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New Development in the Grinding and Granulation Process of Fertilisers and Soil Conditioners

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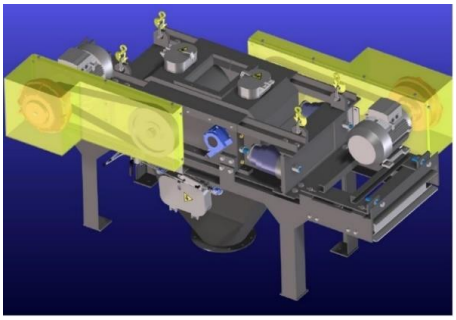
The topic concerns the improvement of technologies that has taken place in recent years in the construction of machines and plants for grinding and granulating solid fertilisers, mostly granular. The fertiliser industry has intensively experimented with the typical features of the years 2010-2020 that combine technological complexity with a strong acceleration in the succession of innovations. The Eirich Group, which has always been very active in the research and development of machines and processes of comminution, mixing and granulation, has followed this trend reaching previously unthinkable results. In the fertiliser production sector, this acceleration has led to greater competitiveness among the players and to the formulation of a new regulation of the European Parliament and Council on fertiliser products circulating in the EU, more complete and complex than the previous one. The regulation mentions the need to improve nutritional efficiency in order to reduce the number of fertilisers and to make greater use of recycled or organic materials. In order to avoid risks to human, animal or plant health, safety and the environment, the regulation provides a number of control procedures in the manufacturing chain. Machines and plants for grinding, mixing and granulation and related control systems take these requirements into account also when operating in industry 4.0.

1. Introduction

Soil is a fundamental natural resource on which the entire life of the planet depends. Fertilisers are indispensable to replenish what has been taken away by harvesting agricultural products. In the subdivision of fertilisers, provided by the regulation, there are, among others four fundamental functional categories (PFC): Fertilisers (organic, organo-mineral, inorganic), calcium and/or magnesium remedies, soil conditioners and cultivation substrates. The fertilisers are very interesting as they are produced in the form of granules for the advantages they offer as described in the part concerning grinding and granulation. This manuscript deals exclusively with solid and in particular granular products highlighting the state of the art achieved by mills, mixers and granulators of the Eirich Group. The level obtained is measured in terms of the ability to achieve the required fertiliser quality, reliability, minimum energy consumption, facility and speed of cleaning maintenance, possibility to work different PFCs quickly switching from one type to another and working with the highest degree of automation.

2. Crushing

In most cases, the raw materials are supplied in sizes less than 5 mm; this condition always occurs when working with raw materials obtained by synthesis. In the case of natural raw materials, it is often necessary to carry out a particle size reduction before grinding treatment. Some raw materials are classified Atex, and consequently, crushers are designed, manufactured and certified according to the relevant European standards for potentially explosive materials such as lignite, peat and others. Depending on the degree of reduction and the required size Eirich Impianti produces EMU hammer crushers with 1,2 or 3 impact plates with and without grid and twin-cylinder counter-rotating EC crushers

