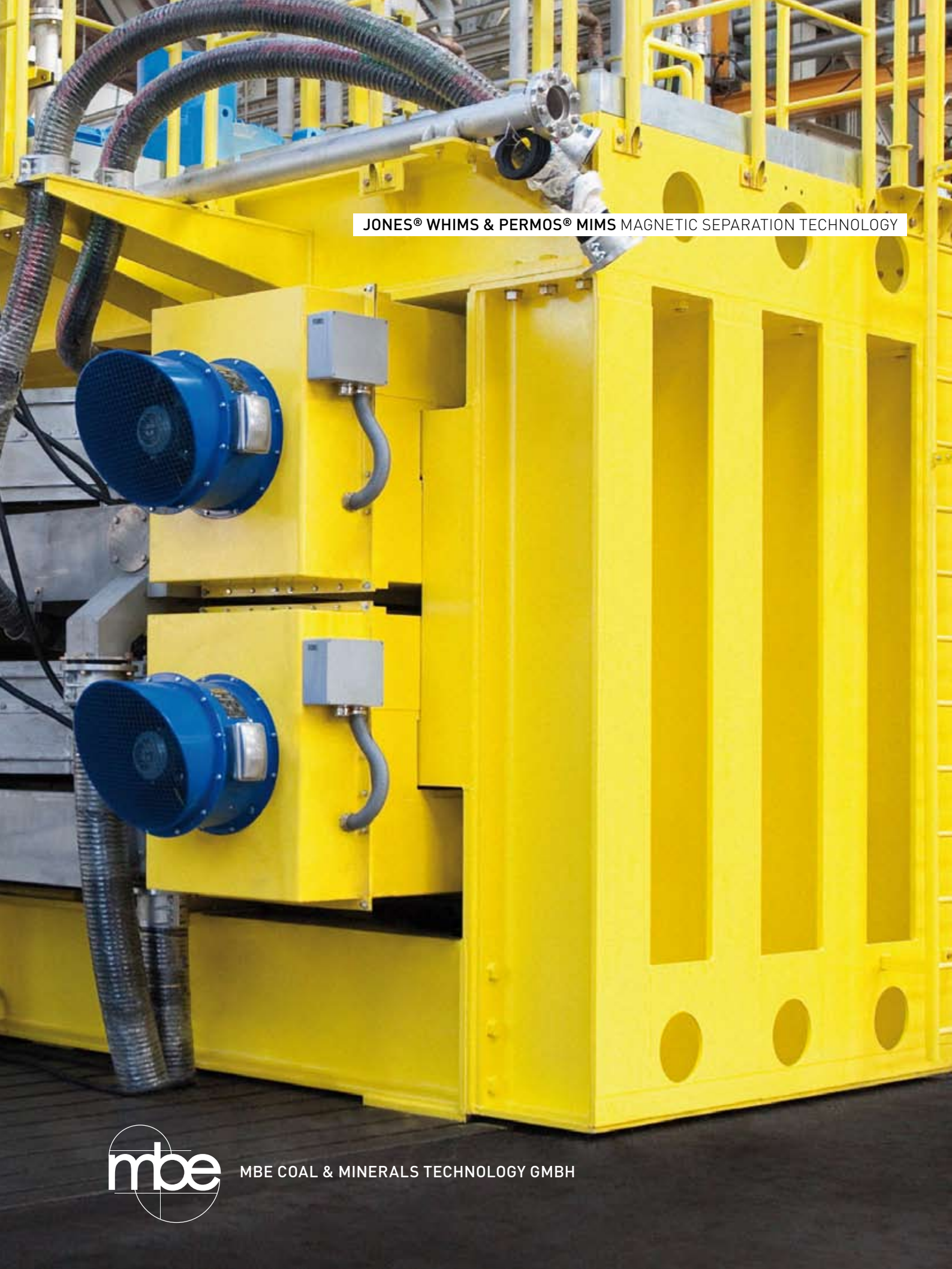
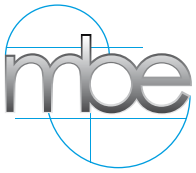


JONES® WHIMS & PERMOS® MIMS MAGNETIC SEPARATION TECHNOLOGY

MBE COAL & MINERALS TECHNOLOGY GMBH



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The purpose of applying a JONES WHIMS (Wet High-Intensity Magnetic Separator) or a PERMOS MIMS (Medium-Intensity Magnetic Separator) is to separate magnetic from non-magnetic minerals by a wet process. The PERMOS is also designed for dry separation processes.

For more than 40 years the JONES WHIMS magnetic separators are known to be highly reliable, robust and extremely compact machines with very high capacity and selectivity. The PERMOS MIMS drum magnetic separators fulfil the demands on medium-intensity separation. Continuous improvements of their technical features and the high acceptance by our worldwide clients testify the lasting success and state of the art of the JONES WHIMS and the PERMOS MIMS.

