Sugar Conditioning – The Basics

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Introduction to SKIL

Sugar Knowledge International Ltd, known throughout the sugar industry as SKIL, is a modern, multinational professional services company with the resources necessary to provide consultancy, project engineering, project management and operational management support to the world’s sugar industry.

We are a truly independent organisation, not connected to any sugar producer, any supplier of equipment and/or consumables nor to any contractor.
Introduction to SKIL

This allows us to provide totally unbiased advice to clients so that we are able to optimise the total project.

The directors and staff of SKIL developed their careers with multinational sugar companies such as Tate & Lyle, British Sugar, Illovo and Sucrogen (CSR). In addition to the proven technical expertise there is therefore a solid base of commercial awareness in terms of project development and implementation. This is recognised by clients that include ED&F Man, Tate & Lyle, Bunge and Louis Dreyfus.
Introduction to SKIL

SKIL projects in the last 12 months:

- ASC Bahrain Refinery
- Bunge Sugar and Bioenergy - worldwide
- E D & F Man Sugar - worldwide
- Eritrea sugarcane factory
- La Gloria sugarcane factory
- Louis Dreyfus Commodities – Xiamen Refinery
- Raceland sugarcane factory
- Rusagro sugarbeet storage
- Salim Group training and commissioning
- Sri Lanka sugarcane agriculture
- Yelets sugarbeet power station
Sugar Caking - Why Condition Sugar?

• Thailand has developed a reputation for a caking/lumping problem over the last few years.
• In the worst cases this is apparent in 50 kg bags over a very short time period – one to two weeks.
• The Thai industry is competitive in terms of its refined sugar cost but, to utilise this good price structure, one needs to be able to ship good quality, free flowing sugar to all markets in any form of packaging – 25 or 50 kg, big bag and bulk.
Sugar Caking - Why Condition Sugar?

- Mitr Phol and Korach currently have the ability to condition sugar. Others will follow.
- Competitors in neighbouring countries have recently installed conditioning.
- A number of design and process control issues can make caking worse while good refinery practices can help to alleviate poorly designed equipment.
- Modern practice combines counter current drying / cooling with short residence time conditioning. This is now being implemented in Thailand.
Where does the problem start?

• Crystallisation is the first area to have a major influence in sugar drying/cooling and the need or otherwise for conditioning.

• Good Coefficient of Variation – CV.

• CV’s of 28 – 32 are considered good by producers although some conditioning suppliers ask for lower and this is very difficult and costly to maintain.

• The shape of the CV curve also has an influence. If there is a bias towards the smaller particle size then this will increase the surface area and make the problem worse.
Graph of Typical Sugar Screening Results
Vacuum Pans

- Modern designs are different to those from 30 years ago
- Older designs were tall with poor circulation and weak stirrers.
- Modern design are low head, short calandria with centre wells, good heating surface to volume ratios and powerful stirrers.
- Good automatic control systems and care in the preparation of slurry help in obtaining consistent results.
Centrifugal Machines

- Should be run as consistently as possible.
- Dryers do not like large flow variations.
Dryers

• There have been many changes in dryer design over the last thirty years:
  – Vibrating bed – hot air
  – Fluidised bed – hot and cold air, horizontal and vertical
  – Rotary – co-current, counter current, mixed flow, cascade, cruciform, falling film, multi-barrel

• The aim is to dry the crystal as gently as possible while limiting the amount of crystal damage.
Dryers

• In the last five years most new build refineries have used counter current, low temperature, rotary falling film. Air flow can be linked to sugar flow.

• Good drying does 90% of the work in obtaining free flowing sugar.
How is Sugar Conditioned?

• Pass low rH air through the mass of sugar for sufficient time to bring the total moisture down to an acceptable level.
How is Sugar Conditioned?

• Pass low rH air through the mass of sugar for sufficient time to bring the total moisture down to an acceptable level.
  – What time is sufficient?
  – What rH?
  – What temperature?
  – What is an acceptable starting point?
  – What is an acceptable final point?
Typical Parameters

• Input temp not too different to sugar temp – avoid temperature shock.
• Input rH – normally 30-45 – again avoid air that is very low rH.
• Time? As long as it takes to get total moisture to a “reasonable” level – between 0.04 to 0.06. Anything from 6 hrs to plus 72 hrs.
• Final test is 75 days in bulk form in a container across different climatic zones.
Tips and Tricks

• How to get the sugar in.
• How to get the air in.
• How to get the sugar out.
• How does the design avoid channelling – does the air reach all the sugar and is all the sugar conditioned for the same time – one of the biggest problems.
History

• The beet industry has used conditioning for 50 years – short seasons and direct white sugar production means that sugar needs to be stored for up to nine months. Their solutions combine conditioning and storage.

• It did not start in the cane sugar refining industry until decades later.

