

Compaction with Roller Presses

Specialists in Compaction-Granulation



Köppern

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Köppern – Specialists
in engineering,
manufacturing and
technical services for
compaction-granulation
with roller presses
worldwide.





Specialists in Compaction-Granulation

Founded in 1898 and headquartered with its main manufacturing facilities in Hattingen, Germany, Maschinenfabrik Köppern remains a family-run enterprise reflecting its traditional values of technology leadership, highly dependable manufacturing quality and a unique regard for the individual needs of its customers. Köppern's worldwide network of subsidiaries, including manufacturing plants and engineering offices, provides customer-focused service on all continents.

Köppern's history is linked to the utilization of roller presses for briquetting hard coal. Over the years, the briquetting process has been extended to the agglomeration process, which is relevant for a variety of materials including fertilizers, burnt lime and salts.

The design of our machinery and equipment is highly flexible and can be tailored to customers' specific requirements. Our range of services in this segment is supplemented by specially developed, comprehensive testing programs plus the equipment needed for designing the machines and systems. For this very purpose, Köppern maintains and operates an industrial-scale pilot plant.

Köppern roller presses are designed for heavy-duty applications and for easy maintenance, and are in operation throughout the world in the toughest conditions.

If you feel that this can be of interest to your company, we would invite you to read on in order to gain more insight into our specialist roller press and compaction-granulation technology.

The Köppern Chronicle – Focusing on Compaction-Granulation

1898

Wilhelm Köppern acquires the "Berninghaus-Hütte" in Hattingen, Germany

1913

First exports to England

1926

The company is renamed "Maschinenfabrik Köppern & Co. KG"

1954–1985

Further development of roller presses for briquetting and compaction opens up new markets

1957

First plant for potassium chloride compaction

1971

First roller press for NPK fertilizer (Switzerland)

1981

First roller press for potassium chloride in Russia

1988

First complete NPK compaction plant (Turkey)

1995

First roller press for potassium sulfate

1998

New potash (MOP) roller press design, 1000 mm roller width with double screw feeder, single shaft drives via planetary gear

Up to 2016

Köppern designs and supplies complete compaction-granulation plants for MOP, SOP, NPK and AS fertilizers.

So far more than 160 roller presses have been supplied for compaction-granulation.

Compaction-Granulation

Materials Granulated by Compaction

- » Ammonium chloride
- » Ammonium sulfate
- » Burnt lime
- » Calcium nitrate
- » Dry municipal sludge
- » De-icing salts
- » Industrial potash (K99)
- » Micro-nutrients
- » NPK fertilizers
- » Potassium nitrate
- » Phosphate rock
- » Potassium chloride
- » Potassium sulfate
- » Sodium carbonate (soda)
- » Sodium chloride
- » Sodium nitrate
- » Sulfate of potash magnesia
- » Urea

Compaction is the process of compressing fine-grained solids between two counter-rotating smooth or profiled rollers. The resulting band of material, known as flake, is an intermediate product from which the final granulate is produced using crushing and screening processes.

While the technology is also found in many chemical industry applications, the compaction process traditionally is mainly used to produce either single-component (KCl, SOP, AS) or multi-component (NPK) fertilizers.

Technology Focused on Fertilizer Production

Besides single-component fertilizers which for example contain only K (potassium), mixed fertilizers are also available. These each contain either two or all of the nutrients N (nitrogen), P (phosphor) and K.

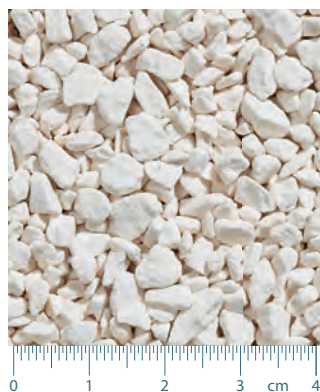
The use of granulated fertilizers largely avoids segregation, uncontrolled agglomeration and unsatisfactory flow characteristics, or losses during application due to dusting or run-off.

Several fertilizer granulation techniques have been developed which are based on either wet or dry (compaction) agglomeration without binding agents, with subsequent crushing and sizing into the final granular size. In contrast to the wet granulation process, compaction-granulation requires neither drying nor the addition of binders.

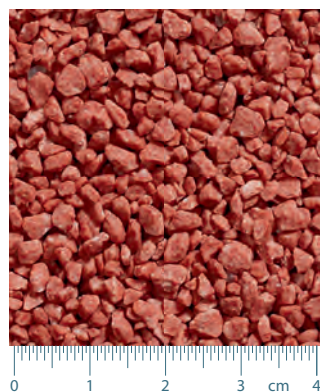
Köppern not only manufactures roller presses but also provides complete fertilizer production plants. Additionally, our range of services includes compaction tests, process layout, basic engineering plus installation and start-up support.

