ARCHCELL®泡沫的热成型

ARCHCELL®泡沫在 190℃-210℃ 之间，可以进行塑性变形。加热过程可以在烘箱或红外加热装置中。保温的持续时间根据板材的厚度确定。(大约 1mm/min)。

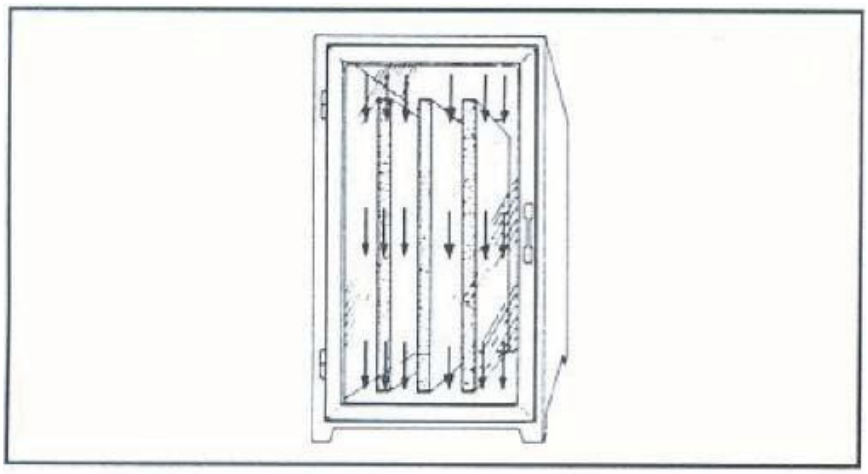

图 1 在空气循环烘箱中加热

由于泡沫的比热容较低，另外板材表面由于大量切开的闭孔泡沫成倍的增加了表面积，所以泡沫表面的温度会很快降低。所以，从炉中取出到成型的这段时间内，要尽可能缩短暴露时间，并且一定需要对 ARCHCELL®板材加以保护，防止温度降低过快，不能满足热成型工艺的温度要求。热量的防护材料，可以是棉布、透气毡、玻璃布或硅橡胶布。

拟成型的芯材，其曲面变化尽量只在一个维度上有很大的变形，或者在两个维度上有较小的曲面变形。以雷达罩为例，由于雷达罩为不可展开曲面，所需要将雷达罩分割为 6-8 个相同形状的扇形，在分别进行热成型之后，粘接成为一个完成的雷达罩芯材。

热成型过程对模具的耐热要求不是很高。因此，采用木材、聚脂或环氧树脂或玻璃钢制成的模具就足够了。一旦成形好的构件的温度降低到 100℃以下，就可以从模具中取出。

利用泡沫热成型工艺，主要有模具压力成型、真空压力成型和“冷变形热定型”三种成型方法。前面两种工艺都需要将泡沫先加热后成型。后一种工艺先成型泡沫后加热定型。

模压成型

如果使用模压工艺，在泡沫板材热成型以后，需要使用机械后加工到设计尺寸，而后加

工过程中的精确定位实现起来比较复杂。模压工艺和冷变形、热定型工艺相比，变形量可以设计得大一些。根据模具使用的不同，具体可以通过两面硬模，单面模压和一面硬模、一面软模实现。

1. 两面硬模：这种模具设计的优点是可以准确地控制成型过程中，泡沫板材的厚度，变形后的板材可以是可展开的曲面，也可以是不可展开的曲面。缺点是需要制造阴阳模。
2. 单面硬模：通常，在泡沫厚度较大或变形量较大的情况下，利用压机，可以使用单面模具热成型。但是模压过程中，板材厚度方向的变化很难控制。泡沫的变形后的曲面是一个不可展开的球面，板材两个方向上都有变形。
3. 一面硬模加一面软模：缺点和单面模具模压成型相似。但是和前面相比，板材的变形通常是沿一个方向，也就是说变形后的板材是可展开的曲面。

真空吸附热成型

真空吸附热成型也是采用一面硬模、一面软模的模具设计。但是和上面介绍的一面硬模、一面软模的模压成型工艺相比，借助真空吸附力，可以实现对不可展开曲面的热成型。在泡沫板材热成型以后，需要机械后加工到设计尺寸。不过由于真空吸附力的限制，相对单面模具模压工艺，变形量受到一定的限制。

