

# Manufacturing 5-gallon PET bottles

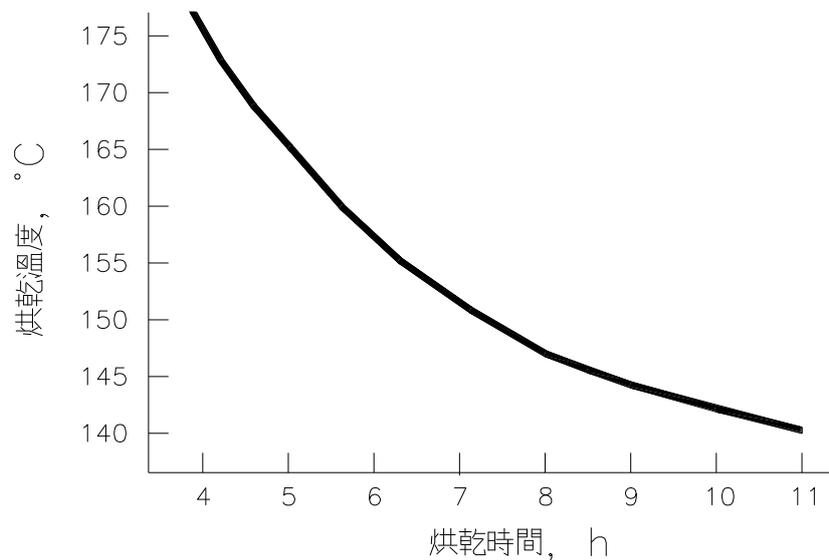
By Tat Ming Technology Co. Ltd.

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Traditionally, 5-gallon bottles for drinking water machines are made of polycarbonate (PC) material by the extrusion blow moulding process. There is a trend in China towards using PET material and the inject stretch blow moulding process. The experience making the latter is described below.

## Dehumidifying dryer

As PET material is hygroscopic, and moisture has a negative effect on the intrinsic viscosity of PET material during the melting process, it is important that the material is properly dried before use. The relation between drying temperature and drying time is shown in the graph below.



It is suggested to dry PET material from 5 to 9 hours at between 165°C and 145°C. It was proved that the material intrinsic viscosity is highest after drying for 9 hours at 145°C which represents the lowest degradation to the material.

The dew point and flow rate of the drying air also affect drying.

The drier the PET material, the more transparent the preforms are. We recommend the use of the dehumidifying dryer.

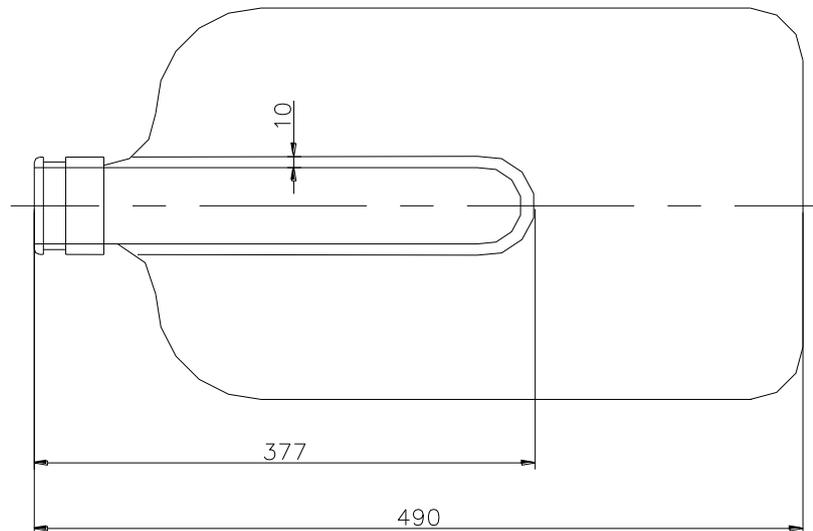
## Increased strength

When transporting 5-gallon bottles filled with water, bottles will inadvertently drop. How many times could the bottle withstand dropping depends on which drop test is used.

One such test is dropping from a height of 3 meters for 20 times without breaking. To pass such a test, the selection of PET material is of utmost importance.

Preforms of the same weight could be designed thicker but shorter. Increased wall

thickness and increased stretching would increase the strength of a bottle. Such a design is shown in the diagram below.



