SUPERSATURATION, PRODUCT QUALITY, YIELD AND COST OF PRODUCTION.

It is well known that excessive supersaturation results in unwanted nucleation (formation of fines) and besides poor circulation it is made responsible for the formation of twins and conglomerates as well. When advised not only to monitor on-line, but also to modify the previous supersaturation profile during the strike, conglomerate content was reduced by 40 % in a refinery in North America.

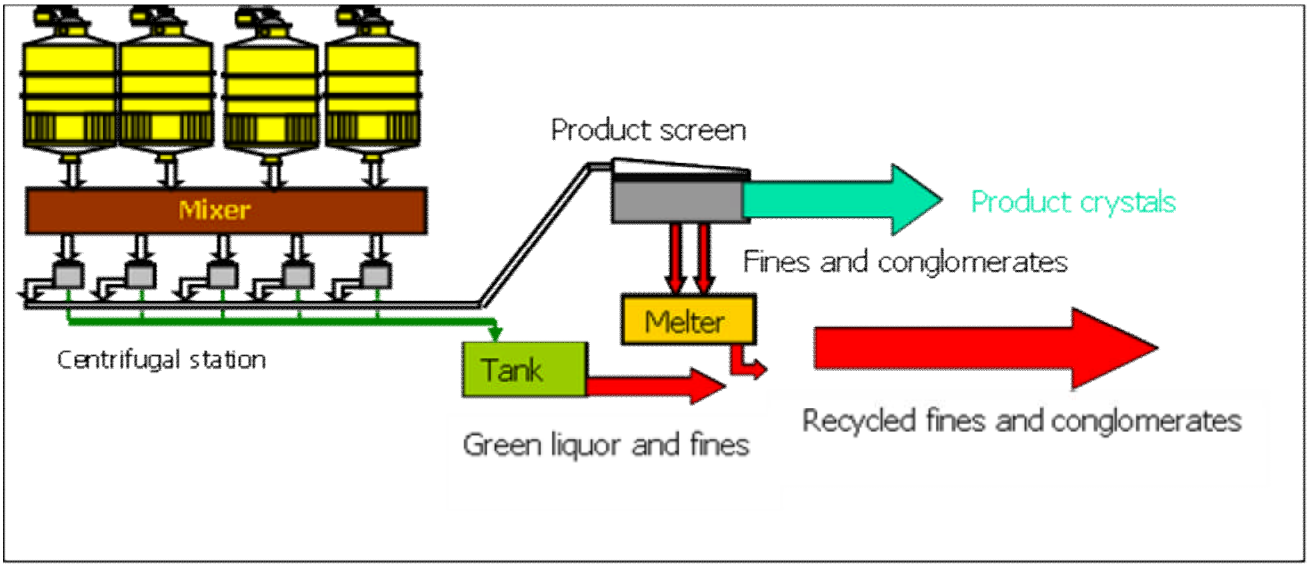

Fig.1. Material flow in crystallization

Besides other parameters the speed of crystal growth is proportional to supersaturation. In order to increase the rate of production plant managers often instruct their staff to reduce boiling time. This will perhaps unknowingly result in supersaturation well above the critical limit. As a first approximation the rate of production is measured by the number of strikes during a shift, or day. Problems with crystal quality and the ***true yield*** (the actual amount of product per strike) will turn out only later, if ever. ***Fines and conglomerates are recycled in the process resulting in considerable losses (Fig.1.)***. It is informative to have a closer look at this problem by using material balances on crystallization. We can define the following 2 parameters:

Yield of crystallization (K): amount of crystals produced over amount of dissolved sugar entering the process.

Product yield (Yp): % of final product from the total amount of sugar entering the process.

THE IDEAL CASE OF CRYSTALLIZATION:

Let us assume that we have a crystallization station where 1 t of dissolved sugar in the thick juice is crystallized to result in 0,6 t of perfect quality product (obviously an idealization), while 0,4 t sugar leaves the station dissolved in the green syrup (K = 0,6). In this case there is no recycled crystallized sugar, that is product yield Yp = 60 % (Fig.2.).

