



Depositing - The Future of Hard Candy

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Introduction

Hard candy depositing is a process that has developed and grown rapidly over the last 20 year. .Deposited hard candies and lollipops are now produced in every major confectionery market around the world by manufacturers ranging from regional specialists to major multi-nationals. First introduced over 50 years ago, depositing remained a niche technology until confectioners recognised its potential to meet increasing market demand for premium, high-quality, innovative products. Since then it has, time and again, been the technology that has enabled them to push back the boundaries of innovation by developing hard candies and lollipops that would be inconceivable with traditional processes. Today, it continues to progress, offering manufacturers an ever widening range of opportunities to blend visual appeal with exciting taste and texture combinations.

This paper will review the basic principles of depositing and discuss the fundamental aspects of design that should be considered when engineering a complete depositing solution. A study will also be made of each of the main candy types frequently produced today; solid, striped, centre-filled, short and long layered, and lollipops with the important process and engineering criteria highlighted. The paper will also examine many of the changes and improvements seen over the last 50 years, and speculate about the developments that will shape the future of depositing.

Deposited Candy

First, we should remind ourselves what deposited hard candies look like. Figure 1 shows some typical examples.



Range of Deposited Sweets

Figure 1 – Range of Deposited Sweets

They are made in specially coated moulds that impart a uniform size and shape, and a smooth, glossy surface finish. Even plain candies are visually appealing while candies with multiple colours or different materials are further enhanced. They have excellent flavour release and a smooth mouth feel with no sharp edges.

An obvious distinguishing feature is the witness mark left by the mould ejector pin. Typically these are 5 or 6mm diameter but can occasionally be smaller. Deposited hard candy is generally regarded as a premium product and this characteristic has come to be seen as an indication of quality. So much so, that some die-formed candies have even been marketed with simulated pin marks.

Basic Depositor Principle

At first glance the manufacture of deposited hard candy is a relatively simple process, although there is a lot more to it than meets the eye. Cooked candy syrup is fed continuously to a heated hopper positioned over a chain-driven mould circuit. Pistons in the hopper meter the syrup accurately into individual cavities in the moulds, which are then conveyed into a cooling tunnel. Generally, the products remain in the moulds for the forward and return runs of the circuit before being ejected onto a take-off conveyor. This process is illustrated in Figure 2.



Depositor

Figure 2 – Schematic of Standard Depositor

Usually the mould circuit runs continuously with the depositing head utilising a fore-and-aft reciprocating motion to match the mould circuit while depositing. Occasionally hard candy depositors use static heads and intermittent mould circuits with loose moulds, but these tend to be slower and more prone to mould jams.

Production of deposited hard candy is highly efficient, with very low scrap rates and depositing is at final solids so no additional processing is required. Candies can go directly to packaging where they are usually wrapped individually. They will either be flow- or twist-wrapped depending on the climatic conditions and required shelf life. Some sugar-free candies (usually Isomalt based) do not require individual wrapping.

The fundamental principles of depositing have remained the same since it was introduced over 50 years ago. However, advances in technology, particularly control systems, would render modern machines virtually unrecognisable to the pioneers of the process. The first continuous depositors were relatively low output, usually just one mould wide, with no more than 8 cavities across. These depositors were mechanical with all the machine movements driven by cams linked to the mould circuit. They would have one hopper typically producing about 200 to 500 single colour candies per minute. Figure 3a illustrates one of these early depositors.

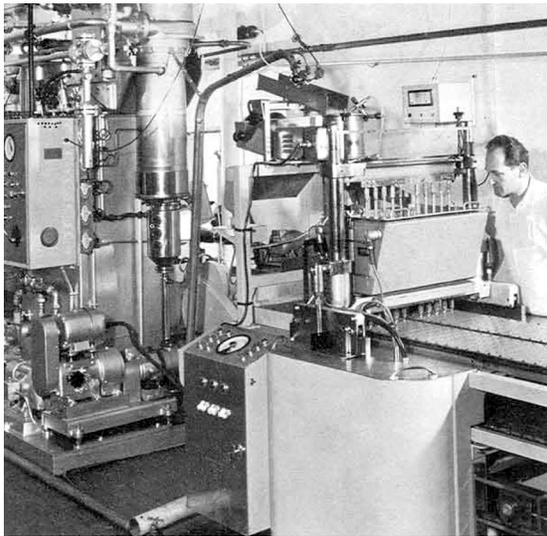


Figure 3a – Early Depositor – Circa 1960

Today's machines feature sophisticated servo-drives and PLC control systems instead of mechanical cams and linkages. These enable the same depositor to be used to make a very wide range of products and to be changed over at the touch of a button. Current depositors are usually wider, up to 1.5 metres, often have double hoppers, operate at higher speeds and deposit 2, 3 or 4 rows of candies on each cycle. Multi-headed versions are available to further increase versatility and output. It is quite common for modern plants to produce over 10,000 candies per minute. One of these recent high output flexible depositors is illustrated in Figure 3b.



Figure 3b – Modern Depositor

Depositor Process Design

While the principles of depositing are straightforward the successful production of deposited hard candies and lollipops requires a good understanding of the whole process, from raw materials through to wrapping. With this knowledge it is possible to make a very high-quality sweet very efficiently. However, if starting with poor-quality raw materials even the best depositor will be unable to make a high-quality product. Similarly, a poor depositor running with high-quality ingredients will not make a good product either.

Recipes

There are many deposited hard candies available today, but the majority fall into one of three generic categories: clear candy, cream candy and milk boil (high-milk) candy (Figure 4). All of these recipes are continuously cooked, typically to a final moisture content of 2.5% to 3%. To achieve this it is necessary to cook the syrup atmospherically to approximately 150°C or lower if vacuum is applied.

The clear candy recipe is typically used to make coloured fruit-flavoured candies, often with layers or multiple stripes, or clear mint candies. It is also used for many centre-filled candies with either solid or liquid centres. If the correct raw materials and process are used very clear sweets can be produced.