冷变形热定型

可以将泡沫板材首先加工出精确的曲面展开尺寸，然后将泡沫真空固定在模具上，放入烘箱内加热到热变形温度，持温 1 小时，再从烘箱中取出，缓慢均匀地将温度降至室温。该方法的优点是热成型工艺过程可以实现很好地控制，如果定位准确，热成型以后不用进行后期外形加工。缺点是泡沫的冷变形量有一定的限制，不能太大，尤其是在不可展开曲面成型的情况。

值得提醒的是，作为小概率的事件，由于泡沫的生产工艺特点，成品泡沫板在放置一段时间后，会发生小幅度的翘曲。这是吸潮和内应力释放双重作用的结果，而不是产品的缺陷。这一过程是可逆的，且不影响产品质量，具体的整形过程如下：

1. 将泡沫水平放置，在上面均匀分布的压上重物，比如钢板，铝板等，直到泡沫板在室温下弹性变形至平整状态。重物的放置应当注意均匀放置，且一定不能出现在某一区域集中施加，否则在整形后会在泡沫表面产生凹坑。
2. 将泡沫与重物载荷放入空气循环式加热炉中，按照一分钟一度的升温速率，升温至 200℃后，保温 8-10 个小时（根据泡沫板的厚度来确定），随炉冷却至室温后取出。

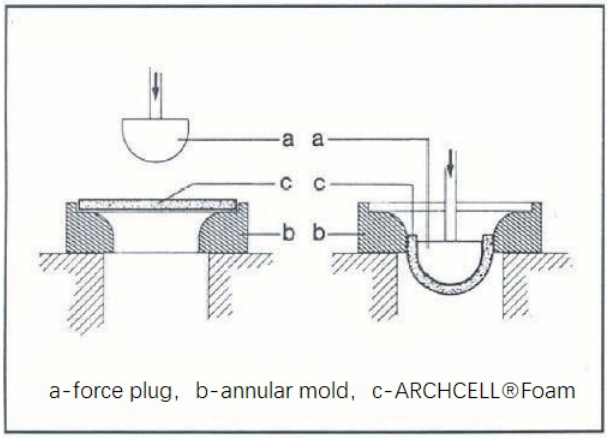

图2 半圆形ARCHCELL®成型

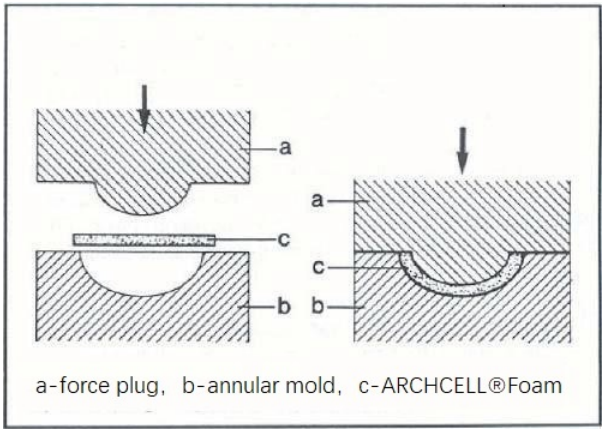

图3 在模具中成型

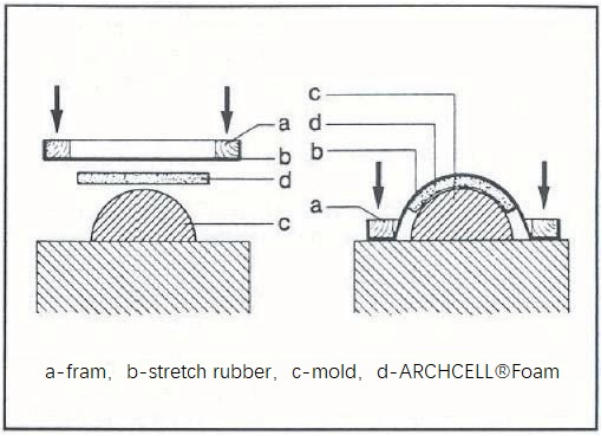

图 4 用拉延橡胶成型

Thermoforming of ARCHCELL®

ARCHCELL® can be thermoformed between 190℃-210℃. The sheets can be heated in an oven or with infrared heaters. The duration depends on the sheet thickness (approximately 1mm/min).