This brochure provides information on the technology and the principle of magnetic separation. On the following pages, both technologies are presented in detail. Further information with flow sheets, illustrations and machine photos will complete the description.

Finally, we introduce the MBE R&D facilities where your material can be tested on a pilot scale equipment to yield an accurate forecast for separation efficiency.

JONES WHIMS during no-load test run

Grooved plates arrangement

JONES® WHIMS
MAGNETIC SEPARATION TECHNOLOGY

The JONES is a unique designed Wet High-Intensity Magnetic Separator (WHIMS) which can separate feeble magnetic material from non-magnetic material at very fine grain sizes (< 2 mm), depending on the application.

The JONES provides very high gradients of the magnetic field (up to 15,000 Gauss) at low-energy consumption and thus guarantees low operating and maintenance costs – meeting your demands as cobber/rougher, scavenger and cleaner stage.

With regard to the compact size and the unique design of the JONES an installation in small buildings is possible and high throughput rates can be achieved.

Due to the special design of the grooved plates the gaps keep their dimension for a long operation time, generating a uniform magnetic force which is essential for selective separation.

The simple arrangement of the matrix minimizes the blockage of the gaps by ferrous parts with high magnetic susceptibility and the feed slurry can flow unhindered through the stages. With the correct gap size and the respective setting of the magnetic field even very small quantities of magnetic impurities in the feed can be eliminated.

FEED REQUIREMENTS & THROUGHPUT CALCULATION

Material: paramagnetic minerals with Satmagan value < 2 %
Grain size: < 2 mm, based on liberation grade of iron particles and depending on gap size setting
Solid content: approx. 200 – 800 g/l, e.g. ≈ 40 – 50 wt. %
Dry solid throughput: up to 220 t/h per single machine

Installation of JONES
at iron ore plant, Venezuela

JONES® WHIMS
IN THE FIELD

THE FOLLOWING OPERATION OPTIONS ARE GIVEN: If the magnetic material is the required product, the JONES produces a magnetic concentrate e.g. hematite, pyrrhotite, ilmenite, siderite, ores of chromium, manganese, tungsten, zinc, tantalum, niobium, nickel, molybdenum and other feeble magnetic materials.

Non-magnetic material, e.g. glass sand, apatite, clay, talc, kaolin, feldspar, coal, fluorspar, nepheline, barite, graphite, bauxite, cassiterite etc. can be upgraded by removing magnetic impurities. Such particles include biotite and muscovite, iron-stained particles, garnet, iron silicates etc.

For additional treatment by a different process, such as scavenging from sub-grade deposits or tailings (gold, platinum, chromium, manganese), the JONES serve as a pre-concentrator.

THE SEPARATION WILL CONSIST OF THREE STEPS:

1. Attraction of magnetic particles within the magnetic field by grooved plates and non-magnetic particles passing straight through.
2. Washing of the magnetic fraction to remove any entrained non-magnetic particles to generate a middlings product.
3. Scouring of the magnetic fraction in the neutral zone to yield the magnetic product.

JONES rejects and concentrate of hematite ore in collecting launders

Feed device and collecting launder

Rotor disc of JONES DP 317

TYPICAL JONES PARAMETERS

- Advanced feeding devices
- Air-cooled coil boxes
- Adjustable rotor speed
- High capacity
- Robust and reliable design
- Particle size up to 2 mm
- Grooved plates of high-quality stainless steel
- High-gradient magnetic field
- Local control panel via touch screen
- Low current consumption
- Low operating and maintenance costs

KEY FACTORS TO ENSURE GOOD SEPARATION RESULTS WITH JONES

Liberation: Good liberation required to ensure clean separation and high recovery.

Dispersion: A dispersing agent may be added to the feed pulp in case of particularly fine grain size in order to avoid flocculation.

Feed pulp density: The feed pulp density has a direct influence on the capacity of the separator.

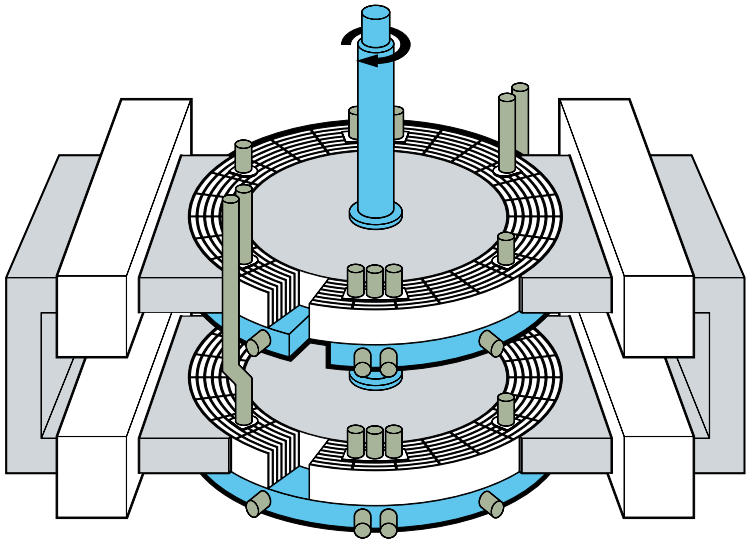
Throughput: The required throughput defines the adequate size of the equipment. The JONES tolerates considerable fluctuations in the feed.