The cream candy recipe is one of the most popular today. This is usually the base recipe for striped fruit and cream candies, of which many types are produced globally. These recipes typically contain about 5% cream, which should have a high fat and low protein content to avoid the syrup caramelising. In the United Kingdom Double Cream (48% fat, 1.7% protein) is often used whereas in the United States Heavy Cream (40% fat, 1.7% protein) is preferred.

Ingredient	Clear Candy	Cream Candy	Milk Boil
Sugar	46%	41%	39%
42DE Glucose (Corn Syrup)	42%	38%	35%
Water	12%	10.5%	8%
Coconut Oil		5%	
Fresh Cream			5%
Butter		5%	8%
Full Cream Sweetened Condensed Milk			2%
Whey Powder			2%
Emulsifier		0.25%	0.50%
Salt		0.25%	0.50%



Figure 4 - Hard Candy Recipes

The milk boil recipe is usually used to produce a high milk content, solid hard candy with a rich, caramelised flavour. Recently many manufacturers have started to centre-fill these products with real chocolate or soft caramel. The recipes deliberately have higher protein contents than the previous cream-candy recipe, to ensure caramelisation takes place. It is sometimes also necessary to increase the residence time between the cooker and depositor to allow the colour to develop. These recipes will often contain full-cream sweetened condensed milk or whey powders, which have higher protein levels.

When it is difficult to source a suitable fresh cream it is usually possible to make an acceptable alternative using either milk powder with additional fat or, preferably, a cream powder with a high fat content. These powders have to be carefully rehydrated and mixed using high-shear mixers or homogenisers. To maximise cooker output the amount of added water should be minimised.

Advances in ingredient and cooking technologies have enabled sugar-free candies to be deposited with few problems. The most common sugar-free material used is Isomalt. To achieve a stable product the Isomalt has to be cooked to lower moisture contents than sugar candy (typically 1% to 1.8%) requiring higher cook temperatures with increased vacuum.

Maltitol syrups are also used but do not necessarily need cooking to such high temperatures. However the final candies are very hygroscopic and need to be individually wrapped.

Most sugar-free recipes are less sweet than sugar recipes. To overcome this intense sweeteners are added (aspartame, acesulfame-K, sucralose, Stevia etc.) It is also possible to make sugar-free products using cream and other additions.

Graining and Inversion

All the recipes tabled contain predominantly sugar and glucose (corn syrup) and it is important that the ratio between them is correct. If the sugar level is too high there is the possibility that the candy will re-crystallise or grain. This may occur in the final product only after wrapping, affecting shelf life and leading to consumer complaints. It is more likely that it will first be seen in the depositor hopper as the shearing action of the pistons can initiate the re-crystallisation process. It will start as a slight cloudiness in the syrup, possibly around the pistons, and then spread, throughout the hopper, eventually necessitating a production shutdown and thorough wash-out.

Conversely, if the glucose level is too high there may be excessive inversion (presence of invert sugars). This can also lead to shelf life problems and consumer complaints about candies being discoloured and sticky. On the production line this inversion will first be seen as discoloured candy and may lead to difficulties with ejection and wrapping.

Many of these problems can be avoided or minimised by choosing the right recipe and selecting the correct raw materials. Often depositors are installed in factories that already run other processes, for example die-forming, and although it is tempting to assume that the same raw materials and recipes can be used, depositing is a unique process and manufacturers should appreciate that different recipes will be required.

High-maltose glucose warrants a special mention. It is now regularly used in deposited candy recipes instead of standard 42DE glucose. Glucose syrups with high maltose levels are more fluid and produce lower viscosity candy syrups, which reduces tailing. The final candies are also clearer, less prone to discolouration and less hygroscopic. However they can be slightly more brittle.

Cooking

Having developed a recipe and selected the raw materials the next stage is to choose the best cooking process to feed the depositor. A good understanding of sugar boiling curves and the effect of pressure and vacuum will help with this selection.

The cooking is usually considered in two discrete stages: dissolving the granulated sugar and evaporating the resultant syrup to achieve the required final solids. The dissolving stage should have a retention time long enough to ensure all the sugar is fully dissolved. The most common continuous dissolving systems today are coil cookers or plate heat exchangers (PHE). Sometimes these will be configured with back pressure to allow less water to be used with a resultant energy saving.

For depositing, the candy syrup must be evaporated to final solids as quickly as possible. This avoids heat degradation and process inversion, which can cause shelf life problems such as cold flow and stickiness. Continuous cookers with short residence times and the ability to use vacuum should be selected. The application of vacuum allows the required final moisture to be achieved at lower cooking temperatures.

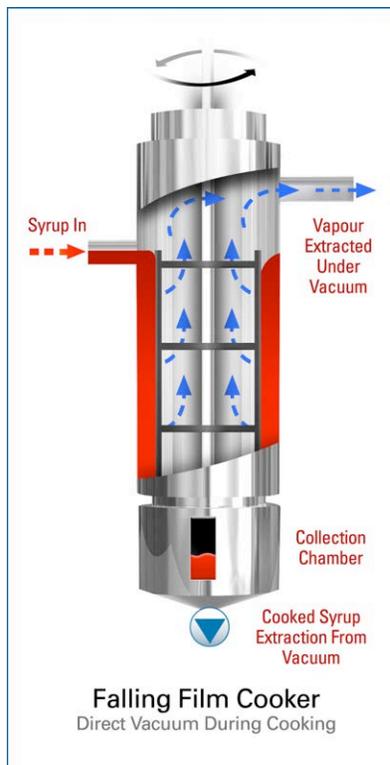


Figure 5a – Falling Film Cooker

The most common cookers for this application are either falling-film or rising-film cookers (Figures 5a and 5b).

Both designs have rotating elements that either scrape the syrup against the cooker tube or create enough turbulence to avoid burning when processing milk recipes. Both cooker designs can also operate with vacuum. This is particularly advantageous when used with falling-film cookers because the vacuum can be applied to the syrup while evaporation takes place. This enables even lower cooking temperatures to be used, which helps minimise the process inversion.