*5-gallon preform and bottle*

### **Thick wall moulding**

PET material is crystalline. When cooled slowly, the PET melt would crystallize. PET crystals reflect light, making the preforms cloudy or even opaque.

Low crystallization grade of PET material uses glycol to reduce crystallization rate. CB608-S from Far East (Shanghai), Aqua PJ003 from Eastman and Polyclear from Invista are low crystallization materials. They make thick wall preforms with very good transparency.

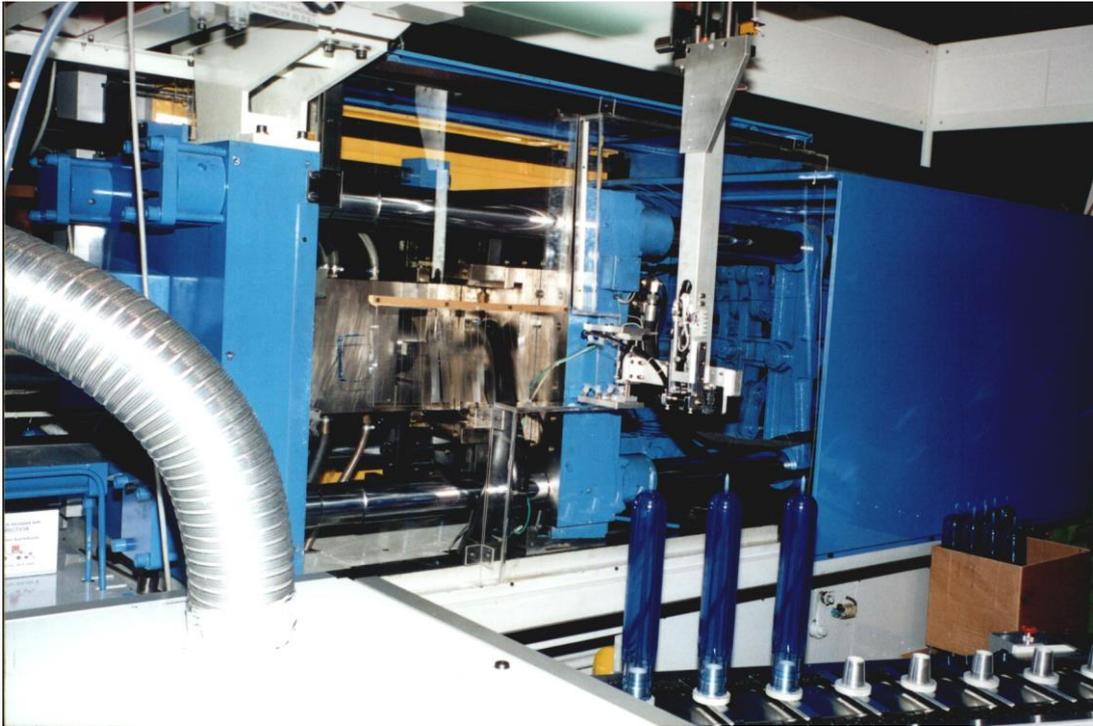
The holding pressure time is a significant part of the cycle time in preform making. The shrinkage during cooling is made up for by filling the cavities by more melt.

The holding pressure time for preforms 10 mm thick is as long as 80 to 100 s. Increasing the speed of cooling is a way to improve cycle time and to reduce haze.

### **Increasing the speed of cooling**

Using high conductivity core material e.g. BeCu significantly reduces cooling time.

Cooling the mould to 6° C and blowing the mould with dry air at 3° C dew point ensure fast cooling without condensation on the mould.