Quality of grooved plates and gap size: The type of plates and the gap setting are determined by the nature of the feed material and the degree of separation. The quality, the design and the fabrication precision determine the life-time and the separation grade.

Wash water: The amount and the pressure have a direct influence on the grade of product and the quantity of the middlings.

Magnetic field intensity: Stepless adjustable for all separation demands via local control touch screen.

Separation stages: On request a rougher/cleaner or rougher/scavenger combination can be arranged in a single machine.



Principle of the JONES WHIMS

Assembly of the JONES WHIMS
at MBE, Cologne

The homogenized feed slurry with particles up to 2 mm flows from the distribution bins through feed hoses and boxes into the matrix (grooved plates).

The feed points are positioned at the leading edges of the magnetic fields. Due to the rotation of the plate boxes fixed to the rotors the feeding is a continuous process. Each rotor has two symmetrically disposed feed points.

Within the magnetic field the grooved plates concentrate the magnetic flux at the tips of the ridges. By correct selection of plate gap and magnetic field intensity the selective collection of feebly magnetic particles can be ensured.

In the magnetic zone the magnetic particles adhere to the plates whereas the non-magnetic particles pass straight through the plate boxes and are collected in the launders underneath. Before leaving the magnetic field any entrained non-magnetic particles are washed out by adjustable pressure wash water. This middlings fraction is collected in a separate launder under each rotor.

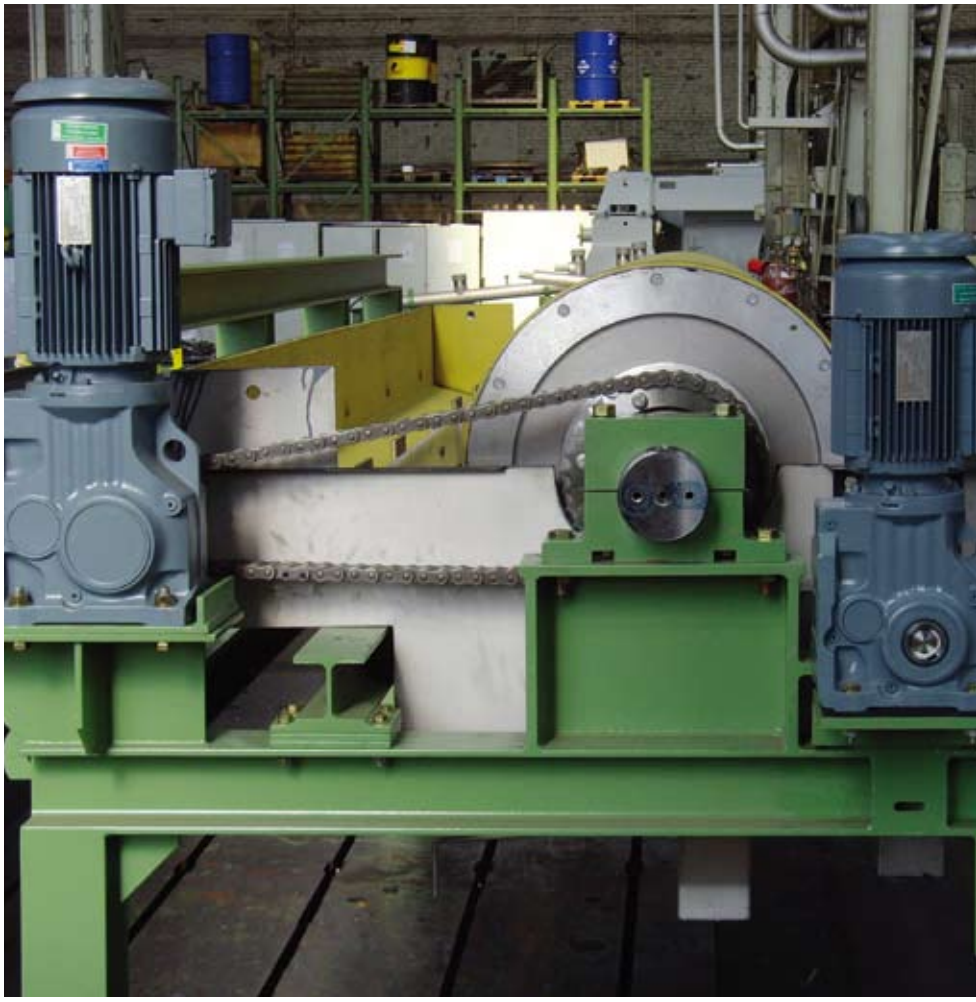
During rotation the plate boxes reach the demagnetized zone where the adhering magnetic particles are scoured out with high-pressure water. The demagnetized zone is located approx. halfway between the two magnetic poles, where the magnetic flux changes the direction and the magnetic force is essentially zero.