Typical Fertilizer Granulate Sizes

2.0–5.0 mm



2.0–4.0 mm



1.0–2.0 mm

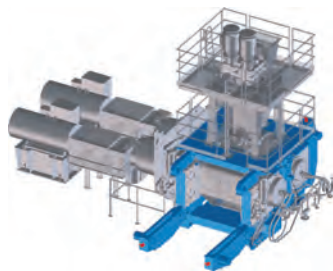


0.5–0.8 mm

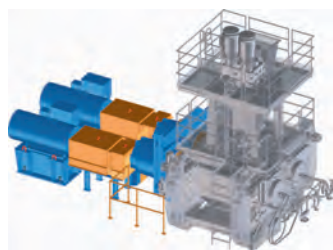




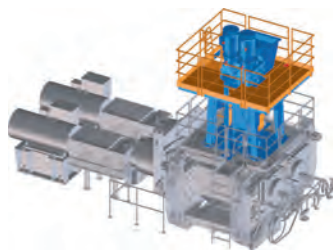
Design Features



Hinged press frame



Main drive with reduction gear



Material feeder equipment

Modular Design for Customized Flexibility

Compaction with roller presses follows a simple principle: a fine raw material is fed into the space between two counter-rotating rollers, where it is then compressed and formed into flakes. The main functional assemblies provided for this purpose are:

- » press frame
- » pressing rollers with bearings and bearing housings
- » main drive with reduction gear
- » material feeder
- » hydraulic pressurizing system
- » grease lubrication
- » roller housing

The press frame accommodates the fixed roller and a floating roller as well as the hydraulic pressurizing system and the roller housing. The hinged frame design allows a roller set to be exchanged by removing and replacing the rollers via the frame ends. Thus, a roller set can be changed in a short time without dismantling any of the upper parts of the machine.

The fixed roller is supported directly in the press frame, while the so-called floating roller is supported in the frame by a hydro-pneumatic spring. The movement of the floating roller constitutes the basic principle of a roller press. The rollers are driven either by one electric motor in combination with a double-shaft gear box and tooth couplings, or two electric motors in combination with planetary gear boxes.

The extent of the roller movement defines the roller gap. It is a function of the pressing force generated by the hydraulic system in relation to the reaction forces exerted by the material being processed and the preset "zero-position" of the roller gap. Depending on the requirements of the specific process, the gap itself is controlled by means of feed screw speeds.

These design features guarantee that all the feed material passes through the roller gap under the same process conditions, thus ensuring that the output quality of the product remains constant.

Normally, profiled rings are used in compaction-granulation to meet the specific requirements of the feed to be processed. The materials used are tailored to customers' needs as well as to the requirements of the material being processed. They are sufficiently wear-resistant to ensure maximum service life and minimum expense, whereby conventional pressing tools can be refurbished and re-used.

Roller surface patterns are generated by electrochemical machining (ECM). High-alloy materials such as nickel-based or titanium alloys, powder metallurgy materials or hardened metals can be easily machined. This machining process leaves no burrs, ensures excellent surface quality and does not subject the work piece to thermal stress, as machining temperatures are below 90°C.

A roller housing is provided for safety reasons and to minimize dust emission.

Factors determining the selection of machine type are:

- » required application
- » attainable peripheral speed
- » specific pressing force requirements
- » product shape and size
- » design of pressing tools and material feeders

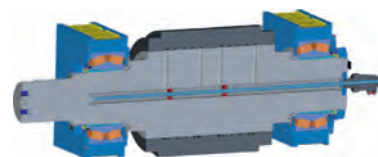
Press types	40	52	60	72	92	500	630
Max. press force	1,430 kN	2,330 kN	2,910 kN	4,970 kN	7,350 kN	8,700 kN	12,950 kN

Flake Breaker

Flakes exiting the roller press are typically too large to be conveyed. This is why a flake breaker is often installed directly beneath the roller press. A special chute can be added that allows flake samples to be taken. Flake-breaking takes place between two counter-rotating rollers which are equipped with exchangeable toothed crushing rings. The rollers run in self-aligning roller bearings and are driven individually by two shaft-mounted gear drives. The crusher housing consists of welded multi-sectional steel plates with inspection flaps, and is labyrinth-sealed towards the rotating rollers. The breaker inlet flange is connected to the roller press outlet flange by a chute with an internal flake-guiding arrangement.



Hydraulic pressurizing system



Floating and fixed roller with optional water cooling



Grease lubrication

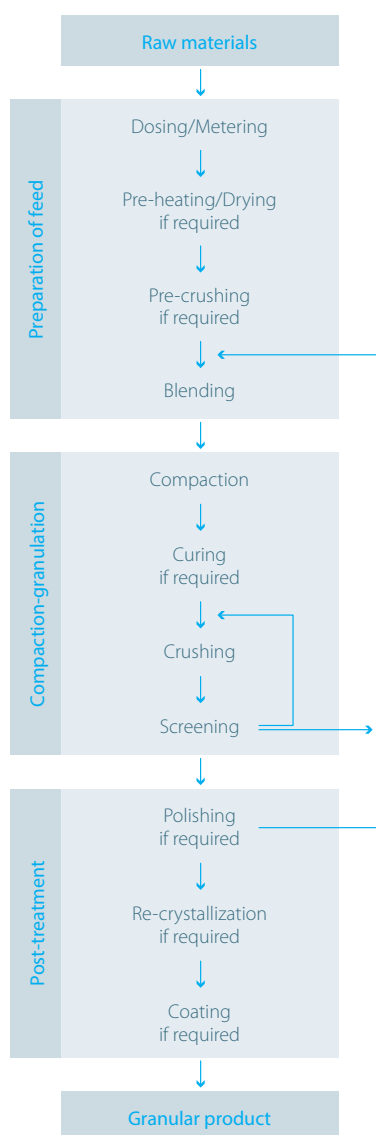


Roller housing



Flake breaker

Process Technology



Comprehensive and Customized

The general flow sheet of a fertilizer compaction-granulation plant comprises three process groups of machinery corresponding to the following process steps:

- » Feed material preparation
- » Compaction-granulation
- » Post-treatment

The material is transported within the plant by various means such as bucket elevators or belt and trough chain conveyors.

