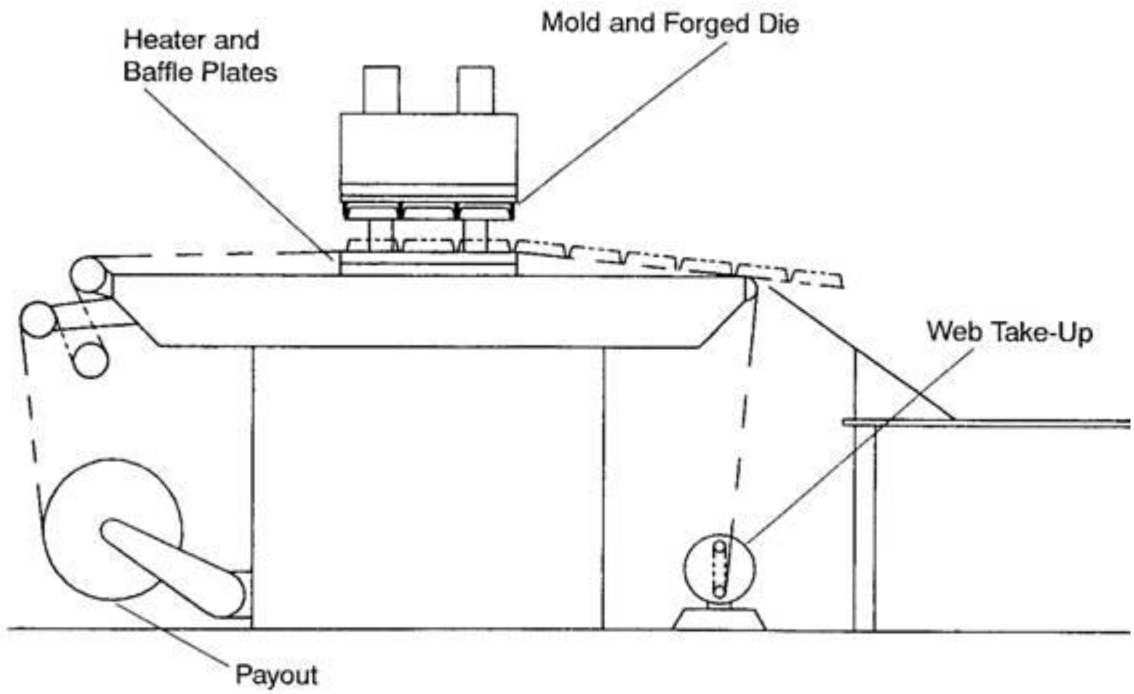
Cut-in Place Thermoforming Process

Simplified Drawing of a Cut-in-Place Thermoformer



Cut-in-Place Process Overview

With this type of machinery, the forming and cutting are accomplished in a single station, and the desired geometry is accomplished without the benefit of a mechanical plug assist. This can be accomplished because the mold is mounted to an upper platen, inside of the perimeter of the forged steel die, directly above the lower heated platen. The process begins by first holding the sheet against the heated platen by means of air pressure introduced through the mold, or vacuum introduced through the heated platen, after the leading edge of the forged steel cutting die engages the surface of the plastic. This contact provides the seal needed for the next step in the forming process. Now air pressure, usually introduced through the heated platen, pushes the heated plastic into the mold geometry mounted inside the perimeter of the forged steel die. After cooling, the forged steel die is pushed the rest of the way through the plastic, into contact with the platen, and the part is cut. The part is ejected from the mold by means of air pressure, spring assisted ejection rings, or both. It is then conveyed to the next station inside the web. This is facilitated by tiny precise notches in the cutting edge of the die. These notches hold the plastic in the web while being conveyed, but are kept small enough so the parts can be easily separated from the web for packing or filling. A simplified cut-in-place process description would look like this:

1. The plastic is pulled from the roll by index arm bars at the front of the machine, just above the roll stand and indexed into the heat/form/cut station.
2. The bottom platen strokes up as the top platen strokes down
3. The leading edge of the forged steel cutting die engages the surface of the sheet and penetrates far enough to create a perimeter seal.
4. Air pressure is introduced through the mold, or in some cases vacuum introduced through the lower platen, holds the plastic against the heated lower platen.
5. The heated plastic is pushed off the lower platen upward into the mold on the platen above.
6. Once cool enough to maintain the desired geometry, the part is cut as forged steel die is brought into contact with the lower platen.
7. Both platens retract and the part is ejected from the mold with air or mechanical assistance or both.
8. The machine indexes and conveys the formed parts to the packing station.
9. Parts are removed from the web manually or mechanically.
10. The web is conveyed to a coreless winder that rolls the web into bales for recycling.