Underneath the rotors collecting launders are installed and equipped with spray water devices for a better material discharge.

AVAILABLE MACHINE SIZES

TYPE	THROUGHPUT CAPACITY (t/h)	ROTOR DIAMETER (m)	WATER REQUIREMENT (m^3/h)	POWER REQUIREMENT (kW)	WEIGHT (t)
DP 335	220	3.350	260	120	110
DP 317	140	3.170	150	85	96
DP 180	40	1.800	50	30	41
DP 71	5	0.710	6	21	12.6
P 40	0.5	0.400	0.5	4.6	2.7

PERMOS MIMS during no-load test run



Side view of PERMOS 630 with drive units for drum and discharge roll

PERMOS MIMS is a Medium-Intensity Magnetic drum Separator which allows wet and dry separation of coarse and fine materials with a medium susceptibility at high throughput rates.

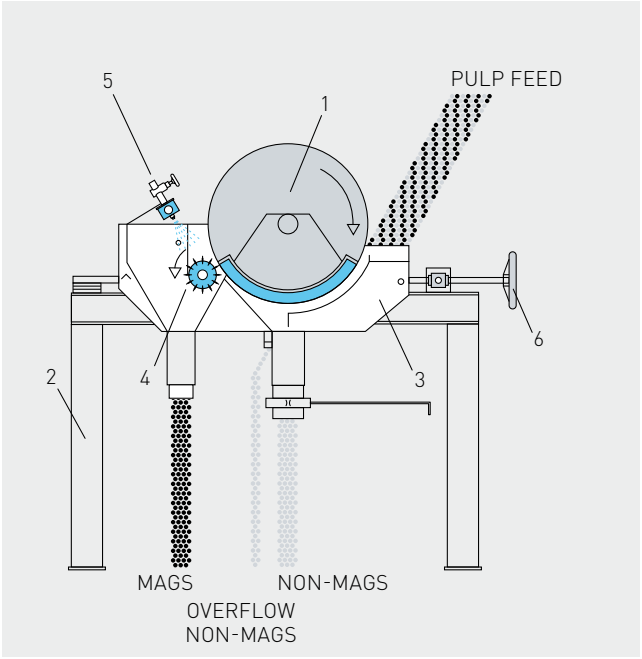
Working with a permanent magnet, the PERMOS MIMS does not require electric power for generating the magnetic force. Strong field intensities and an advanced design of the magnet system guarantee low operating costs.

The PERMOS MIMS operates at field intensities of 5,000 Gauss on the drum surface and meets the demand for cost-effective solutions for many applications.

Compared to conventional magnetic drum separators, PERMOS MIMS has the following characteristics and advantages:
- equipped with a high-quality and powerful permanent magnet (NdFeB: neodymium, iron, boron)
- specially magnetized heavy-duty magnet blocks
- high magnetic field of 5,000 Gauss on the drum surface (industrial scale)
- for dry and wet processes
- drum shell made of stainless steel
- rubber lining for wear protection
- discharge roll for easier discharge of magnetic concentrate driven by a separate motor
- cost-effective low-energy consumption and high throughput rates

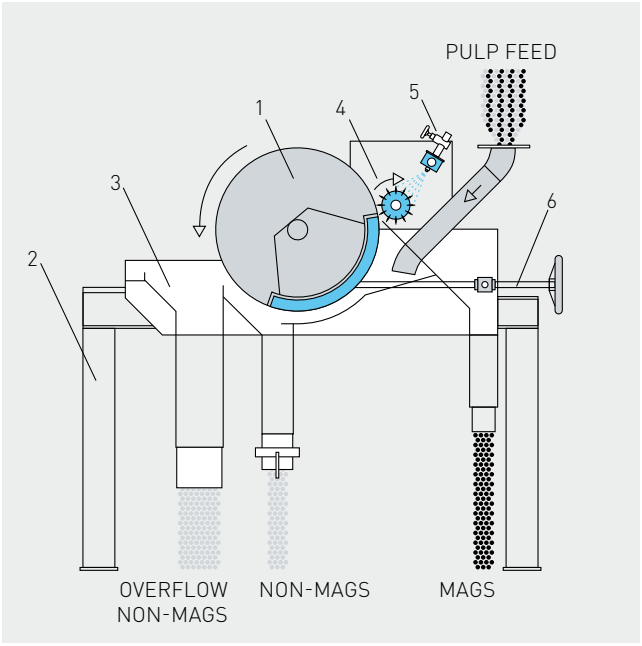
FEED REQUIREMENTS & THROUGHPUT CALCULATION

