

FUNDAMENTAL MANUFACTURING PROCESSES

Plastics Machining & Assembly

SCENE 1.
CG: Plastics Assembly
white text centered on black

SCENE 2.
tape 739, 01:11:33-01:22:14
peter carey narration
tape 724, 11:01:00-11:03:00
GRAPHIC: sme branding logo
tape 736, 23:13:43-23:13:53
ultrasonic insertion welding of
plastic parts
tape 735, 22:27:36-22:27:49
bonding of plastic parts
CG, SUPER: Part Materials
Product Design
End Use Conditions of
the Finished Product

NARRATION (VO):
THERE ARE MANY METHODS OF ASSEMBLING, OR JOINING,
PLASTIC-TO-PLASTIC, AND PLASTIC-TO-METAL PARTS
TOGETHER. VARIABLES SUCH AS PART MATERIALS,
PRODUCT DESIGN, AND THE END USE CONDITIONS OF THE
FINISHED PRODUCT MUST BE CONSIDERED WHEN DESIGNING
AN ASSEMBLY METHOD.

SCENE 3.
tape 722, 08:02:54-08:03:03
manual assembly operation
tape 664, 01:00:42-01:00:52
automatic assembly operation

NARRATION (VO):
ASSEMBLY OPERATIONS CAN BE PERFORMED EITHER
MANUALLY...,
OR AUTOMATICALLY.

SCENE 4.
tape 736, 23:10:20-23:10:29
plastic parts being
ultrasonically welded together
CG, SUPER: Snap-Fits
tape 658, 14:05:18-14:05:24
snap-fit components clipped
together
CG, SUPER: Hinges
tape 721, 07:23:19-07:23:26
c.u. hinge
CG, SUPER: Mechanical Fasteners
tape 658, 14:01:34-14:01:39
mechanical fastener being
tighten on plastic part
CG, SUPER: Bonding
tape 718, 04:04:32-04:04:40
adhesive bonding of plastic
parts
CG, SUPER: Welding
tape 726, 13:21:29-13:21:34
ultrasonic welding of plastic

NARRATION (VO):
THE MOST COMMON METHODS OF ASSEMBLING PLASTIC
COMPONENTS TOGETHER INCLUDE THE USE OF:
SNAP-FITS...,
HINGES...,
MECHANICAL FASTENERS...,
BONDING...,
AND WELDING.

--- TOUCH BLACK ---

parts

SCENE 5.

CG, SUPER: Snap-Fits

tape 738, 01:20:43-01:20:52

c.u. part with snap fit

tape 725, 12:28:35-12:28:45

snap fit part coming out of injection mold

tape 738, 01:22:03-01:22:08

side view same part being snap fit into another part

tape 738, 01:23:54-01:23:59

c.u. snap fit snapping into place

tape 658, 14:05:51-14:05:56

c.u. snap fit operation

tape 738, 01:16:33-01:16:41

snap-fit part being disassembled

NARRATION (VO) :

SNAP-FITS ARE INTEGRAL FASTENERS MOLDED INTO PLASTIC PARTS, WHICH WHEN ASSEMBLED, LOCK INTO PLACE. SNAP-FITS ARE QUICK AND EASY TO USE IN PERMANENT ASSEMBLY OPERATIONS, AND FOR WHEN DISASSEMBLY IS REQUIRED.

SCENE 6.

tape 718, 04:19:15-04:19:21

snap fit part being assembled

tape 737, 00:00:54-00:01:00

ANI: cantilever snap fit pushed into place

CG, SUPER: Cantilever Arm/Beam Snap Fits

tape 737, 00:01:14-00:01:19

ANI: annular snap fit pushed into place

CG, SUPER: Annular/Ring Snap Fits

NARRATION (VO) :

SOME COMMON TYPES OF SNAP-FITS INCLUDE: CANTILEVER ARM OR BEAM SNAP FITS..., AND ANNULAR, OR RING, SNAP FITS.