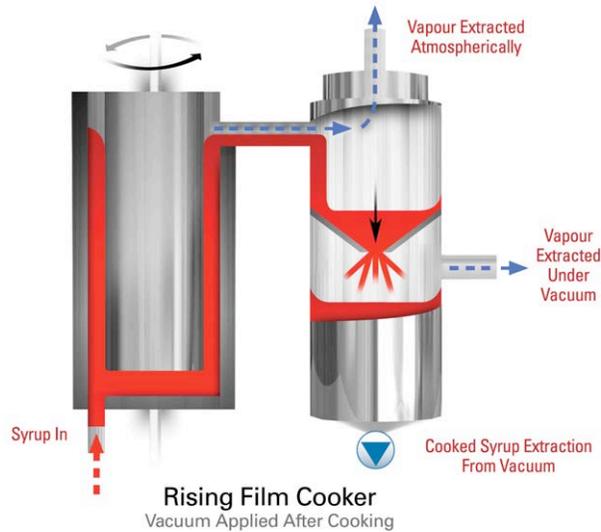


Figure 5b – Rising Film cooker

Colour, Flavour & Acid Additions

It is the addition of colour, flavour and acid (CFA) that gives candies their great appeal. As with the base recipe, it is important that the additions are suitable for depositing. Buffered lactic acid is preferred for hard candy depositing. It is typically added at a rate between 0.5% and 2% depending on the desired flavour profile. It is particularly suitable for use with cream-candy recipes.

Other acids (malic, citric and tartaric) may be considered but their use dramatically increases the degree of inversion and potential for other problems. Colours are best added as liquids but using minimal additional water. Flavours should be chosen with the correct carrier solvent, with a suitable flashpoint temperature that avoids excessive bubbling.

It is preferable to continuously meter these additions into the candy stream towards the end of cooking or, even better, just before depositing. Buffered lactic acid is often added into the cooker's outlet chamber. Depending on the final product it may be necessary to split the cooked candy into multiple streams each with their own additions.

The simplest method is to mechanically split the output from the cooker using a series of chutes. The chutes can be moved manually to balance the syrup flow rate down each leg (Figure 6a). Liquid additions can then be pumped through open pipes to mix with the candy over a series of mechanical baffles or pre-mixers. If powders are added (e.g. encapsulated flavour or Vitamin C) screw feeders and rotating mixing cones can be used.

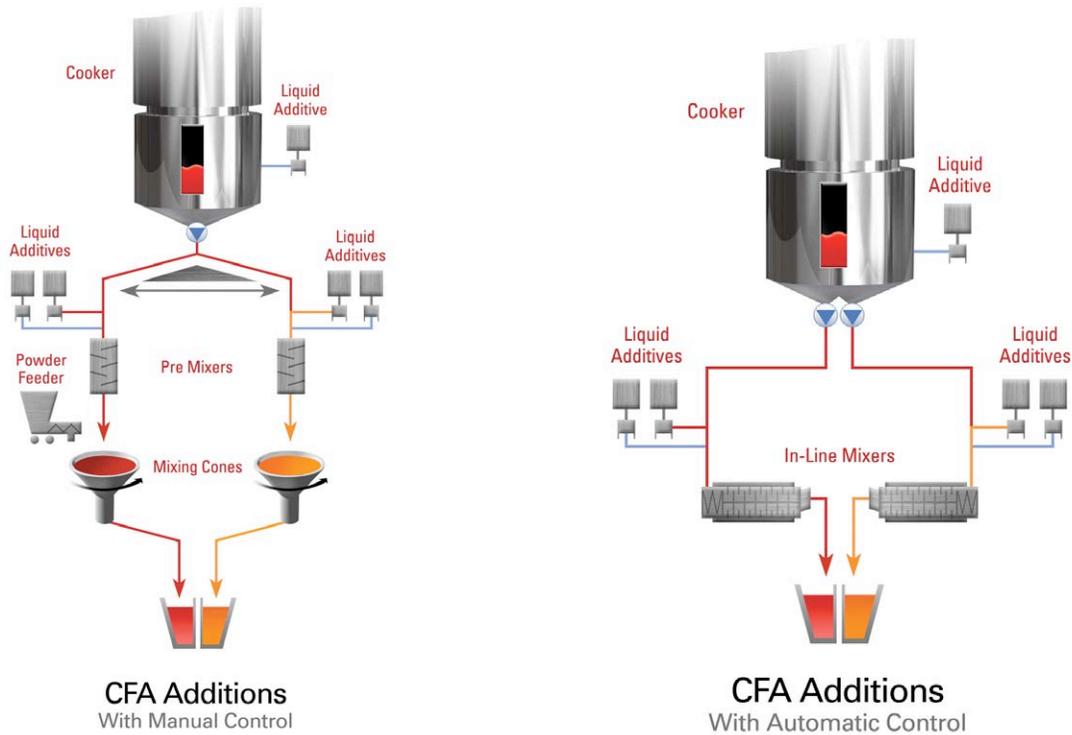


Figure 6a & 6b – CFA Additions with Manual & Automatic

An increasingly popular method, more suitable for automatic control is illustrated in Figure 6b. Here separate pumps are used to feed each candy stream through static or dynamic inline mixers and feeding directly to the depositor hoppers. If just two streams are required the cooker will often be fitted with the two discharge pumps. Alternatively if three or more streams are required a separate intermediate buffer tank with multiple pumps is often preferred.

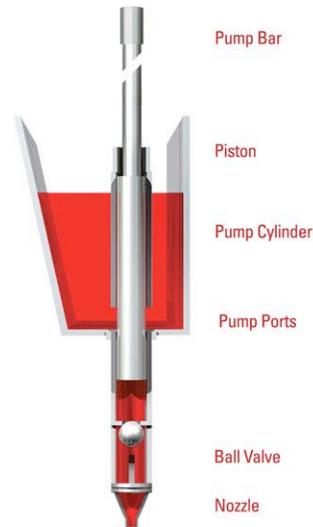
The cost of instrumentation is continually falling so many producers now install flow-meters throughout their CFA addition systems. Their use can ensure that product quality remains high and consistent, and financial losses are minimised. Poor selection of additions and the mixing system elements can easily lead to bubbles in the candy.

