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ALPINE FLUIDISED BED OPPOSED JET MILL FROM THE PICOJET TO THE 1500/3 AFG



HOSOKAWA ALPINE Aktiengesellschaft

Hosokawa Alpine is a member of the Hosokawa Micron Group, responding to global needs through emphasis on materials science and engineering. The Group is an international provider of equipment and technology for powder and particle processing, plastics processing and confectionery products. The Group maintains facilities for research, engineering, manufacturing and service in each of the world's major industrial markets.

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HOSOKAWA ALPINE

PROCESS TECHNOLOGIES FOR TOMORROWSM

THE ORIGINAL:

AFG – ALPINE FLUIDISED BED OPPOSED JET MILL



IDEALLY EQUIPPED FOR ANY TASK

A QUANTUM LEAP IN PROCESS TECHNOLOGY

The fluidised bed opposed jet mill: several gas jets intersect at the speed of sound in the centre of a chamber. Powder particles suspended in a fluidised bed become entrained in the gas jets and are accelerated. The particles impact against each other in the focal point of the gas jets and are thus comminuted. Because powder particles collide against powder particles without any mechanical mill components being involved, the product cannot be contaminated by abrasion. In combination with a high-performance air classifier, fluidised bed

opposed jet mills achieve extremely fine particle sizes – regardless of the hardness: even diamonds with a value of 10 on the Mohs' scale can be efficiently comminuted. Developed by Hosokawa Alpine while under the name ALPINE AG, the company launched its development onto the market in 1981. Within a very few years, this technology was being applied to a great number of different applications. With this mill, users not only improve the quality of their powders, but are also able to master completely new application fields.

In the following decades, we have continually improved and refined the jet milling process. Dependent on the product, milling is performed at low or high pressure, with inert gas such as N₂ or with hot gas. Megajet nozzles improve the milling capacity and state-of-the-art air classifiers achieve ever finer powders at a simultaneously sharp precision of cut.

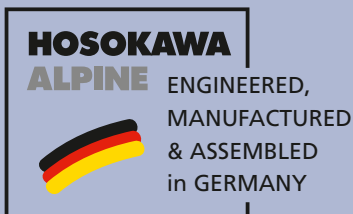
Today, Hosokawa Alpine AG has a fund of know-how gathered from the sale of well over 1,000 fluidised bed opposed jet mills and numerous trials in our spacious testing centre. Together with our customers, we always succeed in finding the best solution to every application. Customers are glad to draw on our experience and our high quality standards when it comes to selecting a system with a constant high product quality, efficiency, reliability and cost-effectiveness.

Our performance range includes:

- Trials with original products in our application testing centre
- Scale-up of the test results to production scale: configuration of the opposed jet mill and all auxiliary components, e.g. compressor
- Process-technological layout of the entire system
- If necessary, customised adaptation of the system including the fluidised bed opposed jet mill to special requirements
- Machine manufacture and assembly in our factory
- Installation and commissioning by our specialists
- Service throughout the entire life of the machines

Milestones in the AFG history:

- 1981 Market launch
- 1983 AFG with multi-wheel classifier, 3D nozzle arrangement and bottom nozzle
- 1985 N₂ circuit gas with load cells
- 1986 AFG for low-pressure operation
- 1987 AFG for hot-gas operation
- 1988 AFG for circuit-gas operation using argon
- 1990 AFG with monobloc ceramic wear protection (inc. classifying wheel)
- 1993 AFG with Megajet nozzles
- 1993 AFG with SIP function
- 1998 AFG as multi-processing mill
- 2000 AFG with TFG classifier specially for toner
- 2001 AFG for selective milling
- 2002 AFG integrated into an isolator
- 2002 Delivery of a 1500/3 AFG, the largest AFG ever built
- 2001 AFG Hastelloy® version
- 2005 AFG with TTC classifier head
- 2007 100 AFG-EC for abrasive products
- 2008 Picojet (miniature AFG for batches < 1 g)



EVERYTHING FROM ONE SINGLE SOURCE MEANS CENTRAL RESPONSIBILITY



With jet milling, advantage is taken of the fact that as the compressed gas exits the nozzles, it is accelerated to extremely high velocities.

PRINCIPLE OF OPERATION

In expanding, the energy contained in the compressed gas in the form of heat is converted to kinetic energy. The speed of sound is initially a natural limit for the exit velocity. But by using Laval nozzles, the exit velocity can be increased to above the speed of sound. Laval nozzles are characterised by their hourglass shape, which widens downstream of the narrowest cross-sectional point, the nozzle throat. The length of the divergent part of the nozzle is adapted to suit the operating pressure. Compressed air of 20°C and 6 bar overpressure is frequently used as the grinding gas, and delivers nozzle exit speeds of around 500 m/s. As a result of drawing in gas and product from the fluidised bed, the speed of the gas jets sinks extremely rapidly after exiting the nozzles.

Comminution is a result of interparticle collision in the jets of air and also in the core area, i.e. the point where the opposing jets intersect.

Jet mills are impact mills which are used to achieve maximum fineness values at maximum product purity. Such particle sizes can only be obtained in connection with an air classifying step. Spiral jet mills have a static air classifier integrated into the mill housing, whereas fluidised bed opposed jet mills are equipped with a dynamic deflector-wheel classifier. The fineness is set as a function of the classifying wheel speed.

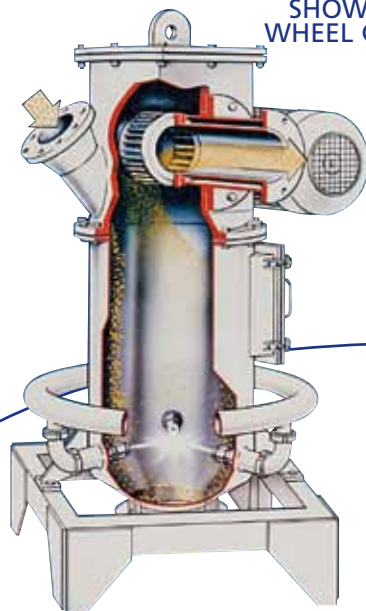
All-important is a high product loading of the nozzle jets in order to achieve a high concentration of particles and thus high

impact probabilities. The patented Megajet® nozzles were developed with this in mind. They consist of four small nozzles which as a result of their close proximity generate an underpressure at their common centre, and thus draw particles from the fluidised bed direct into the centre of the nozzle jet. The product level in the machine is controlled by means of load cells or by monitoring the current loading of the classifier drive.