Material: ferromagnetic and paramagnetic minerals
Grain Size: < 3 mm, based on liberation grade of iron particles
Solid Content: approx. 500 – 800 g/l, e.g. ≈ 40 – 50 wt. %
Dry Solid Throughput: ≈ 25 – 40 t/h per m drum length
Pulp Throughput: approx. 150 – 200 m^3/h



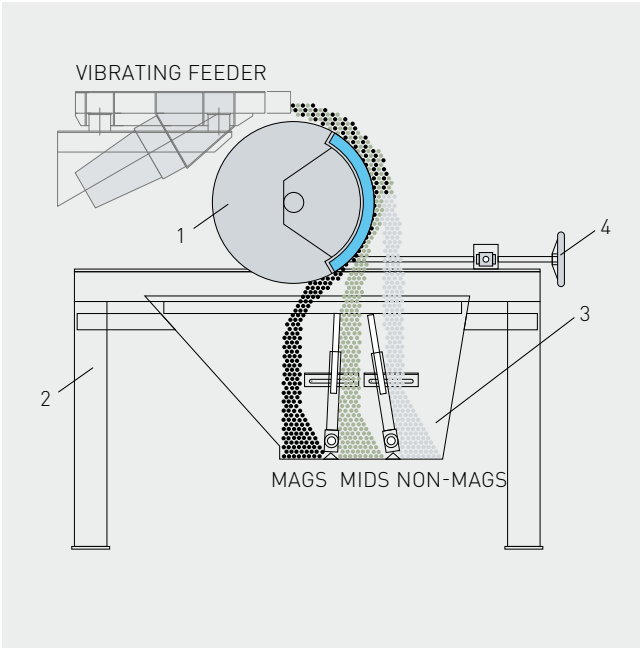
PERMOS drum separator with a concurrent tank design

1. Drum with magnetic system
2. Frame
3. Tank
4. Discharge roll
5. Washing device
6. Adjustment device for the magnetic system



PERMOS drum separator with a c ountercurrent tank design

1. Drum with magnetic system
2. Frame
3. Tank
4. Discharge roll
5. Washing device
6. Adjustment device for the magnetic system



PERMOS drum separator for dry operations

1. Drum with magnetic system
2. Frame
3. Splitter box
4. Adjustment device for the magnetic system

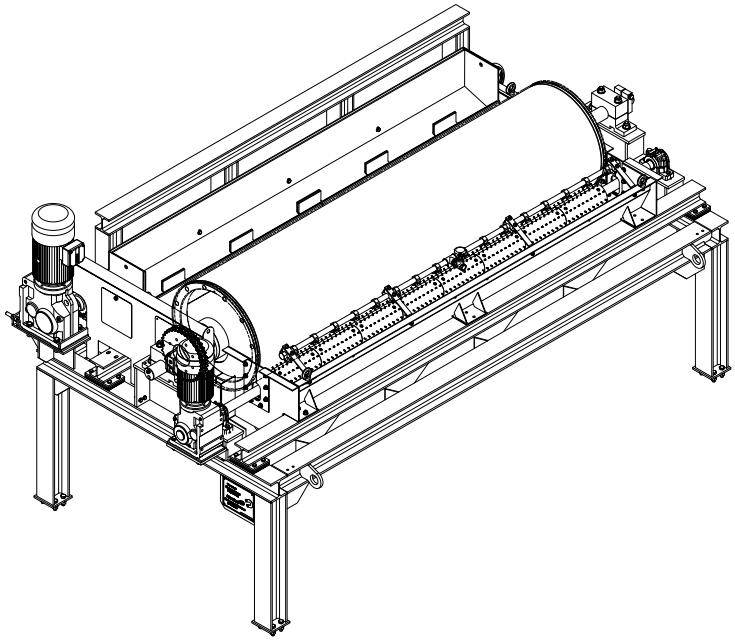
The PERMOS drum separator can be applied in wet and dry processes.
For wet operations the slurry is fed through the feed box into the separation tank. The magnetic system is positioned horizontally in the drum which is installed and driven inside the tank. The magnetic material is attracted to the drum surface and discharged by the discharge roll into the product chute. The non-magnetic material is discharged through adjustable valves inside the bottom of the tank. For an optimum of separation process concurrent and countercurrent tank designs are available.

For dry operations a vibrating feeder distributes the material on the complete width on top of the rotating drum. Thanks to the adjustable drum speed the material is transported to the magnetic zone. Non-magnetic particles are not influenced by the magnetic force and fall off the drum directly into the discharge compartment of the splitter box. The magnetic particles are attracted and transported by the drum to the end of the magnetic field. Paramagnetic particles are less diverted and collected as a middlings fraction. The splitter box is installed underneath the machine and divides the different products to the downstream process.

