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Wattage Calculation Formulas

Wattage Calculation Data

Basic Heating Formulas

The following formulae can be employed in determining wattage capacity required for different materials.

Formula A: Wattage required for heat-up = $\dfrac{\text{Weight of material (lbs) x Specific Heat x Temperature Rise °F}}{\text{3.412 x Time (Hours of fraction Thereof)}}$

For specific heat and weights of each material being heated, see tables 1, 2, and 3 on pages 145, 146, and 147

Formula B: Wattage losses at operating temperature = Wattage loss/sq. ft. x Area in sq. ft.
See curves on pages 150-151.

Formula C: Wattage for melting or vaporizing = $\dfrac{\text{Weight of material (lbs) x Heat of fusion or vaporization (BTU/lb)}}{\text{3.412 x Heat up time (Hours of fraction Thereof)}}$

When the specific heat of a material changes at some temperature during the heat-up, due to melting (fusion) or evaporation (vaporization), perform Formula A for heat absorbed from the initial temperature up to the temperature at the point of change, add Formula B, then repeat Formula A for heat absorbed from the point of change to the final operating temperature. See tables 1, 2, and 3 on pages 145-147, for heats of fusion and vaporization and temperatures at which these changes in state occur.

Specific Applications

For specific applications, substitute the Basic Heat Formulas (A, B, or C above) into the following:

To Heat Liquids
Wattage for initial heat-up = (a) + $\dfrac{(b)}{2}$

Wattage for operating requirements = (a) for new material added + (b)
To insure adequate capacity, add 20% to final wattage figures. This will compensate for added losses not readily computed.

To Melt Soft Metals
Wattage for initial heat-up = (a) to melting point + (c) to melt + (a) to heat above melting point + $\dfrac{(b)}{2}$

Wattage for operating requirements = [(a) to melting point + (c) to melt + (a) to heat above melting point] for added material + 11. To insure adequate capacity, add 20% to final wattage figures. This will compensate for added heat losses not really computed.

To Heat Ovens
Wattage = (a) (for air) + (a) (all material introduced into oven) + (b)
Add 25% to cover door heat losses

Forced Air Heating

Wattage = $\dfrac{\text{C.F.M. x temperature rise (°F)}}{3}$

For explanation of Basic Heat Formulas, see examples on pages 142-144.

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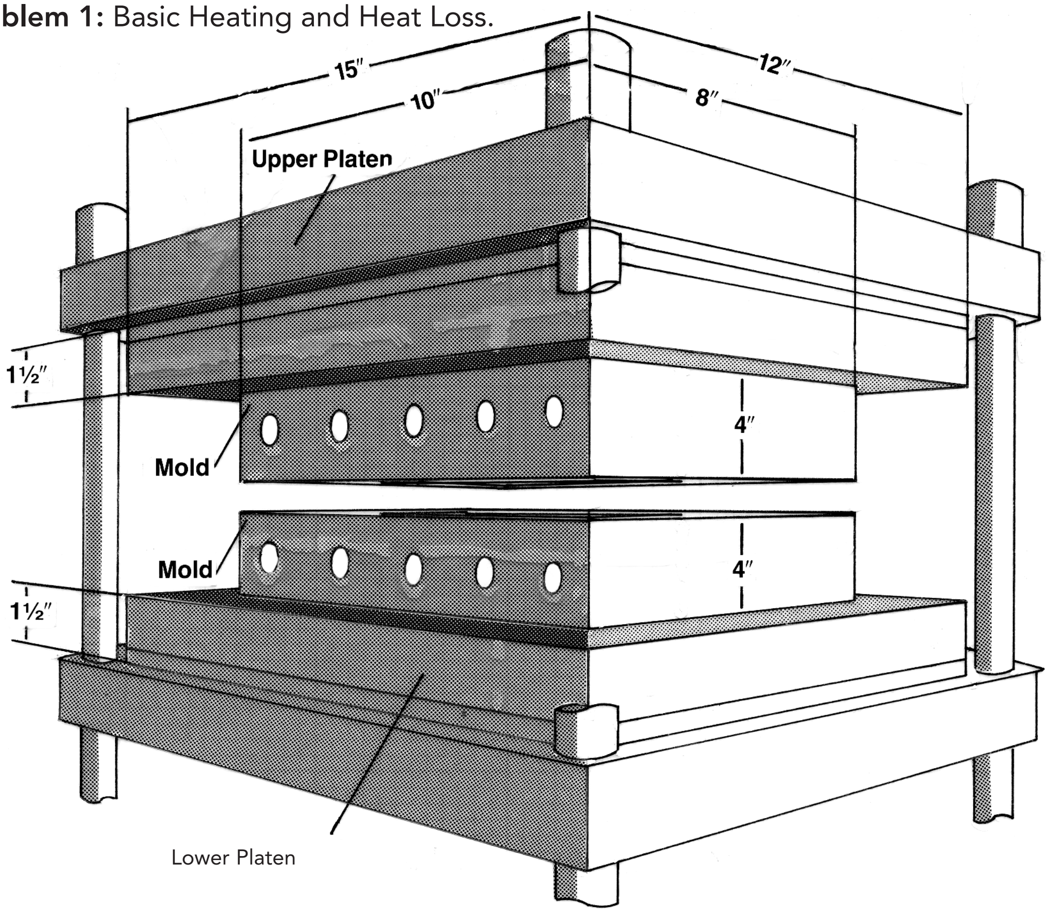
Problem 1: Basic Heating and Heat Loss.



