

FUNDAMENTAL MANUFACTURING PROCESSES

Plastic Thermoforming

SCENE 1.

PT01A, GRAPHIC: FBI warning
white text centered on black to blue
gradient

WARNING

Federal law provides severe civil and
criminal penalties for the unauthorized
reproduction, distribution or exhibition
of copyrighted media.

Copyright © 2006

Society of Manufacturing Engineers

SCENE 2.

PT02A, GRAPHIC: disclaimer
white text centered on black to blue
gradient

Always read the operating manual and safety
information provided by the manufacturer
before operating any
plastic thermoforming equipment.
Make sure all machine guards are in place,
and follow all safety procedures
when working with or near
plastic thermoforming equipment.

SCENE 3.

PT03A, GRAPHIC: PCC/SME screen
white text centered on black to blue
gradient

This program was produced using the technical
resources of the Plastics, Composites &
Coatings Community of SME.
For more information on plastic thermoforming,
please visit our website at:
www.sme.org

SCENE 4.

PT04A, SME logo open, with music

SCENE 5.

PT05A, FMP series open, with music
PT05B, peter carey narration
PT05C, GRAPHICS: blue background

MUSIC UP AND UNDER

NARRATION (VO) :

THE FUNDAMENTAL MANUFACTURING PROCESSES VIDEO
SERIES, EXAMINING THE TOOLS AND TECHNIQUES OF
PRECISION MANUFACTURING.

SCENE 6.

PT06A, GRAPHIC: Plastic
Thermoforming

NARRATION (VO) :

white text centered on black

THIS PROGRAM IS AN INTRODUCTION TO PLASTIC
THERMOFORMING.

SCENE 7.

PT07A, tape 630, 08:06:20-08:06:29
thermoforming operation

NARRATION (VO) :

THERMOFORMING IS THE PROCESS OF HEATING AND
SHAPING PLASTIC SHEET AND FILM, AND IS ONE OF
THE FASTEST-GROWING METHODS OF PROCESSING
PLASTICS.

SCENE 8.

PT08A, archival footage of
thermoforming
PT08B, archival footage of
thermoforming

NARRATION (VO) :

THERMOFORMING GREW IN POPULARITY DURING THE
1950'S WHEN HIGH QUALITY, LOW COST,
THERMOFORMABLE PLASTIC SHEETS BECAME AVAILABLE
FOR GENERAL USE.

SCENE 9.

PT09A, tape 929, 12:22:00-12:22:35
zoom out, thermoforming operation
PT09B, CGS: Packaging
Food
Medical
Automotive
Appliance
Recreational
Signage

NARRATION (VO) :

TODAY, THERMOFORMING PROCESSES ARE USED
EXTENSIVELY TO PRODUCE BOTH LOW- AND HIGH-
VOLUME PRODUCTION PRODUCTS FOR MANY
INDUSTRIES, SUCH AS THE PACKAGING INDUSTRY,
FOOD,
MEDICAL,
AUTOMOTIVE,
APPLIANCE,
RECREATIONAL,
SIGNAGE,
AND MANY MORE.

SCENE 10.

PT10A, tape 920, 03:15:52-03:16:14
thermoforming operation

NARRATION (VO) :

THE BIGGEST ADVANTAGE OF THE THERMOFORMING
PROCESS IS ITS LOW COST TOOLING. FURTHERMORE,

COMPARED TO OTHER PLASTIC PRODUCTION PROCESSES
SUCH AS INJECTION MOLDING AND BLOW MOLDING,
THERMOFORMING EQUIPMENT IS RELATIVELY
INEXPENSIVE.

SCENE 11.

PT11A, tape 926, 09:16:12-09:16:22
excess material being taken up on
spool

NARRATION (VO) :

THE BIGGEST DISADVANTAGE TO THERMOFORMING IS
THAT THE PROCESS CAN PRODUCE SUBSTANTIAL
SCRAP.

--- FADE TO BLACK ---

SCENE 12.

PT12A, GRAPHIC: Thermoforming
Process Components
white text centered on black

SCENE 13.

PT13A, peter carey narration
PT13B, tape 919, 02:22:45-02:23:05
thermoplastic material secured to
frame
PT13C, tape 920, 03:15:00-03:15:15
zoom in, thermoplastic material
heated
PT13D, tape 920, 03:02:02-03:02:21
hot, flexible thermoplastic material
forced against a form
PT13E, tape 919, 02:22:33-02:22:43
thermoformed part being pulled from
thermoforming machine
PT13F, tape 920, 03:03:20-03:03:35
thermoformed part secured to
fixture, tool used to trim
thermoformed part

NARRATION (VO) :

TYPICALLY, MOST THERMOFORMING PROCESSES
CONSIST OF CLAMPING AND SECURING A FLAT
THERMOPLASTIC SHEET IN PLACE...,
AND THEN HEATING THE SHEET TO ITS SOFTENING
TEMPERATURE....,
ONCE THAT TEMPERATURE IS REACHED,
THE HOT, FLEXIBLE THERMOPLASTIC MATERIAL IS
FORCED AGAINST THE CONTOURS OF A MOLD OR FORM
EITHER BY MECHANICAL, AIR, OR VACUUM PRESSURE.
ONCE COOLED, THE THERMOPLASTIC SHEET RETAINS
THE SHAPE AND DETAIL OF THAT MOLD OR FORM.
AFTERWARDS THE THERMOFORMED PART OR PARTS ARE
TRIMMED AND SEPARATED FROM THE SHEET, WHICH IS
THEN RECYCLED FOR REUSE.

--- TOUCH BLACK ---

SCENE 14.