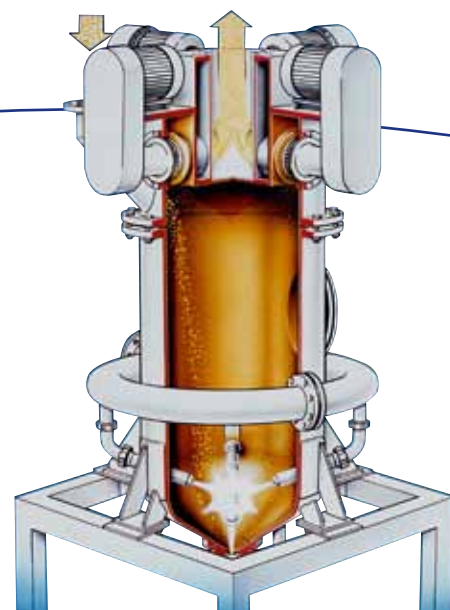
MILLING CHAMBER AND MEGAJET NOZZLES



SCHEMATIC SHOWING SINGLE-WHEEL CLASSIFIER



SCHEMATIC SHOWING MULTI-WHEEL CLASSIFIER



DESIGN

An important design parameter for a jet milling system is the flow rate of grinding gas V_L m³/h in standard condition (1 bar, 20°C). For cold compressed air, it is calculated as follows:

$$V_L = 0.55 \cdot n \cdot p \cdot d^2$$

where n is the number of nozzles in the machine. The grinding gas pressure p must be inserted in bar absolute and the nozzle diameter in mm.

Different conditions of the compressed grinding gas have to be compared on the basis of the mechanical jet power. The mechanical jet power increases not only as a function of the gas flow rate but also as a function of the grinding gas pressure and temperature. During compression, the grinding gas heats up. However, the less it is cooled, the more energy is transported to the nozzles and is then available for the size reduction. If the product permits, running

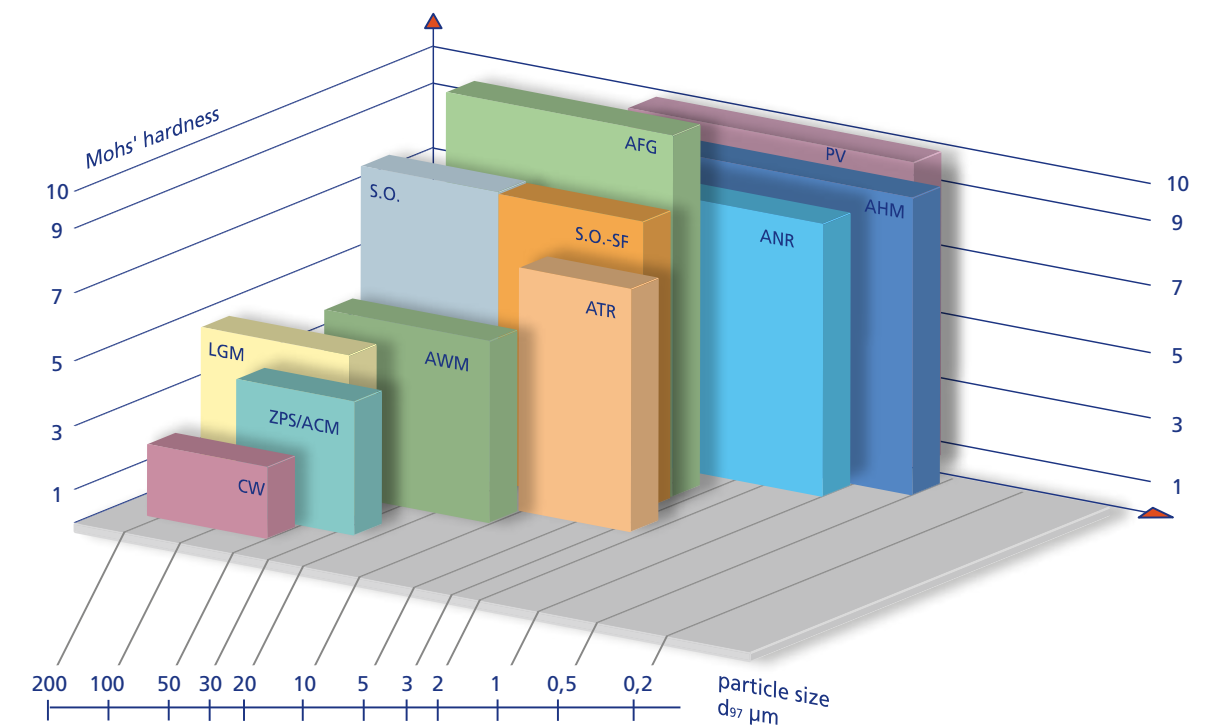
the mill in hot-gas mode will increase the efficiency of the milling system. The efficiency of compressed air generation is at its best if it is possible to work with low pressures, i.e. with a one-stage compressor.

JET MILLS FOR CONTAMINATION-FREE MILLING

Comminution in a jet mill is exclusively the result of particles impacting against each other in the gas jets, and is therefore contamination-free. This means that products of extraordinary purity can be obtained. Even extremely hard and abrasive products are comminuted efficiently in fluidised bed opposed jet mills. The wear to the mill can be kept under control by taking special measures, and products with no iron contamination can also be produced, e.g. by using ceramic components.

Because comminution in a gas jet rules out the inevitable heating of the product known from mechanical mills, jet mills are particularly suitable for milling temperature-sensitive products.

Alpine has a number of different jet mill product lines available to do justice to the different applications. They differ in the design of classifier head, which is tailored to the application. The universal AFG is equipped with a Turboplex ATP classifier head. This is frequently used on the AFG in multi-wheel design because the object here is usually production of finer products. The TFG was developed to grind toner. The classifier head design on TPS-basis unites jet milling and the latest classifying technology. It permits the cost-effective manufacture of extremely fine bulk materials.



FULLY DEVELOPED TECHNOLOGY FOR CUSTOM-MADE SOLUTIONS



The fluidised bed opposed jet mill AFG provides the widest application range. Based on our long years of experience with this technology, we are able to offer our customers exactly the right configuration for the task in hand.

FLEXIBLE FEATURES TO SUIT THE APPLICATION

- Single-/multi-wheel classifier head
- Monobloc ceramic classifying wheels ensure minimum wear when processing abrasive products
- Lining: PU, ceramic or special-grade steel to suit the product
- Stainless steel or mild steel, Ni alloy
- Horizontal or 3D nozzle arrangement, Megajet nozzles
- Selective milling, semi-batch mode, automatic quality control for high quality
- Load cells for product level control
- Material feed via a feed metering system

into the classifier head or direct into the milling chamber, or injector feed

- Explosion-pressure-shock-proof to 10 bar (g) with type test certificate as defined in 94/9/EC
- Pharma design up to machine size 630/1 AFG, steep particle size distribution, high bioavailability for active substances,

minimum off-spec batches, low manpower requirement

- Hot-gas mode for mineral products permits cost-effective manufacture of large amounts of ultrafine mineral powders
- Circuit-gas systems for pyrophoric products provide maximum safety
- If frequent colour change is necessary, the TFG for coloured toner reduces the costs and ensures optimum throughput rates

200/400 TTG WITH TURBO TWIN CLASSIFIER HEAD



400/1 AFG ON LOAD CELLS



APPLICATIONS

Even difficult products can be processed efficiently with the AFG jet mills.

Heat-sensitive materials such as toner, resin, wax, fat, ion exchangers, plant protectors, dyestuffs and pigments.

