Waste Not, Want Not

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If film insert forming of shells for IMD parts were easy, as the saying goes—"Everybody would be doing it". As it is, many production houses end up throwing out expertly printed or decorated "rejects" that should have been a good-looking exterior, ready for injection moulding. The problem is that some of the controls on existing high-pressure forming machines are either too difficult to manoeuvre, or simply don't make sense for creating accurately-placed formed features to the decorated film. Thankfully, there are certain aspects to setup that can be improved by making changes to machine design. The results not only reduce make-ready materials costs, but also utilise less film when creating the general layout for the job.

Imagine that you're a job cost-estimator for a large production house. Your company makes a lot of film insert moulded shells or formed parts for the automotive, telecommunications, household appliance and white goods industries, and you're frustrated over the high operating costs and excessive expenses for material. Your IMD forming department people say that setup on their pressure forming equipment is the main issue. When they're done making adjustments to the machine, and finally find a setting that forms an acceptable part, dozens, if not hundreds of printed sheets have gone to the waste pile. Somehow, you must get cost overruns under control and turn this situation around.

Heat

Of all the issues involved in applying high air pressure when forming a decorated film, it's the heating of the film that seems to cause a large portion, if not most of the problems. It revolves around two points—the amount of heat used, and the method of pre-heating the film.

Heating of the film plays an important role in choosing which forming method will be used for a particular part. "Pressure forming" ("high pressure forming", or "solid-phase pressure forming") was created so that graphical detail, such as logos, text, numbers, or other features could be formed and positioned with a reasonably high degree of accuracy. Both print-to-print registration, and form-to-print registration are key components of the process, with form-to-print tolerance often in the neighbourhood of ±.1 to .125 mm. In pressure forming, the "cold-formed" film heating range is normally at or less than the glass transition (softening point) temperature of the plastic film. In general, the film will retain some of its firmness, and this helps make the film become more predictable in its ability to faithfully conform to the tool.

For this reason, pressure forming is a very good complement to thermoforming, where for the most part, overall decorated elegance is important, but highly-detailed graphical positioning is not. Thermoforming temperatures apply heat to the film so that it intentionally droops or becomes limp, and therefore challenges positioning accuracy. Making a printed, walnut-grained car interior, for example, can successfully use thermoforming for deeper-drawn paneling, but for the shallower heater grills and other smaller dashboard components, pressure forming is a better choice, especially for designs having embedded printed dials and gauges.

Regardless, the application of heat to the film in pressure forming still can be troublesome. This is due to most systems currently in use preheating the film with an infrared heating source. Infrared emitters, whether they are lamps or ceramic-based, provide quick, intense energy to the decorated film. The difficulty is that this type of heating source doesn't become heat until it reaches the surface of the film, where the energy is absorbed or reflected to varying degrees, based upon the colours printed on it. This causes darker-coloured parts of the film to become hotter than the lighter-coloured areas. Additionally, infrared energy accumulates—the longer the time spent under the IR source, the hotter the film becomes. Imagine how all this causes film to move over the tool in some spots differently than in others.

Some finished shells are made with similar, but slightly different printed images over one tool shape. Cell phone manufacturers make a lot of custom designs in this manner, and will change the artwork and colours as needed. With an infrared heating source, each design and colour scheme has its own set of forming circumstances. "Educated guessing" that is based on previous experiences and thence used to arrive at a number of values for setup parameters, are an accepted part of working with a new form and design. But the combination of infrared and colour/artwork design-changes make an outcome expectation for each design quite unpredictable. Setup costs can and do go out of control, when tightly registered graphics are involved and surface heat absorption is erratic.

A solution to stabilising film temperature, is to use a different heat source. Conductive heating suits this purpose well. Conductive-heating contact-plates that have been PTFE-coated, provide a fast, consistent and stable transfer of heat from the plates to the film. There are no "hot spots"—in fact, the film remains at the same temperature as the plates. This also means that the issue of how much time is spent in pre-heating becomes much less important, so that if, for instance, the forming dwell time for your part needs to be longer than what is considered necessary under an IR heat source, you're not faced with the task of making complicated pre-heat dwell adjustments.

Pressure forming also allows the artwork department to be more creative by using "planned distortion" techniques over the tool. However, unpredictable movement of the film due to excessive heating can make you wonder if the pre-printed distortion you've programmed into the artwork was done correctly or not. Needless to say, a lack of control of the heating of the film directly affects other integrated processes.

Many machine operators assume that if the part is not forming well, the film needs more heat. Often, the opposite is true. Sometimes more heat has been applied because it is thought that surface blemishes or stretch marks will vanish. As in any process, this is often a question of applied conditions and forces. You've set up a condition of applying temporary heat to a plastic, which is currently in a solid state, in order to make it pliable. By applying a force of high air pressure, the softened membrane is expected to move to conform to the various contours contained in the design, without incident. Heat appears to be an easy fix in order to eliminate surface irregularities. But in pressure forming, the objective is for the shape and the graphical detail to match consistently, from one part to the next. Overheating solves one problem and exacerbates the originally intended purpose.