PT14A, tape 929, 12:28:11-12:28:32
zoom out, roll-fed thermoplastic material

PT14B, tape 932, 00:02:12-00:02:41
zoom out, thermoforming operation

PT14C, CGS: Polyvinyl Chloride/PVC
Polyethylene
Impact Modified
Polystyrene
Acrylic
Acrylonitrile Butadiene
Styrene/ABS
Polycarbonate

NARRATION (VO) :

AMORPHOUS, OR NON-CRYSTALLINE THERMOPLASTICS ARE THE MOST WIDELY THERMOFORMED MATERIALS SINCE THEY ARE EASY TO PROCESS AND MORE FORGIVING THAN THE CRYSTALLINE THERMOPLASTICS. OF THE AMORPHOUS THERMOPLASTICS, THE MOST POPULAR TYPES FOR THERMOFORMING INCLUDE: POLYVINYL CHLORIDE, OR 'PVC', POLYETHYLENE, IMPACT MODIFIED POLYSTYRENE, ACRYLIC, ACRYLONITRILE BUTADIENE STYRENE, OR 'ABS', POLYCARBONATE, AND MANY OTHERS.

SCENE 15.

PT15A, tape 929, 12:19:56-12:20:25
pan, thermoforming operation using color

PT15C, tape 926, 09:22:40-09:23:15
cutting co-extruded sheet

PT15D, tape 925, 08:14:54-08:15:17
thermoforming co-extruded sheet

NARRATION (VO) :

THESE THERMOPLASTIC MATERIALS OFTEN INCORPORATE COLORS, ANTI-STATIC AGENTS, ULTRAVIOLET INHIBITORS, FIRE RETARDANTS AND OTHER ADDITIVES THAT ARE USED TO IMPART VARIOUS PROPERTY ENHANCEMENTS TO THE FINISHED PRODUCT. ADDITIONALLY, CO-EXTRUDED AND PRESS LAMINATED SHEETS CONTAINING SEVERAL LAYERS OF VARIOUS MATERIALS IN THEIR WALL STRUCTURES MAY BE THERMOFORMED. THESE LAYERS OFFER A WIDE RANGE OF ATTRIBUTES SUCH AS OXYGEN OR MOISTURE BARRIERS TO GAIN PROPERTIES THAT ARE

UNACHIEVABLE USING CONVENTIONAL THERMOPLASTIC SHEETS.

SCENE 16.

PT16A, tape 924, 07:01:50-07:02:10
sheet stock extruded then cut
PT16B, tape 926, 09:09:14-09:09:34
thermoforming operation using roll-fed sheet stock

NARRATION (VO) :

MATERIAL STOCK FOR THERMOFORMING IS AVAILABLE IN TWO DIFFERENT FORMS: CUT SHEET, WHICH IS PRIMARILY USED FOR HEAVIER GAUGE PRODUCTS REQUIRING THICKER WALL SECTIONS..., AND THINNER GAUGE ROLL-FED SHEET, WHICH IS USED IN HIGH-VOLUME, LIGHT WEIGHT PACKAGING APPLICATIONS.

--- TOUCH BLACK ---

SCENE 17.

PT17A, CGS: Clamping Systems
PT17B, tape 927, 10:06:06-10:06:21
part pulled from clamping frame
PT17C, tape 918, 01:17:19-01:17:27
sheet clamped into frame
PT17D, tape 932, 00:00:08-00:00:18
zoom out, transport chain

NARRATION (VO) :

CLAMPING SYSTEMS ARE USED TO ENSURE THAT THERMOPLASTIC SHEETS DO NOT TWIST, SHRINK, OR WARP DURING HEATING AND FORMING. THE TWO MAIN TYPES OF CLAMPING SYSTEMS USED IN THERMOFORMING ARE: CLAMPING FRAMES..., AND TRANSPORT CHAIN SYSTEMS.

SCENE 18.

PT18A, CGS: Clamping Frames
PT18B, tape 922, 05:09:56-05:10:06
sheet clamped into frame
PT18C, tape 919, 02:23:22-02:23:45
zoom in, sheet clamped into frame

NARRATION (VO) :

WINDOW-STYLE CLAMPING FRAMES ARE USED FOR CUT SHEET THERMOFORMING. CLAMPING FRAMES COMMONLY CONSIST OF ONE UPPER AND ONE LOWER SECTION THAT ARE HINGED ON ONE SIDE. AN INDIVIDUAL PRE-CUT SHEET OF PLASTIC IS PLACED INTO POSITION WITHIN THESE SECTIONS, AND THE FRAME

IS CLOSED TO SECURE THE SHEET FOR THERMOFORMING.

SCENE 19.

PT19A, CGS: Transport Chain Systems
PT19B, **tape 926, 09:16:32-09:16:45**
zoom out, roll-fed sheet pulled on transport chain
PT19C, **tape 929, 12:01:01-12:01:10**
thermoforming operation using roll-fed sheet stock
PT19D, **tape 929, 12:05:44-12:06:20**
zoom out, c.u. sharp teeth of chain holding, pulling sheet to heating area

NARRATION (VO) :

TRANSPORT CHAIN SYSTEMS ARE USED FOR HIGH PRODUCTION ROLL-FED SHEET OPERATIONS. THE ROLL WHICH IS LOCATED AT ONE END OF THE THERMOFORMING SYSTEM IS PULLED BY TWO CONTINUOUS TRANSPORT CHAINS, ONE AT EACH EDGE OF THE ROLL-FED SHEET. THESE CHAINS HAVE SHARP TEETH THAT ARE USED TO PIERCE THE EDGES OF THE SHEET AND DRAG IT INTO POSITION FOR SUBSEQUENT HEATING, THERMOFORMING AND POST PROCESSING.

--- TOUCH BLACK ---

SCENE 20.

PT20A, CGS: Heating Systems
PT20B, **tape 919, 02:04:06-02:04:16**
plastic sheet brought into oven
PT20C, **tape 923, 06:13:20-06:13:53**
plastic being heated up, indexed to thermoforming position
PT20D, CGS: Radiant Electric
Gas Infrared
Direct Contact
PT20E, **tape 926, 09:03:24-09:06:14**
plastic being heated up, extra shot if needed

NARRATION (VO) :

ONCE THE THERMOPLASTIC SHEET IS SECURED IN THE HEATING AREA, IT IS HEATED TO ITS PROPER FORMING TEMPERATURE. THERE ARE VARIOUS HEATING METHODS USED WITH THE MOST COMMON INCLUDING: RADIANT ELECTRIC, GAS INFRARED, AND DIRECT CONTACT HEATING SYSTEMS.