TYPICAL PERMOS APPLICATIONS

- Recovery of highly susceptible particles (e.g. magnetite, heavy media materials)
- Recovery of both medium (e.g. martite) and lower susceptible particles (e.g. hematite, goethite) in one machine
- Protection of high-intensity matrix separators (JONES WHIMS) from clogging by highly or medium susceptible ore particles
- Removal of abrasive iron particles in grinding circuits
- Removal of highly and medium susceptible contaminants from industrial minerals (e.g. glass sand) in dry and wet processes

Installation of Permos at iron ore plant, Venezuela



PERMOS 3-D arrangement

Discharge roll and wash water spray

A PERMOS MIMS magnetic separator essentially consists of the following components:

- rotary drum of stainless steel with inside mounted magnetic system made of NdFeB
- rotary drum with rubber protection against wear
- hand wheel for adjustment of the magnetic systems position
- rotary drum driven by a chain or direct drive unit
- tank made of stainless steel with rubber protection against wear
- discharge roll for wet operations driven by a separate motor. No physical contact between drum and discharge roll to minimize wear of the drum surface.
- adjustable slurry level in the tank for wet operations
- speed of drum and discharge roll can be adjusted via frequency converter

The discharge roll driven by a separate motor is a concept specially designed by MBE CMT to minimize the wear of the drum surface:

The powerful magnet material NdFeB allows the designer to select practically any random arrangement of the magnet blocks to ensure an optimized system. NdFeB has a maximum remanence of up to 1.25 Tesla and a coercive field intensity of approximately 10^3 A/m at energy products of almost 300 kJ/m³. As a consequence it means that external fields have only little influence on the magnetization of the system and its components.

It is to be considered that a high-intensity magnet cannot be switched off. Thus a contact between magnetic particles and the magnets has to be avoided as the particles can scarcely be removed. Operational failure and potential damage to the magnet blocks would be the result if direct contact occurs. Taking this aspect into account, a completely enclosed magnetic system is of significant premise. The magnets are accommodated on a rectangular shaft within a rotating drum on surface of which the separation takes place. Special rubber linings on the surface of the drums prevent wear whereas individually chosen thickness of the lining reduces the magnetic intensity.

AVAILABLE MACHINE SIZES

	LABORATORY SIZE (m)	INDUSTRIAL SIZE (m)
DRUM DIAMETER	0.6	0.6
DRUM LENGTH	0.2	0.6 , 1.2 , 1.8, 2.4, 3.0

TYPE	THROUGHPUT CAPACITY (t/h)
PERMOS 202	Labor Unit
PERMOS 602	Pilot Unit
PERMOS 606	20
PERMOS 612	40
PERMOS 618	60
PERMOS 624	80
PERMOS 630	120

Installation of the magnetic system inside the drum

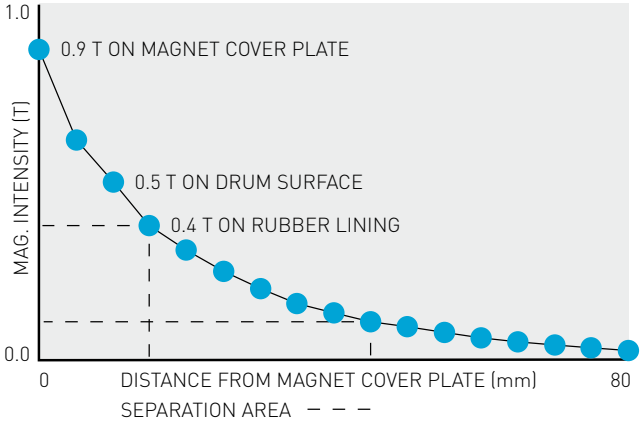
PERMOS MIMS ready for dispatch

In order to ensure that up-scaling data are as reliable as possible, we believe that the process conditions in a pilot scale trial should truly represent the industrial scale. This is why our pilot JONES P40 is dimensioned just like an industrial machine for continuous operation enabling equal magnetic intensities and wash and scour water pressure conditions.

The significant difference of the pilot arrangement is the use of only one rotor. The maximum throughput is approximately 500 kg/h dry feed solids. Due to an easy matrix arrangement various gap adjustments are possible. The magnetic intensity is stepless adjustable up to 15,000 Gauss. Flow meters for the wash and scour water make sure that the correct amount of water is used.