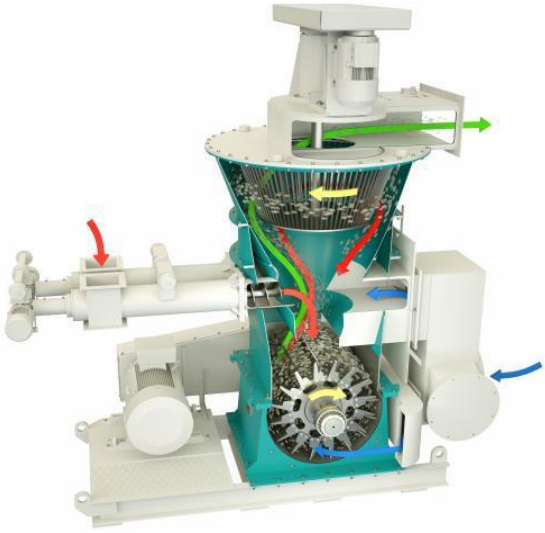


Double cylinder crusher Eirich Impianti EC30-40

Hammer crusher Eirich Impianti EMU89

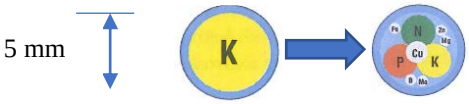
3. Grinding

The raw materials arrive in the establishment mainly in granular form to optimise their management from a technical, economic and environmental point of view. The grinding of the raw materials upstream of the mixing-granulation or mixing-granulation reaction processes is a priority step for the final quality of the fertiliser, and in recent years it is becoming increasingly important. Grinding increases the specific surface area and makes the product more active, facilitating granulation and improving the homogeneity of the final product. The characteristics that are at the basis of the quality of the granulates are beside the homogeneity of the single components: the mechanical resistance to compression, abrasion, fall and last but not least the sphericity. All these properties are improved when ground raw materials are used for the homogenising-granulation process. For this phase of the process, Eirich Impianti builds suitable mills to process inert or potentially explosive materials, hygroscopic, abrasive and adhesive materials. When the prevailing characteristics of the material to be ground are hygroscopicity and adhesiveness, the choice is for TurboGrinder (TG) friction mills. When the prevailing characteristic is abrasiveness, the centrifugal mills OrbitMill (OM) are preferred. For the grinding of lignite, for example, and apatite, centrifugal mills (OM) are preferred; instead for the grinding of kieserite, either centrifugal mills (OM) or friction mills (TG) are used.
The first choice, which is made at this point in the process, concerns the technical and economic convenience of carrying out a total or partial co-grinding of the raw materials. If co-grinding is planned, the Eirich Industrial ***OptimaBlend APS*** mixer is used advantageously before grinding.
When most of the materials already have the appropriate fineness for the subsequent homogenising-granulation, separate comminution of the materials with out-of-specification grain size can be considered.



Eirich Impianti Mill Turbogrinder 100-90

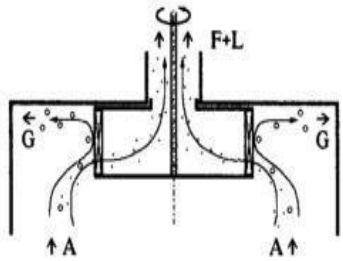
Eirich Impianti Orbit Mill 60



It is necessary to grind to obtain homogeneous granules with mixgranulators as highlighted in paragraph 7

4. Pneumatic Classification

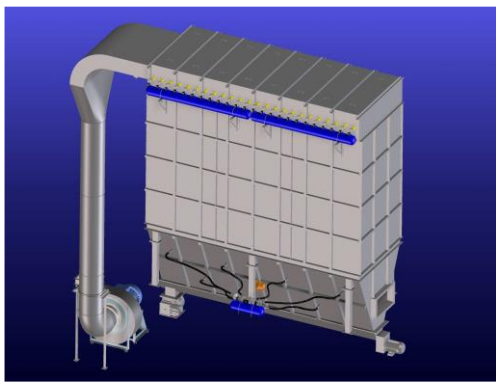
The desired grain size rarely comes out of the mill, and therefore a pneumatic classifier is installed above the mill. The fine grain size and the tendency of the products to adhere to each other often make it inadvisable to use mechanical or electromechanical vibrating screens. Even if often the required grain size suggested the use of static classifiers, it is preferable to install dynamic pneumatic classifiers because they allow adjusting the grain size very quickly by acting on the control PC and to keep it constant by controlling the operating parameters with special sensors. Moreover, the centrifugal force generated by the rotor has a self-cleaning effect on the impeller itself. In both TurboGrinder and OrbitMill mills, the material transport from the loading point of the mills to the exit of the fine fraction of the pneumatic classifier is made pneumatically.



Classifier Eirich Impianti Maxx Class Operation Principle Classifier Eirich Impianti Maxx Class 80

5. Air-Material Filtration

The fluidised material exits from the pneumatic classifier, with the conveying air through a pipe and reaches the bag filter that separates the ground dust from the air. The energy required to transport the material and to move the air (medium) is generated by the process fan, located downstream of the bag filter. For this purpose, only bag filters with compressed air are used.
The position of the process ventilator makes it possible to have the entire grinding system in under pressure.
Paradoxically, the dust production system does not create dust in the surrounding environment; on the contrary, by suctioning it makes the air near the system cleaner. Downstream of mills with a maximum power of 132 kW circular EFC filters are installed beyond this power rectangular EFR filters.

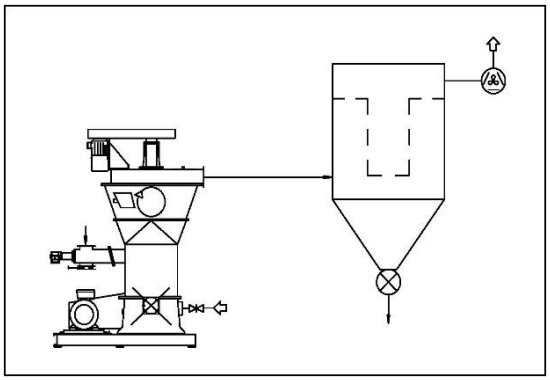


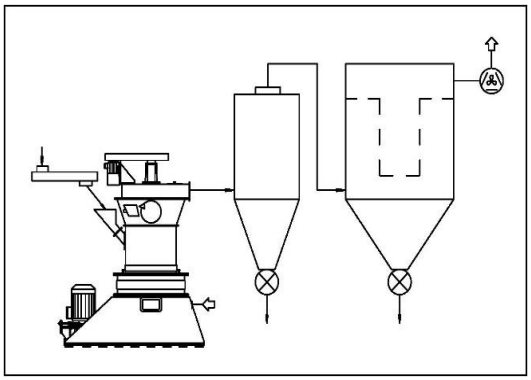
Circular filters Eirich Impianti Type EFC