--- TOUCH BLACK ---

SCENE 7.

tape 721, 07:23:38-07:23:55

zoom out, part with hinge

CG, SUPER: Hinges

tape 727, 14:01:32-14:01:42

zoom in, part with integrated hinge

CG, SUPER: One-Piece Integral Hinges

tape 738, 01:10:16-01:10:34

zoom out, part with two piece integrated hinge

CG, SUPER: Two-Piece Integral Hinges

tape 738, 01:15:08-01:15:16

c.u. part with multi-part hinge

CG, SUPER: Multi-Part Hinges

NARRATION (VO) :

HINGES ARE USED IN ASSEMBLIES REQUIRING REPEATED OPENING AND CLOSING, AND ARE PRIMARILY DIVIDED INTO THREE CATEGORIES: ONE-PIECE INTEGRAL HINGES..., TWO-PIECE INTEGRAL HINGES..., AND MULTI-PART HINGES.

SCENE 8.

CG, SUPER: One-Piece Integral

NARRATION (VO) :

Hinges

tape 727, 14:08:01-14:08:10
part with integrated hinge
opening and closing
CG, SUPER: The Living Hinge
tape 727, 14:06:33-14:06:48
part with living hinge

ONE-PIECE INTEGRAL HINGES ARE THIN, FLEXIBLE
INTEGRAL HINGES CONNECTING PART COMPONENTS
TOGETHER. THE LIVING HINGE IS THE MOST COMMON TYPE
OF ONE-PIECE INTEGRAL HINGE, AND IS TYPICALLY
CREATED BETWEEN THE PART COMPONENTS DURING THE
INJECTION MOLDING PROCESS.

SCENE 9.
CG, SUPER: Two-Piece Integral
Hinges
tape 738, 01:06:00-01:06:19
zoom out, part with two-piece
hinge

NARRATION (VO) :
TWO-PIECE INTEGRAL HINGES HAVE ALL THE HINGE
COMPONENTS MOLDED INTO THE PLASTIC PARTS, BUT ARE
MANUFACTURED AS SEPARATE ELEMENTS AND ASSEMBLED
AFTERWARDS.

SCENE 10.
CG, SUPER: Multi-Part Hinges
tape 738, 01:08:32-01:08:53
pan, multi-part hinge moving

NARRATION (VO) :
MULTI-PART HINGES ARE USED IN APPLICATIONS WHERE
ONE- AND TWO-PIECE HINGES ARE NOT WELL SUITED,
SUCH AS THOSE REQUIRING HEAVY LOADING, AND LOW-
PRODUCTION VOLUMES.

SCENE 11.
continue previous shot
tape 738, 01:13:50-01:14:06
multi-part hinge moving

NARRATION (VO) :
THE THREE-PIECE LUG-AND-PIN HINGE IS THE MOST
COMMON TYPE OF MULTI-PART HINGE. EACH PART HALF
CONTAINS A COMPONENT OF THE MOLDED HINGE DESIGN.
THE THIRD PIECE IS TYPICALLY A METAL PIN OR RIVET
INSERTED THROUGH THE HINGE COMPONENTS.

--- TOUCH BLACK ---

SCENE 12.
CG, SUPER: Mechanical Fasteners
tape 719, 05:16:21-05:16:36
zoom in, mechanical fasteners
used to assemble plastic parts
together
CG, SUPER: Threaded Fasteners
tape 658, 14:03:42-14:03:48

NARRATION (VO) :
MECHANICAL FASTENERS ARE A FREQUENTLY USED, LOW-
COST MEANS OF ASSEMBLING AND HOLDING SIMILAR OR
DISSIMILAR PLASTIC PART COMPONENTS TOGETHER.

c.u. threaded fastener
CG, SUPER: Non-Threaded
Fasteners
tape 738, 01:01:03-01:01:12
zoom in, eyelets on part
tape 738, 01:01:23-01:01:29
plastic parts with rivets

THERE ARE NUMEROUS MECHANICAL FASTENING TYPES,
WITH THE MOST COMMON INCLUDING:
THREADED FASTENERS...,
AND NON-THREADED FASTENERS, SUCH AS EYELETS...,
AND RIVETS.