Depositor Features

Depositor Head

The final cooked candy with its additions is normally fed directly to the depositing head. To prevent re-boiling and bubble formation the hoppers should be heated to a temperature just below the candy's boiling point. Electric or oil heated hopper jackets are usually used for this.

In the base of the hopper a number of individual sleeves or pump cylinders are each fitted with a piston (Figure 7). The pump cylinders have a number of holes or ports to allow syrup to enter from the hopper. These ports are positioned close to the bottom of the hopper. All the pistons are connected to a pump bar above which reciprocates up and down to deliver the individual deposits.



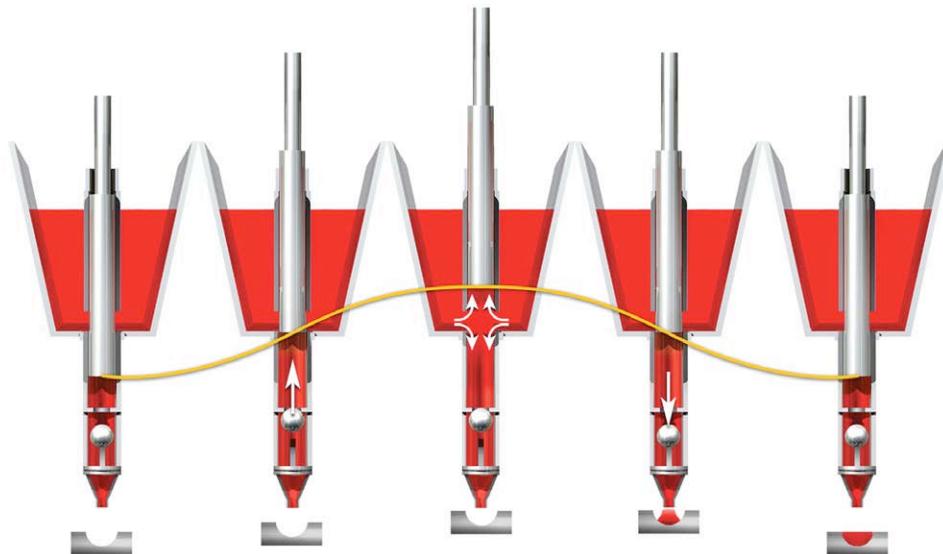
Hopper & Pump Arrangement

Figure 7a – Hopper & Pump Arrangement

On older depositors this pump bar is connected to mechanical cams which generate the piston movement, or pump profile. On modern depositors the pump bar is connected to a servo-drive where the pump profile is determined by a series of positional co-ordinates.

At the bottom of each pump cylinder there is a nozzle with a valve. The simplest and most common valve is a ball sitting on a spring or support stool. This overall design is elegantly simple and reliable with no mechanically moving parts. Some depositors have more complicated rotary or slide valves. These require mechanical seals with the potential for product leaks and have a high risk of seizing during production.

As the piston moves upwards the ball valve is lifted by the combined action of the spring (if used) and the piston's suction. This helps break the candy deposit tail. As the piston clears the pump cylinder's ports candy enters the pump cylinder. The piston continues upwards to draw in candy then starts to move downwards. As soon as the piston closes off the ports the candy will start to deposit through the nozzle. The deposit weight will be equivalent to the volume displaced below the ports by the piston. This sequence is illustrated in Figure 7b.



Pump Profile

Figure 7b – Pump Profile & Deposit Sequence

A clear understanding and ability to interpret pump profiles can be very instructive when trying to troubleshoot and improve depositing performance, or achieve a certain visual effect. Changes can be made to the pump profile and the effect on depositing action observed. In the past this process was very time consuming as it involved making and fitting new mechanical cams. Today, with servo-drives, changes can be made on the run.

Deposit Weight Calculation

To select the right pistons for a product it is necessary to be able to predict what candy weight can be deposited.

The deposit weight (W) for a specific piston diameter (D) can easily be calculated using the piston's displaced volume (V), candy density (ρ) and pumping efficiency (η):

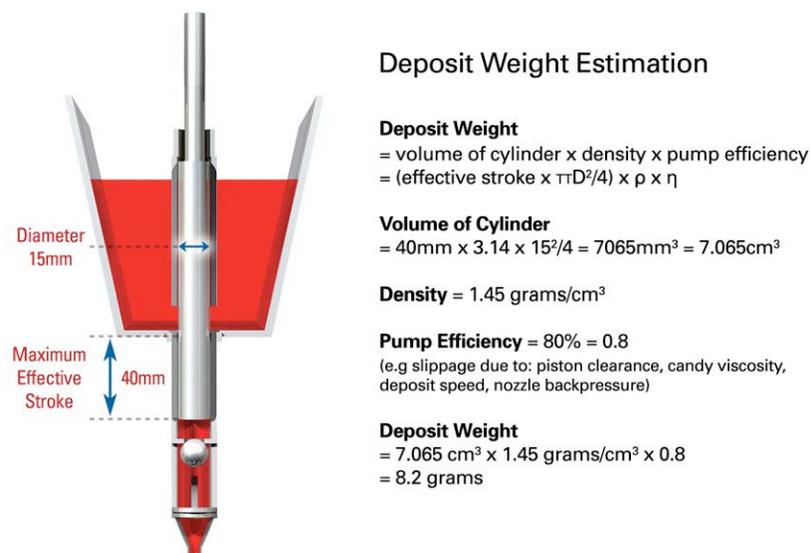


Figure 9 – Deposit Weight Estimation

Figure 9 shows the estimated maximum weight calculation for a 15mm diameter piston. This equation can also be rearranged to predict the effective stroke length that is needed to deposit different target weights.

Nozzle Selection

Having sized the pistons the next task is to select the most appropriate nozzle.

A small diameter nozzle will produce the finest tail, but the back pressure will be high resulting in a fast deposit velocity which may lead to the candy bouncing out of the mould cavity. Larger diameter nozzles will produce bigger tails, but the back pressure will be less.