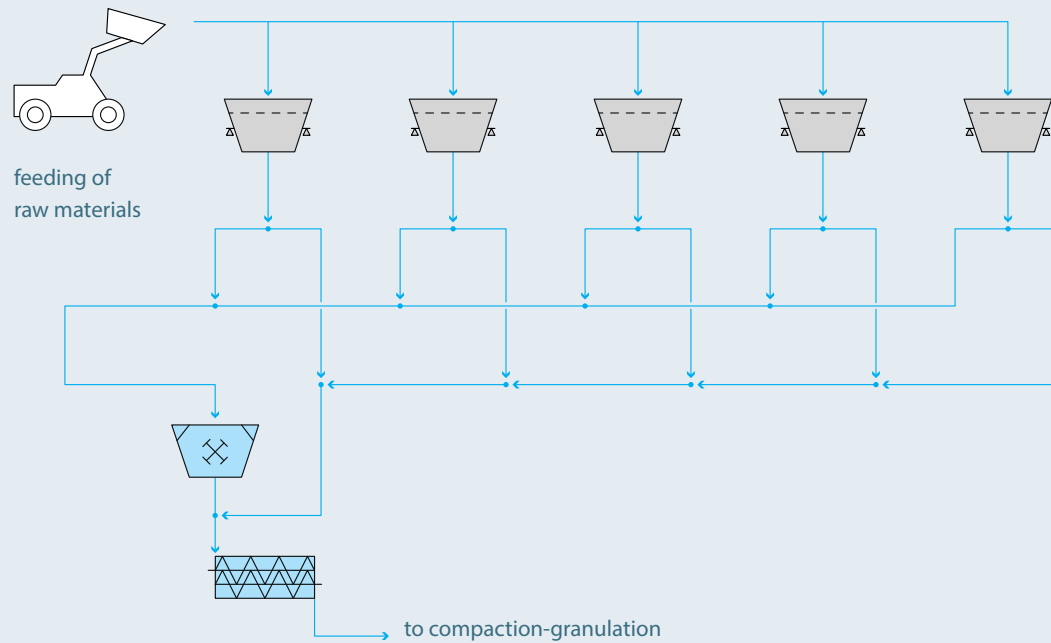
Feed Material Preparation

Typically, the feed materials are dosed and processed continuously, whereby the number of bins used depends on the number of feed material components to be incorporated in the final product. Some feed materials require crushing, either to reduce feed size or to break up coated surfaces. Drying or pre-heating may need to be foreseen depending on the feed material.

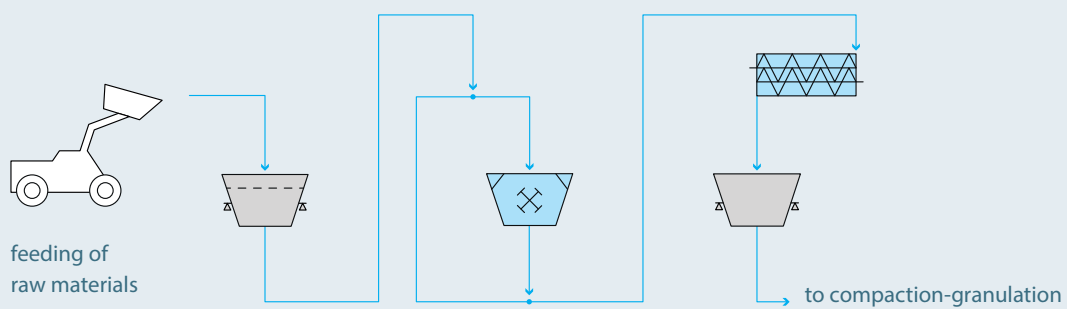
In some multiple fertilizer plants (NPK fertilizers), batch dosing and mixing has also been applied. Components are metered into a weigh bin. The completed formulation is then discharged into a batch mixer. A surge bin connects the discontinuous feed preparation with the continuously operating compaction process.

Whichever operation is used, the selection as well as the arrangement of mixer, crusher and dosing equipment requires careful consideration.

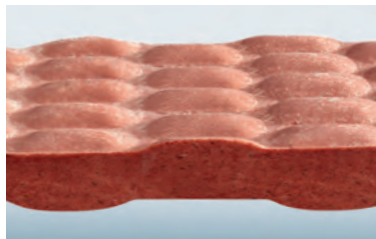
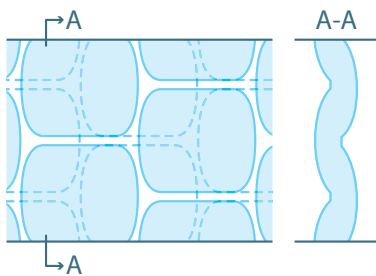
Continuous Feeding of Raw Materials



Discontinuous Feeding of Raw Materials



Process Technology



Compaction-Granulation

Using Köppern roller presses based on the principle of press-agglomeration, particulate material is introduced into the nip of the two counter-rotating rollers by means of vertical feed screws. As the material is compacted, pressure within the material increases, reaching a peak just above the line of closest approach between the rollers, and subsequently dropping rapidly to zero.