SCENE 21.

PT21A, **tape 920, 03:09:08-03:09:20**
zoom in, plastic heating up
PT21B, **tape 931, 14:13:20-14:13:38**
pan, plastic heated up, thermoformed

NARRATION (VO) :

ACCURATE TEMPERATURE CONTROL IS REQUIRED FOR CONSISTENT THERMOFORMING QUALITY. EACH THERMOPLASTIC POLYMER HAS A SPECIFIC HEATING RANGE IN WHICH IT WILL SOFTEN. DEPENDING ON MATERIAL TYPE, THAT TEMPERATURE RANGES

SOMEWHERE BETWEEN 250 TO 700 DEGREES
FAHRENHEIT, OR 120 TO 370 DEGREES CELSIUS.

--- TOUCH BLACK ---

SCENE 22.

PT22A, CGS: Thermoforming Molds
PT22B, **tape 930**, **13:29:05-13:29:18**
pan, thermoforming mold
PT22C, **tape 919**, **02:09:38-02:09:51**
zoom out, male mold
PT22D, **tape 925**, **08:10:05-08:10:18**
tilt down, female mold, freeze frame
at end if necessary

NARRATION (VO) :

THERMOFORMING MOLDS PROVIDE THE SHAPE TO WHICH
THE PLASTIC SHEET CONFORMS TO PRODUCE A
THERMOFORMED PART. TYPICALLY, THERMOFORMING
MOLDS HAVE PROTRUDED, OR CONVEX SURFACES, AND
ARE REFERRED TO AS MALE, OR POSITIVE,
MOLDS... ,
OR CONCAVE, CAVITY SURFACES, AND ARE REFERRED
TO AS FEMALE, OR NEGATIVE, MOLDS.

SCENE 23.

PT23A, **tape 667**, **00:27:53-00:28:13**
machining of thermoforming mold
PT23B, **tape 922**, **05:28:32-05:28:42**
zoom in, thermoforming operation
PT23C, **tape 922**, **05:12:24-05:12:34**
thermoforming operation

NARRATION (VO) :

THERMOFORMING MOLDS ARE PRODUCED FROM A WIDE
VARIETY OF MATERIALS, DEPENDING ON THE
PRODUCTS BEING PRODUCED AND THE ANNUAL VOLUME
OF PRODUCTS REQUIRED.

SCENE 24.

PT24A, **tape 924**, **07:14:05-07:14:20**
wood mold used for thermoforming
PT24B, **tape 921**, **04:26:22-04:26:32**
pan, wood mold

NARRATION (VO) :

FOR SHORT RUNS, PROTOTYPES, AND ONE-OF-A-KIND
FORMING, INEXPENSIVE MATERIALS SUCH AS WOOD,
EPOXY, PLASTER, AND URETHANE ARE COMMONLY
UTILIZED. THESE MOLDS ARE NOT TEMPERATURE
CONTROLLED.

SCENE 25.

PT25A, **tape 930**, **13:21:33-13:21:53**
zoom out, metal mold used for
thermoforming
PT25B, **tape 921**, **04:18:54-04:19:08**
aluminum mold used for thermoforming

NARRATION (VO) :

FOR HIGH VOLUME PRODUCTION RUNS, TEMPERATURE
CONTROLLED MOLDS PRODUCED FROM ALUMINUM ARE
ALWAYS USED. ALUMINUM IS THE IDEAL METAL FOR

THERMOFORMING MOLDS BECAUSE OF ITS LIGHT WEIGHT, MACHINABILITY, AND HIGH RATE OF HEAT TRANSFER.

SCENE 26.

PT26A, tape 925, 08:09:50-08:10:04
zoom out, cooling channels for thermoforming mold

PT26B, tape 919, 02:12:50-02:13:06
pan, mold to cooling unit

NARRATION (VO) :

BUILT INTO THE THERMOFORMING MOLD ARE CHANNELS FOR CIRCULATING WATER WHICH IS THE MOLD'S PRIMARY COOLING MEDIUM. THE WATER IS PUMPED CONTINUOUSLY THROUGH THE MOLD TO AND FROM A TEMPERATURE CONTROL UNIT, REMOVING THE HEAT AND SOLIDIFYING AND COOLING THE THERMOFORMED PLASTIC TO A CONSISTENT TEMPERATURE.

SCENE 27.

PT27A, tape 927, 10:02:38-10:02:54
part demolded from thermoforming operation

NARRATION (VO) :

PROPER CONTROL PROVIDES A CONSISTENT TEMPERATURE AND COOLANT FLOW RATE, WHICH CONTRIBUTES TO CONTROLLED SHRINKAGE AND OTHER PROPERTIES.

SCENE 28.

PT28A, tape 925, 08:29:00-08:29:20
thermoforming operation

NARRATION (VO) :

TO ACHIEVE DETAIL TRANSFER FROM THE MOLD TO THE HEATED THERMOPLASTIC, ALL THE AIR TRAPPED BETWEEN THE PLASTIC SHEET AND THE MOLD MUST BE EVACUATED THROUGH EITHER VACUUM OR VENTING HOLES DURING THERMOFORMING.

SCENE 29.

PT29A, tape 918, 01:25:41-01:25:59
zoom in, thermoforming operation

PT29B, tape 918, 01:23:10-01:23:33
zoom out, vent holes in thermoforming mold

NARRATION (VO) :

PROPER PLACEMENT OF THE VACUUM OR VENT HOLES IS EXTREMELY IMPORTANT TO ENSURE THAT ALL AIR IS REMOVED. FOR IDEAL AIR REMOVAL, HOLES ARE COMMONLY PLACED AT LOW POINTS IN THE MOLD,

ALONG THE BOTTOM, CORNERS AND SIDEWALL INTERSECTIONS, WITHIN MOLD RIBBING AND STIFFENING DETAILS, AND WITHIN ENGRAVED LETTERING AND PATTERNS.

--- TOUCH BLACK ---

SCENE 30.