Moulds

On a typical depositing line the candy moulds are filled with syrup at 140°C, and then cooled to 30°C in the cooling tunnel. Most of the heat is absorbed by the moulds which are cooled in turn by air circulating in the tunnel. The moulds have to be very robust and capable of repeating this cycle every 5 to 6 minutes.



Figure 10 – Hard Candy Moulds

If the moulds are too heavy they will absorb the heat too quickly, which leads to the candies cracking. If the moulds are too light cooling times will be extended and the moulds may distort. Usually the moulds are made from die cast or machined aluminium and coated in special FDA-approved non-stick coatings. They are fitted with sprung ejector pins to help demould the candies. (Figure 10)

Mould Lifter

At the end of the depositing stroke the nozzle valve closes to seal off the flow of syrup but a certain amount can remain in-flight due to the viscous nature of the syrup. This trails from one row of candies to the next and is known as a tail or 'angel-hair'. The raw materials, recipe and cooking process all affect the syrup viscosity and can be adjusted to reduce tailing.

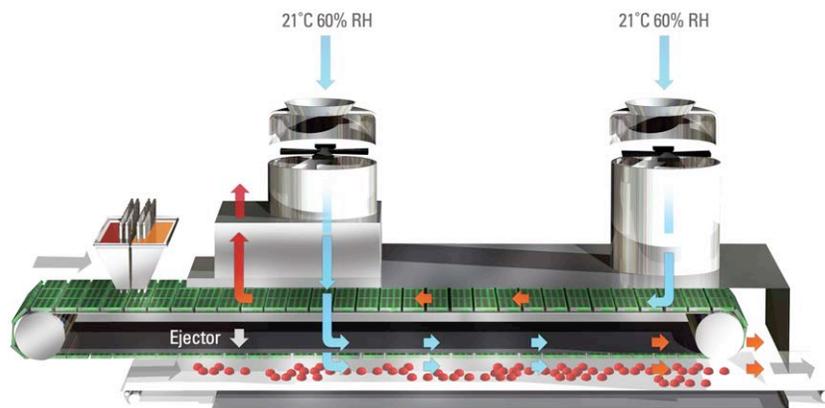
Tailing can also be reduced mechanically. A mould lifter is used to raise the mould close to the nozzle just before the deposit starts. As the deposit finishes the mould lifter drops, helping to break any tail that forms. The timing of the mould lifter, lift height and speed can all be adjusted to optimise performance.

Cooling Tunnel

To prevent the candies becoming sticky they have to be cooled relatively quickly using conditioned air. Ideally they are ejected while still warm (30°C to 40°C), to stop condensation forming, and conveyed directly to the air-conditioned wrapping room.

Cooling can be achieved with either ambient or refrigerated tunnels (Figures 11a & 11b). Ideally the cooling air should be about 21°C with a maximum 60% relative humidity (RH). Using lower air temperatures may shock-cool the candies and lead to cracking.

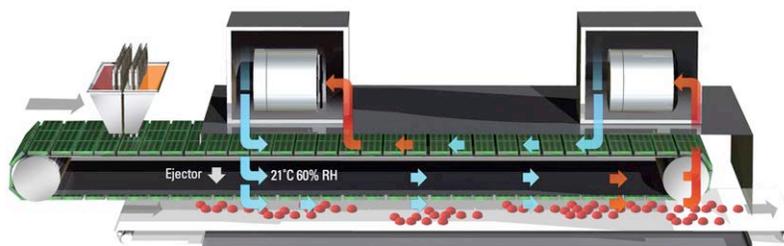
Many hard candy depositors are installed with the cooling tunnel in the wrapping room and the depositor head in the cooking area, with a partition wall across the depositor. The cooling tunnel fans then take in the conditioned wrapping room ambient air. The air is used to cool the moulds and is then discharged back into the wrapping room. It is necessary to determine the total heat load and ensure that the wrapping room air-conditioning has sufficient capacity.



Ambient Cooling Tunnel

Figure 11a – Ambient Cooling Tunnel

Refrigerated cooling tunnels are self-contained units that recycle the air within the tunnel. They are more commonly found on toffee or fondant depositors but can be used with hard candy. Care must be taken to ensure that the cooling is not too rapid and that the candies are not damaged.



Refrigerated Cooling Tunnel

Figure 11b – Refrigerated Cooling Tunnel

Solid and Layered Candy

An alternative to simple solid sweets is to make layered candies. Figure 12a illustrates a ‘short-term layered’ candy where the second layer is deposited immediately after the first layer, partially displacing the first deposit. This product can be made on many single headed depositors provided that there are two candy hoppers.

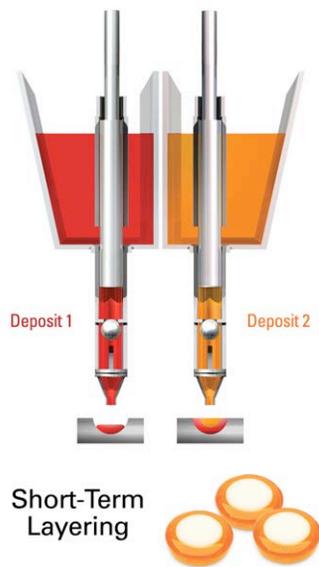


Figure 12a – Short-Term Layering

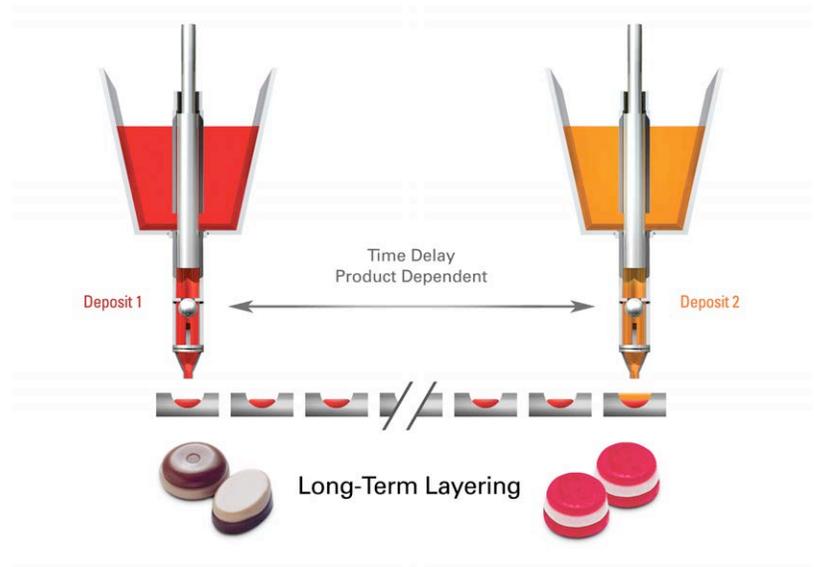


Figure 12b – Long-Term Layering

Figure 12b illustrates a ‘long-term layered’ candy which requires a depositor equipped with two depositing heads spaced apart. Each method gives a different visual effect to the candy. It is also possible to use different recipes or materials for each layer.