During this process, the apparent density of the mixture increases by a factor of 1.5 to 2 due to the decreasing void volume of the bulk material. The resulting product is typically a flake of 5–20 mm thickness.

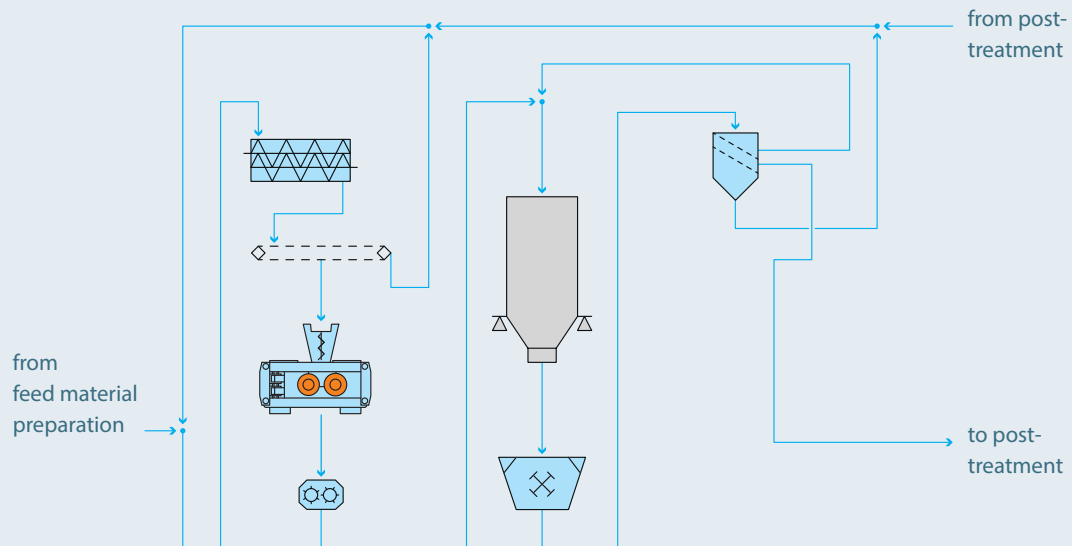
The flake produced in the roller press must be broken up and classified into the desired particle size range. Often, the first crushing step takes place in a specially designed flake breaker installed directly below the roller press. The flake is broken into smaller pieces which make suitable feed for subsequent crushers.

Using a multi-deck screen, the material is then separated into oversize, product and undersize fractions. The undersize (which passes directly through to the lowest screen deck) is re-circulated for compaction, while the oversize forms a residue on the upper screen deck which is fed into the crushing process.

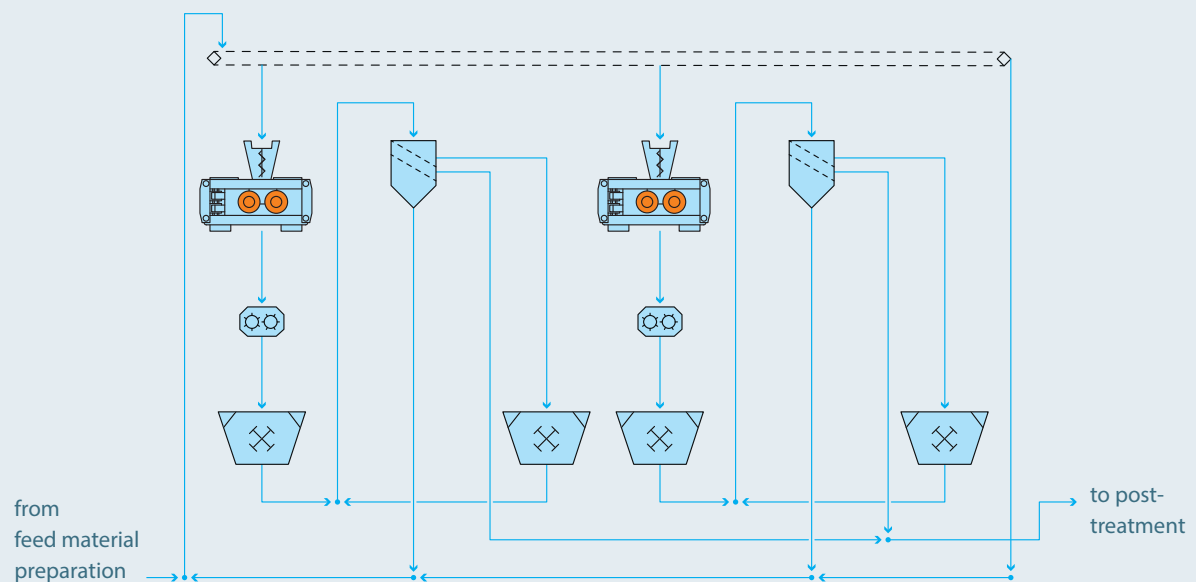
Many mixed fertilizers, particularly those containing phosphates and/or urea, initially produce relatively soft, plastic flakes that harden during aging. For this, a curing bin is installed ahead of the crusher.