Hard and abrasive materials such as silicon carbide, zircon sand, corundum, glass frits, aluminium oxide, metallic compounds.

Highly pure materials where the requirement is contamination-free processing such as fluorescent powders, silica gel, silica, special metals, ceramic raw materials, pharmaceuticals.

High-performance magnetic materials based on rare earth metals such as neodymium-iron-boron and samarium-cobalt.

Mineral raw materials such as kaolin, graphite, mica, talc.

Selectively ground composite materials such as metal alloys.

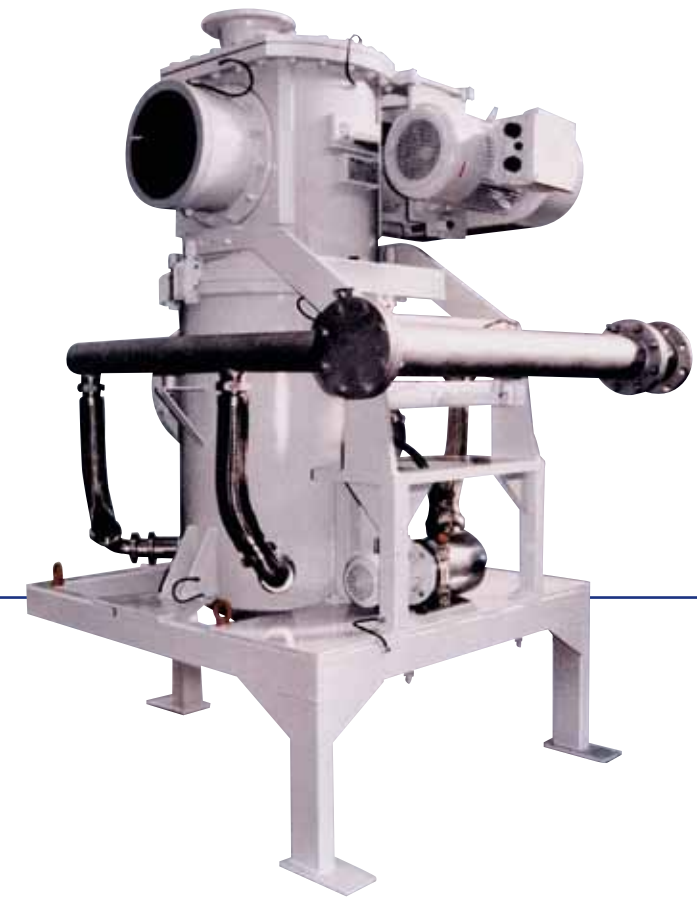
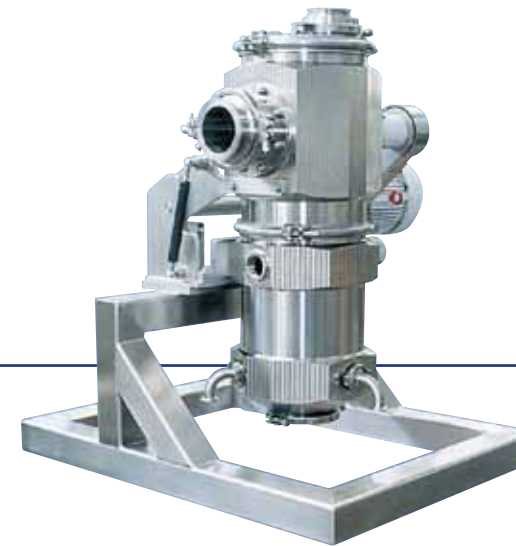


PICOJET FOR MINI BATCHES (SEPARATE BROCHURE)

CIP-DESIGN 200/1 AFG SYSTEM FOR MANUFACTURING INHALER LACTOSE WITH CONTROL UNIT AS DEFINED IN 21 CFR PART 11



280/1 AFG FOR PLANT PROTECTORS



630/1 AFG, PRESSURE-SHOCK-PROOF TO 10 BAR (g) WITH CLASSIFIER HEAD IN HYDRAULIC HINGE-BACK DESIGN

The AFG ensures optimum throughput rates, lower costs due to quick and easy cleaning as well as high product quality due to a sharp top cut.

Product line													
Opposed jet mill AFG, AFG-R	Type*	200/1	280/1	400/1	400/4	630/1	710/1	710/4	800/1	800/3	1000/1	1250/6	1500/3
Scale-up factor	F	0.25	0.5	1	1	2.5	4	4	7	7	10	14	21
Fineness d ₉₇ approx.	µm	4 - 60	4 - 100	5 - 120	4 - 100	6 - 150	7 - 150	5 - 120	8 - 150	6 - 150	9 - 200	6 - 150	8 - 150
Nominal air flow rate	Nm ³ /h	300	600	1200	1200	3000	4800	4800	8400	8400	12000	16800	22500
Number of grinding nozzles													
Type AFG (horizontal arrangem.)		3	3	3	3	4	4	4	4	4	4	4	4
Type AFG-R (3D arrangement)		3	3	4	4	5	5	5	5	5	5	5	5
Ultrafine classifier													
Turboplex ATP	Type	100	140	200	100	315	400	200	500	315	630	315	500
Number of classifying wheels		1	1	1	4	1	1	4	1	3	1	6	3
Total drive power	kW	3	4	5,5	12	11	15	22	30	33	45	90	120
Max. class. wheel speed	rpm	11500	8600	6000	11500	4000	3150	6000	2400	4000	2000	4000	2400

* For type 100 and 140 please refer to page 9

MULTI-PROCESSING SYSTEM FOR THE HIGHEST DEMANDS



One of the tasks of laboratories or development centres is the manufacture of small amounts of product samples for tests with the aim of defining an industrial manufacturing process.

The laboratory-scale systems used for this must offer process reproducibility and the possibility of scaling up at a later date to production-scale equipment. The 100 AFG fluidised bed opposed jet mill was developed especially for this task.

Fluidised bed opposed jet mills require less energy than any other conventional jet mill. The optimum utilisation of the jet energy and the extremely high precision of cut of the integrated Turboplex ultrafine classifier allow up to 50% energy savings. Another advantage is that fluidised bed opposed jet mills always deliver ultrafine powders with a sharp top cut across the whole working range. Ultrafine powders can also be manufactured with extremely steep particle size distributions to match market and application demands. Because only air and no material is routed through the

grinding nozzles, the AFG is also extremely low in wear.

FEATURES

- For materials with a Mohs' hardness up to 10
- Fineness values of $d_{97} = 2$ to $40 \mu\text{m}$
- Products with steep PSD and free from oversized particles
- The use of PU keeps the end products free from iron contamination
- Throughput approx. 1 to 25 kg/h
- Explosion-pressure-shock-proof to 10 bar overpressure
- To order, integrated into an isolator

Laboratory systems are generally inerted with nitrogen if used for processing potentially explosive products. Under special conditions, an explosion-pressure-shock-proof system design to 10 bar (g) is possible.



50 AFG

MULTIPROCESSING SYSTEMS FOR A HOST OF COMBINATIONS

Suitable for 5 processes - also for CIP/SIP procedures.