Rectangular filters Eirich Impianti Type EFR

6. Grinding Circuits

Basically, four grinding circuits are used: A) Grinding circuit with expulsion of all process air, B) Open grinding

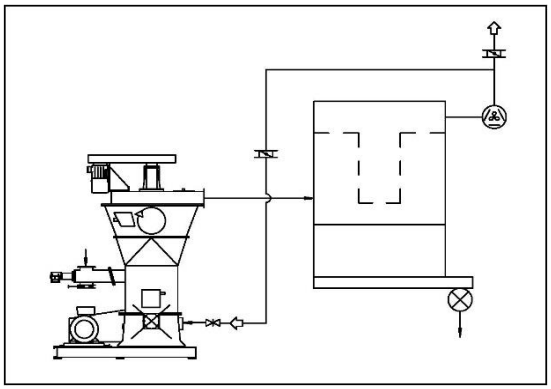


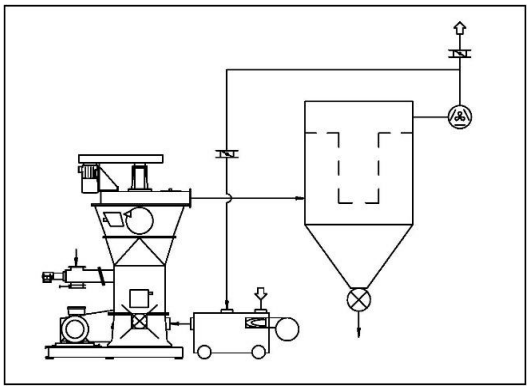


circuit with cyclone before the filter, C) Grinding circuit with recirculation of a certain amount of air to the mill, D) Grinding circuit with recirculation of air and drying of the material by introducing thermal energy to heat the air coming from the hot gas generation system or from the cogenerator. By inserting cyclones or multi-cyclones into the process air circuits, the number of possible circuits is multiplied. Today the use of cyclones can be said to be almost totally outdated, and the choice, more than technical economic, appears increasingly philosophical.

A)Turbogrinder mill in open circuit

B) OrbitMill in open circuit with cyclone





C) Turbogrinder mill with partial air recycling

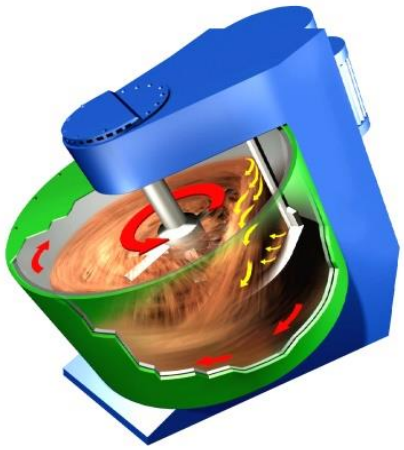
D) Turbogrinder mill with simultaneous drying

7. Mixing and Granulation

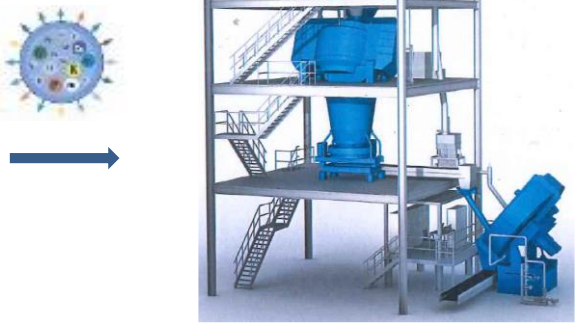
The raw materials used are often numerous and have very different physical and chemical characteristics. Sometimes abrasive sliding materials are combined with corrosive, fibrous, adhesive, humid, hygroscopic, deliquescent materials and sometimes pastes, press filter panels and suspensions are added to these. This extreme heterogeneity complicates the formation of a homogeneous mixture in which the same characteristics are found at each point. Another typical requirement of these mixtures is the requirement to incorporate

