DRUMMILLS

Introduction:
Drummills are most frequently used for crushing / grinding of solid materials. The particle size reduction in this usually discontinuous process can be regarded as the enlargement of surface of materials. Physically, the grinding process can be described as a permanently repeated creation of break surfaces. Drummills are characterized by a rotating vessel that is loaded with grinding media (mostly grinding balls) and to be processed material up to different filling ratios determined by the application. Drummills therefore belong to the class of ballmills.

Operating principle:
Ballmills are devices where a product is treated by the load of moving grinding media. Basically the distinguishing features of drummills are different kinds of this treatment which can fundamentally divided into shear, friction and collision where a strict distinction is possible very rarely only. The grinding media transfers kinetic energy either from a rotating vessel (rollermill, ballmill BM or drummill) or from a rotating impeller/rotor (Simoloyer®) into the product. In ballmills that allow a high kinetic energy input (Simoloyer®), this transfer mainly is performed by collision of free moving balls, in systems of a lower kinetic (e.g. drummills) predominantly by shear and friction in a rolling to cascading adjusted ball-packet.

Application:
The application range of drummills leads in dependency of adjusted parameters from mixing, dispersing, de-agglomerating and particle size reduction up to the influencing of materials-structure sometimes in interaction with chemical and solid state reactions which can lead to Mechanical Alloying. Due to the relatively low kinetic and the incontrovertible barrier of the critical velocity in case of rotating vessels, here this application is extremely limited and should preferably be carried out in high kinetic systems.
Drummills are basically used in industrial applications exclusively. This leads from porcelain-made or ceramic-lined (coated) mills for the chemical-, pharmaceutical-, food- and ceramic-industry, here in particular the production of paint-pigments and glass fluxes, up to the processing of hard-phase materials which is usually performed in steel-mills often using hard-coated or lined vessels. Here also rubber-linings are applied.

Options and accessories:
The accessories for the drummills include charge-bearings, safety-valves and cooling- or heating systems. Related devices are screens/vibrating screens, magnetic filters, feeders, grinding media classification systems and agitator tanks by which the complete material-transfer, the product handling and plant-operation is covered.

Construction of a drummill:
Drummills in support-design are build up in a unit construction system (122 standard-sizes including 14 types with porcelain-pans) and therefore the less cost-intensive design-type. However, the two supports must be fixed on the floor or basement always. In case of drummills in compact-design, this is not necessary but recommended, drummills in frame-design are build for integration in storey ceilings or working platforms.
Drummills are characterized by the following criteria:

- the to be processed product (quality) determines the **vessel-type** with respect to the material;
- the to be processed product quantity determines the **unit-size** of the drummill;
- the condition of the product and the process determine the **operation mode** (wet- or dry-operation);
- the process and in particular the processing procedure determine the necessity of **options**;
- the set-up possibilities determine the **design-type**;

Vessel-type (mill-lining): *A* = Al_2O_3, *M* = Steatit, *G* = Rubber Lining, *T* = Hard-Porcelain, *S* = Manganese Steel					
	Unit size: grinding chamber volume V = x • 100 (e.g.. V = 10 • 100 = 1000 l)				
		Operation mode: *N* = wet operation *T* = dry operation			
			Grinding media: *A* = Al_2O_3, *M* = Steatit, *G* = Al_2O_3- /steel-core rubber lined, *P* = Hard-Porcelain, *S* = Steel, *H* = Hardmetal		
				Options: *z* = charge-bearing, *k* = cooling-system, *h* = lifters, *s** = spezial application, (see table options)	
A	**10**	**N**	**A**		1000 liter / wet-operation / alumina lining / alumina-grinding media
S	**10**	**T**	**S**	**zk**	1000 liter / dry-operation / manganese steel vessel / steel-grinding media / with charge bearing and cooling jacket

Economical operation of a drummill:
In the grinding vessel, the grinding balls (media) are effected next to the gravitational force $m_k\, g_e$ also by the centrifugal force $m_k\, v^2\, r^{-1}$, where v is the rotational speed of vessel and r the radius of ball orbit. The interaction of these forces describes the relation friction and collision in a drummill. For a fixed mill-unit-size with fixed milling balls, the rotational speed where centrifugal force is in equilibrium with gravity is defined as the critical velocity (n_k).
The diameter is the main geometric parameter of the vessel since it determines the rotational speed at a fixed number of revolutions of the vessel.
For the definition of the milling capacity per vessel-volume, further the filling parameters (grinding media piece-volume and density, piece-volume and density of the to be ground material as well as filling ratios in % of grinding media and to be ground material) are to be regarded. They influence the critical velocity of the system.
The total filling ratio (grinding media, agents and product) decides at a fixed rotational speed (% n_k) upon the remaining free-fall-height respectively rolling-height of milling balls that lift up from the ball orbit at the deviation line. At fixed grinding media and to be processed material, the total filling determines the number of contact faces doing the milling work.
In practice the kinetic of drummill-systems is adjusted that the transition of cascade- and cataract-mode is reached which means that the grinding media just lifts up but in any case hits the ground within the ball packet and does not hit the vessel directly. This condition is reached between 60 and 80 % of the critical velocity (n_k) at a total filling ratio between 50 and 70 % in a vessel with the diameter-length proportion of 1:1.

Filling (loading) directions for drummills

Type	total filling ratio [%] up to approx.	filling weight [kg] up to approx. grinding chamber volume [l] x	Grinding media portion [kg] up to approx. grinding chamber volume [l] x
A+G+TxxNx	70	1,6	1,0
A+G+TxxTx	50	1,3	1,0
GxxNS	60	1,6	1,4
GxxTS	40	1,8	1,4
SxxNS	60	2,2	1,6
SxxTS	40	1,9	1,6