- Opposed jet milling with the 100 AFG for materials with a Mohs' hardness up to 10 and end-product fineness values of between 2 and $40 \mu\text{m}$,
- Ultrafine classifying with the 50 ATP, separation range from 2 to $120 \mu\text{m}$
- Fine grinding with integrated 50 ZPS classifier for materials with a Mohs' hardness up to 3.5
- Ultrafine grinding with spiral jet mill 100 AS for fineness values between $5 \mu\text{m}$ and $30 \mu\text{m}$
- Fine impact milling with 100 UPZ

This concept revolves around the fact that the installation frame, the feed metering unit, the valves for bearing rinsing air and milling air, the drive, the product collection filter, the fan, the electrics and the control unit are common to all processes.

Combination possibilities

	AFG	ATP	ZPS	AS	UPZ
1)	100	50	50	100	100
2)	140	70	70	140	-
3)	200	100	100	200	160



50 ATP

ATP FEATURES

- For materials with a Mohs' hardness up to 10
- Separation/fineness range steplessly adjustable from $d_{97} = 2$ to $80 \mu\text{m}$
- Extremely high precision of cut
- End products free from oversized particles with a steep PSD
- Ideal for materials of high density
- Excellent dispersion of cohesive materials
- Throughput approx. 3 to 50 kg/h



50 ZPS

ZPS FEATURES

- For soft materials with a Mohs' hardness up to 3.5
- Fineness values of $d_{97} = 8$ to $80 \mu\text{m}$
- End products free from oversized particles with a steep PSD and exact top-size limitation

Product line				
Opposed jet mill AFG, AFG-R	Type	100	140/1	140/4
Scale-up factor	F	0.06	0.15	0.6
Fineness d_{97} approx.	μm	2 - 40	3 - 60	3 - 60
Nominal air flow rate	Nm^3/h	100 - 120	150	600
Number of grinding nozzles				
Type AFG (horizontal arrangem.)		-	3	3
Type AFG-R (3D arrangement)		3	3	3
Ultrafine classifier				
Turboplex ATP	Type	50	70	70
Number of classifying wheels		1	1	4
Total drive power	kW	1	2.2	8.8
Max. class. wheel speed	rpm	22000	17000	17000

THE 140 AFG - A PILOT AND SMALL PRODUCTION SYSTEM

The 140 AFG bridges the gap between laboratory equipment and production-scale machines. This machine size is frequently used in the production of dental ceramics. In spite of producing on a pilot scale, it nevertheless offers multi-processing functions as well as ease of operation. The product-contact parts are available in wear-protected design or in a design suitable for operation without iron contamination.

Practical examples 50 ATP	Powder fineness % < μm^* Analysis points of PSD			Feed rate kg/h	Fines kg/h
Aluminium oxide	97% < 11.5	50% < 2.6		17	7.5
Aluminium powder	97% < 8	50% < 3.7		6	1.5
Boron carbide	97% < 6	50% < 2.5		10	0.36
Bronze powder	97% < 16	50% < 8		7	4.1
Glass beads	97% < 4.5	50% < 2		17.5	1.1
Glass powder	97% < 8	50% < 9		3.5	0.8
Limestone	97% < 4	50% < 2		6.3	2
Fluorescent powder	97% < 5.5	50% < 2.5		16	0.9
Silicon (pure)	97% < 6	50% < 2.7		13	0.15
Silicon carbide	97% < 10	50% < 4.5		7	0.7
Talc	97% < 8.5	50% < 4		35	12.3
Wax	97% < 7.5	50% < 4.2		7.5	2.3
Dental ceramic	97% < 26.8	50% < 7.5		17	7.9

* All values are non-binding reference values.

Practical examples 50 ZPS	Powder fineness % < μm^* Analysis points of PSD			Feed rate kg/h
Aluminium hydroxide	97% < 22	50% < 9		30 - 35
Lead sulphate	97% < 8	50% < 2.6		10 - 15
Calcium stearate	97% < 11	50% < 4.7		10 - 15
Graphite	97% < 70	50% < 22		8 - 10
Limestone	97% < 8	50% < 3.5		12.5 - 2
Limestone (soft crystalline)	97% < 15	50% < 4.5		8 - 10
	97% < 80	50% < 9		30
Copper-oxide-chloride	97% < 12	50% < 4.8		15 - 20
Lactose	97% < 25	50% < 8		20 - 25
Phenolic resin	97% < 60	50% < 24		20 - 30
Starch derivative	97% < 80	50% < 30		20 - 25
Talc	97% < 12	50% < 7.5		10 - 15
Tricalcium phosphate	97% < 9	50% < 3.2		5 - 10
Zinc chromate	97% < 4	50% < 1.6		3 - 5
Zinc phosphate	97% < 12	50% < 5.9		15 - 20
Sugar	97% < 15	50% < 5.2		3 - 5

* All values are non-binding reference values.



The 100 AFG-EC is now available, a standard version that was developed especially for abrasive products and which offers all the main functions of its big sister.

100 AFG-EC

The 100 AFG-EC was developed for processing strongly abrasive, mineral raw materials. It is characterised by the following features.:

FEATURES

- Processing of mineral raw materials without iron contamination
- Wear-optimised fines discharge
- Milling chamber with PU lining
- Wear-protected (PU) ductings
- End-product bagging with pivoted slide gates and special containers
- Equipped with temperature sensors
- Visualisation with Simatic Panel 170 B with keyboard
- Machine and system components made of stainless steel for frequent cleaning using water
- Preliminary collection of ground product in a cyclone; cyclone with high collection efficiency, wear-protected with PU
- Automatic reverse jet filter, can be dismantled into its component parts for easy cleaning
- Feed screw with large supply bin for processing batches up to 25 kg .

100 AFG-EC SPECIAL DESIGN FOR ABRASIVE PRODUCTS

Technical specifications 100 AFG-EC	
Mains power connection	3 phases, 16 A
Compressed air consumption:	60 Nm ³ /h, 6 bar (g)

