

FUNDAMENTAL MANUFACTURING PROCESSES

Plastic Thermoforming

SCENE 1.
PT12A, GRAPHIC: Thermoforming
Process Components
white text centered on black

SCENE 2.
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 3.
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

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

Styrene/ABS
Polycarbonate

POPULAR TYPES FOR THERMOFORMING INCLUDE:

POLYVINYL CHLORIDE, OR 'PVC',

POLYETHYLENE,

IMPACT MODIFIED POLYSTYRENE,

ACRYLIC,

ACRYLONITRILE BUTADIENE STYRENE, OR 'ABS',

POLYCARBONATE,

AND MANY OTHERS.

SCENE 4.
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 5.
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 6.
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 7.
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 8.
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.

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SCENE 9.
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 10.
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 11.
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 12.
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 13.
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 14.
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 15.
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 16.
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 17.
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 18.
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 19.
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

NARRATION (VO):

FOR SHORT RUNS OR ONE-OF-A-KIND REQUIREMENTS, A SINGLE CAVITY THERMOFORMING MOLD, ALSO

molds being used

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 20.
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 21.
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 22.
PT33A, tape 921, 04:10:58-04:11:11
twin sheet thermoforming operation
PT33B, tape 930, 13:17:54-13:18:09
pressure forming thermoforming
PT33C, CGS: Vacuum/Negative Pressure
Positive Air Pressure

NARRATION (VO):

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 23.
PT34A, tape 927, 10:27:41-10:28:30

NARRATION (VO):

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

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 24.
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 25.
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 26.
PT37A, CGS: Cavity Thermoforming

NARRATION (VO):

PT37B, ANI: cavity thermoforming operation

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 27.
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 28.
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 29.
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 30.
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 31.
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 32.
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 33.
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 34.
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 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 thermoformed part
PT45L, CGS: Laser Trimming
PT45M, 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.

--- TOUCH BLACK ---

SCENE 35.
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 36.
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 37.
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 38.
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 39.
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 40.
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 41.
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 42.
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 43.
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 44.
PT55A, tape 923, 06:25:24-06:25:32
zoom out, thermoformed parts trimmed

NARRATION (VO):

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

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 45.
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 46.
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 ---