Advantages

The cut-in-place technology available today has several advantages. This type of equipment generally produces the least amount of trim waste. This is primarily because the cutting die not only cuts the part perimeter, but is also used to form the airtight perimeter seal needed to form the plastic. Another advantage is that the plastic is generally warm when it is trimmed. This is highly desirable when cutting PET because warm plastic requires dramatically less pressure to trim. These lower pressures usually extend the usefulness of the cutting edge of the die significantly. An additional advantage is in accuracy of trimming the part geometry. Today's modern contact heat formers are achieving trim accuracy that approaches the precision found in match metal trim stations, at a significant cost savings. Finally, some plastics allow for extremely short cycle times, especially in geometries that feature shallow draw.

Disadvantages

The Cut-in Place thermoforming machine is not optimal if the end use of the PET parts made with this process requires cold temperature resistance to fracture failure. Parts produced using this technology tends to exhibit higher percentages of residual stress when examined using polarized light. Birefringence reveals this stress in clear PET parts and is observed as prismatic rainbows of color. These rainbows reveal where the stress is in the clear PET part. The likelihood of fracture failure is much greater in the highly stressed areas of these parts. Birefringence is caused when the light passing through the plastic splits, bends, or changes direction. When not all the stress can be eliminated, the process should then be adjusted to balance the observable stress. Parts that have unbalanced stress can also experience a significantly higher incidence of fracture failure than parts that exhibit low or balanced stress, at any temperature. The incidence of residual stress in contact heat thermoforming are usually attributable to the inability to heat both sides of the sheet equally, or to a limited number of temperature zones in the heated lower platen.

Thermoforming Troubleshooting Guide

1. Forming Defects
2. Poor Detail
    1. Be sure knife edge is penetrating sheet enough to make a seal
    2. Material is too cold
        1. Check heat time
    3. Form Pressure too low
        1. Check seals and vents
        2. Check hoses for leaks
        3. Be sure compressor and vacuum pump are functioning
    4. Plastic is too hot
        1. The plastic is cloudy due to overheating. The cloudy condition is caused by heat induced crystallinity
    5. Plastic has been heated for too long
        1. Time and temperatures under 190 degrees Fahrenheit will induce crystallinity that is transparent and will make the sheet very stiff
    6. Inadequate vacuum
        1. Check hoses and seals for leaks
        2. Vacuum hole may be plugged
            1. Clean mold and clear vents
            2. Probe vents after texturing to clear obstructions
    7. Sheet over gauge
3. Too Much or unwanted Detail
    1. Vent holes too large
    2. Plastic is under gauge
    3. Air Pressure too high
4. Webbing or bridging
    1. Material is stalling instead of flowing
        1. Plastic or mold surface may be too cold
    2. Adjust timing of forming
    3. Adjust vacuum timing
    4. Be sure vacuum is adequate and effective
    5. Adjust Air pressure timing
    6. Failure in temperature control system
    7. Blown fuse to thermocouple or controller, bad wire
    8. Index length too short
    9. Adjustment in zone heating profile needed
    10. Thin spot in the plastic
    11. Sheet is being pulled under knife edge
        1. Be sure knife edge is providing and adequate seal
5. Distorted geometry or warped parts
    1. Cooling time too short
        1. Part coming off mold too hot
    2. Surface temp of mold too warm
        1. Increase coolant efficiency through turbulence inducing inserts
        2. Be sure water circulating pump is running
    3. Insufficient cooling to the mold