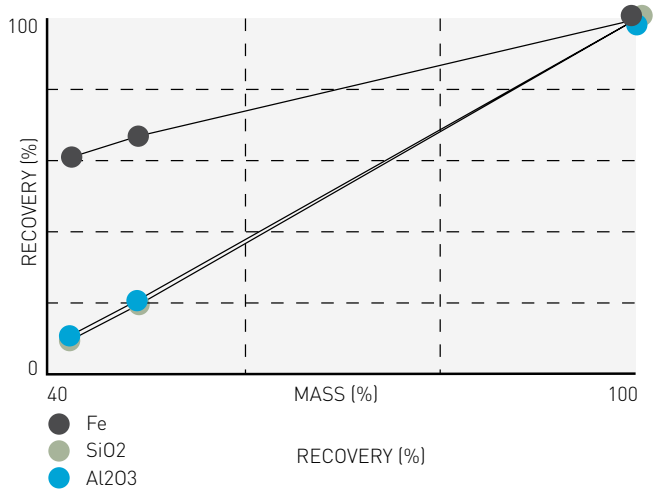
The design facilitates tests of all different kinds of ores as well as other minerals, e.g. glass sand. Approx. 20 kg of ore solids are requested for first batch tests and around 100 – 150 kg of sample for a detailed test program.

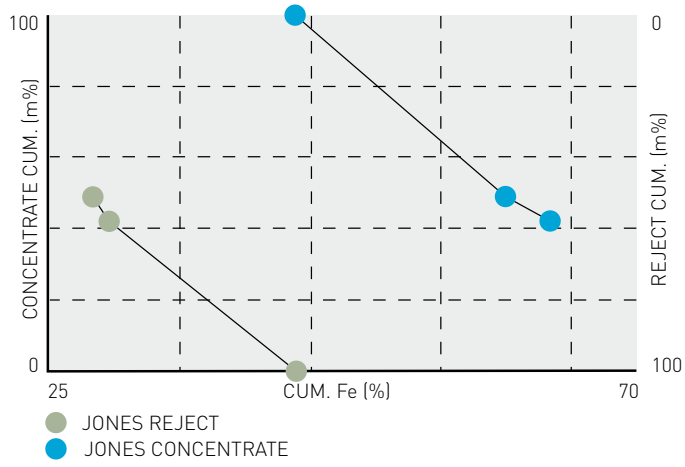
During the tests the best adjustments and settings are determined for:
– the grooved plates arrangement
– the wash and scour water amount and pressure
– the magnetic intensity
– the feed slurry density
– the maximum throughput
– the mass and iron recovery



Magnetic induction curve of the PERMOS 630

JONES P40 pilot machine





TECHNICAL DATA

Rotation speed: 3 rpm — **Number of cells:** 11
Type of matrix: groove plates — **Gap settings:** various
Coils strength: max. 6.3 A — **Flux density:** max. 15,000 Gauss
Water requirement: 0.5 m³/h — **Inst. power:** 4.6 kW
Machine weight: 2.7 t — **Throughput:** max. 500 kg/h

Detailed test report includes mass recovery, iron grade of products,
iron recovery etc. and gives all required information about the optimum machine settings