SCENE 13.
CG, SUPER: Threaded Fasteners
tape 736, 23:05:21-23:05:40
wide, threaded fasteners used in
assembly
tape 718, 04:29:03-04:29:19
part being disassembled
CG, SUPER: Self-Tapping Screw
tape 719, 05:18:35-05:18:42
self-tapping screws used in
assembly

NARRATION (VO) :
THREADED FASTENERS ARE THE MOST FREQUENTLY USED
FASTENER TYPE FOR PLASTIC PART ASSEMBLY. THEY COME
IN A VARIETY OF STYLES, AND ARE COMMONLY USED WHEN
DISASSEMBLY AND REASSEMBLY OF COMPONENTS IS
REQUIRED. ONE COMMON TYPE OF THREADED FASTENER IS
THE SELF-TAPPING SCREW.

SCENE 14.
continue previous shot
tape 719, 05:13:29-05:13:38
self-tapping screws used in
assembly

NARRATION (VO) :
SELF-TAPPING SCREWS HOLD PLASTIC ASSEMBLIES
TOGETHER BY TAPPING, OR CREATING, A THREAD IN THE
PLASTIC AS THE SCREW IS INSTALLED.

SCENE 15.
tape 736, 23:15:31-23:15:50
zoom in, threaded metal insert
being added to part
ultrasonically

NARRATION (VO) :
IF DIRECT SCREW-TO-PLASTIC CONTACT DOES NOT
PROVIDE ENOUGH RETENTION STRENGTH, THEN THE
ADDITION OF A THREADED METAL INSERT IN THE PLASTIC
PART IS RECOMMENDED.

--- TOUCH BLACK ---

SCENE 16.
CG, SUPER: Bonding
tape 735, 22:28:15-22:28:32
plastic parts being bonded
together

NARRATION (VO) :
THE USE OF BONDING METHODS IN JOINING TOGETHER
PLASTIC COMPONENTS IS WIDE SPREAD IN
MANUFACTURING. BONDING FORMS PERMANENT JOINTS THAT
CANNOT BE DISASSEMBLED WITHOUT DAMAGING OR

DESTROYING COMPONENTS.

SCENE 17.

continue previous shot
tape 719, 05:06:34-05:06:43
zoom out, plastic parts being
adhesive bonded together
CG, SUPER: Adhesive Bonding
tape 721, 07:26:42-07:26:49
plastic parts being solvent
bonded together
CG, SUPER: Solvent Bonding

NARRATION (VO) :

THE BONDING OF PLASTICS CAN BE ARRANGED INTO TWO
MAIN CATEGORIES:
ADHESIVE BONDING...,
AND SOLVENT BONDING.

SCENE 18.

CG, SUPER: Adhesive Bonding
tape 726, 13:22:00-13:22:08
plastic parts being adhesive
bonded together
tape 726, 13:25:35-13:25:52
zoom out, adhesive bonded parts
coming out of ultraviolet curing

NARRATION (VO) :

ADHESIVE BONDING USES ADHESIVES THAT JOIN
COMPONENTS TOGETHER WHILE ADHERING TO THE SURFACE
OF THE PLASTIC. ADHESIVE BONDING COMPOUNDS
TYPICALLY REQUIRE CURING, OR POLYMERIZATION, TO
ACHIEVE THEIR BOND.

SCENE 19.

CG, SUPER: Solvent Bonding
tape 718, 04:25:57-04:26:01
zoom out, plastic parts being
solvent bonded together
tape 737, 00:01:28-00:01:34
ANI: solvent bonding, molecular
interlocking weld between the
part surfaces upon evaporation
tape 737, 00:01:46-00:01:55
ANI: c.u. molecular interlocking
weld between the part surfaces,
GRAPHIC: add red circle cut-out

NARRATION (VO) :

SOLVENT BONDING USES CEMENTS THAT MELT THE SURFACE
OF THE PLASTIC COMPONENTS BEING BONDED, CAUSING A
MOLECULAR INTERLOCKING WELD BETWEEN THE PARTS UPON
EVAPORATION.

