PMMDA

GUIDE TO **MOULD TEMPERATURE CONTROL**

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Introduction
This document has been compiled by the PMMDA to provide plastics processors with a guide to mould temperature control and a code of practice against which mould temperature controller specification can be measured.

The Need for Mould Temperature Control

Mould temperature controllers are used to bring a connected mould (consumer) to an operating temperature, and maintain the set temperature by either heating or cooling.

The benefits are:

a. Preheating the mould to production temperature

b. Optimisation of the cycle time

c. Improves product finish

d. Reduced reject rate particularly during machine start up.

Glossary Terms

"Leak Stopper" Facility	Feature to either reverse the pump flow or use a venturi system, to allow the run to be finished before the lead in the mould is rectified. A dedicated vacuum unit can also be used for a more permanent leak stop capability.
Mould Draining	Introduction of air into the system via a solenoid valve. Compressed air is also an option.
Open System	Tank open to atmosphere - operates below 90°c for water and 130c for oil.
Closed System	Forced flow to facilitate operating temperatures up to 350°c for oil.
Closed System (pressurised)	To facilitate operating temperatures above 90°c for water.
Direct Cooled	Mixes cooling water directly in to the heat transfer fluid.
Indirect Cooled	Heat exchanger between heat transfer fluid and cooling water.
Submersible Pump	Pump immersed in process fluid tank on "open systems".
Centrifugal Pump	Pump used in closed system for oil and water. Output flow can be dependent on pressure.
Positive Displacement pump	Lobe or gear pump usually used with oil. Must have a pressure relief valve.
Temp. Sensor - Internal	Temperature measuring point of the system, installed in the unit.
Temp. Sensor - External	Temperature measuring point of the system installed outside the unit - usually in the mould.
Set Point	Operating temperature required at the process.
Set Point Tolerance	Deviation from the set point temperature.
Serial Interface	A type of electrical connection to allow transfer of information/control to process machinery/ or other host computer.
"Hard Wired Interface"	Alternative to serial interface, but with limitations. It allows control of the piece of equipment to be "handed over" host processing machine.
Consumer	Mould, extruder barrel rolls etc.

Heat Transfer Fluids

WATER	Positive →	Operating with water is more economical, cleaner and presents fewer problems. In the case of leaks in the temperature control circuit (e.g. hose couplings) water loss may be simply run into the drainage system without any further precautions (unless additives are included).
	Negative →	Water has a low boiling point. Depending on the water quality, there is the risk of corrosion and calcification of the system (temperature control unit and mould) which will eventually lead to a decrease in flow in the mould and to deterioration of heat exchange between the mould and the circulating water.
OIL	Positive →	Thermal oils do not exhibit the disadvantages of water as mentioned above. As they have a far higher boiling point, they can be used for temperatures up to and above 350°c. No corrosion and calcification of the temperature control circuit.
	Negative →	Heat transfer efficiency is approximately one third that of water. Production of odours starting at 150°c in open systems. Tendency to "cracking" (property degradation). Flammable under certain conditions. Not particularly suitable for moulds with very small heating/cooling channels eg.6mm dia. High fluid cost.

Standard Units of Measurement

Heat Capacity	kW
Temperatures	°C
Cooling capacity at "X" °c operating And "Y" °c Cooling Water	kcal/hr
Pump capacity / Flow Rate	l/min
Delivery Pressure	bar or m.head
Total power consumption (inc. pump)	kW
Dimensions	mm
Weight	kg
Tank Capacity	litres

Determination of the unit

Main Characteristics

Outlet Temperature max	°c
Heat Transfer Fluid	Water/oil
Heating Capacity	kW
Cooling Capacity	kW
- at outlet temperature of	°c
- cooling water inlet temperature	°c
Pump Capacity	
- flow rate	l / min
- delivery head	m
or pressure	bar
Operating Voltage	V/Hz/Phases

NB: Flow rate should be specified at the corresponding pressure

The selection of the temperature control unit depends on:

- Material to be processed (determines mould temperature and type of heat transfer fluid)
- Weight of the mould (kg), required warming up time - for calculating head capacity.
- Material throughput (kg/h) - for calculating cooling capacity

Standard Calculations

How to calculate required heating capacity in kW

A x (B-C) = kcal/h
Kcal/h ÷ 860 = kW
A = net weight of mould (kg) x specific heat capacity of mould material - see table A
B = operating temperature of the mould (°c) - see table B
C = initial temperature of the mould (°c)

How to calculate required cooling capacity in kcal/h

D x E x (F-G) = kcal/hr
D = throughput of raw material (kg/h)
E = specific heat of raw material - see table A
F = melt temperature of raw material (°c) - see table B
G = operating temperature of the mould (°c) - see table B

In practice, a safety factor of at least 1.2 is added to the above calculations to compensate for heat losses to the surroundings.
It is necessary to state the "outlet temperature" to which the cooling capacity relates. "Cooling capacity as a function of fluid temperature" graph should be referred to in the manufacturers leaflet.
For determination of the "pump capacity", maximum values are not sufficient and the "characteristics curve of the pump" should be referred to in the manufacturers leaflet.