The economics of a fertilizer compaction-granulation system depend strongly on the appropriate roller press design and the correct selection of crushing and sizing equipment. In addition to particle shape and size ranges, the compaction process as well as the crushing and screening circuits determine the yield and output of a plant.

Single-Circuit Design with Curing Bin



Multiple-Circuit Design without Curing Bin



Process Technology



Post-Treatment

Fertilizer granules are exposed to multiple stresses in the logistics chain during transportation, storage and packaging. Such stresses can be caused by:

- » static strain due to the high load during storage
- » friction between the granules under high load while being removed from storage
- » friction between the granules while being conveyed in bulk streams (conveyor transfer points, chutes)
- » impact on each other, or on metal or concrete surfaces
- » absorption and emission of water during storage and/or transport.

Two possible post-treatment methods can be used to reduce the effect of these stresses:

Standard post-treatment

Standard post-treatment is defined by the process steps of:

- » polishing
- » coating.

First of all, the irregular-shaped particles are polished in an abrasion drum or mixer in order to round off sharp edges and corners. The fines produced are removed by single-deck screening and subsequently re-circulated to the compaction circuit. They are then coated with an anti-caking agent, which helps to prevent not only the caking of individual particles but also dust generation caused by abrasion.

Advanced post-treatment

Advanced post-treatment is defined by the process steps of:

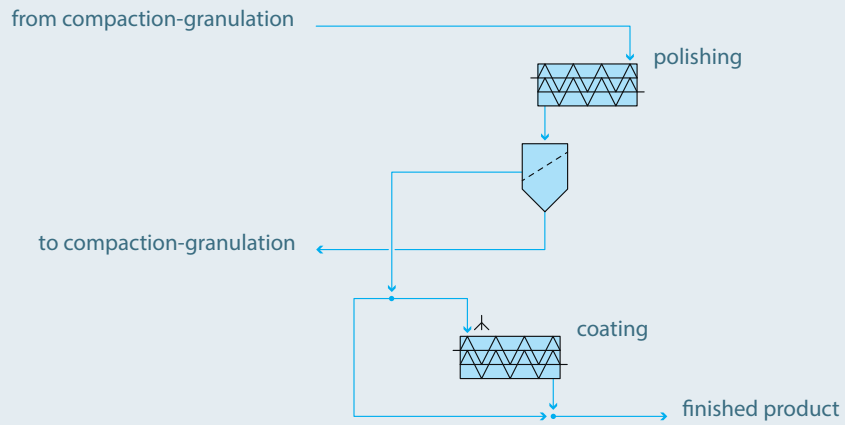
- » polishing
- » moisturizing
- » drying/cooling
- » coating.

Additional finishing steps, such as moisturizing followed by drying and cooling, improve the abrasion resistance of individual fertilizer granules.

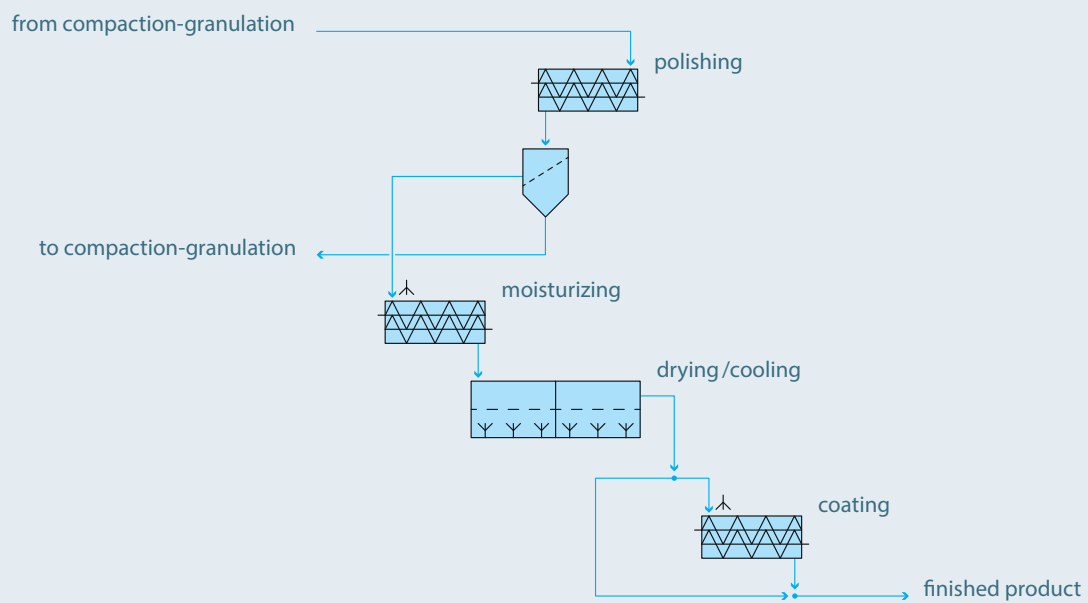


Source: PotashCorp (Potash Corporation of Saskatchewan Inc.)