PT30A, tape 925, 08:04:43-08:05:02
zoom in, single cavity thermoforming mold being used
PT30B, tape 926, 09:12:32-09:12:54
zoom out, multi-cavity thermoforming molds being used

NARRATION (VO) :

FOR SHORT RUNS OR ONE-OF-A-KIND REQUIREMENTS, A SINGLE CAVITY THERMOFORMING MOLD, ALSO CALLED A ONE-UP MOLD, IS SUFFICIENT. HOWEVER, FOR LONGER THERMOFORMING PRODUCTION RUNS, MOLD ARRANGEMENTS SUCH AS MULTIPLE CAVITY MOLDS, OR FAMILY MOLDS CAN BE USED.

SCENE 31.

PT31A, CGS: Multiple Cavity Molds
PT31B, tape 925, 08:14:12-08:14:24
zoom out, 2-up multiple cavity mold
PT31C, tape 929, 12:18:43-12:19:10
zoom out, thermoforming operation using multiple cavity molds

NARRATION (VO) :

MULTIPLE CAVITY MOLDS CAN BE BUILT IN ANY NUMBER OF CONFIGURATIONS WITHIN THE FOOTPRINT OF THE THERMOPLASTIC SHEET BEING FORMED. THE HIGHER THE NUMBER OF CAVITIES, THE LOWER THE INDIVIDUAL THERMOFORMED PIECE PRICE, BUT THE HIGHER THE TOOLING COST.

SCENE 32.

PT32A, CGS: Family Molds
PT32B, tape 927, 10:11:21-10:11:42
pan of family mold

NARRATION (VO) :

FAMILY MOLDS ARE MULTIPLE CAVITY MOLDS USED TO PRODUCE MORE THAN ONE PART DESIGN SIMULTANEOUSLY FROM THE SAME SHEET STOCK MATERIAL.

--- TOUCH BLACK ---

SCENE 33.

PT33A, tape 921, 04:10:58-04:11:11
twin sheet thermoforming operation

NARRATION (VO) :

PT33B, tape 930, 13:17:54-13:18:09
pressure forming thermoforming
PT33C, CGS: Vacuum/Negative Pressure
Positive Air Pressure

IN THE THERMOFORMING PROCESS, HEATED
THERMOPLASTIC SHEET STOCK IS FORCED INTO OR
AGAINST A MOLD TO FORM THE SHAPE OF THE FINAL
PRODUCT. THIS FORCE IS TYPICALLY SUPPLIED
USING EITHER A VACUUM, WHICH IS NEGATIVE
PRESSURE,
OR POSITIVE AIR PRESSURE,
OR A COMBINATION OF BOTH.

SCENE 34.

PT34A, tape 927, 10:27:41-10:28:30
zoom in, vacuum forming
thermoforming operation
PT34B, CGS: Thermoplastic Molding
Material Type
Material Size &
Thickness
Mold Material & Design
Product Aesthetics
Final Product Size
Annual Volume of Parts
Required

NARRATION (VO) :

THE TYPE OR TYPES OF FORCE USED IN SPECIFIC
THERMOFORMING METHODS IS DETERMINED BY MANY
FACTORS, INCLUDING:
THE THERMOPLASTIC MOLDING MATERIAL TYPE,
THE MATERIAL SIZE AND THICKNESS,
THE MOLD MATERIAL AND DESIGN,
PRODUCT AESTHETICS,
FINAL PRODUCT SIZE,
AND THE ANNUAL VOLUME OF PARTS REQUIRED.

SCENE 35.

PT35A, tape 927, 10:10:18-10:10:44
drape thermoforming operation, loop
at end if necessary
PT35B, CGS: Drape Thermoforming
Cavity Thermoforming
Pressure Thermoforming
Plug Assist
Thermoforming
Twin Sheet Thermoforming

NARRATION (VO) :

THE VARIETY OF THERMOFORMING METHODS IS
EXTENSIVE, WITH SOME OF THE MOST COMMON TYPES
INCLUDING:
DRAPE THERMOFORMING,
CAVITY THERMOFORMING,
PRESSURE THERMOFORMING,
PLUG ASSIST THERMOFORMING,
AND TWIN SHEET THERMOFORMING.

--- TOUCH BLACK ---

SCENE 36.

PT36A, CGS: Drape Thermoforming
PT36B, ANI: drape thermoforming
operation

NARRATION (VO) :

IN DRAPE THERMOFORMING, THE CLAMPED, PREHEATED THERMOPLASTIC SHEET IS DRAPED AND STRETCHED OVER A MALE MOLD. ONCE THE STRETCHED THERMOPLASTIC SEALS AGAINST THE MOLD EDGES, A VACUUM IS INITIATED PULLING THE THERMOPLASTIC SHEET AGAINST THE MOLD, FORMING THE PART.

SCENE 37.

PT37A, CGS: Cavity Thermoforming
PT37B, ANI: cavity thermoforming
operation

NARRATION (VO) :

IN CAVITY THERMOFORMING, THE CLAMPED, PREHEATED THERMOPLASTIC SHEET IS LAYED OVER A FEMALE MOLD. ONCE THE PLASTIC SHEET SEALS ALONG THE TOP EDGES OF THE MOLD CAVITY, A VACUUM IS APPLIED PULLING THE SHEET AGAINST THE INSIDE SURFACE OF THE MOLD.

SCENE 38.

PT38A, CGS: Pressure Thermoforming
PT38B, ANI: pressure thermoforming
operation

NARRATION (VO) :

IN PRESSURE THERMOFORMING, THE PREHEATED THERMOPLASTIC SHEET IS SEALED BETWEEN A PRESSURE PLATE AND MOLD. AIR PRESSURE IS THEN APPLIED THROUGH THE PRESSURE PLATE, PUSHING THE THERMOPLASTIC SHEET AGAINST THE MOLD SURFACES.

SCENE 39.

PT39A, tape 930, 13:25:18-13:25:31
zoom in, pressure thermoforming
operation
PT39B, still, pressure formed part

NARRATION (VO) :

PRESSURE THERMOFORMING REQUIRES STRONGLY CONSTRUCTED MOLDS AND PRESSES TO WITHSTAND THE FORMING PRESSURES, AND IS COMMONLY USED FOR THERMOFORMING APPLICATIONS REQUIRING PARTS

WITH HIGHLY DEFINED MOLDED-IN DETAILS.