← **READY FOR OPERATION IMMEDIATELY**



Practical examples* 100 AFG	Powder fineness % < μm Analysis points of PSD				Feed rate kg/h		
Aluminium oxide	99.0%	<	5	69.0%	<	2	0.1
	99.0%	<	50	9.5%	<	10	
Aluminium titanate	99.9%	<	6	41.5%	<	2	0.4
Aluminium silicate	99.9%	<	6	56.0%	<	3	25.0
Bentonite	91.0%	<	16				30.0
Lead titanate	99.5%	<	40	41.0%	<	10	10.5
Boron carbide	99.6%	<	6				0.2
Dicalcium phosphate	99.7%	<	3	33.0%	<	1.5	0.5
Dolomite	99.5%	<	5				2.4
Iron oxide	99.8%	<	4	63.1%	<	1.5	0.2
Frits	98.7%	<	8	29.0%	<	2	1.5
Gypsum (raw gypsum)	99.9%	<	12	49.0%	<	4	2.2
Mica	98.0%	<	20				6.0
Graphite	95.0%	<	8	19.0%	<	2	0.5
Limestone	99.0%	<	6	50.0%	<	2	0.4
Ceramic powder	99.9%	<	4	66.0%	<	1	0.68
Silica (precipitated)	97.0%	<	12	50.0%	<	4.0	1.0
Corundum	97.0%	<	8	50.0%	<	4	1.3
	97.0%	<	45	50.0%	<	25	5.8
Copper powder	94.2%	<	12	50.0%	<	5	2.9
Lactose	99.0%	<	8	50.0%	<	3.5	2.5
	99.0%	<	5.9	50.0%	<	2.7	2.0
Fluorescent powder	99.8%	<	16	24.0%	<	2	3.8 - 5
Magnesium oxide	99.2%	<	5	45.1%	<	1.5	1.5
Magnesium zirconate	97.0%	<	10	50.0%	<	3	1.0
	97.0%	<	60	50.0%	<	32	8.0
Molybdenum powder	98.7%	<	2	50.2%	<	1.5	1.2
Neodymium-iron-boron	50.0%	<	3.5 - 4	(FSSS)			2.5 - 7
Quartz (highly pure)	99.9%	<	75	55.0%	<	20	8.8
Quartz	97.0%	<	8.5	50.0%	<	4	2.5
Samarium-cobalt	50.0%	<	3...6.5	(FSSS)			1.5 - 4
Silicon (pure)	99.6%	<	10	20.4%	<	3	0.6
	99.3%	<	5	24.4%	<	2	0.3
Silicon carbide	99.6%	<	5	12.3%	<	1.5	0.3
	98.7%	<	8	14.5%	<	2.5	1.1
Silicon nitride	99.3%	<	10	36.3%	<	2	1.7
	99.9%	<	5	45.0%	<	1.5	0.8
Talc	50.0%	<	1.7				5.5
	50.0%	<	3.1				15.5
Toner (black)	50.0%	<	6...10				1 - 3
Toner (coloured)	50.0%	<	5...8				1 - 3
Wax	90.0%	<	15				1.0
Tungsten carbide	97.0%	<	2				2.5
Zirconia	97.0%	<	40				8.5
	97.0%	<	9	50.0%	<	4.5	3.5
	97.0%	<	3	50.0%	<	1.2	2.8

* All values are non-binding reference values.



IRON OXIDE

Synthetic iron oxides are produced using a number of different chemical processes, i.e. by means of thermolysis or oxidative processes. A calcining process that significantly influences the product behaviour of the iron oxide is performed prior to milling. It is above all the agglomerates that are affected, which dependent on the degree of calcination, display different degrees of hardness. The task of the milling process is to deglomerate these hard coarse particles and to fine-grind them, whereby it has been found in this context that red iron oxide is much more difficult to grind than yellow or black iron oxide.

PRACTICAL EXAMPLE

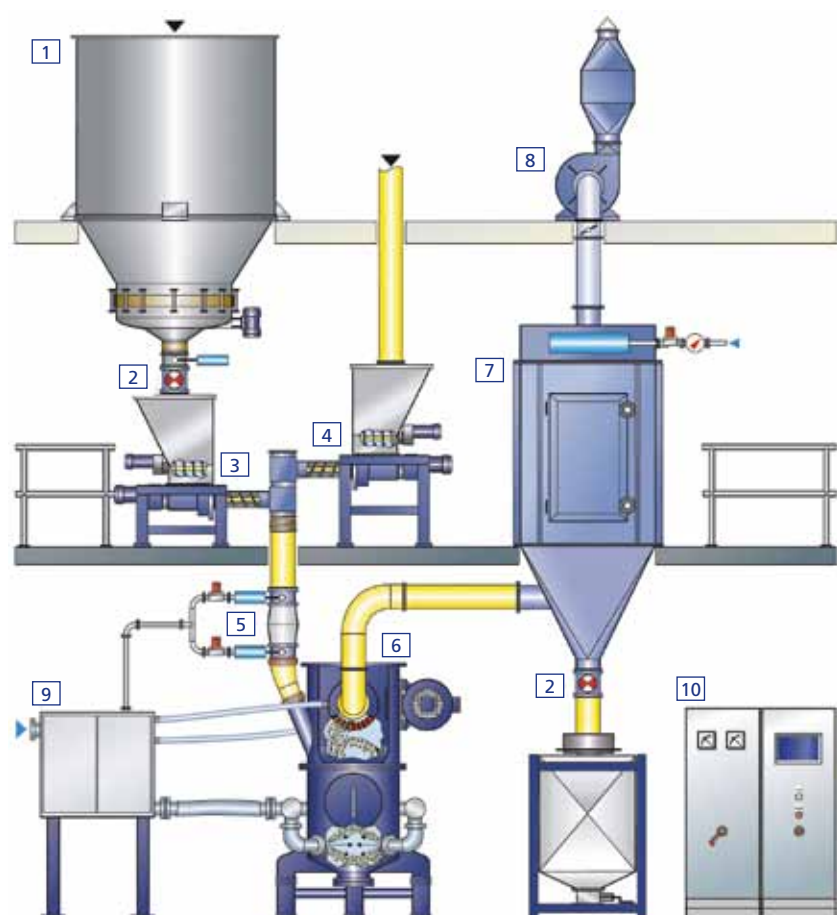
Reference values of an Alpine fluidised bed opposed jet mill 400/1 AFG

Feed material:	red iron oxide, pre-crushed
Feed size:	< 100 µm
Feed temperature:	20 - 30°C
Additives:	powdery or liquid, approx. 0.2% added to feed
Feed rate:	Quality A: approx. 370 kg/h Quality B: approx. 550 kg/h
End-product fineness:	0.01% residue on 38 µm (wet screening)
Hot-gas process:	compressed air temperature +145°C

APPLICATIONS

The main applications for iron oxides are as colourants in building materials, paints and varnishes as well as in plastics. The milling systems are operated with hot gas to improve the flow behaviour and to minimise the formation of deposits. The result is an extremely high degree of deglomeration, whereby to reduce the reagglomeration rate, additives are used.

- 1 Feed bin with activated discharge
- 2 Rotary valve
- 3 Feed metering screw with agitator
- 4 Feed metering unit for additives
- 5 Flap valve
- 6 Fluidised bed opposed jet mill AFG
- 7 Automatic filter
- 8 Fan
- 9 Control unit for process gas
- 10 Process control



POLYTETRAFLUORETHYLENE (PTFE)

PTFE is a fluorinated polymer which is more commonly known under its commercial name Teflon. The many and varied special features such as resistance to chemical attack, low coefficients of friction and hydrophobic surface make this material ideal for a great number of different applications, e.g. as non-stick coatings for pots and pans, for the manufacture of water- and wind-proof clothing, for coating bearings, seals and medical implants and for cable insulation.

Typical requirements made of PTFE after milling are:

- Fineness values in the range of $d_{97} = 40 \mu\text{m}$ with a sharp top cut
- Contamination-free and iron-free processing
- Highly pure processing for special applications in aerospace engineering

Alpine's fluidised bed opposed jet mills AFG in special design are ideally suited to meet all these requirements. Special construction materials with high surface qualities are used. A hinge-back mill design is often requested to ensure quick and easy cleaning.