Standard Post-Treatment



Advanced Post-Treatment



Fields of Application



Compaction-Granulation Plant

MOP with 60 % K₂O

Single-Nutrient Fertilizers

The illustration shows a compaction-granulation plant for MOP with 60 % K₂O content. Compaction of such fertilizers typically takes place at elevated feed temperatures, the crushers working in a closed-loop cycle with multi-deck screens to crush the flakes into granules.

In some cases, raw materials already possess good abrasion resistance, so that post-treatment of the granulate is not required.

The granulate capacity depends on raw material properties and the desired product grain sizes, as well as on the equipment selected for subsequent crushing and screening.

Further components for individual compaction-granulation are:

- » ammonium sulfate (AS)
- » potassium sulfate (SOP)
- » MOP with 40 % K₂O.

For AS and SOP, a small amount of moisture is added prior to compaction. Since these materials are also typically processed at elevated temperatures, no additional drying is required.

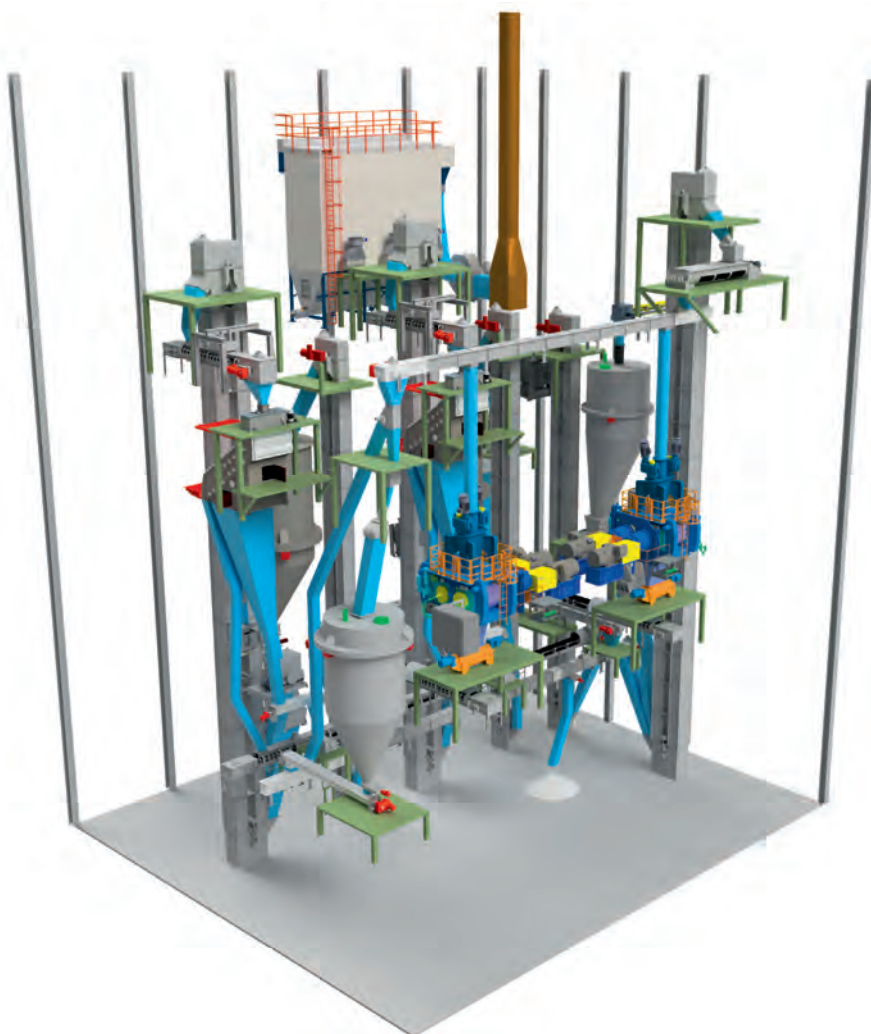
Multi-Nutrient Fertilizers

Today's intensive farming demands the use of multi-nutrient fertilizers. To improve their application to the fields, several techniques have been developed which produce

- » uniform,
- » dust-free,
- » and non-segregating

granular products (also known as straight, compound or complex fertilizers) from fine-grained or powdery raw materials.

In contrast to conventional wet methods, the granulation of fertilizers by compaction uses dry feed material. These materials can come from an almost unlimited number of sources, whereby there are no special requirements regarding particle size or distribution, and no drying is necessary.



Compact Plant Design

30 m (W) x 38 m (H) x 26 m (D)

Composition of Fertilizers



Fertilizer formulations can be customized to the needs of the specific crop and/or soil to ensure optimal growth. This means that the formulation can be realized within every single grain. Each grain contains the same formulation, irrespective of its size.