SCENE 20.

tape 735, 22:26:50-22:27:18
thermoplastic plastic parts
being solvent bonded together
CG, SUPER: Cyanacrylate
CG, SUPER: Methylene chloride
Methylene Chloride
Acetone

NARRATION (VO) :

BONDING COMPOUNDS FOR THERMOPLASTICS CAN BE EITHER
ADHESIVE- OR SOLVENT-BASED. CYANACRYLATE IS THE
MOST COMMON BONDING ADHESIVE, AND
METHYLETHYLKETONE,
METHYLENE CHLORIDE,
AND ACETONE ARE THE MOST COMMON BONDING SOLVENTS.

SCENE 21.

tape 698, 02:29:01-02:29:23

zoom in, adhesive being applied to thermoset plastic part

CG, SUPER: Epoxies

Polyurethanes

Silicone Adhesives

NARRATION (VO) :

BONDING COMPOUNDS FOR THERMOSETS, SINCE THEY CANNOT BE RESOFTENED, ARE ONLY ADHESIVE-BASED. THE MOST COMMON TYPES OF THESE BONDING COMPOUNDS INCLUDE THE EPOXIES, POLYURETHANES, AND SILICONE ADHESIVES.

SCENE 22.

tape 736, 23:08:31-23:08:55

cleaning of plastics before bonding

NARRATION (VO) :

SURFACE CLEANLINESS IS CRITICAL FOR OPTIMUM BONDING PERFORMANCE. ALL GREASE, MOLD RELEASE AND OTHER CONTAMINANTS MUST BE REMOVED FROM THE CONTACT SURFACES, OR JOINT REGION, BEFORE BONDING.

SCENE 23.

tape 718, 04:02:33-04:02:40

zoom out, joint of plastic parts being bonded together

tape 737, 00:02:03-00:02:24

ANI: bonded joint being pulled side to side for shear strength, out top and bottom for tensile strength, then in from top and bottom for compressive strength, show arrows too

CG, SUPER: Shear Strength

CG, SUPER: Tensile Strength

CG, SUPER: Compressive Strength

NARRATION (VO) :

CAREFUL ATTENTION MUST ALSO BE PAID TO JOINT DESIGN WHEN BONDING TOGETHER PLASTIC COMPONENTS. JOINT SURFACES THAT COMBINE SHEAR STRENGTH..., TENSILE STRENGTH..., AND COMPRESSIVE STRENGTH ARE PREFERRED.

SCENE 24.

tape 737, 00:03:44-00:03:53

ANI: lap joints

CG, SUPER: Lap Joints

tape 737, 00:02:48-00:02:55

ANI: strap joints

CG, SUPER: Strap Joints

tape 737, 00:03:01-00:03:08

ANI: butt joints

CG, SUPER: Butt Joints

tape 737, 00:03:14-00:03:22

ANI: tongue-and-groove joints

CG, SUPER: Tongue-&-Groove Joints

tape 737, 00:03:27-00:03:34

NARRATION (VO) :

TYPICAL JOINT DESIGNS INCLUDE: LAP JOINTS..., STRAP JOINTS..., BUTT JOINTS..., TONGUE-AND-GROOVE JOINTS..., AND SCARF JOINTS.

ANI: scarf joints
CG, SUPER: Scarf Joints

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SCENE 25.
CG, SUPER: Welding
tape 626, 06:07:22-06:07:43
zoom out, ultrasonically welding
plastic parts together

NARRATION (VO):

WELDING IS THE JOINING, OR COALESCENCE, OF
THERMOPLASTIC COMPONENTS TOGETHER. WELDING
PROVIDES AN EXCEPTIONAL JOINT THAT IS AS STRONG AS
THE SURROUNDING PLASTIC.

SCENE 26.
continue previous shot
tape 729, 17:16:12-17:16:19
hot-gas welding operation
tape 733, 20:14:00-20:14:06
vibration welding
tape 731, 18:14:50-18:14:53
spin welding operation, freeze
last frame
CG, SUPER: Spin Welding
tape 729, 17:05:42-17:05:49
hot-gas welding operation
CG, SUPER: Hot-Gas Welding
tape 725, 12:14:30-12:14:38
ultrasonic welding operation
CG, SUPER: Ultrasonic Welding
tape 731, 18:17:34-18:17:41
vibration welding operation
CG, SUPER: Vibration Welding
tape 732, 19:07:11-19:07:23
staking operation
CG, SUPER: Staking

NARRATION (VO):

THERE ARE VARIOUS TYPES OF WELDING PROCESSES USED
TO ASSEMBLE PLASTIC COMPONENTS TOGETHER, WITH THE
PRIMARY TYPES INCLUDING:
SPIN WELDING...,
HOT-GAS WELDING...,
ULTRASONIC WELDING...,
VIBRATION WELDING...,
AND STAKING.