SCENE 40.

PT40A, CGS: Plug Assist Thermoforming

PT40B, ANI: plug assist thermoforming operation

NARRATION (VO) :

PLUG ASSIST THERMOFORMING IS SIMILAR TO CAVITY FORMING, BUT USES A MALE PLUG TO PUSH THE PREHEATED THERMOPLASTIC SHEET INTO A FEMALE MOLD. AS THE PLUG SEALS THE SHEET AGAINST THE MOLD, A VACUUM IS APPLIED PULLING THE SHEET AGAINST THE MOLD SURFACE. ADDITIONAL AIR PRESSURE APPLIED FROM AROUND THE PLUG MAY ALSO BE UTILIZED.

SCENE 41.

PT41A, **tape 931, 14:06:35-14:06:46**
plug assist thermoforming operation

NARRATION (VO) :

PLUG ASSIST THERMOFORMING IS POPULAR SINCE IT IS FAST, AND HELPS MAINTAIN EVEN WALL THICKNESSES.

SCENE 42.

PT42A, CGS: Twin Sheet Thermoforming

PT42B, **tape 930, 13:02:10-13:02:22**
twin sheet thermoforming operation

PT42C, ANI: twin sheet thermoforming operation

PT42D, **tape 930, 13:09:40-13:10:02**
zoom in, twin sheet thermoforming operation

NARRATION (VO) :

TWIN SHEET THERMOFORMING IS USED TO CREATE HOLLOW PARTS AND IS PERFORMED IN A VARIETY OF WAYS. ONE SUCH METHOD CONSISTS OF TWO PREHEATED THERMOPLASTIC SHEETS POSITIONED BETWEEN MOLD HALVES. THESE MOLD HALVES ARE BROUGHT INTO POSITION WITH THEIR RESPECTIVE PREHEATED SHEETS, SEALING THEIR TOP EDGES. A VACUUM IS THEN APPLIED, FORMING THE TWO INDIVIDUAL PART HALVES. BEFORE THE THERMOFORMED SHEETS COOL, THE MOLD HALVES ARE BROUGHT TOGETHER WELDING THE HALVES INTO A HOLLOW CONSTRUCTION. IN SOME INSTANCES, HIGH

PRESSURE AIR IS INJECTED BETWEEN THE MOLD HALVES AS THEY ARE WELDED TOGETHER TO ASSIST IN THE FORMING AND COOLING OF THE HOLLOW THERMOFORMED CONSTRUCTION.

--- TOUCH BLACK ---

SCENE 43.

PT43A, tape 929, 12:17:27-12:17:48
tilt down, zoom in, thermoformed parts being trimmed in-process
PT43B, tape 918, 01:28:32-01:28:51
zoom out, post thermoforming trimming operation, scrape placed on pile for recycling

NARRATION (VO) :

ONCE PARTS ARE THERMOFORMED, THEY MUST BE TRIMMED FROM THE INITIAL THERMOPLASTIC SHEET. THIS MAY BE PERFORMED IN-CYCLE WITHIN THE THERMOFORMING SYSTEM..., OR AS A POST THERMOFORMING OPERATION.

SCENE 44.

PT44A, tape 921, 04:13:50-04:14:03
pan, leftover sheet material being reground

NARRATION (VO) :

THE LEFTOVER SHEET MATERIAL IS THEN TYPICALLY RECYCLED OR REGROUND FOR REUSE IN FUTURE PRODUCTION.

SCENE 45.

PT45A, tape 716, 01:04:32-01:04:45
zoom out, laser trimming of thermoformed part
PT45B, tape 929, 12:14:34-12:14:48
zoom out, thermoformed parts being trimmed in-process
PT45C, tape 923, 06:17:27-06:17:38
zoom in, machining of thermoformed part
PT45D, CGS: Hand Trimming
PT45E, tape 921, 04:19:55-04:20:09
hand trimming of thermoformed part
PT45F, CGS: Punch & Die Sets
PT45G, tape 717, 02:01:02-02:01:15
c.u. trimming of thermoformed part using punch and die
PT45H, CGS: Steel Rule Dies
PT45I, tape 925, 08:22:03-08:22:17
zoom in, steel rule die
PT45J, CGS: CNC Machining
PT45K, tape 923, 06:21:50-06:21:58
zoom in, machine trimming of

NARRATION (VO) :

PROPER TRIMMING IS CRUCIAL TO THE FINAL QUALITY OF THE THERMOFORMED PART OR PARTS AND IS ACCOMPLISHED USING A VARIETY OF METHODS, INCLUDING:
HAND TRIMMING...,
PUNCH AND DIE SETS...,
STEEL RULE DIES...,
'CNC' MACHINING...,
AND LASER TRIMMING.

--- TOUCH BLACK ---

thermoformed part
PT45L, CGS: Laser Trimming
PT45M, **tape 716**, **01:17:45-01:17:55**
zoom out, laser trimming of
thermoformed part

SCENE 46.
PT46A, CGS: Hand Trimming
PT46B, **tape 921**, **04:23:20-04:23:40**
zoom out, hand trimming of
thermoformed part using router
PT46C, CGS: Hand-Held Knives
Saws
Routers

NARRATION (VO) :

HAND TRIMMING, AS THE NAME IMPLIES, IS
PERFORMED MANUALLY USING A VARIETY OF TOOLS,
INCLUDING:
HAND-HELD KNIVES,
SAWS,
AND ROUTERS.

SCENE 47.
PT47A, **tape 920**, **03:05:48-03:06:06**
zoom in, thermoformed part secured
to fixture, tool used to trim
thermoformed part

NARRATION (VO) :

TYPICALLY, THE THERMOFORMED PART IS SECURED
ONTO A HOLDING FIXTURE CONTAINING A PRESCRIBED
TRIMMING GUIDE OR JIG. THE OPERATOR PUSHES THE
TOOL THROUGH THE PLASTIC SHEET AND THEN
FOLLOWS THE GUIDE TO TRIM OFF THE UNWANTED
PLASTIC.