Applicable Nutrients

- » Primary nutrients:
 - Nitrogen
 - Phosphorus
 - Potassium
- » Secondary nutrients:
 - Sulfur
 - Calcium
 - Magnesium
- » Micro-nutrients:
 - Iron
 - Manganese
 - Zinc
 - Boron
 - Copper
 - Molybdenum
 - Chlorine

Raw materials	Nutrient content			Formulation examples									
	N [%]	P [%]	K [%]	15-15-15			20-20-20		16-16-16	16-20-0	18-20-0		
UR	46	–	–	12	15	27	21	25	25	21	21	21	
AS	21	–	–	19	26	14	–	–	–	13	13	13	
DAP	18	46	–	34	17	–	34	42	42	17	17	17	
TSP	–	46	–	–	17	34	–	–	–	–	–	–	
RP	–	31	–	–	–	–	–	–	–	24	24	24	
MOP	–	–	60	25	25	25	25	33	33	25	25	25	
Filler	–	–	–	10	–	–	20	–	–	–	–	–	
Total:				100	100	100	100	100	100	100	100	100	

Compatibility of raw materials

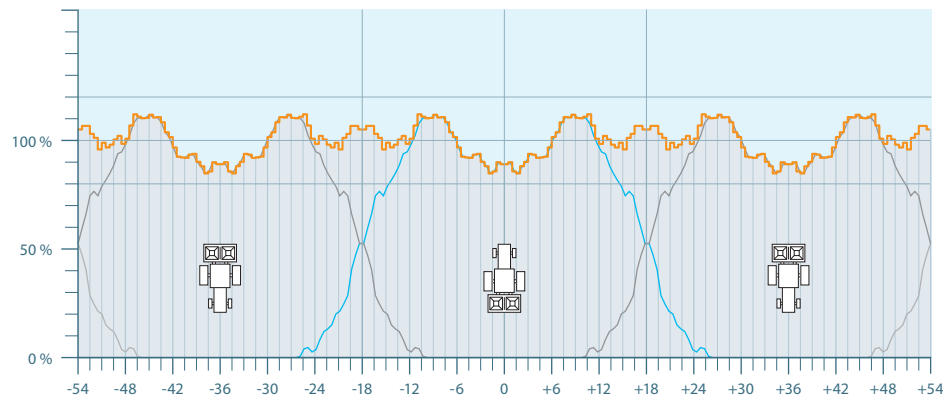
There are only very few limitations relating to the selection of fertilizer components to achieve a formulation:

UR												
CC	AS											
LC	CC	TSP										
LC	CC	CC	SSP									
CC	CC	LC	LC	DAP								
CC	CC	CC	CC	CC	MAP							
CC	CC	CC	CC	CC	CC	MOP						
CC	CC	CC	CC	CC	CC	CC	SOP					

- » CC – compatible combinations, LC – limited compatibility
- » Depending on the water content, urea (UR) can be completely incompatible with single or triple superphosphates (SSP, TSP)
- » The chemical reaction between diammonium phosphate (DAP) and single superphosphate (SSP) has caused caking in long-term storage tests

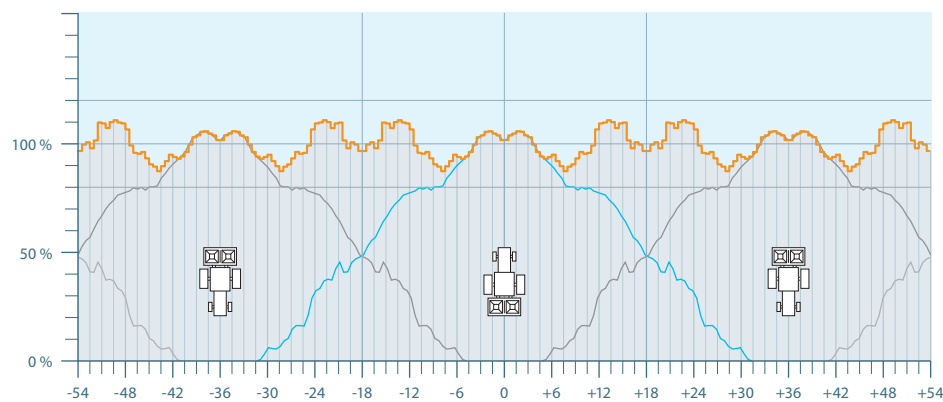
Application of Fertilizers

Compacted, irregular-shaped granulate can be spread over a width of 36 m with a low variation coefficient similar to the spreading of round-shaped granulate.



Irregular-Shaped Granulate

- » Spreading width 36 m
- » D_{50} : 3.18 mm
- » Bulk density: 1.14 kg/l
- » Variation coefficient: 8.0 %



Round-Shaped Granulate

- » Spreading width 36 m
- » D_{50} : 3.10 mm
- » Bulk density: 1.14 kg/l
- » Variation coefficient: 6.7 %



Source: Amazone (AMAZONEN-Werke H. Dreyer GmbH & Co. KG)