--- TOUCH BLACK ---

SCENE 27.
CG, SUPER: Spin Welding
tape 731, 18:15:22-18:15:27
spin welding operation, freeze
last frame
tape 733, 20:06:04-20:06:38
zoom in, spin welding operation

NARRATION (VO):

SPIN WELDING IS A RAPID METHOD OF WELDING PLASTIC
COMPONENTS, TYPICALLY IN BUTT JOINTS, BY
FRICTIONAL HEAT. FRICTIONAL HEAT IS GENERATED BY
RAPIDLY SPINNING A WORKPIECE AT UP TO 5,000
REVOLUTIONS PER MINUTE AGAINST A STATIONARY
WORKPIECE. AS THE CONTACT SURFACES HEAT, THEY
MELT, FUSING THE TWO PLASTIC WORKPIECES TOGETHER.

SCENE 28.
CG, SUPER: Hot Gas Welding

NARRATION (VO):

tape 729, 17:17:37-17:18:15
zoom out, hot-gas welding
operation

HOT-GAS WELDING FUSES PLASTIC COMPONENTS TOGETHER USING A WELDING ROD COMPOSED OF THE SAME PLASTIC AS THE MATERIAL TO BE JOINED. HOT GAS IS CREATED BY PASSING EITHER AIR OR INERT GAS OVER HEATING ELEMENTS WITHIN THE WELDING GUN. AS THIS HEAT EXITS THE GUN, IT MELTS THE PLASTIC WELDING ROD, AS WELL AS THE PLASTIC TO BE JOINED, FUSING THE MATERIALS.

SCENE 29.
tape 729, 17:06:43-17:07:00
med, hot-gas welding operation

NARRATION (VO) :

MATERIALS MOST SUCCESSFULLY JOINED USING HOT-GAS WELDING INCLUDE RIGID POLYVINYL CHLORIDE OR 'PVC', 'ABS', ACRYLICS, POLYETHYLENE, POLYPROPYLENE, POLYSTYRENE, AND POLYCARBONATE.

SCENE 30.
CG, SUPER: Ultrasonic Welding
tape 726, 13:18:08-13:18:33
zoom in, ultrasonic welding
operation

NARRATION (VO) :

ULTRASONIC WELDING USES HIGH-FREQUENCY, LONGITUDINAL MECHANICAL VIBRATIONS TO WELD TOGETHER THERMOPLASTIC COMPONENTS, OR PLASTIC-TO-METAL COMPONENTS.

SCENE 31.
continue previous shot

NARRATION (VO) :

THESE MECHANICAL VIBRATIONS ARE IN THE RANGE OF 15,000 TO 40,000 CYCLES PER SECOND, OR 15 TO 40 KILOHERTZ. THE VIBRATIONS CAUSE INTERMOLECULAR AND SURFACE FRICTIONAL HEAT, THAT QUICKLY MELTS AND FUSES THE COMPONENTS.

SCENE 32.
tape 731, 18:03:02-18:03:20
wide, ultrasonic welding
operation, zoom in to power
supply
CG, SUPER: Power Supply

NARRATION (VO) :

THE PRIMARY ELEMENTS OF AN ULTRASONIC WELDING SYSTEM INCLUDE:

tape 731, 18:07:21-18:07:44

tilt down open front of
ultrasonic welding machine
CG, SUPER: Converter
CG, SUPER: Booster
CG, SUPER: Horn

tape 731, 18:09:04-18:09:22
zoom in horn during ultrasonic
welding

THE POWER SUPPLY, WHICH RECEIVES ELECTRICAL POWER
AND AMPLIFIES IT TO 15 TO 40 KILOHERTZ,
THE CONVERTER, WHICH CONVERTS THE 15 TO 40
KILOHERTZ ELECTRICAL INPUT TO 15 TO 40 KILOHERTZ
MECHANICAL VIBRATORY OUTPUT...,
THE BOOSTER, WHICH INCREASES OR DECREASES THE
AMPLITUDE OF THE MECHANICAL VIBRATION...,
AND THE HORN, WHICH CONTACTS THE PARTS AND FOCUSES
THE MECHANICAL VIBRATIONS UNDER PRESSURE FOR
WELDING.