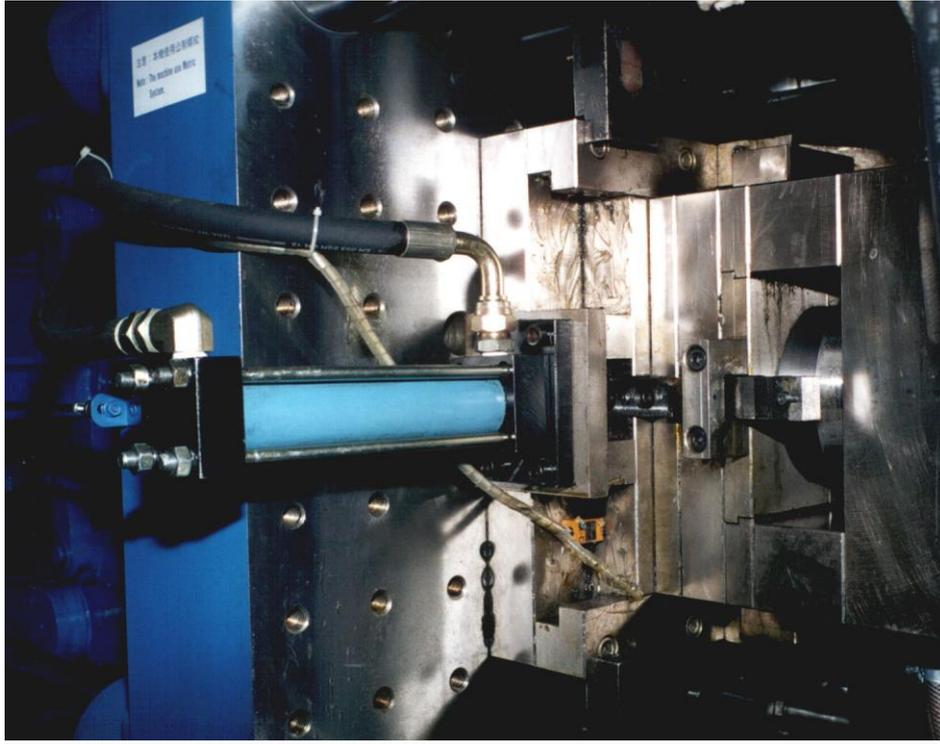
*Enclosed clamping unit, robot arm, mould sweat protector and drapes*

### **Save power during holding pressure time**

During holding pressure time, the injection moulding machine is essentially motionless. A fixed displacement pump delivers most of the oil back to the tank at holding pressure is wasteful of power. The injection moulding machine needs to be installed with a variable displacement pump.

### **Mould opening stroke**

There are 5-gallon preforms as long as 420 mm. A preform mould of the usual design would need a machine mould opening stroke of more than 840 mm. Only a machine in the 600 to 650-ton clamping force range has such an opening stroke. If the core is designed to move transversely after the mould opens, the opening stroke need only be slightly bigger than 420 mm. A toggle machine in the 150-200-ton range would have such an opening stroke.



*Traverse moving preform mould*

### **Shot weight**

A general-purpose injection moulding machine in the 150-200-ton clamping force range does not have a 750 g shot weight in PET. The PET series of injection moulding machine from Tat Ming is designed for thick-wall moulding. It has a shot weight more than 2 times that of a general-purpose machine. The PET1000 has sufficient opening stroke (488 mm) and shot weight (1000 g) to take care of 1 cavity of 5-gallon PET preform. The PET2100 and PET4200 have sufficient shot weights (2081 g and 4198 g) for 2 cavities and 4 cavities respectively.

### **Robot takeout arm**

Other than avoiding scratches during dropping, a robot takeout arm could also reduce cycle time by doing out-of the mould cooling.

The robot arm passes through drapes to remove the preforms so the minimum amount of dry air is leaked. This is superior to opening the gate manually to remove the preforms.

### **Cycle time**

With a holding pressure device, the mould cooled to 6° C and dried by air at 3° C dew point, using high conductivity core material, robot arm takeout, Aqua PJ003 PET material, a single cavity traverse motion mould on a PET1000 injection moulding machine makes crystal clear 5-gallon preforms at 10 mm wall thickness at a cycle time of 120 s.