TABLE "A" Specific Heat Values

Material	Specific Heat (kcal/kg °c)
Steel	0.11
Aluminium	0.21
Brass	0.09
Water	1.00
Oil	0.45 (at 100°c)
LDPE	0.60
HDPE,PA,PP	0.48
ASA,PMMA,POM Copolymer	0.36
PP reinforced, PS,SAN,SB	0.36
ABS,PC,PVC Rigid	0.29
PET	0.30 - 0.55

TABLE "B" Typical Processing Temperatures for Plastics

Material	Abbreviation	Melt Temp °c	Mould Temp °c
Acrylonitrile Butadiene Styrene	ABS	240-280	50-80
Styrene Acrylonitrite	SAN	200-270	40-80
Acrylate Styrene Acrylonitrile	ASA	240-280	40-80
ASA/PC Blend	ASA + PC	260-300	60-90
Poly Methyle Methacrylate	PMMA	200-260	50-80
Low Density Polyethylene	LDPE	170-240	10-40
Polypropylene	PP	200-270	10-40
High Density Polyethylene	HDPE	180-270	10-40
Polystyrene	PS	180-260	10-40
Nylon 6.6	PA 66	280-300	40-60
	PA 66 + GF	285-310	80-120
Nylon 6	PA 6	230-290	40-60
	PA 6 + GF	260-290	80-120
Polyacetal	POM copolymer	180-230	60-120
Polybutylene Terephthalate	PBTP	245-270	60-80
Polyether Sulphone	PES	320-360	140-160
Polysulphone	PSU	310-360	120-160
Polycarbonate	PC	280-310	80-120
Polyvinyl Chloride (rigid)	PVC	170-210	20-50

GF= Glassed Fibre   PMMDA Guide only. Consult material supplier for details

Connections to the Mould

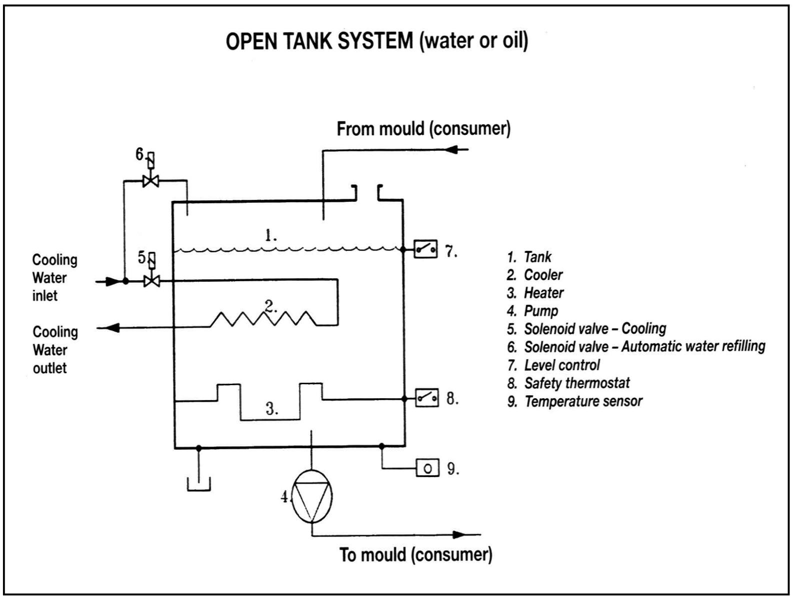
The following hose recommendations are made on the basis of safety in operation and should be confirmed as suitable by the hose supplier.

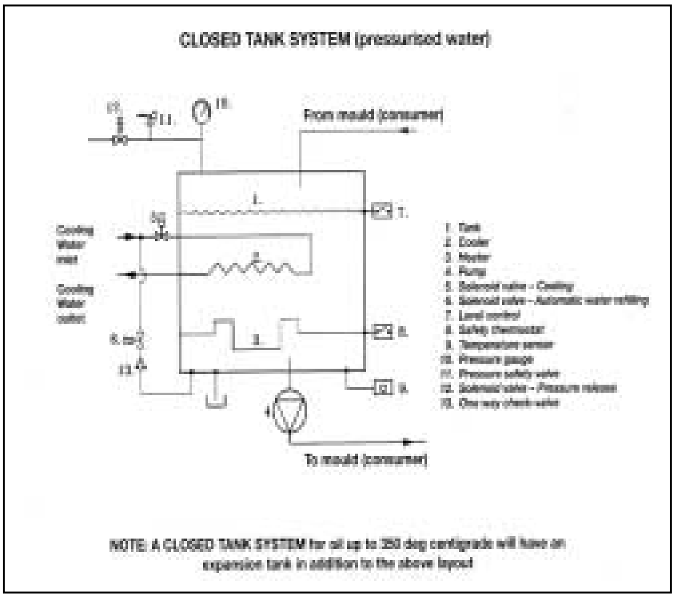
1. Water up to 90°c
   Oil up to 120 °c   High Temperature, fabric reinforced rubber hose

2. Water up to 200 °c
   Oil up to 250 °c   PTFE, stainless steel braided hose

3. Oil up to 350 °c   All stainless steel flexible hose

Note: to ensure optimum flow rates, the use of reducing adapters on hoses is not recommended





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