A steel mold is being used to form polyethelyne parts. Each hour, 90 ounces of nylon is introduced to the mold. The mold itself measures 10″ x 8″ x 4″. The mold is attached between two stainless steel platens, each measuring 15″ x 12″ 1½″ thick. The platens are insulated from the press mechanism with ½″ thick insulation. Operating temperature of the mold is 400˚F and is required to reach this temperature in 1 hour with an ambient temperature of 70˚F.

1) From Table 1, page 145: Specific heat of steel - .12/BTU/lb ˚F
2) From Table 1, page 145: Specific heat of stainless steel - .12/BTU/lb ˚F
3) From Table 2, page 146: Specific heat of polyethelyne - .55/BTU/lb ˚F
4) From Graph 1, page 150: Heat losses curves – A + B @ 400˚F
5) From Table 1, page 145: Converting cubic inches into pounds (density lb/cu. in.)

Formula A: Wattage required for heat-up

To heat mold	$\frac{(10'' \times 8'' \times 4'') = 320 \text{ cu.in.} \times 2 \times .284 = 181.7 \text{ (lbs)} \times .12 \text{ BTU/lb °F} \times (400 - 70)\text{°F}}{3.412 \times 1} =$	2,110 watts
To heat Platens	$\frac{(15'' \times 12'' \times 1\frac{1}{2}'') = 270 \text{ cu.in.} \times 2 \times .286 = 154.5 \text{ (lbs)} \times .12 \text{ BTU/lb °F} \times (400-70) \text{°F}}{3.412 \times 1} =$	1,800 watts
To heat Polyethelyne $\frac{90}{16}$	$= \frac{5.6 \text{ (lbs)} \times .55 \text{BTU/lb °F} \times (400-70) \text{°F}}{3.412 \times 1} =$	300 watts
Compensation Factor 20% (2,110 + 1,800 + 300) =		840 watts
Total wattage required for Heat-up =		**5,050 watts**

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Formula B: Wattage losses at operating temperature (see graphs on pages 150 and 151).

Heat loss from mold (vertical surfaces)

$$\frac{10'' \times 4'' \times 4'' + 8'' \times 4'' \times 4''}{144''} = 2 \text{ sq. ft.} \times 350\text{w/sq.ft./hr.} = \qquad 700 \text{ watts}$$

Heat loss from platen (vertical surfaces)

$$\frac{1\tfrac{1}{2}'' \times 15'' \times 4'' + 1\tfrac{1}{2}'' \times 12'' \times 4''}{144''} = 1.1 \text{ sq. ft.} \times 350\text{w/sq.ft./hr.} = \qquad 385 \text{ watts}$$

Heat loss from platen (horizontal surfaces, uninsulated)

$$\frac{15'' \times 12'' \times 2'' - (10'' \times 8'' \times 2'')}{144''} = 1.3 \text{ sq. ft.} \times 250\text{w/sq.ft./hr.} = \qquad 350 \text{ watts}$$

Heat loss from platen (insulated surface) 250 watts

$$\frac{15'' \times 12'' \times 2''}{144''} = 2.5 \text{ sq. ft.} \times 100\text{w/sq.ft./hr.} =$$

Compensation factor:	20% (700w + 385w + 350w + 250w) =	340 watts
	Total wattage losses at operating temperature =	2,025 watts
	Total wattage required for heat-up =	5,050 watts
	Total wattage required =	**7,075 watts**

The number of holes in the mold would dictate the number of heaters required. Divided the wattages by the number of heaters will equal the wattage rating of each heater.