Striped Candy

One of the most successful products of recent years has been the striped cream candy. This has truly become a global product. Usually it is produced with two colours, but is sometimes made with three or four.

For two-colour stripes there are two hoppers depositing candy through a manifold arrangement (Figure 13). A special stripe nozzle with a series of grooves and holes is fitted in the manifold. One colour is fed directly through the nozzle and out of the nozzle holes. The second colour feeds through the manifold and down the nozzle grooves. The two colours converge at the nozzle tip.

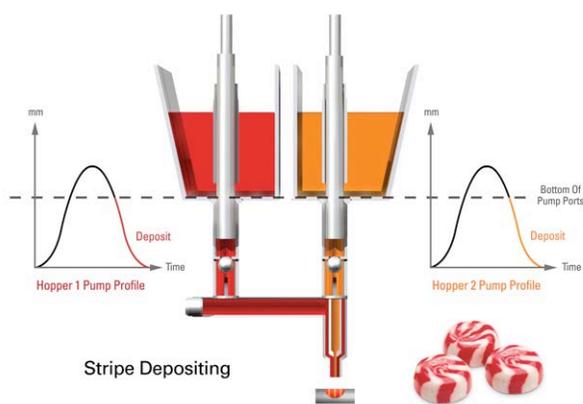


Figure 13 – Stripe Depositing

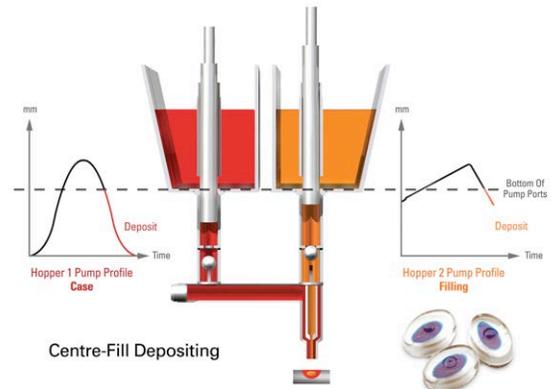


Figure 14 – Centre-Fill Depositing

For three- and four-colour products there are additional hoppers, or partitioned hoppers with increasingly complex manifolds and nozzles.

Typically, these products are made with equal candy weights for each colour. The usual way to do this is for all the pistons to be the same diameter, follow the same pump profile, have the same weight offset and be moving in time with each other.

However by breaking these conventions it is often possible to create unique and innovative products.

Centre-Filled Candy

A filling fully encapsulated in hard candy is an increasingly popular product option and one that can be achieved reliably only by one-shot depositing. The easiest product to make is a hard candy with a hard candy centre. But it is possible to centre-fill with jam, chocolate or even caramel.

One hopper is filled with the shell, or case material: a second hopper is filled with the centre material (Figure 14). Like stripe depositing a manifold is used to bring the two components together. Typically the centre will be between 15% and 25% of the total candy weight.

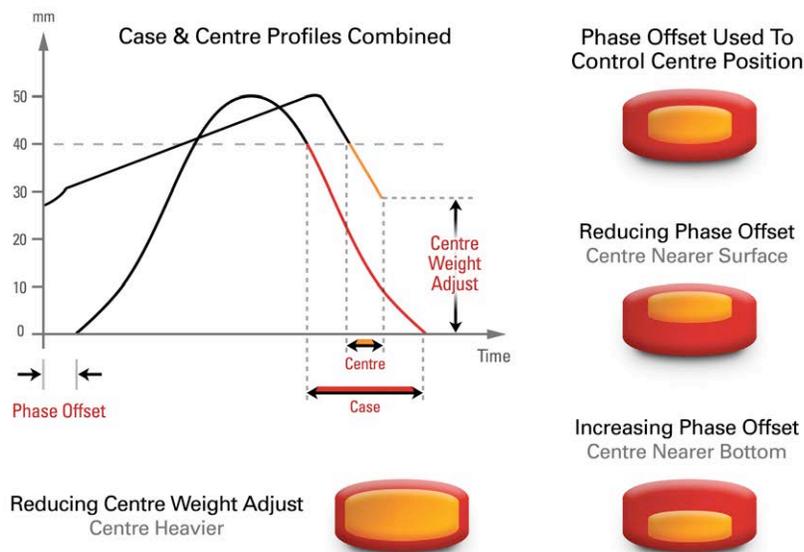


Figure 15 – Centre-Fill Pump Profiles

A centre-fill inner nozzle with a small diameter outlet is fitted into an outer nozzle with a larger diameter outlet. This nozzle assembly is fitted into the manifold directly below the centre hopper.

To fully encapsulate the centre the case material pistons should start to deposit slightly before the centre pistons. The centre is then deposited very quickly, finishing before the case piston finishes. To achieve this effect the case and centre often have very different pump profiles which are more clearly illustrated in Figure 15.

Centre-Fill Trouble Shooting

There are of course many other factors that affect the success of centre-filling candies. Two of the most common problems are due to centre viscosity and moisture content.

The centre may be very different to the case with both materials at different temperatures e.g. hard candy and chocolate. This is not necessarily a problem as long as the two materials have similar viscosities. However it should be remembered that as the two materials come together in the manifold and nozzle the case will heat the centre. This can then change the centre viscosity and affect the distribution of the centre within the candy. By cutting cooled candies it is possible to look at the centre shape and distribution. Figure 16 illustrates some typical examples.