--- TOUCH BLACK ---

SCENE 48.
PT48A, CGS: Punch & Die Sets
PT48B, **tape 717**, **02:02:33-02:03:00**
zoom out, punch and die set used to
trim thermoformed parts

NARRATION (VO) :

PUNCH AND DIE SETS ARE USED TO TRIM THE ENTIRE
PERIMETER OF THERMOFORMED PARTS AND FOR HIGH
PRECISION SHAPED OPENINGS THAT ARE DIFFICULT
TO PRODUCE USING POWER TOOLS.

SCENE 49.
PT49A **tape 717**, **02:01:31-02:01:54**
zoom out, punch and die set used to
trim thermoformed parts

NARRATION (VO) :

THE METAL PUNCH AND DIE SET IS ARRANGED IN
SUCH A WAY THAT THE PART TO BE TRIMMED IS LAID
BETWEEN THEM. THE PUNCH IS THEN BROUGHT DOWN

AGAINST THE SHEET AND CONTINUES ON UNTIL IT CUTS THROUGH THE SHEET AND ENTERS THE DIE, TRIMMING THE PART.

--- TOUCH BLACK ---

SCENE 50.

PT50A, CGS: Steel Rule Dies

PT50B, **tape 918**, **01:03:07-01:03:27**

zoom out, steel rule die,
thermoformed part placed on it

NARRATION (VO) :

STEEL RULE DIES CONSIST OF HARDENED, SHARPENED, KNIFE-EDGED STEEL STRIPS ASSEMBLED INTO A FORM THAT MATCHES THE SHAPE OF THE REQUIRED TRIMMING.

SCENE 51.

PT51A, **tape 918**, **01:07:57-01:08:16**

zoom out, steel rule die being used
to trim thermoformed parts

NARRATION (VO) :

TYPICALLY, THE THERMOFORMED PRODUCT IS LOCATED ON THE STEEL RULE DIE ASSEMBLY. THEN PNEUMATIC, HYDRAULIC OR MECHANICAL PRESSURE IS APPLIED TO PUSH THE PRODUCT THROUGH THE STEEL RULE DIE, TRIMMING THE PLASTIC.

--- TOUCH BLACK ---

SCENE 52.

PT52A, CGS: CNC Machining

PT52B, **tape 925**, **08:05:14-08:05:44**

zoom out, trimming of part on cnc
machine tool

PT52C, **tape 717**, **02:05:54-02:06:16**

trimming using robot

NARRATION (VO) :

PART TRIMMING USING 'CNC', OR COMPUTER NUMERICAL CONTROL, MACHINING IS ACCOMPLISHED USING SEMI-AUTOMATIC AND FULLY AUTOMATIC MACHINE TOOLS..., AND ROBOTS.

SCENE 53.

PT53A, **tape 668**, **01:04:05-01:04:14**

zoom out, computer screen

PT53B, **tape 925**, **08:06:14-08:06:35**

zoom out, trimming operation

NARRATION (VO) :

UNDER NUMERICAL CONTROL, INSTRUCTIONS FOR MACHINING ARE IN THE FORM OF A CODED PART PROGRAM. THE TRIMMING MACHINE'S COMPUTER

TRANSLATES THIS PROGRAM INTO SIGNALS THAT GOVERN THE AXIS MOTORS TO TRIM THE PART.

SCENE 54.

PT54A, tape 923, 06:27:40-06:27:55
toolchanging operation during trimming

NARRATION (VO) :

THESE MACHINES OFTEN INCORPORATE TOOLCHANGERS TO MOVE CUTTING TOOLS FROM STORAGE TO THE SPINDLE TO PERFORM A VARIETY OF CUTTING OPERATIONS AUTOMATICALLY.

SCENE 55.

PT55A, tape 923, 06:25:24-06:25:32
zoom out, thermoformed parts trimmed with saw
PT55B, tape 923, 06:23:47-06:24:10
thermoformed parts trimmed with router cutting tool using machining center

NARRATION (VO) :

SAWS..., AND ROUTERS ARE THE MOST COMMON CUTTING TOOLS USED FOR 'CNC' TRIMMING OF THERMOFORMED PARTS. IN EITHER CASE, THE CUTTING EDGES OR TEETH MUST BE OF A SPECIAL DESIGN COMPATIBLE FOR USE WITH PLASTIC MATERIALS.

--- TOUCH BLACK ---

SCENE 56.

PT56A, CGS: Laser Trimming
PT56B, tape 716, 01:20:29-01:21:00
zoom out, laser trimming of thermoformed part

NARRATION (VO) :

LASER TRIMMING USES A HIGH POWERED LASER BEAM TO CUT THROUGH THE PLASTIC MATERIAL. THIS PRODUCES A THIN, HIGH PRECISION CUT WHICH USUALLY RESULTS IN A VERY CLEAN, POLISHED EDGE WHICH TYPICALLY REQUIRES NO FURTHER PROCESSING.

SCENE 57.

PT57A, tape 716, 01:11:52-01:12:11
laser trimming of thermoformed part

NARRATION (VO) :

THE MOST COMMON TYPE OF LASER USED FOR PLASTIC TRIMMING IS THE NEODYMIUM-DOPED YTTRIUM-ALUMINUM GARNET, OR 'YAG', SOLID-STATE LASER.

--- FADE TO BLACK ---

SCENE 58.

PT58A, GRAPHIC: Review
white text on black
PT58B, peter carey narration

MUSIC UP AND UNDER

NARRATION (VO) :

LET'S REVIEW THE MATERIAL CONTAINED IN THIS PROGRAM.

SCENE 59.

PT59A, tape 630, 08:06:20-08:06:29
thermoforming operation
PT59B, tape 929, 12:22:00-12:22:35
zoom out, thermoforming operation
PT59C, FMP review music

NARRATION (VO) :

THERMOFORMING IS THE PROCESS OF HEATING AND SHAPING PLASTIC SHEET AND FILM, AND IS USED EXTENSIVELY TO PRODUCE BOTH LOW- AND HIGH-VOLUME PRODUCTION PRODUCTS FOR MANY INDUSTRIES.

SCENE 60.