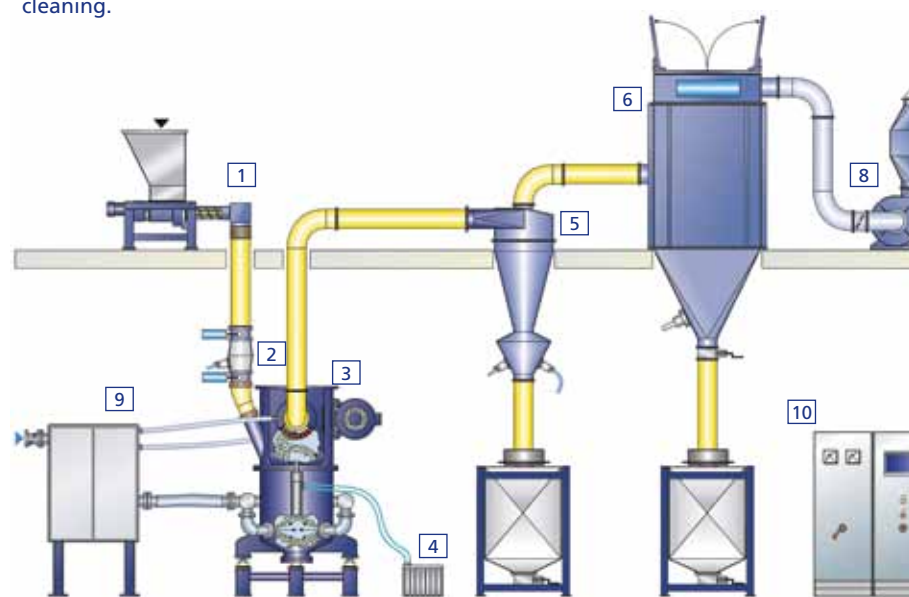
PROCESS DESCRIPTION

The milling process takes place in a Hosokawa Alpine fluidised bed opposed jet mill AFG. The feed product is gravity-fed to the milling chamber. The finely ground product is collected in a cyclone, and the cyclone exhaust air is dedusted in a downstream reverse jet filter.

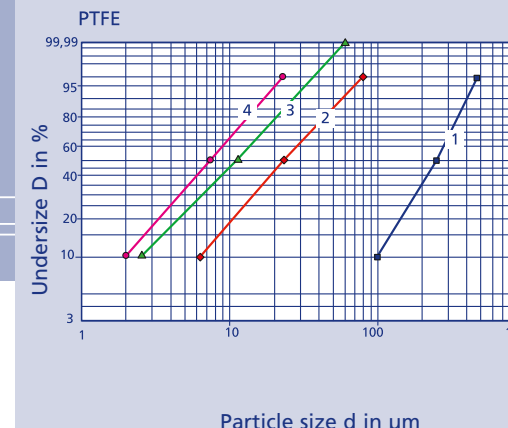
Finely ground PTFE tends to form flakes when conveyed through rotary valves or flap valves. Because of this, discharge elements of this type are not used and instead, correspondingly large material collection bins are connected up direct to the cyclone outlet and to the filter outlet.

Standard values for an Alpine fluidised bed opposed jet mill 710/1 AFG in special design:

Feed material:	PTFE chips max. 20 mm
End-product fineness:	$d_{99,5} < 50 \mu\text{m}$
Throughput rate:	approx. 250 kg/h
Air flow rate	approx. 3200 Nm ³ /h



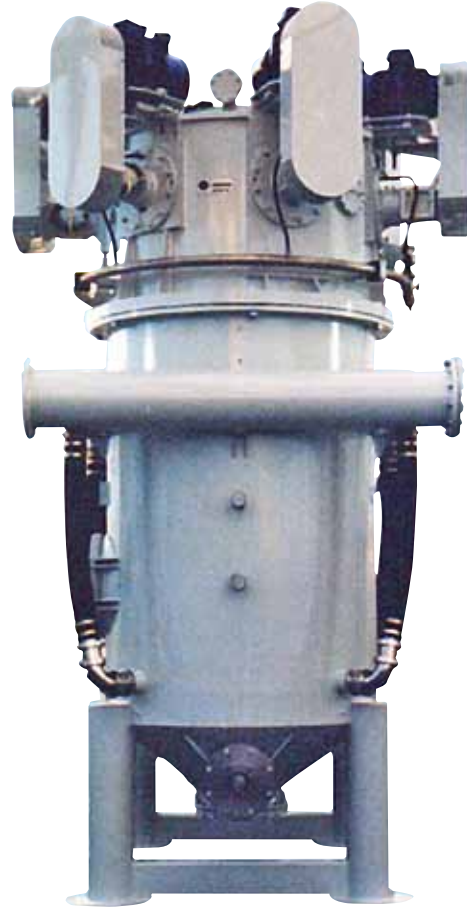
- 1 Feed metering unit
- 2 Flap valve with fluidisation
- 3 Fluidised bed opposed jet mill AFG
- 4 Hydraulic unit
- 5 Cyclone
- 6 Automatic filter
- 7 Shut-off valve
- 8 Fan with outlet-side silencer
- 9 Process-gas distributor
- 10 Process control



Standard values for 400/1 AFG

- Curve 1 Feed size 97% < 480 µm
- Curve 2 97% < 80 µm approx. 200 kg/h
- Curve 3 97% < 38 µm approx. 60 kg/h
- Curve 4 97% < 22 µm approx. 25 kg/h



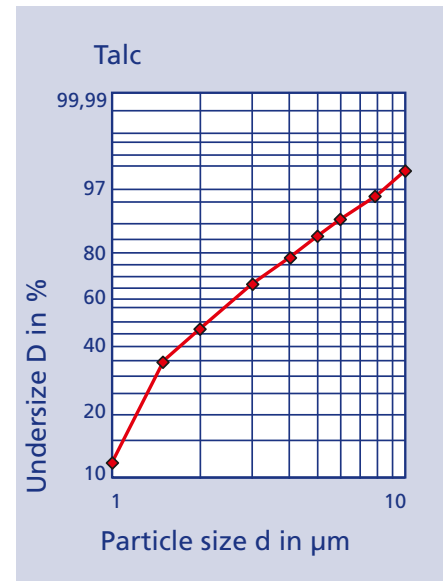


TALC

Alpine's fluidised bed opposed jet mill has become a standard the world over for ultrafine milling. The use of a multi-wheel classifier in the AFG jet mill allows high fineness values (e.g. $d_{50} = 1 \mu\text{m}$) at high throughput rates to be achieved. This is the reason why our large jet mills (800/3 AFG and 1250/6 AFG) are in use by all market leaders on the talc sector. The new 1500/3 AFG - the world's largest jet mill (max. air flow rate $20,000 \text{ Nm}^3/\text{h}$) - has made it possible to significantly increase the throughput rate.

