White and Fine

The reliable and effective Milling of Icing Sugar

Whether used for the fine icing on cakes and cookies, in the production of confectionery and drinks, or for the visual rounding off of delicious desserts, in our latitude we cannot imagine a life without white sugar crystals for the sweetening of foodstuffs. Apart from the "coarse" crystal sugar or refined sugar which is mainly used, the considerably finer form of sugar, icing sugar, is required for many applications in the household and in industry. The manufacture of this fine sugar is carried out by mechanically milling sugar crystals on modern impact mills.

Even today, a little over half the worldwide sugar is produced from sugar cane, which grows in tropical and in subtropical areas. Some of the largest sugar suppliers, which produce sugar from sugar cane are Brazil, Cuba, Kazakhstan, Mexico, India, Australia, Thailand, China and the USA. The rest of the sugar is nearly all produced from sugar beet, which grows in temperate climates. In most parts of Europe sugar, which is absolutely identical chemically as well as in taste, is produced from sugar beet. Some of the main producers are Russia, the Ukraine, Germany, France and Poland.

Before the actual icing sugar milling can begin, the beet must be processed to produce sugar:
The beet is washed and chopped into small pieces after harvesting. The sugar is extracted from the beet using hot water, and a so-called raw juice is the result. This is cleaned and boiled until sugar crystals form. If this raw sugar undergoes the so-called crystallization process once again and a further cleaning is also carried out, refined sugar is produced (household sugar).

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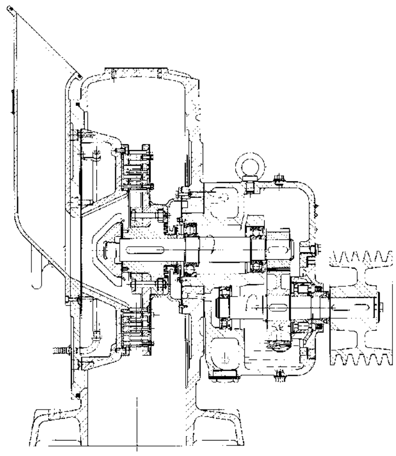

Fig.1

Icing sugar is produced by milling the sugar crystals. In this way the refined sugar is milled so fine, that the crystals are no longer visible to the naked eye. The broken crystals cause a multiple refraction of the light; which gives icing sugar its typical very white colour. Icing sugar dissolves quickly and is used for the manufacture of icing as well as for the dusting and decorating of sweets and cakes.
Approx. 5 – 10% of the total amount of refined sugar produced is milled to give icing sugar, of which only a small fraction is used in households.

The milling of icing sugar has always been carried out mechanically. In the past, conventional pinned disc mills were nearly always used (picture 1). These days considerably higher throughput capacities can be obtained with so-called blast mills of similar sizes. The usual icing sugar finenesses are between 80 – 95% < 100 µm (picture 2), with a clear tendency to higher finenesses.
During the use of a blast mill, the higher product quality, thanks to lower invert sugar content due to lower milling temperatures, is considered to be more important than high mill throughputs and product finenesses. Due to their construction, blast rotors installed in the mill obtain a higher air volume compared to pinned discs, which were used in the past. This leads to a lower temperature of approx. 30°C. Experiments carried out in NETZSCH-CONDUX´s test lab in Hanau, on a CUM universal mill, to provide a comparison between the two milling systems, showed temperatures of between 30 and 40°C for the blast rotor system compared to between 60 and 70°C with pinned discs (picture 3).
A further advantage of the large air volume is the possibility of operating the mill with natural aspiration, i.e. the sugar is fed pneumatically into the mill via a suction piping. The resulting more flexible arrangement variations are particularly advantageous for the operator. It could eliminate additional mechanical or pneumatic equipment required to convey the sugar to a level above the mill inlet. The arrangement of the sugar silo and milling installation next to each other on one level is the most simple variation!

The functioning of the universal mill CUM used as a blast mill is shown in illustration 4:
The feeding of the sugar is carried out directly into the centre of the machine.
A solid rotor is equipped with a large number of exchangeable beater blades and is operated with a peripheral speed of up to 110 m/sec. The product processing is carried out by impact and shearing reduction. During the milling process the crystal sugar fed into the machine is impacted on the beater blades of the rotors and flung by them radially outwards onto the stationary basket. In the leeward side of the beater blades the particles are again lifted up and once more impacted upon the following beater blades. The fineness of the icing sugar can be determined by using different stationary tools and/or varying the speed of the rotor. For the manufacture of icing sugar, the stator is usually equipped with a continuous screening ring.
The throughput capacity of the mill is shown in relation to the desired fineness in picture 5. Depending on the desired fineness, various screen perforations and designs (angular slits- or „Conidur“ - screens) are used and/or the rotor speed is modified.

