particles can dirty the wrapping machine or spoil the surface of the product. According to the Agathon company, this problem can sometimes be reduced by using an ionising (anti-static) device.

14.2.17 Mould design, care and innovations

14.2.17.1 Mould design

Any reputable mould manufacturer will give advice on the basics of mould design. It is vital to follow such guidance to ensure good demoulding, with gloss and minimum of marks due to uneven cooling or sticking. Mould life will also be dependent on good design and a efficient injection moulding process.

The following points are examples of the details that must be designed in to any successful mould (Harbecke, 2005).

- Impression tapers must be large enough to allow the product to be released from the mould, 8–10° is the minimum. Sharp angles should be avoided, or air bubbles will remain in the cavities giving poor appearance and demoulding. External radii should be about 1.5 mm (0.06 in).
- Engravings give a sweet a unique appearance and identify it. They also assist demoulding, as they enlarge the surface of the item and help contraction. They will reduce cool spots and demould marks. Engravings should be about 0.18 mm (0.007 in) deep and well-rounded with a taper of 15–20°.
- Engraving lines can be incorporated in the side walls of a flat thin item to avoid a vacuum forming and holding the product in the mould.
- For a typical 100 g (3.5 oz) bar, the base or raft should be at least 5 mm (0.2 in) thick compared to the total height of the bar of approximately 12 mm (0.5 in). If a thinner base is desired, there should be reinforcing ribs of chocolate, preferably around the outside of the bar between the cubes.
- Radii on the back of the mould are important. Any notched or non- rounded area will soon result in breakage of the plastic mould itself. For those which undergo rough treatment, radii of 0.5–1.0 mm (0.02–0.4 in) should be specified to avoid early breakage.
- Flexibility is important. Should you make use of the natural property of the plastic material which is flexibility, or have a rigid mould leading to a longer life because of its frequent abuse on shaker tables? It is a balance between having a more rigid mould that could last longer and a flexible one that will cope with the stress imparted by the demould twister and the hammers. The shaking of a rigid mould is more even as vibration energy is transmitted rather than absorbed as in a flexible one. Ribs add strength and rigidity to the primary walls of a mould. They are thin wall protrusions that extend perpendicularly from a wall or under surface of the mould. They can be both length and crosswise, as a continuation of the cavity sidewalls, or diagonal when top rigidity is required. The ribs are good channels for distribution of the polycarbonate in the injection moulding tool. They also act as connecting points between the outside frames and help keep the mould straight on the line.

14.2.17.2 Mould construction and care

Most chocolate moulds are nowadays made with polycarbonate (PC) or derivatives of polycarbonates. Commercial grade PC is an amorphous, engineering thermoplastic which is based on bisphenol A (BPA) and has an aromatic structure. It is the aromatic constituents that provide PC with its excellent physical properties (broad temperature usage, high glass transition temperature, high toughness and rigidity). Polyesters such as PC are hygroscopic and will absorb moisture from its surroundings. A chemical reaction between PC and water causes a reduction in molecular weight, therefore reducing the mechanical properties significantly. In order to retain the engineering properties of PC, moisture content during PC processing must be maintained below 0.01%.

Polycarbonate obtained in granular form is used for manufacturing chocolate moulds using the injection moulding process. Prior to injection moulding, the PC granules need to be pre-dried at about 120 °C (248 °F) for around 2–4 h. During the injection process the temperature of the material should be at 280–300 °C (536–572 °F). Moisture uptake continues for 24 h after moulding, from which point the moulds are dimensionally stable. Polycarbonate is a naturally clear polymer. A colourant is added to the PC at very low weight percentage, 0.1–0.2%, to make any broken pieces visible and look less like glass if broken pieces should get into a product. The level of colourants added should be as low as possible since they can potentially weaken the PC structure. There is not normally any premium payable for colour addition. Several modified PCs have also been tested, thus the option exists to choose a material that is more resistant to certain processes such as extreme exposure to cold or hammering.

The distribution of the injection points (gates) for the PC when making the mould will have a direct impact on its strength. The optimal flow length of a typical PC will be about 280 mm (11 in; Harbecke, 2005). Any flow length higher than this could result in the formation of stress points and early aging of the mould. Large moulds will require more gates and therefore will be more expensive to manufacture.

Broken moulds should be examined and the reason for breakage logged. Action must be taken to find and eliminate the cause of any trend that is established, that is several moulds showing similar damage. Up to 1% breakage shortly after first use and mainly attributed to manufacturing defects is normal: above that amount, the causes should be investigated. Avoid excessive hammering of the moulds, that is solve problems of poor demoulding. Twisting during demould shortens mould life and should be adjusted to an effective minimum.

Mould breakage can be a significant source of foreign bodies in a product and, for standard PC moulds, there are no satisfactory means of detection or removal.

Common causes of breakage due to mechanical stress are:
- Poorly aligned turn points,
- Plant components moving out of alignment and touching the moulds,