Centre-Fill Position - Viscosity Effect

Figure 16 – Centre-Fill Position & Viscosity Effect

Many manufacturers wish to centre-fill with jams or liquid centres. Often the case material reheats the centre to just above its boiling point and causes the centre to bubble as water vapour tries to escape. This rises to the surface and breaks through the case material leaving a small hole for the centre to leak from.

The problem can be minimised by careful formulation. The centre should ideally be 88% Brix or higher. If a more fluid centre is required a small amount of glycerine can be used in place of some of the water.

Lollipops

In the last 10 years the major development has been the launch of technology for deposited ball lollipops. These lines are capable of producing over 1,000 lollipops per minute with a final quality similar to deposited candies. They are usually configured with two-part hinged book-moulds that form the ball shape, accept the automatic stick insertion, cool the product in the closed position then open to eject it. Complex 3D shapes and simple traditional flat lollipops are also possible. Figures 17 and 18 detail the process steps involved.

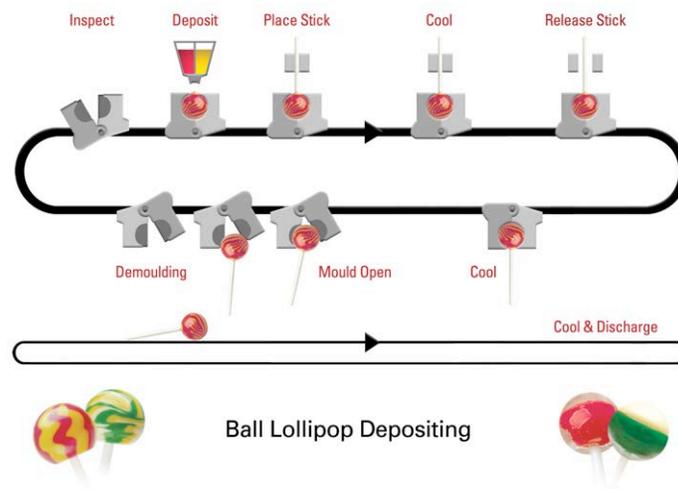


Figure 17 - Ball Lollipop Depositing

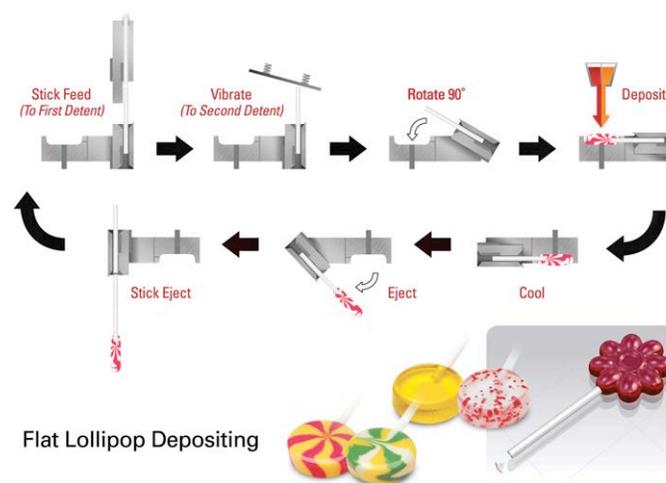


Figure 18 - Flat Lollipop Depositing

Innovation

Recent Developments

Depositing has been widely adopted in developing markets, particularly Africa and Asia, including China and the Indian subcontinent. Here, despite tough climatic conditions, there is a significant demand for high-quality candy. In the developed countries of North America, Europe and South East Asia (notably Japan) depositing has found many applications where the manufacturers' focus is on innovation and increasingly complex candies that are difficult to copy.

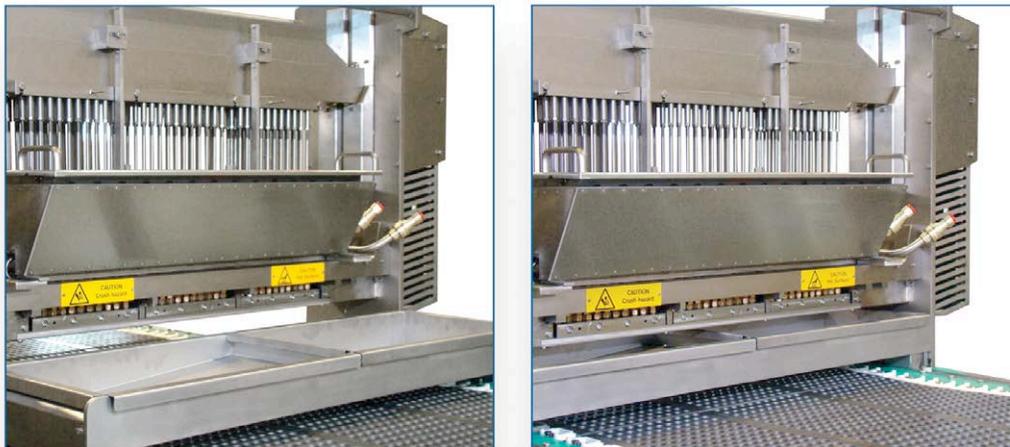
A recent example is the production of three layered candies using Isomalt sugar-free candy to sandwich a layer of crystallised Xylitol. They are produced using multi-headed depositors with elaborate ingredient preparation and cooking processes. They are expensive to make but sell at a premium price on the grounds of unique flavour and texture combinations as well as dental health benefits.

Future

Currently the market seems to be splitting into two types of candy manufacturer. There are those that want dedicated lines to produce just one product variant. These depositors need to operate extremely efficiently at ever-increasing outputs. Floor space, operating overheads and downtime must be minimised.

The alternative approach is to have very flexible lines with a more modest output. These depositors allow the manufacturers to operate in to different market sectors and also react quickly to changes in demand. Lines have multiple mould sets to make different shapes, or even change parts so that candies and lollipops can be made on the same line. Cooking equipment is also flexible and capable of quick recipe changes, often on-the-run.