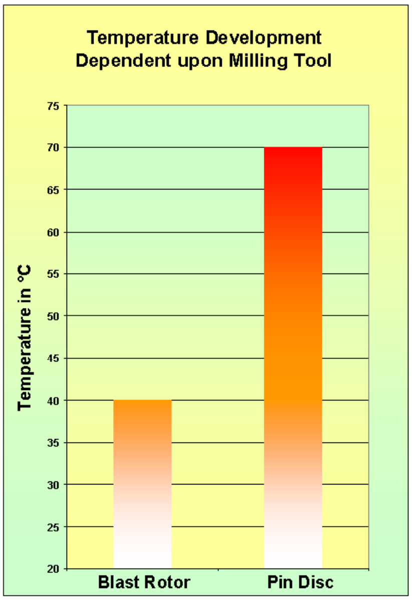

Fig. 3

According to the latest levels of knowledge, the CUM universal mill equipped with a blast rotor is the best suited mill for the manufacture of usual commercial types of icing sugar. Thanks to its advantages it has become very successful on the market.

Up until a few years ago, it was usual in the field of sugar processing to use the „powder mill“ in mild steel. Meanwhile, in all areas of the foodstuff industry stainless steel designs are gaining more and more acceptance. All product-contacted parts of the mill or the complete milling system are executed in the materials 1.4301, 1.4541 or even in 1.4571.
Within the framework of machine- and plant technology, the development of "icing sugar milling" has also been greatly influenced by new knowledge in the theory of dust explosions, and its integration into new safety concepts. The ever increasing safety standards which must be implemented require new concepts for the installation and arrangement of milling plants.

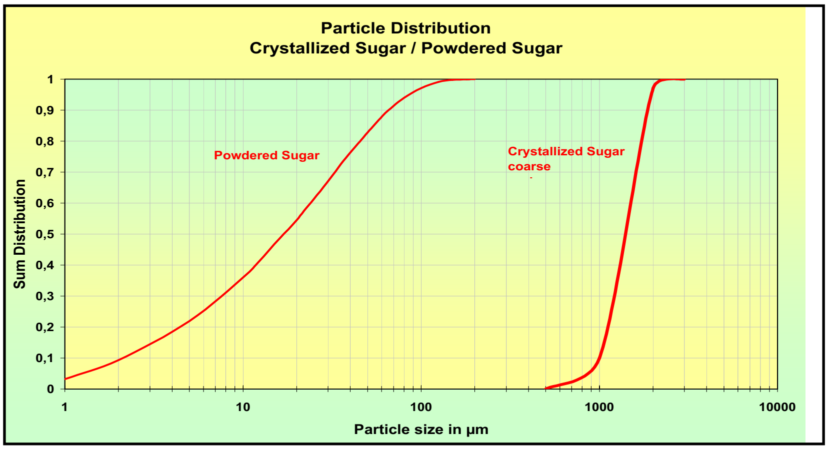

Fig. 2

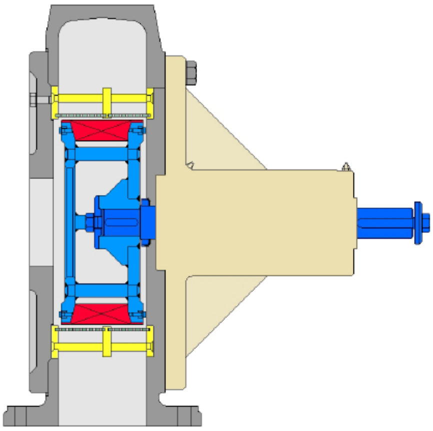

Fig. 4

When sugar is mechanically milled (dust explosion class: St1; max. explosion overpressure: 9 bar; KSt-value 140 bar m/s) the danger of a dust explosion cannot be ruled out, as foreign bodies within the milling chamber as well as a screen breakage can cause sparks and consequently lead to an explosion. In addition to this, there are other possible exterior influences such as static discharge etc. An explosion can only be prevented under inert conditions (nitrogeninerting). However, this is seldom used in the foodstuff industry due to its high costs. For this reason, other suitable constructive explosion protection measures are necessary.
For the processing of sugar two different safety concepts are usually used.

