LyondellBasell Technical Tip

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Faster Cooling — The Answer is in the Wind

To cool blow molded bottles faster, take a tip from the weather. If you stand outside on a cold day in a calm wind, you can stay fairly comfortable. But if the wind is blowing, it feels a lot colder than the thermometer says it is. The weatherman calls the colder "feel" to windy air the “wind chill.” In blow molding – and in a lot of other places – the term is heat transfer.

For a blow molding cycle to be efficient, heat must be removed from the hot plastic bottle as rapidly as possible. Most of this heat removal is done via cooling channels in the mold. If not enough heat is removed, a number of problems result, including poor trimming and volume changes, for example.

To remove heat faster, it is possible to lower the temperature of the cooling water in the mold, but this process has limitations. For example, if the cooling water temperature lowers the temperature of the molds below the dew point, the molds sweat, the surface appearance of the molded part is marred and water drips on the floor, creating a safety hazard. Figure 1 illustrates how the dew point varies with atmospheric conditions (temperature and relative humidity) in your blow molding shop.

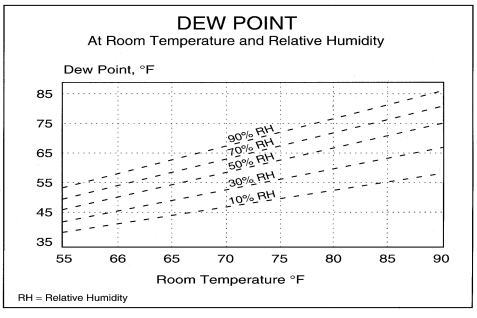

Figure 1: Dew point at room temperature and relative humidity

Then how can heat be removed from blow molded bottles more quickly without decreasing the cooling water temperature – just like the wind chill effect? The answers are turbulent flow and flow volume.

As chilled water flows through the cooling channels of your blowing mold, the water contacts the inside walls of the cooling channels and carries away the heat. If that water flow is smooth and uniform through the channels, a state called laminar flow exists. Very little mixing of the cooling water occurs during laminar flow. The same water slides along the tube wall. If, as with the wind, more "fresh" cooling water is placed in direct contact with the cooling channel wall, heat transfer occurs more rapidly and cooling becomes more efficient. The mold temperature does not decrease to the dew point and below. Good mixing of the coolant water occurs when the coolant flow through the cooling channels is not laminar, but turbulent.

How is a turbulent coolant flow through the cooling channels of a mold achieved and how can you determine if you have achieved it? Basically, increase the speed (or volume per minute) of coolant flowing through the molds to increase turbulence. Engineers use a dimensionless number, called the Reynolds number, to determine if turbulent flow exists.

Turbulent flow occurs if the Reynolds number is greater than 3,000. The actual calculation of a Reynolds number is rather complicated. However, for a typical dairy blow molding machine with mold cooling channels

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equation: Flow rate (gal./min.) = 0.61516 x # of molds. For a four-head machine, the minimum coolant flow rate is 2.46 gallons per minute. For a six-heat machine, 3.69 gallons per minute are needed. These flow rates are relatively low, but they are not the whole story.

As the Reynolds number goes up and turbulence increases, the ability of the coolant to rapidly remove heat increases. Doubling the Reynolds number increases the heat transfer rate by about 75%. Therefore, if we increase the rate of coolant coming in, we also are increasing the efficiency at which the coolant absorbs the heat from the molds.

What does this all mean? It means that cooling your bottles as quickly as possible does not automatically mean lowering the coolant temperature coming off your chiller. Often, simply increasing the coolant flow rate is more efficient.

To obtain the best flow rate, pay close attention to piping, connections and plumbing. Quick-disconnect couplings are convenient, but if they form restrictions, they can reduce flow rates. Other restrictions to the coolant plumbing that reduce the flow rate should be eliminated. Of course, the coolant channels in the molds themselves should be periodically cleaned to avoid mineral buildup. The chiller must be able to remove the heat and should have a pumping system designed for high-volume, coolant delivery.

For more information about blow molding, contact your LyondellBasell sales or technical service representative.

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LyondellBasell Industries
P.O. Box 3646
Houston, TX 77252-3646
United States

www.LYB.com

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