• It is not common in the cane sugar refining industry but the requirement is increasing as different shipping methods are used and customers are becoming more demanding.
History

• Conditioning silos are different to storage silos.
• Conditioning silos are small while storage silos may be as big as 80,000 tonnes.
FIFO or Mass Flow

- The whole content slides down evenly; in the tapered or conical section sugar is compressed sideways.
- Due to friction and compression loads there are large forces on walls.
- Strength calculations are difficult and are best carried out by a Specialist.
- The cost is relatively high because of the height and sometimes complicated shape and reinforcements.
FIFO or Mass Flow

• There are not many types full mass-flow FIFO silos.
• Examples of high aspect ratio silo: mainly South Africa – Wellman/Bosch.
• Examples of medium aspect ratio silo: Portasilo, Mitr Phol flat side design.
### FIFO or Mass Flow

Different types of mass-flow silos have been developed

<table>
<thead>
<tr>
<th>High aspect ratio</th>
<th>Medium aspect ratio</th>
<th>Low aspect ratio</th>
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</thead>
<tbody>
<tr>
<td>• H/D 5</td>
<td>• H/D 3 - 4</td>
<td>• H/D 1.5 – 2</td>
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<tr>
<td>• H 40 – 50 m</td>
<td>• H 35 – 40 m</td>
<td>• H 25 – 35 m</td>
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<tr>
<td>• D 8 – 10 m</td>
<td>• D 11 m</td>
<td>• D 15 – 22 m</td>
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<tr>
<td>• Inverted cone outlet</td>
<td>• Steep cone outlet(s)</td>
<td>• Multiple outlets</td>
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<tr>
<td>• 1,000 – 3,000 t</td>
<td>• 1,000 – 3,000 t</td>
<td>• 3,000 – 10,000 t</td>
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<tr>
<td>• Full mass-flow</td>
<td>• Full mass-flow</td>
<td>• Partial mass-flow</td>
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<tr>
<td>• Start-up problems</td>
<td></td>
<td>• Clean-out problems</td>
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</table>
High aspect ratio silo 1800 t
Feed rate 40 t/h
Inlet with 12 pipe diverter
12 radial outlets to central hopper
Medium aspect ratio mass-flow silo 1700 t
D 11 m, H 35 m
Feed / reclaim rate 30 t/h
Central inlet
Outlet hoppers (2 x)
Sugar Refinery Mill Phol Thailand (2007)

Huge wall reinforcements

Left container loading station
Flat Bottom Silos

• Silo with numerous outlets in bottom.
• Air diffusers in bottom.
• Sugar should leave silo through all outlets simultaneously.
• In the basement there are quite a number of conveyors to collect sugar and transport it towards a single conveyor to packing.
Flat Bottom Silos

• A large portion sugar remains stagnant (rat holing effect), considerably reducing the retention period. Part of the stagnant sugar requires hand clean-out.

• An improved type is the multi-cone outlet silo (ACMB), where most of the clean-out is without manual interference.
Sugar Refinery Mackay Australia (1995)
Low aspect ratio flat bottom concrete silo 3000 t under construction
Manufert Sugar Terminal Belgium (1993)
ACMB Silo 35,000 t, Ø 43, H 34 m, double steel wall
Multi-cone outlets 3 x 3 m from inside
Manufert Sugar Terminal Belgium
Basement with reclaiming belt conveyors, total capacity 400 t/h
SIS Sugar Refinery Singapore (1993)
Bottom screw reclaimers & air diffusers
Batch Silos

• Simple structure, not requiring complicated calculations
• Core flow pattern.
• Three or four silos required, on filling, one emptying, one or two stationary for maturation.
• More units of equipment are necessary, higher maintenance than single silo.
• Operation however is quite easy.
• There are several examples of batch type conditioning silos at refineries, i.e. Nantes France, Bejaia Algeria, Bahrain, Surin.
Combined Conditioning / Storage Silos

• Additional buffer capacity required when packing is not 24/24 h 7 days.
• Difficult to increase volume of full mass-flow types, limit lies at approximately 3000 t.
• Additional silos have to be installed – expensive solution.
• If mass flow is not required then there is no limitation on size – horizontal, round, flat bottom, multiple outlet.
• Common in Europe at beet factories and terminals.
Sugar Refinery Nantes France (1996?)

Low aspect ratio flat bottom double skin steel silo 5000 t
Diameter 17 m
Warm air wall air heating
Multi-cone outlet bottom
Sugar Refinery USCE
(2007)
Low aspect ratio silo 6000 t
D 22 m, H 22 m
Feed / reclaim rate 75 / 150 t/h
Central inlet
Multi-cone outlets (32 x)
Air flow rate 6000 m³/h
Conclusion

• There are many options
• Each factory/refinery is unique
• A new build refinery is a lot easier
• Older factories may require compromises
• The Thai industry has long seasons and short gaps
• **Independent** advice is recommended to look at the whole solution:
  – Vacuum pans and boiling
  – Centrifugals
  – Drying and cooling
  – Conveyor systems
  – Explosion protection
  – Food safety
  – Materials handling
  – Logistics solutions