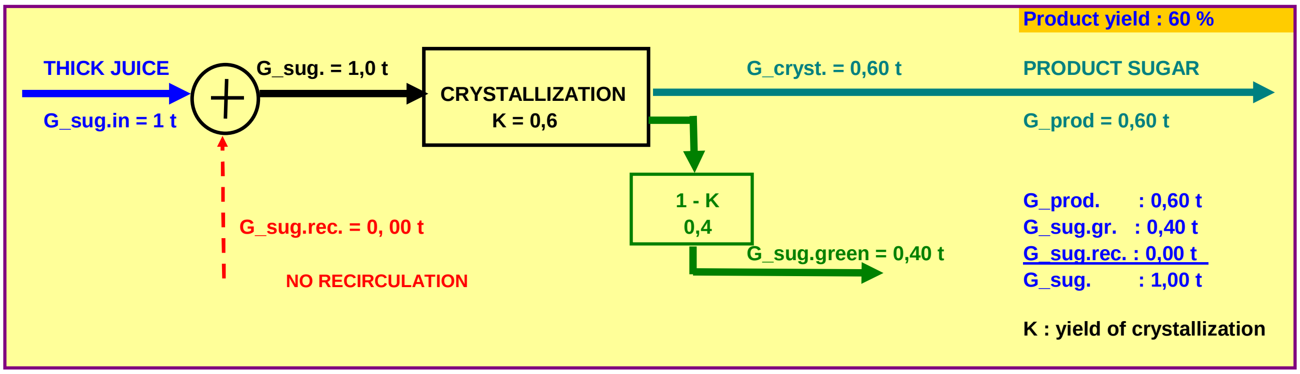

Fig.2. Material balance in an idealized crystallization process

THE REALISTIC CASE:

In a more realistic example due to excessive supersaturation the amount of recycled crystal sugar that is composed of

- crystals which escape through the holes of the centrifuge screen with green syrup and
- fines and conglomerates removed by screening

equals 15 % (rate of recycling R =0,15) of the full amount of crystals produced, while the yield of crystallization remains unchanged (K = 0,6). Fig.3. shows the material flow diagram and data valid for this case.

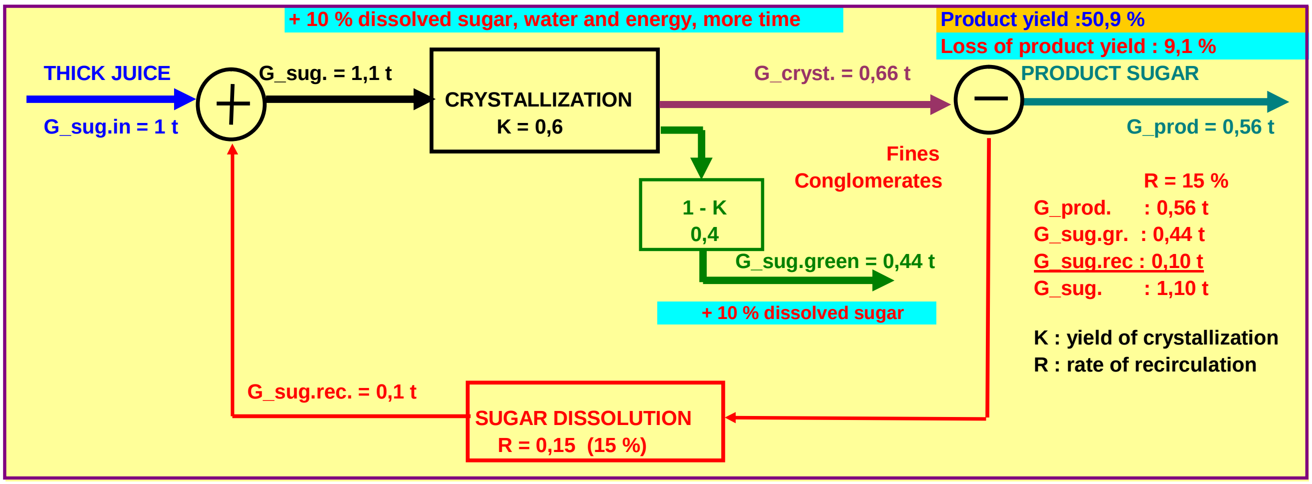

Fig.3. Material balance in a realistic case of crystallization

Assuming the same amount of dissolved sugar in the thick juice (1 t) from the evaporator station it is informative to compare some of the data of the two cases:

	Ideal process	Realistic process	Change
Recycled crystal sugar	0,0 t	0,10 t	+ 0,1 t
Sugar input to crystallization	1,0 t	1,10 t	+ 10 %
Yield of crystallization (K)	0,6	0,6	-------
Amount of product	0,6 t	0,56 t	- 0,04 t (-6,67 %)
Dissolved sugar in the green syrup	0,4 t	0,44 t	+ 0,04 t (+ 10 %)
Product yield (Yp)	60 %	50,91 %	- 9,09 %

Summary:

1. **Sugar input to the crystallizer station (load) in the realistic case has increased by 10 % as compared to the ideal one.**
2. **Despite the increased dissolved sugar input and the identical yield of crystallization (K) the amount of final product was decreased by 6,67 % (0,04 t). This leaves the station with the green syrup.**
3. **Product yield (Yp) was decreased by 9,09 %.**
4. **Consequences: increased use of water and energy, longer boiling time and reduced real product output resulting in increased cost of production.**
5. **When refining already crystallized sugar the same procedure is repeated for the second time again with similar consequences.**

The lessons to learn:

1. "Pushing" the rate of production by exceeding the critical limit of supersaturation results in grave consequences.
2. Supersaturation is the most important parameter in crystallization. It should be controlled on-line during the complete strike.
3. Common sensors (RF, microwave, conductivity, boiling point elevation) in use today are perfectly unfit to provide reliable data on supersaturation.

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