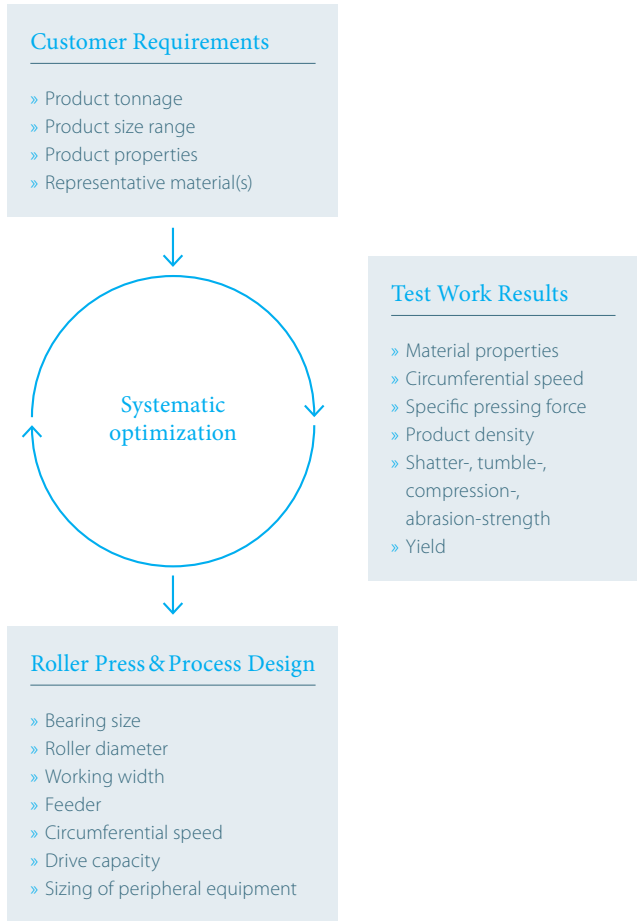
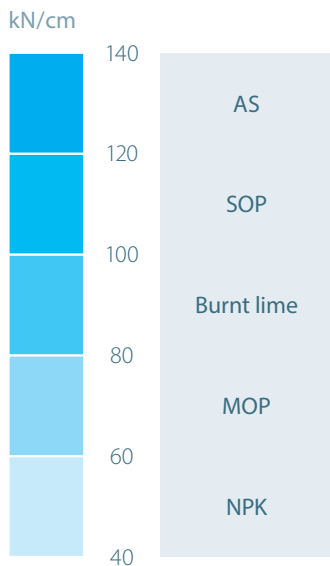
Pilot Plant – Test Work



It is always advisable to conduct test work with representative materials in order to assess their relevant properties prior to processing. Optimized plant layout and settings right from the start will boost efficiency and keep operating costs to a minimum.

Our pilot plant facilities not only support our customers in choosing the right process parameters and roller surfaces, but also by defining the correct technical process chain. Years of process-related know-how are concentrated in our pilot plants, so that all the relevant process data concerning the utilization of a roller press can be established in semi-industrial conditions.

Specific Pressing Force Requirement of Feed Materials



In order to simulate the processes required before and after roller press operation, the pilot plant is also equipped with mixers, crushers, screens, ovens and laboratory tools. The process data collected can be used to plan either individual units or complete briquetting or compaction plants. If required, the results can be included in a basic engineering document to define the plant components.



Overview of pilot plant

Köppern's main pilot plant is located at the Bergakademie Freiberg Technical University in Germany, providing optimum conditions for process-related research and development. Results collected over many years provide data for evaluating the suitability of materials for processing.

Trials need to be carried out to establish the final design and layout of an operating system. For this purpose, two industrial-scale briquetting / compaction machines (1,000 and 650 mm diameters) and two roller presses for grinding tests are available at Köppern's pilot plant in Freiberg.

Depending on the test material, these pilot presses can be equipped with different feeding systems and pressing tools. The presses have variable speed drives and are connected to the central operating data collection system to facilitate the analysis of results.

The industrial-scale trials aim to:

- » optimize feed characteristics
- » determine process parameters
- » select suitable equipment
- » evaluate product parameters
- » examine recycling potentials.

For the benefit of our customers, laboratory and pilot plant data are continually updated in line with our field experience. With its pilot plant facilities and specialist staff, Köppern is in a unique position to help you find the best solution for your specific requirements.



Köppern pilot plant, in cooperation with the Technical University of Freiberg



Roller press type 52/10



Roller press type 52/6.5

Service and Support



Consulting

Backed by decades of experience, Köppern offers its customers the support of qualified engineers and technical advisers, who are able to assist in:

- » analyzing process-related problems
- » providing solutions to optimize your operations and increase production.



Our advisory portfolio comprises:

- » Project studies
- » Basic engineering
- » Pilot-plant test work

Project Studies

For reliable information on the economic feasibility of major projects, Köppern can provide an initial project study including the following topics:

- » Mass flow diagram
- » Flow sheet – representation of the briquetting/compaction system including flow lines, quantities, physical and chemical data, operating conditions
- » Equipment list and plant description
- » Estimated investment costs
- » Manpower estimate for the supervision of construction and commissioning
- » Manpower estimate for local construction and commissioning personnel



Basic Engineering

In addition to the information included in a project study, basic engineering covers plant layout (general arrangement) and a detailed mechanical and electrical equipment description.

This document can form the basis for the purchase of individual items of equipment as well as for the construction of the plant.



Sales and Service Offices

Place your confidence in our worldwide network of service centers and engineering offices. Köppern offers a comprehensive range of customer-focused services starting with process consulting for either your greenfield project or your existing plant update.

- Köppern Headquarters, Hattingen
- Köppern Subsidiary with Sales and Service Offices
- ▲ Köppern Workshops
- Representatives

Worldwide Customer Service

Our specialist services cover pilot-plant test work, plant audits, process layout, engineering, supply of complete briquetting / compaction plants or key equipment, supervision of installation and commissioning as well as training.

Köppern operates service centers at strategic locations throughout the world to ensure a rapid response to customer requirements for spare parts, maintenance and repair services. Experienced personnel from either the Köppern HQ in Germany or any of its subsidiaries can be dispatched to our customers' sites at any time.

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