Overall tool design can help overcome many quality-control situations. How the tool is vented may be at issue, and learning how to successfully vent a tool comes with experience. If the form on the tool base can be separated into key components, so that abrupt changes in draft angles or surface characteristics are treated individually, slight adjustments are possible that allow for example, the narrowing or expanding of air gaps between these pieces. It often doesn't take much to make an improvement, and the extra cost in producing a tool in this manner can save a lot of future aggravation as well as time and money.

And occasionally heated plastic film that has been forced to move doesn't have a place to relocate. It's often necessary to place an additional form or forms on the tool base—away from the intended design—in order to retain unwanted material.

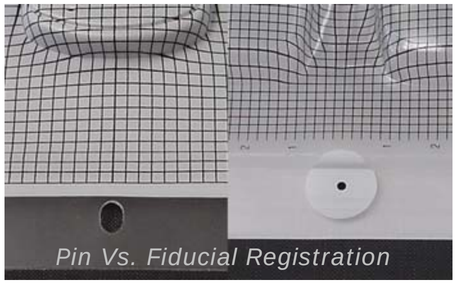
Registration

Pressure forming systems need a quick method to mount film so that it can be pre-heated before forming and so that cycle times are kept short. The choice of a positioning system for aligning the decorated film to the tool is important, since dependency on a pliable material to achieve a specific registration objective is questionable. Typical standard issue has been to use pins mounted on a metal foil frame—usually four, one for each edge—so that the corresponding hole-punched film can be suspended and subjected to infrared heating to both sides.

Again, whilst film temperature stablisation is most important, almost any amount of significant heat to a plastic film can cause a degree of non-linear migration of extruded or cast material. Film brought to its glass-transition state may not be limp, but it is still intentionally softened and subject to distortion.

Pin register has been the mainstay of pressure forming as well as for thermoforming for a long time. Realistically, it has been the best way to fix a film in place over a tool, from a mechanical point-of-view. Even though this method has represented state-of-the-art technique for such a long time, pin registration of softened plastic has some drawbacks, especially when infrared heating is involved. The rising and sagging of heated pinned film puts undo stress on the holes in the film—so much so that many machines are modified with additional pins/holes to try to keep film from shifting during preheat. Because the film is subject to both distortion from heat, and stretching from holding pins, pin register builds an additional layer of inaccuracy into the process.

Pressure forming emphasises that specific graphical features of the design match the formed areas resident in the tool. When looking for the best way to make a form match a design, it's considered beneficial to make a direct match of the tool to the artwork itself, rather than to the substrate, in order to arrive at a substantially close positioning tolerance. To this end, computers and cameras are making a significant change to the forming process.


Pin Vs. Fiducial Registration

It is true that when film distorts from heat, the graphical features distort as well. The problem is that the location point where the material is pinned for register may not have distorted in the same manner as the design. And most often, the design begins at least several centimetres away from the tooling hole. Vision registration tremendously improves this situation, since the cameras find "fiducials" or computer identification marks that are included during artwork preparation and then are printed along with the design. Once the fiducials have been recognised, it becomes an easy task for the computer to instruct the forming mould set and bolster, to move into exacting alignment with the decorated film. Positioning the tool to the design greatly enhances repeatability of the process.

How much do you pay for film?

In fact, computer vision registration has a devastating effect on another front as well, and that is the issue of the empty, unused, surrounding film which too often must be designed into the process. Frame mounts on some pressure forming machines usually amount to two dozen or more for an automatic system. But machines with camera vision registration eliminate this need. Because the fiducial is a part of the design, reliance on a frame for pin mounts is no longer necessary. This not only impacts the number of moving parts on a piece of equipment that can fail, it also permits a variety of film size formats to be embraced, according to the needs of a particular job. It also eliminates the selvedge, or border area between the tooling holes and the material edge, as well as the labour and additional machinery required for prepunching film.

Even newer to the pressure forming process, is the migration away from sheet-fed production to dispensing from a roll. It makes sense—since a sheet will have some measure of border around it, a series of the same design will share the same margin on two edges, which again cuts waste. The roll or web also serves as its own carrier, which keeps the repeat design closely spaced for an increased production speed, compared to many sheet-fed scenarios.

Let's face it—film is expensive. Having a machine that doesn't easily allow you to change the size of the material—so that it matches the required forming area—costs your company a lot of money. Film manufacturers are also not happy about leftover film in the pressure forming process. Your suppliers have a stake in seeing that your company is profitable. The more success you have, the more film they will sell to you. However, if you're leaving perfectly good film behind as a result of a "one-size-fits-all" limitation, it's time to reassess your equipment choices. The film savings can be impressive—as little as 20%, and as much as 50%—depending on design layout and forming requirements. In terms of job costing, it goes straight to the bottom line.

The pressure forming process may be somewhat difficult, but logical steps can help make it predictable. When a process stops being difficult, it is soon on the road to becoming a commodity. In the long run, learning a difficult process and knowing how to do it well is more profitable than dealing in commodities.