homogeneously in the mass very small quantities of additives of the order of mg/kg. The Eirich R and D series intensive mixers have proven to be particularly suitable to meet the requirements described. At the same time and/or after the homogenisation phase in the same mixers, a calibrated granulation is carried out with very high yield in the required range, this operation takes place with the introduction of water or a mainly acidic suspension. The optimal granulation can vary between 1mm and 5 mm. However, there are not rare requirements for granulometries confined in a narrower range or requests to obtain granules in granulometric ranges greater than 8 mm with limits of 2-3 cm. Once the granulation phase is finished, still in the same mixer that has carried out the homogenisation and granulation, the granules can be subjected to a coating finishing process in order to adjust the properties of smoothness, colouring, hygroscopicity, hardness and controlled release of

the nutritive elements. This last series of operations can be carried out not only in the Eirich granulator mixers but also in the Eirich TR pan granulators or in other machines. The numerous historical processes are rarely required starting from apatite with added sulphuric acid or phosphoric acid form the superphosphate (SSP) or triple superphosphate (TSP), respectively, as well as the granulation processes which starting from solutions of urea melt at high temperature and suspensions of ammonium phosphate make granules. For all these processes, using the principle of mixing intensity, granulator mixers and pans granulator have given and still give excellent results.



Intensive granulator mixer Eirich RV16 TR



Mixer Eirich DZ with disc granulator

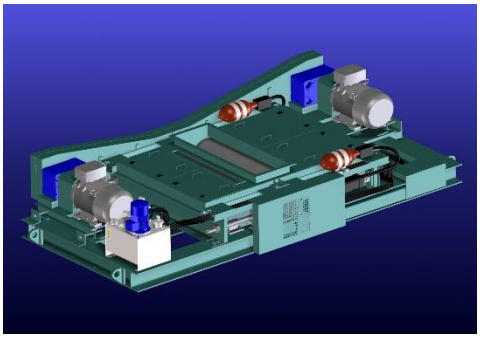
8. Thermal and Mechanical Processes on Granulates

With the exception of the case where mixing and granulation are carried out with raw materials that give rise to sufficiently exothermic reactions, the granulates are passed through a dryer to achieve the final mechanical properties. Drying is normally carried out in fluidised bed or drum dryers. To lower the temperature of the granulate and allow storage and bagging, the dried granules are cooled in an air stream before leaving the manufacturing process. The granules that become stable are screened, the specification fraction proceeds to the packaging or storage sections while the fine fraction together with the milled oversize fraction is sent back to the blender-granulator.

9. Crushing/Milling the Oversize Fraction

In very rare cases where the process is not automatically controlled, large agglomerates are formed that require the use of crushers for their size reduction, in this case, the Eirich Impianti EMU hammer crushers prove to be valid.
Two-cylinder counter-rotating crushers are used, normally, as they are able to cope with the occasional passage of big granules or foreign bodies with humidity feed sizes and non-designed hardness. The best results are obtained with machines equipped with a hydraulic system with nitrogen dampers to control and

regulate the translation of the cylinders and an automatic cleaning device for the crushing cylinders. The operation adjustment is carried out and controlled by the control PC, which receives the information from the sensors installed on the crusher.
When the aim is to reach the highest quality of homogenisation and granulation, the same mills described in point 3 are used when the flow rate is sufficient if this is not possible, other TurboGrinder type mills are installed, generally with lower capacity than the mills that prepare the raw materials upstream of the mixer. During the dimensioning, it is necessary to consider the effects on the milling index due to the introduction of organic materials sometimes used for granulation and coating.
The crushing of the oversize requires a careful evaluation of the feed rate as it is difficult to maintain the planned feed rate due to the inevitable decrease in efficiency of the machines preceding the crusher. The



causes that generate this situation generally depend on the need for maintenance and cleaning.

Crusher Eirich Impianti EC 50-150 for high flow rate

10. **Plant Maintenance and Cleaning**

Fertiliser production plants are subject to very demanding cleaning and maintenance requirements. The working conditions that are typical of the chemical industry make these operations even more onerous. In order to minimise the inconveniences deriving from these aspects, the machines and plants built by the Eirich Group are equipped with all the technically possible devices that facilitate the management and the safety that is necessary during plant maintenance and cleaning.

11. Conclusions

The aspects considered in this manuscript are the starting point both for those who produce fertilisers and for those who build fertiliser plants in order to define what the main aspects are to be taken into account in the revamping of existing plants or in the design of new ones of comminution, mixing and granulation. The multiplicity of final products and raw materials suggests carrying out scale tests before starting a new project. Granular fertilisers are undoubtedly the best way to use solid fertilisers. This is due to the possibility of producing granules containing proportionally all the nutrients.

The high competitiveness of the sector requires the production of high quality fertilisers and from these two fundamental paradigms are born:

There is no quality if the granules are not perfectly homogenised with intensive systems.

There is no quality if, before the intensive mixing-granulation, the material is not ground with control of the granulometry by means of pneumatic classifiers.

12. References

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