PT60A, tape 929, 12:28:11-12:28:32
zoom out, roll-fed thermoplastic material
PT60B, tape 932, 00:02:12-00:02:41
zoom out, thermoforming operation
PT60C, CGS: Polyvinyl Chloride/PVC
Polyethylene
Impact Modified
Polystyrene
Acrylic
Acrylonitrile Butadiene
Styrene/ABS
Polycarbonate

NARRATION (VO) :

AMORPHOUS, OR NON-CRYSTALLINE THERMOPLASTICS ARE THE MOST WIDELY THERMOFORMED MATERIALS, WITH THE MOST POPULAR TYPES INCLUDING: POLYVINYL CHLORIDE, OR 'PVC', POLYETHYLENE, IMPACT MODIFIED POLYSTYRENE, ACRYLIC, ACRYLONITRILE BUTADIENE STYRENE, OR 'ABS', POLYCARBONATE, AND MANY OTHERS.

SCENE 61.

PT61A, tape 924, 07:01:50-07:02:10
sheet stock extruded then cut
PT61B, tape 926, 09:09:14-09:09:34
thermoforming operation using roll-fed sheet stock

NARRATION (VO) :

MATERIAL STOCK FOR THERMOFORMING IS AVAILABLE IN TWO DIFFERENT FORMS: CUT SHEET, WHICH IS PRIMARILY USED FOR HEAVIER GAUGE PRODUCTS REQUIRING THICKER WALL

SECTIONS...,
AND THINNER GAUGE ROLL-FED SHEET, WHICH IS
USED IN HIGH-VOLUME, LIGHT WEIGHT PACKAGING
APPLICATIONS.

--- TOUCH BLACK ---

SCENE 62.

PT62A, CGS: Clamping Systems
PT62B, **tape 927, 10:06:06-10:06:21**
part pulled from clamping frame
PT62C, CGS: Clamping Frames
PT62D, **tape 918, 01:17:19-01:17:27**
sheet clamped into frame
PT62E, CGS: Transport Chain Systems
PT62F, **tape 929, 12:05:44-12:06:20**
zoom out, c.u. sharp teeth of chain
holding, pulling sheet to heating
area

NARRATION (VO) :

CLAMPING SYSTEMS ARE USED TO ENSURE THAT
THERMOPLASTIC SHEETS DO NOT TWIST, SHRINK, OR
WARP DURING HEATING AND FORMING. THE TWO MAIN
TYPES OF CLAMPING SYSTEMS USED IN
THERMOFORMING ARE:
CLAMPING FRAMES...,
AND TRANSPORT CHAIN SYSTEMS.

SCENE 63.

PT63A, CGS: Heating Systems
PT63B, **tape 919, 02:04:06-02:04:16**
plastic sheet brought into oven

NARRATION (VO) :

ONCE SECURED, THE THERMOPLASTIC SHEET IS
HEATED TO ITS PROPER FORMING TEMPERATURE.

SCENE 64.

PT64A, **tape 920, 03:09:08-03:09:20**
zoom in, plastic heating up
PT64B, **tape 931, 14:13:20-14:13:38**
pan, plastic heated up, thermoformed

NARRATION (VO) :

ACCURATE TEMPERATURE CONTROL IS REQUIRED FOR
CONSISTENT THERMOFORMING QUALITY. EACH
THERMOPLASTIC POLYMER HAS A SPECIFIC HEATING
RANGE IN WHICH IT WILL SOFTEN. DEPENDING ON
MATERIAL TYPE, THAT TEMPERATURE RANGES
SOMEWHERE BETWEEN 250 TO 700 DEGREES
FAHRENHEIT, OR 120 TO 370 DEGREES CELSIUS.

--- TOUCH BLACK ---

SCENE 65.

PT65A, CGS: Thermoforming Molds
PT65B, **tape 930, 13:29:05-13:29:18**

NARRATION (VO) :

pan, thermoforming mold
PT65C, tape 919, 02:09:38-02:09:51
zoom out, male mold
PT65D, tape 925, 08:10:05-08:10:18
tilt down, female mold, freeze frame
at end if necessary

THERMOFORMING MOLDS PROVIDE THE SHAPE TO WHICH THE PLASTIC SHEET CONFORMS TO PRODUCE A THERMOFORMED PART. TYPICALLY, THERMOFORMING MOLDS HAVE PROTRUDED, OR CONVEX SURFACES, AND ARE REFERRED TO AS MALE, OR POSITIVE, MOLDS..., OR CONCAVE, CAVITY SURFACES, AND ARE REFERRED TO AS FEMALE, OR NEGATIVE, MOLDS.

SCENE 66.
PT66A, tape 930, 13:21:33-13:21:53
zoom out, metal mold used for thermoforming
PT66B, tape 921, 04:18:54-04:19:08
aluminum mold used for thermoforming

NARRATION (VO) :
FOR HIGH VOLUME PRODUCTION RUNS, TEMPERATURE CONTROLLED MOLDS PRODUCED FROM ALUMINUM ARE ALWAYS USED. ALUMINUM IS THE IDEAL METAL FOR THERMOFORMING MOLDS BECAUSE OF ITS LIGHT WEIGHT, MACHINABILITY, AND HIGH RATE OF HEAT TRANSFER.

SCENE 67.
PT67A, tape 925, 08:09:50-08:10:04
zoom out, cooling channels for thermoforming mold

NARRATION (VO) :
BUILT INTO THE THERMOFORMING MOLD ARE CHANNELS FOR CIRCULATING WATER WHICH IS THE MOLD'S PRIMARY COOLING MEDIUM.

SCENE 68.
PT68A, tape 927, 10:02:38-10:02:54
part demolded from thermoforming operation

NARRATION (VO) :
PROPER TEMPERATURE CONTROL PROVIDES A CONSISTENT TEMPERATURE AND COOLANT FLOW RATE, WHICH CONTRIBUTES TO CONTROLLED SHRINKAGE AND OTHER PROPERTIES.