PERMOS 602 pilot machine with different tanks

TECHNICAL DATA

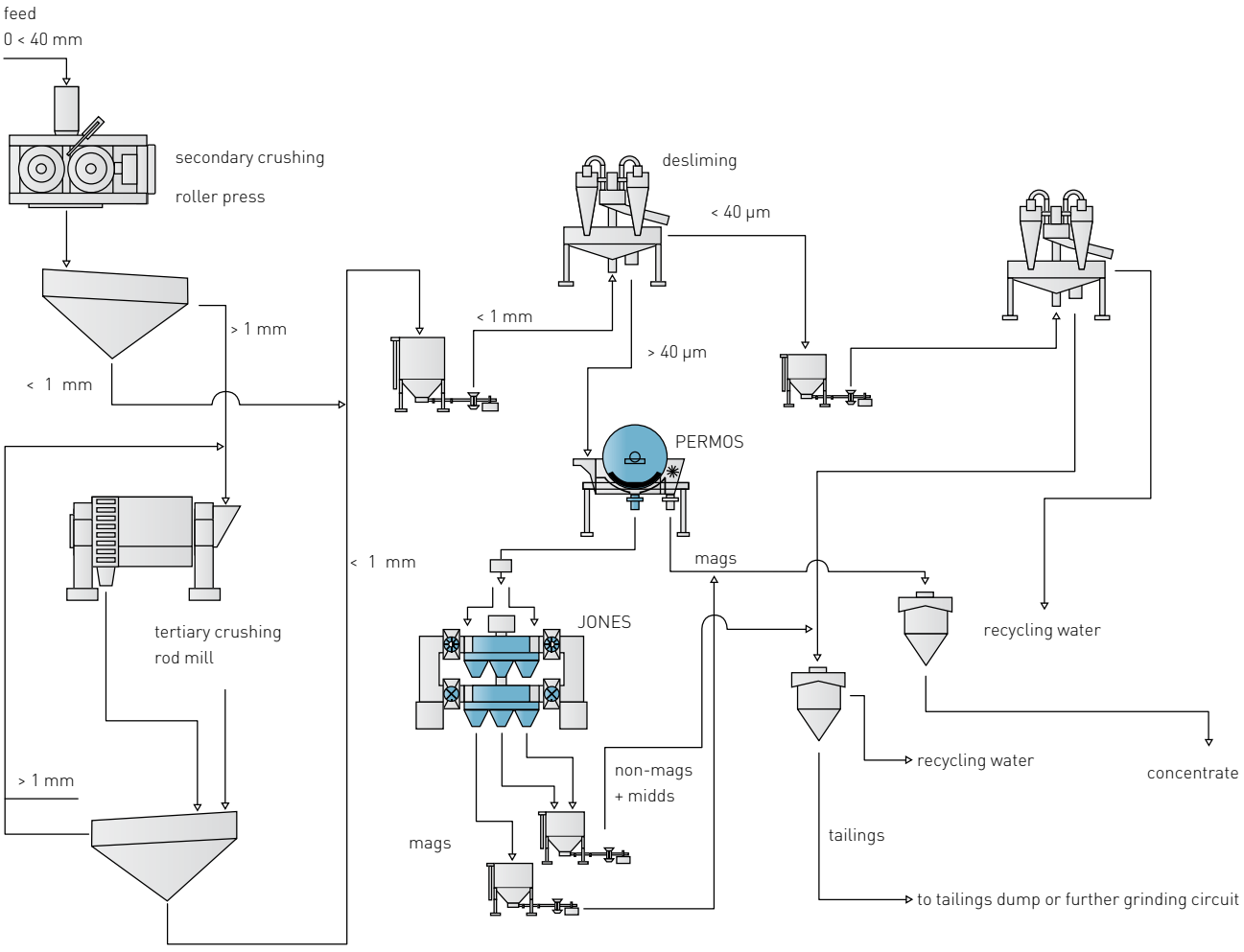
Rotation speed: 5.8 – 33 rpm — **Diameter of drum:** 604 mm
Length of drum: 200 mm — **Gap settings:** various
Flux density: up to 7,000 Gauss on drum surface
Water requirement: 1,000 l/h — **Inst. power:** 1.1 kW
Machine weight: 1,100 kg — **Throughput:** 3,700 kg/h

THE SEPARATOR COMPRISES ESSENTIALLY:

- the magnet drum with the drum shell of stainless non-magnetic steel and the fixed but adjustable magnet system PERMOS with permanent magnets of material NdFeB
- the frame which supports drum, drives, tank and other equipment
- the drum drive with an infinitely variable geared motor with hand wheel
- the discharge roll with an infinitely variable geared motor with hand wheel
- the concurrent, countercurrent and semi-countercurrent tank made from stainless steel
- the splitter box for dry feeding
- the spray water device

Laboratory frame type machine with interchangeable devices:

- concurrent tank
- countercurrent tank



Typical beneficiation flow sheet with JONES WHIMS and PERMOS MIMS

AFTER-SALES SERVICE. Utilising our considerable logistical, engineering and site-service expertise, MBE Coal & Minerals Technology GmbH aim to provide an unparalleled level of ongoing services. These services will maximise the operators' return on their investment throughout the lifetime of the equipment.
We believe that strong partnerships can only evolve with personal contact. From the outset we have assigned an Account Manager who will learn about your business and understand its unique demands. Utilising that knowledge and by focussing on what is important to each individual customer, we can develop an operational plan that will ensure we deliver on our promises – on time and within budget.

The four key services we offer to maintain and improve the operation of your equipment:
- competitively priced OEM spare parts with lead times to meet the customers' operating requirements
- we carry out planned service visits at mutually agreed intervals with an optional emergency call-out service and operator training
- upgrade packages for your equipment to improve performance, based on our most recent product developments
- equipment refurbishment

Continue to utilise our people and expertise to maximise the efficiency of your operations.
"We will not let you down."

FROM THE FIRST STEP UP TO THE COMMISSIONING. To realise your projects you can receive the entire scope of services from one source, i. e. from us:
Project consulting by globally experienced mining, process, mechanical engineers and mineralogists.
Test work in our own R&D centre and laboratories.
Feasibility studies in joint effort of clients' personnel familiar with the project targets and our competent employees, even up to project financing.
Plant design with basic and detail engineering including project management.
Supply of equipment, systems and plants.
Training of end users' personnel for management functions same as for operators and maintenance employees, in our offices, in our R&D centre, in our reference plants all over the world and finally on end users' site.
Installation / supervision of installation of our equipment and systems by our own globally experienced service specialists.
Commissioning of equipment, systems and plants.
After-Sales services including not only supply of parts and respective services but also consultancy in respect of operation and maintenance of our equipment.

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