Problem 2: Paraffin melting

An open top uninsulated steel tank: 18″ wide, 24″ long and 18″ deep weighs 140 pounds. This tank contains 168 pounds of paraffin which needs to be heated from 72˚F to 150˚F in 2 ½″ hours.

1.) From Table 1, page 145: Specific heat of steel - .12 BTU/lb-˚F
2.) From Table 2, page 146: Specific heat of solid paraffin - .70 BTU/lb-˚F
3.) From Table 2, page 146: Melting point of paraffin: -133˚F
4.) From Table 3, page 147: Heat of fusion of paraffin - 63 BTU/lb
5.) From Table 3, page 147: Specific heat of melted paraffin - .71 BTU/lb-˚F
6.) From Graph 5, page 151: Surface loss at 150˚F:70w/sq.ft./hr.
7.) From Graph 1, page 150: Surface loss at 150˚F:55w/sq.ft./hr.

Formula A: Wattage required for heat-up

To heat tank

$$\frac{140\text{lb} \times .12 \text{ BTU/lb-˚F} \times (150 - 72)}{3.412 \times 2.5} = \qquad 155 \text{ watts}$$

To heat paraffin

$$\frac{168\text{lb} \times .70 \text{ BTU/lb-˚F} \times (133 - 72)\text{ ˚F}}{3.412 \times 2.5} = \qquad 845 \text{ watts}$$

To heat melted paraffin (fusion occurs at melting point)

$$\frac{168\text{lb} \times .71 \text{ BTU/lb-˚F} \times (150 - 133)\text{ ˚F}}{3.412 \times 2.5} = \qquad 240 \text{ watts}$$

Formula C: Wattage for melting or vaporizing
Heat of fusion to melt paraffin

$$\frac{168\text{lb} \times 63 \text{ BTU/lb}}{3.412 \times 2.5} = \qquad 1{,}245 \text{ watts}$$

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Formula B: Wattage losses at operating temperature (see graphs on pages 150 and 151)

Average paraffin surface loss

3sq.ft. x 70w/hr. =	210 watts

Total losses

13.5sq.ft. x 55w/hr. =	740 watts

Compensation factor

20% (155 + 845 + 239 + 1,245 + 210 + 740) =	685 watts
Total wattage required =	**4,120 watts**

In addition to calculating the watts required for initial heat-up and heat losses, operating heat requirements must be calculated. Steel pins, each weighing .175 pounds, are to be placed in a 70 pound steel rack and dip-coated in the melted paraffin. 1,750 pins can be processed per hour with 25 pounds of paraffin.

Formula A: Wattage required for heat-up

To heat pins and rack

$$\frac{(1750 \times .175 + 70)\text{lbs/hr} \times .12\text{BTU/lb/°F} \times (150 - 72)\text{ °F}}{3.412 \times 1 \text{ hour}} = \quad 1{,}030 \text{ watts}$$

To heat additional solid paraffin

$$\frac{25\text{lbs/hr} \times .70\text{BTU/lb°F} \times (133 - 72)\text{ °F}}{3.412 \times 1 \text{ hour}} = \quad 310 \text{ watts}$$

To heat additional melted paraffin (fusion occurs at melting point)

$$\frac{25\text{lbs/hr} \times .71\text{BTU/lb°F} \times (150-133)\text{°F}}{3.412 \times 1 \text{ hour}} = \quad 90 \text{ watts}$$

Formula C: Wattage for melting or vaporizing
Heat of fusion, to melt additional paraffin

$$\frac{25\text{lbs/hr} \times 63\text{BTU/lb}}{3.412 \times 1 \text{ hour}} = \quad 460 \text{ watts}$$

Formula B: Wattage losses at operating temperature (see graphs on pages 150 and 151).
Paraffin surface loss

3sq.ft. x 70w/sq.ft./hr. =	210 watts

Tank surface loss

13.5sq.ft./ x 55w/sq.ft./hr =	740 watts

Compensation factor

20% (1,058 + 310 + 90 + 460 + 210 + 740) =	575 watts
Total wattage required =	**3,415 watts**

In the above calculations, the heat-up requirement is the greatest, therefore a heater with a wattage rating of 4,120 watts should be used in this application. The recommended watt density on the heater for this application is 16 watts per square inch (see page 148, table 1).

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