SCENE 69.
PT69A, tape 925, 08:29:00-08:29:20
thermoforming operation

NARRATION (VO) :
TO ACHIEVE DETAIL TRANSFER FROM THE MOLD TO THE HEATED THERMOPLASTIC, ALL THE AIR TRAPPED

BETWEEN THE PLASTIC SHEET AND THE MOLD MUST BE EVACUATED THROUGH EITHER VACUUM OR VENTING HOLES DURING THERMOFORMING.

SCENE 70.

PT70A, tape 918, 01:25:41-01:25:59
zoom in, thermoforming operation
PT70B, tape 918, 01:23:10-01:23:33
zoom out, vent holes in thermoforming mold

NARRATION (VO) :

FOR IDEAL AIR REMOVAL, HOLES ARE COMMONLY PLACED AT LOW POINTS IN THE MOLD, ALONG THE BOTTOM, CORNERS AND SIDEWALL INTERSECTIONS, WITHIN MOLD RIBBING AND STIFFENING DETAILS, AND WITHIN ENGRAVED LETTERING AND PATTERNS.

--- TOUCH BLACK ---

SCENE 71.

PT71A, tape 921, 04:10:58-04:11:11
twin sheet thermoforming operation
PT71B, tape 930, 13:17:54-13:18:09
pressure forming thermoforming
PT71C, CGS: Vacuum/Negative Pressure
Positive Air Pressure

NARRATION (VO) :

IN THE THERMOFORMING PROCESS, THE FORCE USED TO FORM THE SHAPE OF THE FINAL PRODUCT IS TYPICALLY SUPPLIED USING EITHER A VACUUM, OR NEGATIVE PRESSURE, OR POSITIVE AIR PRESSURE, OR A COMBINATION OF BOTH.

SCENE 72.

PT72A, tape 927, 10:10:18-10:10:44
drape thermoforming operation, loop at end if necessary
PT72B, CGS: Drape Thermoforming
PT72C, tape 925, 08:04:43-08:05:02
zoom in, single cavity thermoforming mold being used
PT72D, CGS: Cavity Thermoforming
PT72E, tape 930, 13:25:18-13:25:31
zoom in, pressure thermoforming operation
PT72F, CGS: Pressure Thermoforming
PT72G, tape 931, 14:06:35-14:06:46
plug assist thermoforming operation
PT72H, CGS: Plug Assist
Thermoforming
PT72I, tape 930, 13:02:10-13:02:22
twin sheet thermoforming operation
PT72J, CGS: Twin Sheet Thermoforming

NARRATION (VO) :

THE VARIETY OF THERMOFORMING METHODS IS EXTENSIVE, WITH SOME OF THE MOST COMMON TYPES INCLUDING:
DRAPE THERMOFORMING...,
CAVITY THERMOFORMING...,
PRESSURE THERMOFORMING...,
PLUG ASSIST THERMOFORMING...,
AND TWIN SHEET THERMOFORMING.

--- TOUCH BLACK ---

SCENE 73.

PT73A, tape 929, 12:17:27-12:17:48
tilt down, zoom in, thermoformed parts being trimmed in-process
PT73B, tape 918, 01:28:32-01:28:51
zoom out, post thermoforming trimming operation, scrape placed on pile for recycling

NARRATION (VO) :

ONCE PARTS ARE THERMOFORMED, THEY MUST BE TRIMMED FROM THE INITIAL THERMOPLASTIC SHEET. THIS MAY BE PERFORMED IN-CYCLE WITHIN THE THERMOFORMING SYSTEM..., OR AS A POST THERMOFORMING OPERATION.

SCENE 74.

PT74A, tape 716, 01:04:32-01:04:45
zoom out, laser trimming of thermoformed part
PT74B, tape 929, 12:14:34-12:14:48
zoom out, thermoformed parts being trimmed in-process
PT74C, tape 923, 06:17:27-06:17:38
zoom in, machining of thermoformed part
PT74D, CGS: Hand Trimming
PT74E, tape 921, 04:19:55-04:20:09
hand trimming of thermoformed part
PT74F, CGS: Punch & Die Sets
PT74G, tape 717, 02:01:02-02:01:15
c.u. trimming of thermoformed part using punch and die
PT74H, CGS: Steel Rule Dies
PT74I, tape 925, 08:22:03-08:22:17
zoom in, steel rule die
PT74J, CGS: CNC Machining
PT74K, tape 923, 06:21:50-06:21:58
zoom in, machine trimming of thermoformed part
PT74L, CGS: Laser Trimming
PT74M, tape 716, 01:17:45-01:17:55
zoom out, laser trimming of thermoformed part

NARRATION (VO) :

PROPER TRIMMING IS CRUCIAL TO THE FINAL QUALITY OF THE THERMOFORMED PART OR PARTS AND IS ACCOMPLISHED USING A VARIETY OF METHODS, INCLUDING:
HAND TRIMMING...,
PUNCH AND DIE SETS...,
STEEL RULE DIES...,
'CNC' MACHINING...,
AND LASER TRIMMING.

--- FADE TO BLACK ---

SCENE 75.

PT75A, CG, ROLL: credits
white text on black, fade up mid-screen

Produced By:
Society of Manufacturing Engineers

Executive Producer:
Steven R. Bollinger

Producer/Director/Cameraman:

Jerome T. Cook

Written By:

Douglas M. Bryce,
Texas Plastic Technologies

Graphics By:

Jerome T. Cook
Dennis Summers,
Quantum Dance Works

Technical & Editorial Consulting:

Roger Kipp,
McClarin Plastics, Inc.
Stephen R. Murrill,
Profile Plastics Corporation

Equipment Access Provided By:

BROWN Machine
Clear Pack Company
Fox Lite, Inc.
Maryland Thermoform
McClarin Plastics, Inc.
Peninsula Plastics Company, Inc.
Profile Plastics Corporation
Techniform Industries, Inc.

Production Assistance Provided By:

Lance Rosol

Video Editing:

Jerome T. Cook

SCENE 76.

PT76A, GRAPHIC: disclaimer
white text centered on black

Some machinery in this program had safety
equipment removed to allow better

recording of certain processes.

Always read the safety information provided in
the manufacturers' manual before
machine operation.

SCENE 77.

PT77A, SME logo open, with music