Since the low heat capacity of the foam and the sheets' surface area multiplied due to the vast cut-out closed cell, the sheet will cool rapidly. During the transfer from the heating cabinet to the forming device, cooling of the sheet must be kept at a minimum. To minimize the rapid cooling effect and satisfy the thermoforming process temperature requirements, a protective cover on the heated foam sheet is required. Cotton cloth, breather, glass fabric or silicone rubber can be used as a protective cover.

For shaping core materials, the changes of curve are trying to be deformed greatly in only one dimension or to be deformed slightly in two dimensions. Radome as an example, the radome surface is undevelopable, so it needs to be divided into 6-8 fan-shaped with the same shape, and be thermoformed respectively before bonding into a complete radome core material.

The high heat resistance of the mold during thermoforming is not required. There for, wood, polyester, epoxy resin or fiberglass molds are acceptable. Once the formed part has cooled to 100℃, it may be removed from the forming mold. By the use of foam's thermoforming technology, there are three main molding methods, compression molding, vacuum forming and "Cold-deforming-heat-shaping". The former two methods require the foam to be heated before forming. The latter one requires the foam to be thermoformed after cold forming.

Compression Molding

If using the compression molding process, it's required that the design dimension be processed by machining after thermoforming the foam sheet, while the precise positioning during the processing is relatively complicated to implement. Compare with cold forming, the compression molding deformation could be designed to be a little larger. According to the different usage of molds, it could be implemented by both-sided hardened mold, single-sided mold, one-sided hardened mold with one-sided soft mold.

1. Both-sided hardened mold: this design has the advantages on accurately controlling the thickness of the foamsheet during process, and the deforming sheet could be developable or undevelopable curves. The disadvantage is need to make male and female molds.

2. Single-sided hardened mold: if the foam's thickness or deformation is quite large, generally, could be thermoformed by single-sided mold with the use of press machine. However, it's difficult to control the changes in sheet's thickness direction. The deformed curve of the foam is an undevelopable spherical surface, and the sheet is deformed in both directions.
3. one-sided hardened mold with one-sided soft mold: its disadvantage is similar with the single-sided hardened molding. But compare with the former one, the deformation of the sheet is usually in one direction, that is, the deformed sheet is a developable surface.

Vacuum forming

Vacuum forming is also use the design of one-sided hardened mold with one-sided soft mold. However, comparing with the one-sided hardened mold with one-sided soft mold as the described above, vacuum forming is able to thermoform the undevelopable curve by means of vacuum-sorbing force. It's required that the design dimension to be processed by machining after thermoforming the foam sheet. But compare with the single-sided molding, the deformation is rather constricted due to the vacuum-sorbing fore's restriction.

Cold-deforming-heat-shaping

Machining the foam sheet into the precise developable dimension, and then fix it on a die, by means of a vacuum, heated in an oven to the forming temperature for 1 hour, and slowly cooled to the normal temperature after removing it from the oven. The advantage of this method is that the thermoforming process can be well controlled. And the post-machining process after thermoforming is not required, if the positioning accurately. While the cold deformation has a certain restriction, that is, cannot deform too much, especially in an undevelopable case.

What but is worth reminding, as a rare event, due to the characteristics of foam's production process, there will be a small degree of warpage which occurs in the finished sheet after placing for a period of time. This is the result of dual functions of moisture absorption and internal stresses release, but not the defect of the product. The process is reversible and would not affect the product's quality. The specific shaping process is as follows:

1. Place the foam horizontally and distribute evenly the weights on top like steel plate, aluminum plate, etc. until the foam is resiliently deformed to the flat state at room temperature. The weights must be placed evenly and must not be concentrated in one area. Otherwise, there will be pits on the surface of foam after shaping.
2. Put the foam together with the weights into the air circulation oven up to 200℃ (1℃/1 min) for 8-10hrs (depending on thickness of the shape). Once the oven has cooled to the room temperature, they can be removed from it.