    4. Part is hanging up on mold during ejection
        1. Scrapes and wrinkles are observed
    5. Air pressure too low
        1. Check to be sure air eject ports in mold are not plugged
        2. Make sure hoses are not kinked or cut
        3. Check status of compressor
6. Dents or wrinkles in parts
    1. Part is sticking to the mold
        1. Mold surface may need maintenance
    2. Air eject ports may be obstructed
    3. Timing adjustment in air eject cycle needed
    4. Air eject pressure too high
        1. Bottom of part is caved in or wrinkled
    5. Inadequate clearance for parts in trim die relief or stacker
    6. Sheet advancing before parts clear the mold
    7. Parts hit an obstruction during conveyance
    8. Stacker needs adjustment
7. Poor material distribution
    1. Adjust mold temperature
        1. Mold surface usually too cool
        2. Surface temp of mold inconsistent
    2. Adjust form air timing
    3. Adjust vacuum timing
    4. Thickness of plastic out of specification
    5. Sheet temperature inconsistent
        1. Check heat zone temps
        2. Adjust heat zone profile
8. Thin spots in Parts
    1. Adjust sheet temperature
9. Surface of Parts is dimpled
    1. Adjust mold temperature
    2. Mold surface needs maintenance
    3. Air Trapped between sheet and flat mold surface
        1. Add vent holes to flat surface
        2. Clear existing vent holes
        3. Enlarge existing vent holes
    4. too much release agent on sheet
10. Chill Spots
    1. Water leaking out of mold
    2. Water channel blocked in cooling plate
    3. Sheet touching metal surfaces during index
    4. Mold too cold
        1. Condensation dripping on mold surfaces
    5. Air draft cooling area of sheet
        1. Be sure fans are not blowing toward forming station
        2. Check hoses for air blowing on the sheet while indexing

11. Hot Spots
    1. Be sure vacuum is turned on
        1. Check all valves and breakers
    2. Check for loss of vacuum due to leaks in mold
        1. use good cigar or canned smoke, talcum powder or corn starch to find leaks
    3. Mold surface may need maintenance
    4. Adjust timing of form air
    5. Adjust timing of vacuum cycle
12. Inconsistent forming process
    1. Heated Platen operation is impaired
        1. Be sure the platen is adequately pre-heated
    2. Drafts are effecting even heating of platten
    3. Heater elements operating inconsistently
        1. Check wiring and other power connections
        2. Heaters may be dirty, corroded, or worn out
    4. Check unwind stand and sheet feed system
        1. Sheet may not feeding off roll smoothly
        2. Sheet may be binding
    5. Sheet clamps are ineffective
    6. Mechanical sheet clamps are worn out
    7. Be sure pressure is holding during the cycle
13. Blowing Holes
    1. Air eject pressure too high
    2. Air trapped in cavity
        1. Bring vacuum on earlier in cycle
14. Thick bottom
    1. Bring vacuum on sooner
    2. Increase size of radii on plug
    3. Be sure vacuum bleed valve is functioning
15. Thin Bottom
    1. Be sure vacuum bleed valve is functioning
    2. Check forming air pressure timing

1. Trimming Defects
2. Location of trim is not centered
    1. Adjust or repair die
3. Angel Hair, chaff and fuzz
    1. Check die sharpness
    2. Cut against a hardened plate
    3. Cut lines in trim plate
    4. Be sure there are no burrs on cutting edge
    5. Check backer plates for flatness
    6. Check platens for parallelism

    7. Check conveyance and stacking fixture clearances

4. Feathered edges
    1. Check die sharpness
    2. Cut against a hardened plate
    3. Cut lines in trim plate
    4. Be sure there are no burrs on cutting edge
    5. Check backer plates for flatness
    6. Check platens for parallelism
    7. Conveyance notches too big
5. Surface Defects
6. Check area for sources of airborne particles
    1. Check for open doors, windows, cleaning, fork truck traffic
    2. Remove dirt and debris from under and around machine
7. Mold surfaces may need maintenance
8. Clear chads, punch-outs, and plastic debris from forming and cutting area
9. Adjust mold temperature
    1. Water leaking out of mold
    2. Water channel blocked in cooling plate
    3. Sheet touching metal surfaces during index
    4. Mold too cold
        1. Condensation dripping on mold surfaces
10. Air draft cooling area of sheet
        1. Be sure fans are not blowing toward forming station
        2. Check hoses for air blowing on the sheet while indexing
11. Air Trapped between sheet and flat mold surface
    1. Add vent holes to flat surface
    2. Clear existing vent holes
    3. Enlarge existing vent holes
12. Too much release agent on sheet
13. Check sheet and pallets it came on for dirt or debris
14. Check sheet for air bubbles, black specks, pits and gels