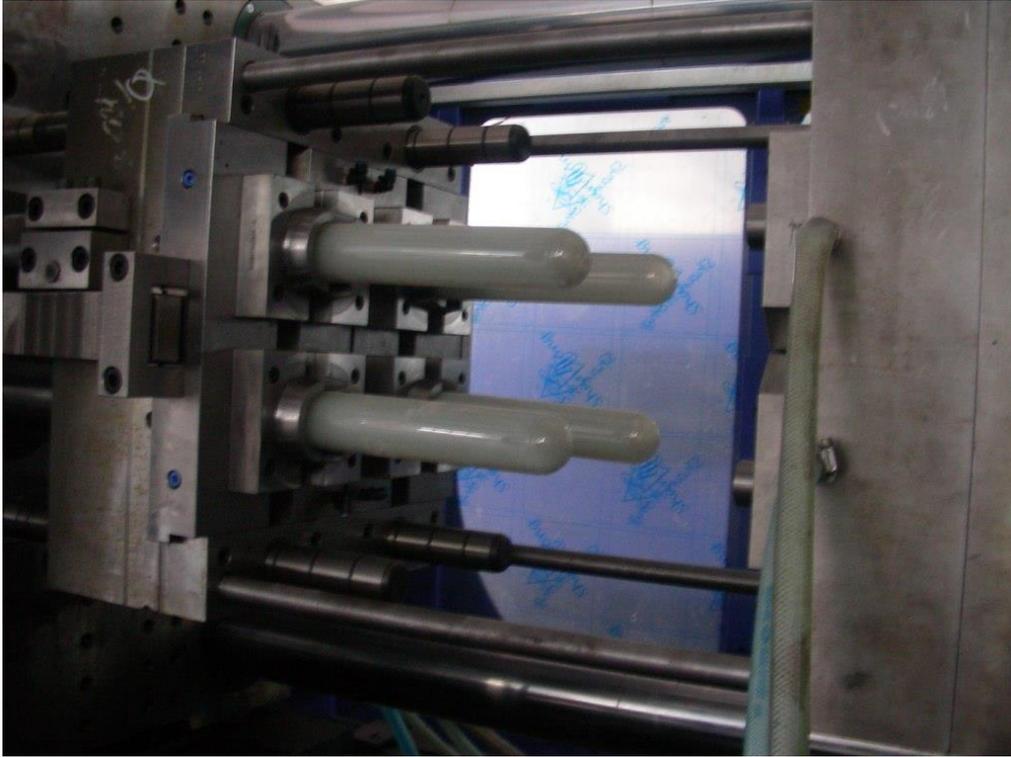
As cooling time is proportional to the square of wall thickness, the cycle time for 8 mm thick preforms is less than 100 s Using machines of higher shot weights, production rate could be doubled and quadrupled.



*Crystal clear 5-gallon preforms*



*2-cavity 5-gallon perform mould*



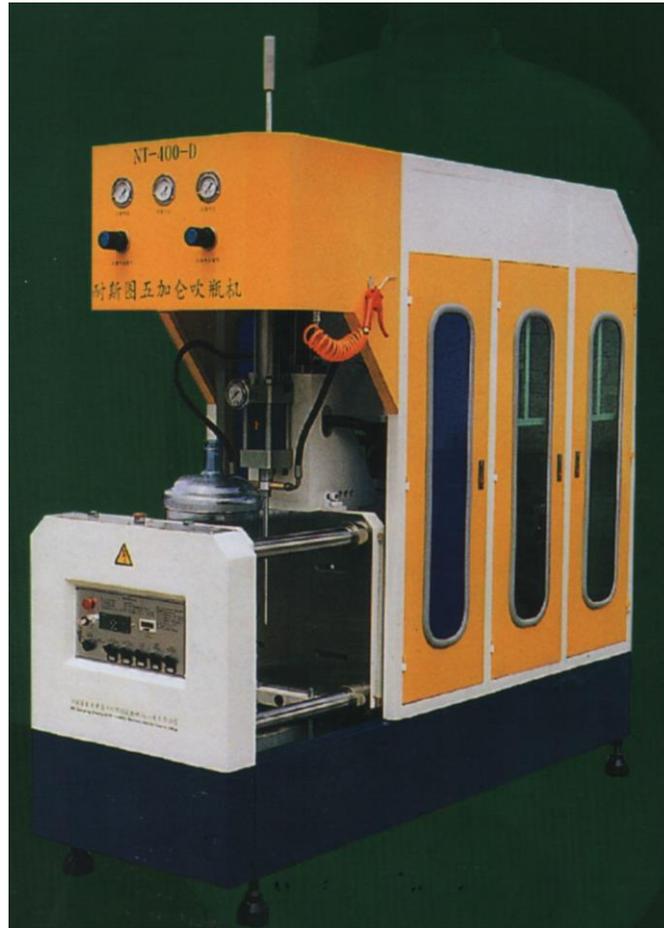
*4-cavity 5-gallon preform mould*

### **Blow moulding machine**

At  $35 \text{ kgf/cm}^2$  of blow moulding air pressure, a 5-gallon bottle blow moulding machine needs a clamping force of 4 tons. Semi-automatic blow moulding machine for 5-gallon preforms could attain a production rate of 60 per hour.



*Rotary reheater for 5-gallon performs*



*5-gallon bottle blow moulding machine*



*5-gallon bottle production line*

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