Standard values for talc

AFG	d_{50} μm	t/h	d_{50} μm	t/h
1500/3	2	5.4	3	9.7
1250/6	2	3.6	3	6.5
800/3	2	1.8	3	3.2
630/1	2	0.65	3	1.2



Standard values for an 800/3 AFG
 $d_{50} = 2 \mu\text{m}$, $d_{97} = 8 \mu\text{m}$

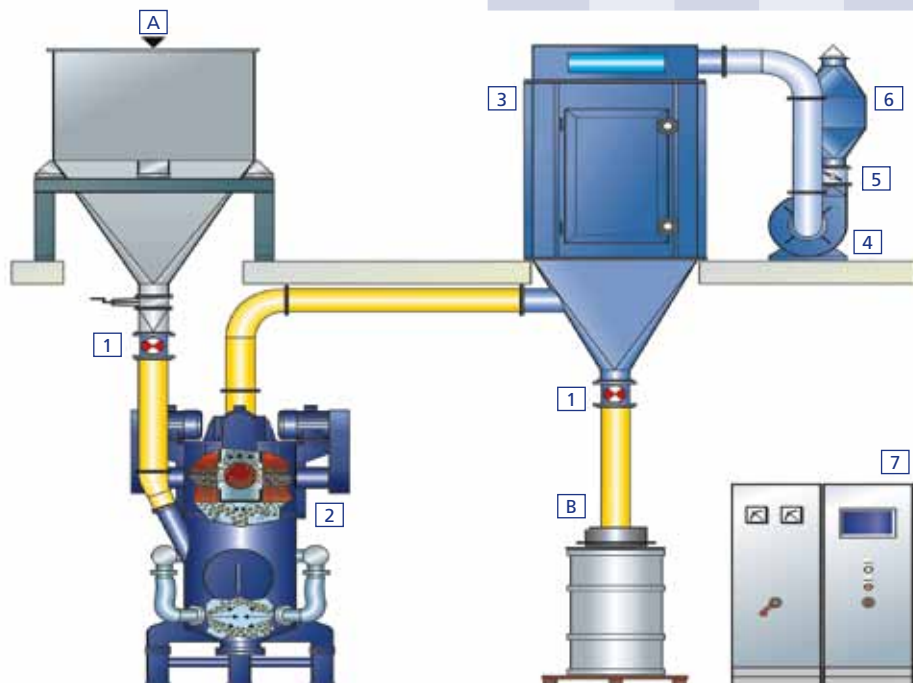
All machines are equipped with patented Megajet nozzles and operate with hot compressed air to boost performance.

Typical for use of the AFG is a fineness range of $d_{97} = 5$ to $20 \mu\text{m}$ and the demand for milling that is free from (iron) contamination. Over and above this, the AFG offers an extremely good delamination function at optimal preservation of the laminar structure of talc.

- 1 Feed metering rotary valve
- 2 Fluidised bed opposed jet mill AFG
- 3 Automatic reverse jet filter with rotary valve
- 4 Fan
- 5 Butterfly valve
- 6 Outlet-side silencer
- 7 Control cabinet

- A Feed product
B End product

1250/6 AFG WITH MULTI-WHEEL CLASSIFIER



710/4 AFG FOR SPECIAL CERAMICS WEAR-PROTECTED DESIGN WITH MONOBLOC CERAMIC CLASSIFYING WHEELS

CERAMIC PIGMENTS (DRY PROCESSING)

Ceramic pigments are used to colour a great variety of different ceramic products such as table and sanitary ware, glass, enamel and coloured building ceramics (e.g. the surfaces of roof tiles). Besides the traditional wet processing method, the dry processing of ceramic pigments with Alpine's opposed jet mill AFG to ultrafine powders with exact top-size limitation has established itself. The employment of hot gas up to 160°C increases the grinding efficiency. Contamination-free processing is a must, and this is achieved in the AFG by a variety of wear-protection measures.

Alpine's opposed jet mill AFG is characterised by good accessibility for cleaning, an important point if cross-contamination is to be avoided when processing ceramic pigments and the product colour is changed frequently.

AL₂O₃ GRINDING CHAMBER



AL₂O₃ CLASSIFYING WHEEL



Wear-protected design of fluidised bed opposed jet mill AFG:

- Classifying wheel: Al₂O₃ monobloc ceramic, WC, TiN, SiC
- Fines discharge: Al₂O₃ monobloc ducting or tiles
- Laval or Megajet nozzles: Al₂O₃ monobloc ceramic
- Classifying head: Al₂O₃ tiles or polyurethane (PU)
- Grinding chamber: Al₂O₃ tiles or polyurethane (PU)

Typical performance data of Alpine's opposed jet mill 400/1 AFG:

Brown ceramic pigment:	$d_{99} = 4.1 \mu\text{m}$	145 kg/h
Red ceramic pigment:	$d_{99} = 5.0 \mu\text{m}$	200 kg/h
Orange ceramic pigment:	$d_{98} = 10.0 \mu\text{m}$	70 kg/h

These examples show just how different the grindability of ceramic pigments is. When the target is high fineness values and high throughputs, Alpine's opposed jet mills AFG with multi-wheel classifier heads such as the 400/4 AFG or 710/4 AFG are used.

GLASS FRITS

In the same way as ceramic pigments, glass frits also belong in the category of abrasive products. Because of this, we at Alpine recommend the same AFG machine design as is used for ceramic pigments. For special glass types, fineness values of $d_{50} = 0.5$ to 2.0

μm are demanded. The feed product already has a fineness of $d_{50} = 3$ - $5 \mu\text{m}$. The high end-product fineness is achieved with a 400/4 AFG multi-wheel classifier at a throughput rate of approx. 40 kg/h .

EXAMPLES FROM THE PHARMA INDUSTRY



PRODUCTION SYSTEMS FOR ACTIVE SUBSTANCES

These production systems are typically employed for large batches of active substances and also for continuous production operations, and can be optimally adapted to the respective product properties. Great attention is paid hereby to the operating costs, whereas accessibility and quick cleaning often have to take a back seat. Pressure-shock-proof design in accordance with the ATEX 94/9/EC Directive for the reliable control of products which are a dust explosion hazard can constitute the ideal solution here. Alpine machines all come with a type test certificate for Zone 20/21.

Dependent on the cleaning cycle requirements and the toxicity of the products, the system is designed for WIP or CIP. If solvents are used within or around the system, the system must be designed for installation in Zone 1 or 2 as per ATEX.

STERILE SYSTEMS FOR CIP/SIP MODE

In view of the sometimes opposing requirements, a great deal of experience is necessary if sterile system concepts for powders are to be translated into systems that are reliable and safe in operation.

The Pharmaplex bearing assembly developed by us permits sterilisation with saturated steam for high-speed, oil-free bearing concepts. The concept has meanwhile been successfully installed in all common mill types. Suitable bearing assemblies are available for just about every machine, from the Ha hammer mill and the UPZ fine impact mills to the AFG jet mills. The SIP cycle of a system is usually preceded by a complete CIP cycle, which must be verified by extensive preliminary tests on different system components in order to determine the best cleaning medium and optimum type and number of CIP nozzles. Critical system components such as the size reduction module or filling unit are often additionally integrated into an isolator in order to guarantee maximum operator protection as well as aseptic conditions even when the system needs to be opened during a machine stoppage.