There is an increasing requirement from candy manufacturers to have more hygienic production lines, which are easier to clean and maintain. Equipment manufacturers are responding to this demand with improved designs and innovative features. Stainless steel is now used routinely throughout the depositor, not just in food contact areas. Automatic depositor washout systems are also being introduced and can be very beneficial, reducing downtime and manpower (Figure 19).



Hygienic Design

Figure 19 – Hygienic Design - Hopper Washout

A number of energy saving technologies have been developed for the Microfilm cooker. These have the dual benefit of helping manufacturers meet emissions targets while saving them money.

Pressure Dissolving

Fitting a valve on the outlet to the plate heat exchanger that dissolves and pre-cooks the syrup creates a back-pressure that increases the amount of sugar that can be dissolved in a given amount of water. Less water is required and the energy required to heat and evaporate this water later in the process is saved. (Figure 20a)

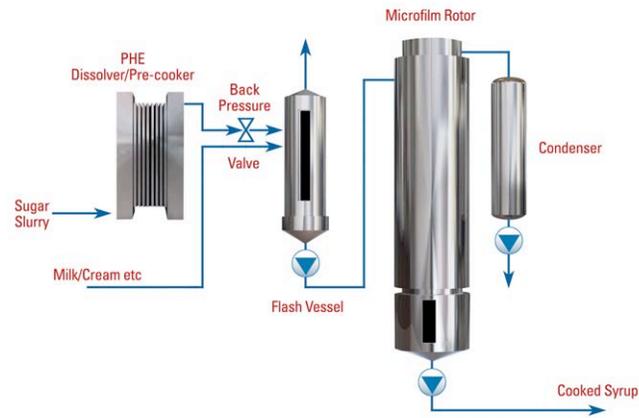


Figure 20a – Pressure Dissolving

Flash Vapour Heat Recovery

Cooking systems are often designed with integrated energy saving heat recovery systems, for lower running costs and environmental impact. Vapour released by the syrup during dissolving and pre-cooking carries significant amounts of energy but is normally vented to atmosphere. Much of this energy can be reclaimed using a shell and tube condensing heat exchanger supplied with recirculating cooling water. This water is heated by the vapour and can be used elsewhere in the production facility (Figure 20b).

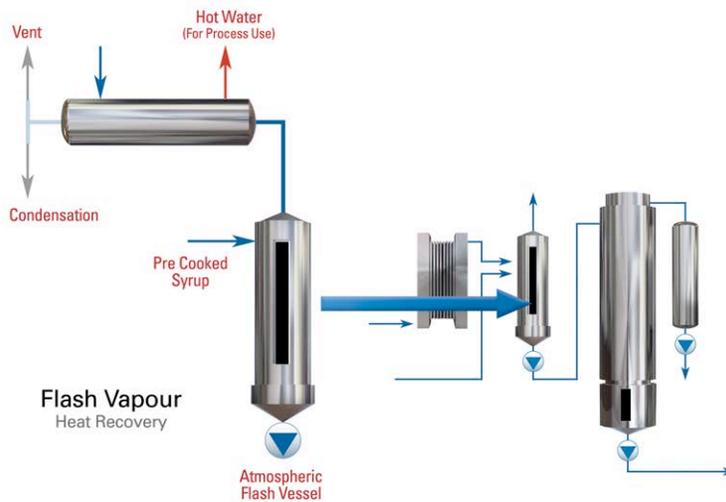


Figure 20b – Flash Vapour Heat Recovery

Flash Steam Heat Recovery

Another source of recoverable energy is the steam used to cook the syrup in the Microfilm. This emerges from the Microfilm as high pressure condensate and is passed through a steam trap where flash steam is generated. This is collected then used elsewhere in the cooker. This reduces the factory steam required to run the cooker. (Figure 20c)

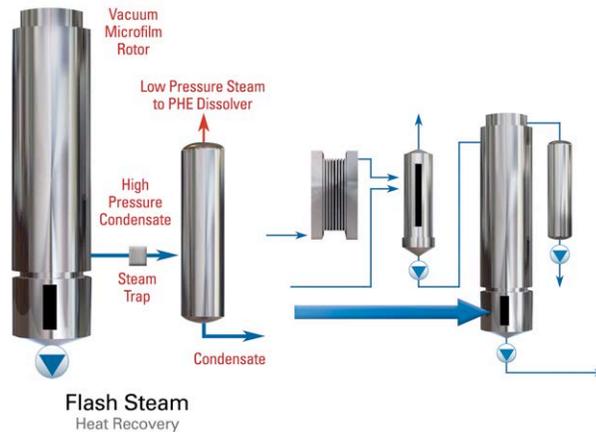


Figure 20c – Flash Steam Heat Recovery

Indirect Condenser

Significant savings in water consumption can be achieved by fitting indirect condensers to candy cooker vacuum systems. Here, vapour from the final cooking process is condensed using a shell and tube heat exchanger rather than the more traditional direct condensers, which spray water into the syrup vapour and then send it to drain. All the cooling water used in the indirect condenser is reclaimed and recycled (Figure 20d).

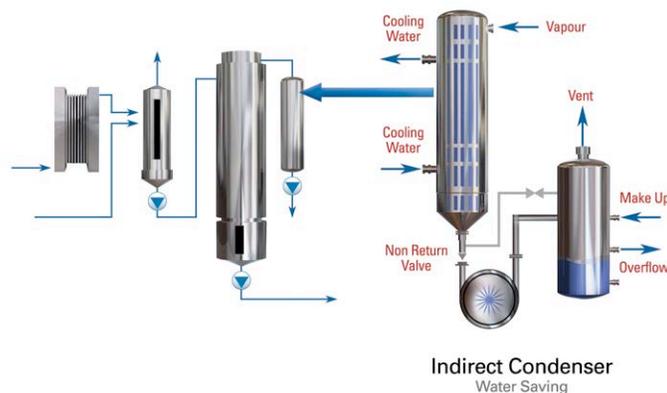


Figure 20d – Indirect Condenser