SCENE 33.

tape 725, 12:18:52-12:19:03
ultrasonic welding operation

NARRATION (VO) :

ULTRASONIC WELDING IS USED EXTENSIVELY THROUGHOUT
THE PLASTICS INDUSTRY.

SCENE 34.

CG, SUPER: Vibration Welding
tape 733, 20:16:28-20:16:38
c.u. vibration welding

NARRATION (VO) :

VIBRATION WELDING USES FRICTIONAL HEAT GENERATED
BY VIBRATING A PART COMPONENT AGAINST A STATIONARY
MATING COMPONENT IN EITHER A LINEAR OR ORBITAL
MOTION TO WELD THEM TOGETHER.

SCENE 35.

tape 731, 18:24:16-18:24:32
med, part set up and vibration
welded

NARRATION (VO) :

THE FREQUENCY OF VIBRATION IS MUCH LOWER THAN WITH
ULTRASONIC WELDING, TYPICALLY 120 OR 240 HERTZ.

SCENE 36.

tape 733, 20:11:14-20:11:21
wide, part placed in machine,
vibration welding beginning, cut
to next shot
tape 733, 20:15:56-20:16:05
c.u. vibration welding in
progress, stopping

NARRATION (VO) :

AS THE PARTS ARE VIBRATED AGAINST EACH OTHER, A
MELT FILM IS FORMED. ONCE VIBRATION STOPS THE
PARTS ARE QUICKLY POSITIONED UNDER PRESSURE. THE
MELT FILM IS THEN ALLOWED TO SOLIDIFY, CREATING
THE WELD.

SCENE 37.

CG, SUPER: Staking

tape 732, 19:09:32-19:09:48

c.u. plastic to plastic staking operation

tape 732, 19:06:14-19:06:26

zoom out, heat staking operation

NARRATION (VO) :

STAKING IS A METHOD OF APPLYING ENERGY AGAINST A THERMOPLASTIC PROTRUSION THAT IS PASSED THROUGH A TO-BE-ASSEMBLED COMPONENT. THE ENERGY HEATS AND SOFTENS THE PROTRUSION, WHICH IS THEN REFORMED INTO A HEAD, MECHANICALLY RETAINING THE COMPONENT. STAKING IS USED TO ASSEMBLE THERMOPLASTIC COMPONENTS TO OTHER PLASTIC, METAL OR COMPOSITE MATERIALS.

SCENE 38.

tape 732, 19:07:48-19:07:57

zoom in, heat staking operation

CG, SUPER: Heat Staking

tape 733, 20:18:06-20:18:08

ultrasonic staking operation, freeze last frame

CG, SUPER: Ultrasonic Staking

NARRATION (VO) :

STAKING IS PERFORMED USING TWO PRIMARY METHODS: HEAT STAKING..., AND ULTRASONIC STAKING.

SCENE 39.

CG, SUPER: Heat Staking

tape 732, 19:10:23-19:10:34

heat staking operation

NARRATION (VO) :

WITH HEAT STAKING THE ENERGY IS APPLIED USING A HEATED TOOL CALLED A 'PROBE' THAT IMPACTS AND MELTS THE PROTRUSION, FORMING THE HEAD AND ASSEMBLING THE COMPONENTS.

SCENE 40.

CG, SUPER: Ultrasonic Staking

tape 733, 20:18:13-20:18:30

zoom out, plastic to plastic ultrasonic staking operation

NARRATION (VO) :

WITH ULTRASONIC STAKING, THE ENERGY IS APPLIED USING AN ULTRASONIC TOOL OR HORN, WHICH CAUSES FRICTION AND RESULTANT MELTING OF THE PROTRUSION FOR ASSEMBLY.

--- FADE TO BLACK ---