Practical examples

Product	End fineness kg/h	Throughput	Machine
7 ADCA	d ₉₅ = 65 µm	720	630/1 AFG
Omeprazol	d ₅₀ = 2 µm d ₉₈ = 7.5 µm	10	200/1 AFG

DESIGN REQUIREMENTS

- Fully aseptic design of shaft bushings and clamp connections
- Smooth all-over design free from dead zones in order to ensure perfect drainage and sterilisability
- Aeration of zones inside the machine with poor ventilation
- Manufacture of pressure-loaded system components in accordance with the pressure vessel regulation (PED)
- Measuring and control instrumentation in sterile design

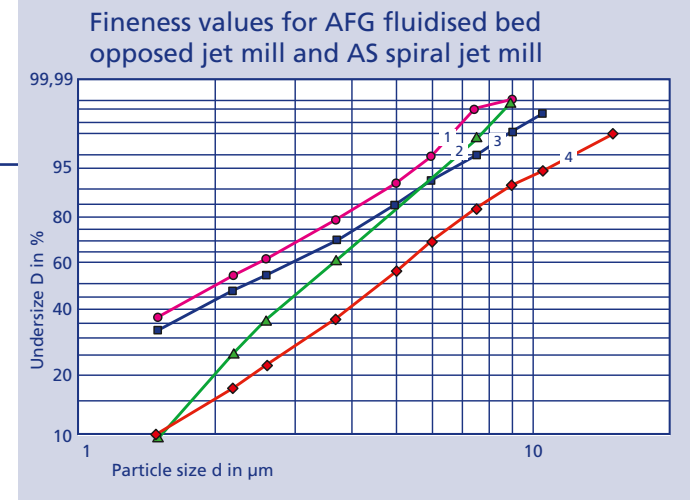
200/1 AFG IN PHARMA DESIGN



EXAMPLES FROM THE FOOD INDUSTRY



- Curve 1 = 99.9% < 9 µm
- Curve 2 = 99.9% < 8.5 µm
- Curve 3 = 99% < 9 µm
- Curve 4 = 90% < 9 µm



MILK MINERALS

The main constituent of milk minerals is calcium phosphate. It can be precipitated from the whey by adjusting the pH value and separated in a centrifuge. The resultant powder after drying has a high calcium content that originates from a biological source, namely milk.

Whey is a by-product yielded from the manufacture of cheese, curd cheese or casein. The milk minerals are offered under different trade names by several of the larger producers in the milk processing industry.

Because the demanded fineness values range between < 7 µm and < 15 µm, it is only jet mills that can be used for milling. Hosokawa Alpine has had great success with its fluidised bed opposed jet mills AFG for the milling step.

Although fineness values < 15 µm can be achieved with the spiral jet mills, higher fineness values with correspondingly steeper particle size distributions are accomplished with the AFG mills.



Reference values, milling with a fluidised bed opposed jet mill AFG*

Machine	End fineness / throughput		
	d ₉₇ = 6 µm d ₉₉ = 7 µm	d ₉₇ = 9 µm d ₉₉ = 10 µm	d ₉₇ = 12 µm d ₉₉ = 13 µm
200/1 AFG	25 - 35 kg/h	40 - 50 kg/h	50 - 60 kg/h
400/1 AFG	100 kg/h	150 - 180 kg/h	200 - 240 kg/h
710/1 AFG	400 kg/h	600 - 720 kg/h	800 - 900 kg/h

* The above values are reference values and can fluctuate dependent on the product composition and manufacturing process..

FLUIDISED BED OPPOSED JET MILL 800/1 AFG





CONSULTING SERVICES

Task specification, exploration of different technical solutions, product-specific processes, consideration of safety aspects, different system concepts, e.g. pressure-shock-proof, inert gas mode, CIP/SIP, etc.

TRIALS

Milling and classifying trials, laboratory analyses, determination of energy requirements and production costs, manufacture of product samples, rental systems.

ENGINEERING

Initial design stage: conceptual studies – basic engineering, flowcharts – installation planning; safety concepts, e.g. ATEX; project documentation
Detail planning: P&I diagrams; calculation and layout; specification of components; design, programming and networking of visualisation systems; structural steel engineering with static calculations; planning the piping and ductwork; official acceptance of subcontractor work.

PROCESS AUTOMATION

Control cabinets, conventional control units (Plexwire), process control with PLC, visualisation systems, process data archiving, logic diagrams, teleservice connection for remote maintenance.

DOCUMENTATION

- Operating instructions, operating manuals
- "As built" documentation
- Software documentation
- Documentation as per 21 CFR Part 11 for the pharmaceuticals industry
- CE certification

MANUFACTURING

The production department comprises the sheet metal and structural steel engineering shop for the production of complex subassemblies, including pressure-shock-proof ones, as well as the machine shop, which is equipped with an extremely wide range of production machines.
In 2007/2008, two completely new production halls were built to accommodate the production and assembly shops as well as the apprentice shop and other associated shops.

ASSEMBLY

- Assembly of complicated subassemblies and machines of different design and dimension
- Design consultancy in all manufacturing issues
- Test runs, factory acceptance tests (FAT)

ENGINEERING PLANNING AND SUPERVISION

- Project coordination
- Installation and assembly of complete systems on the customer's premises by competent field service engineers all over the world
- On-site supervision

COMMISSIONING

- Commissioning, training, test runs, site acceptance tests (SAT)

TOLL PROCESSING

Our affiliated company, Hosokawa Micron Powders GmbH in Cologne, offers a wide range of toll processing services. We would be glad to give you the contact details.

MADE IN GERMANY

A high-quality product calls for competence in development, engineering, manufacture and assembly. And this competence in turn stems from the training, know-how, experience and motivation of the company staff. The environment of the company headquarters in Augsburg has always fulfilled these requirements in the best possible way. And it is here that we find the dedicated and excellently trained staff who render a great service to the company, the products and the success of our customers.

For this reason and in the tradition of our own self-imposed commitment to high quality, we will continue to lay store by Germany as a business location. The new emblem for our letterheaded company paper with the message ENGINEERED, MANUFACTURED AND ASSEMBLED IN GERMANY underlines this commitment.



ALPINE'S TESTING CENTRE



With a floor area of 3000 m² spread over 4 stories, the Hosokawa Alpine application testing centre in Augsburg is one of largest testing centres in Europe dedicated to the wet and dry processing of products in powder form.

With over 60 state-of-the-art machines and complete systems on both a production

and laboratory/pilot scale as well as the associated testing laboratory, we offer you the most comprehensive range of testing possibilities aimed at optimum system layout and determination of process-related guaranteed values.

The 20-strong team in the testing centre is made up of test engineers, laboratory technicians, system assistants and mechanics, is fully conversant with the technical characteristics of every system and has a great deal of experience in handling a wide variety of different products.