Explosion pressure shock resistant execution up to 10 bar(o)

By designing the plant for the maximum explosion pressure, the complete milling plant (picture 6) is protected against the effects of an explosion. Such a plant concept means that the mill, the filter as well as all pipings and components must all be designed for an explosion pressure of 10 bar (o). In addition to this, the suction and exhaust pipings must both be equipped with a „Ventex“ - valve. The product inlet and outlet must each be decoupled with a pressure shock-resistant and flameproof rotary airlock valve.
The actual distance between individual large components, which are regarded as „vessels“ in explosion technology, is also important. Regarded this way, the complete milling plant can be considered to be one “vessel”, if the distance between the components, i.e. the actual mill and the generally used dust filter, is smaller than 3 m. If an explosion takes place, it is assumed that it will take place simultaneously in the complete system.
If the piping distance between the sugar mill and the filter is greater than 3 m, this can possibly lead to a pre-compression in one of the “vessels”. The follow-on flame with pressure wave then leads to the much feared secondary explosion during which uncalculable pressure peaks can be reached. In this case „both vessels“ must be decoupled to prevent explosions, even if the milling plant is designed for 10 bar (o). For this purpose, quick-acting gate valves or extinguisher stop systems must be used.

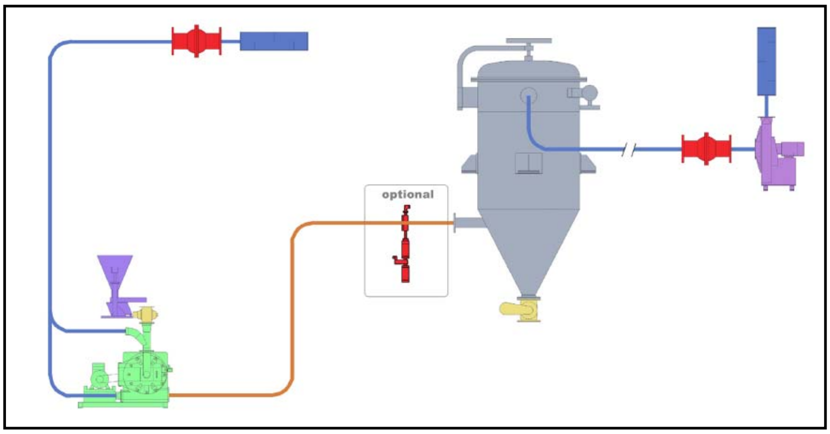

Fig.6

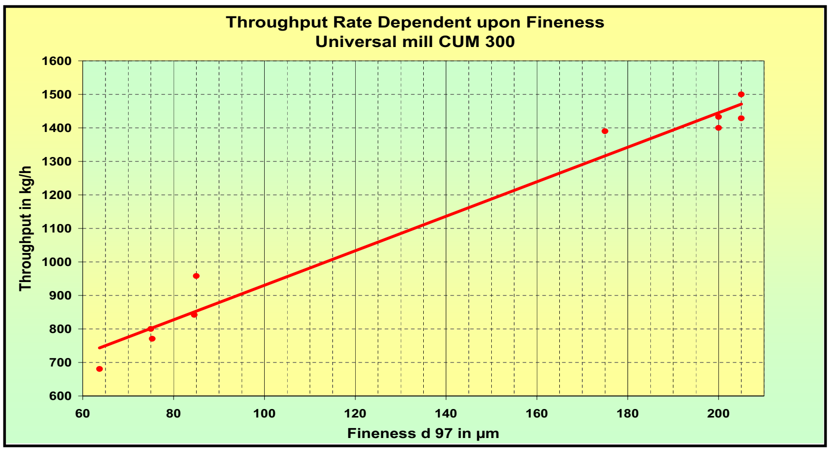

Fig. 5

Mill for sugar CUM 680, 3 bar (o)

3 bar pressure-relieved execution

In this version, the mill is designed for a reduced explosion pressure of 3 bar(o) and the dust filter for a reduced explosion pressure of 0.4 bar(o) and "pressure-relieved" using rupture discs. The surface of the rupture discs is calculated according to the volume of the filter (VDI 3673). The explosion which occurs via the rupture discs is guided to the "exterior" via a short explosion channel. In this case, there must be sufficient room available outside the building.
If not enough room is available for an explosion channel or if the planned location of the dust filter does not permit relief to an outside area, there is also a possibility of relieving the explosion within the assembly area using a so-called quench-pipe instead of an explosion channel.
If the milling plant is arranged (picture 7) with a more than 3 m long conveying pipeline between icing sugar mill and dust filter, the milling unit is regarded as "two" connected "vessels" as far as explosion hazard is concerned. In this case, two explosion-possibilities must be observed:

- The primary explosion in the mill
- The primary explosion in the filter

If the explosion takes place firstly in the mill, relief is provided via the pneumatic conveying pipeline, so that the maximum explosion pressure does not arise. For this reason a reduced hardness of the mill housing is sufficient. The explosion carries on into the filter and a second explosion occurs, which is relieved via the rupture disc. As the volume of the mill is considerably smaller compared to that of the filter, the pre-compression of the filter caused by the mill must only be taken into consideration when designing the rupture discs.
A different behavior can be seen in the case of a primary explosion which takes place in the dust filter. This is the most common type of explosion. In this case the explosion in the filter is initially relieved via the rupture disc. However, as the large volume of the filter causes a pre-compression in the case of an explosion, a further advancing flame front to the mill must be prevented. This is carried out by means of a fire extinguisher which is connected to the rupture disc on the filter by a pull cord switch. If the rupture disc reacts, the explosion is immediately detected and the fire extinguisher automatically actuated. The piping between the mill and filter is flooded with extinguishing powder (sodium bicarbonate) and the incoming flames smothered. In order to allow sufficient time for the ignition, the extinguisher must be located at least 5 m from the filter. The advantage of the detection via a pull cord switch is the very low probability of a false release, generally known and feared by the users of pressure detectors. The extinguisher is only actuated when the pull cord switch is destroyed.
For constructive executions of these „pressure-relieved plants" the mills as well as all pipings and components up to the filter are designed for a reduced explosion pressure of 3 bar (o) and the filter as well as connected components for an explosion pressure of 0.4 bar (o). In this case a „Ventex" – valve must also be installed in the suction piping. A "Ventex" - valve behind the filter is no longer necessary thanks to the pressure relief. In this case, the product inlet and outlet are also decoupled with a pressure shock resistant and flameproof rotary airlock valve.

During the project planning of the very first pressure-relieved sugar milling plants of new generations, this concept was developed in cooperation with the sugar trade association and additionally confirmed in an external report!

In the final analysis the user naturally decides about the best explosion protection solutions „for his new milling plant". As well as constructional „limitations" or safety regulations particular to individual companies, financial matters are also of importance. Basically it can be assumed that for smaller milling plants with throughputs of up to 2000 kg/h, the constructional requirements for pressure shock-resistant executions between 3 bar and 10 bar is low. However, this increases dramatically with increasing construction size. Larger production plants with icing sugar throughputs starting at 3000 kg/h are clearly advantageous in pressure-relieved execution as far as investment sums are concerned, and will surely be preferred by users in the future.

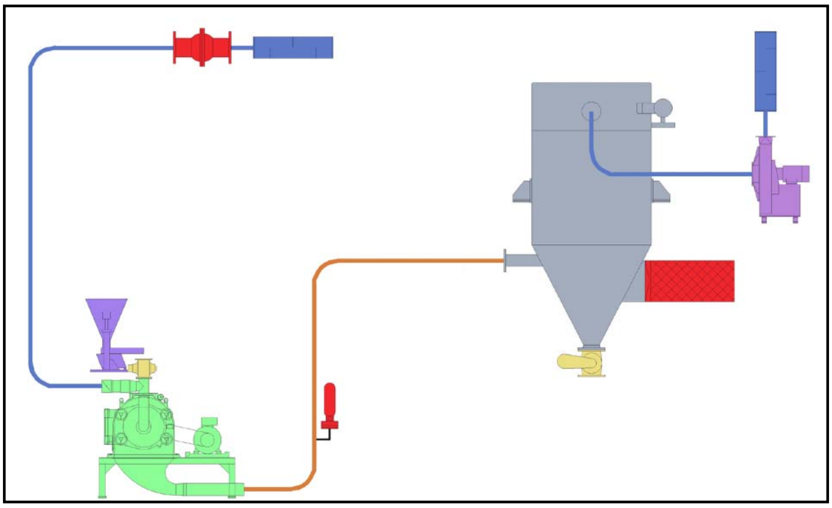

Fig.7

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