FUNDAMENTAL MANUFACTURING PROCESSES

Composite Materials & Manufacturing

SCENE 1.
CG: FBI warning
white text centered on black to blue gradient

WARNING

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SCENE 2.
CG: disclaimer
white text centered on black to blue gradient

Always read the operating manual and safety information provided by the manufacturer before operating any composite materials or manufacturing equipment.

Make sure all machine guards are in place, and follow all safety procedures when working with or near composite materials or manufacturing equipment.

SCENE 3.
CG: CMA screen A
white text centered on black to blue gradient
tape 712, 18:01:10-18:01:50
GRAPHIC: CMA logo

This program was produced using the technical resources of the Composites Manufacturing Association of the Society of Manufacturing Engineers.

SCENE 4.
continue CMA logo graphic
CG: CMA screen B
white text centered on black to blue gradient

For more information on composites, please visit our website at:

www.sme.org/cma

SCENE 5.
tape 40, 01:00:00-01:00:12
SME logo, with music
CG, SUPER: www.sme.org

SCENE 6.
tape 25, 01:01:00-01:01:45
fundamental series open, with music
tape 713, 01:00:26-01:05:38
peter carey narration

MUSIC UP AND UNDER

NARRATION (VO):

THE FUNDAMENTAL MANUFACTURING PROCESSES VIDEO

	SERIES, EXAMINING THE TOOLS AND TECHNIQUES OF PRECISION MANUFACTURING.
SCENE 7. program title: CG: Composite Materials & Manufacturing white text centered on black	**NARRATION (VO):** THIS PROGRAM IS AN INTRODUCTION TO COMPOSITE MATERIALS AND MANUFACTURING.
SCENE 8. **tape 692, 08:10:21-08:10:35** zoom out, part being produced using fiber-reinforced polymers	**NARRATION (VO):** COMPOSITES ARE MADE-UP OF AT LEAST TWO DISTINCT INTENDED MATERIALS, WHICH TOGETHER IMPROVE PRODUCT PERFORMANCE AND/OR LOWER MANUFACTURING COSTS.
SCENE 9. continue previous shot **tape 635, 15:01:15-15:01:45** parts coming out of plating solution **tape 379, 19:00:56-19:01:02** clad metal part **tape 225, 01:03:41-01:03:49** coated parts coming out of furnace	**NARRATION (VO):** MANY MATERIALS ROUTINELY DESIGNATED BY OTHER TERMS ARE ALSO CONSIDERED COMPOSITES, INCLUDING: PLATED..., CLAD..., OR COATED METALS.
SCENE 10. **tape 695, 11:10:03-11:10:12** wide, matrix and reinforcement material together CG, SUPER: Matrix **tape 695, 11:02:39-11:02:50** c.u. matrix material being mixed CG, SUPER: Reinforcement **tape 695, 11:12:39-11:12:45** reinforcement material	**NARRATION (VO):** THE TERM COMPOSITE, HOWEVER, HAS COME TO MEAN A MATERIAL CONSISTING OF A MATRIX, OR BASE MATERIAL..., AND A REINFORCEMENT MATERIAL.
SCENE 11. CG, SUPER: Matrix **tape 694, 10:09:03-10:09:09** matrix material sprayed onto reinforcement **tape 694, 10:06:37-10:06:45** matrix/reinforcement material used in lay-up **tape 698, 02:17:18-02:17:26** zoom in, matrix material put under load **tape 711, 00:00:50-00:00:59** ANI: part matrix transferring	**NARRATION (VO):** THE MATRIX FUNCTIONS AS A BINDER FOR THE REINFORCEMENT, AND CONTROLS THE PHYSICAL SHAPE AND DIMENSIONS OF THE PART. THE PRIMARY PURPOSE OF THE MATRIX IS TO TRANSFER THE LOAD, OR STRESS, APPLIED TO THE COMPOSITE TO THE REINFORCEMENT. THE MATRIX

load exerted upon it to the reinforcement
tape 712, 19:02:38-19:02:52
zoom out, matrix protecting reinforcement from adverse environmental effects

ALSO PROTECTS THE REINFORCEMENT FROM ADVERSE ENVIRONMENTAL EFFECTS.

SCENE 12.
CG, SUPER: Reinforcement
tape 700, 13:23:16-13:23:34
pan, reinforcement fibers being added to composite lay-up
tape 701, 14:02:01-14:02:07
composite reinforcement particles being used

NARRATION (VO):

THE REINFORCEMENT'S FUNCTION IS TO IMPROVE THE MECHANICAL PROPERTIES OF THE COMPOSITE, AND IS TYPICALLY THE MAIN LOAD-BEARING ELEMENT.

REINFORCEMENT IS USUALLY IN THE FORM OF FIBERS..., OR PARTICLES.

SCENE 13.
tape 696, 12:08:14-12:08:40
composite filament winding operation
CG, SUPER: Polymers
Metals
Ceramics
Carbon
tape 688, 04:04:27-04:04:50
zoom in, fiber-reinforced polymer operation

NARRATION (VO):

BOTH MATRIX AND REINFORCEMENT MATERIALS CAN BE

POLYMERS,

METALS,

CERAMICS,

OR CARBON.

THE FOCUS OF THIS PROGRAM IS ON THE MOST WIDELY USED COMPOSITE MATERIALS, FIBER-REINFORCED THERMOSETTING POLYMERS.

--- TOUCH BLACK ---

SCENE 14.
tape 693, 09:10:23-09:10:32
zoom out, part curing
tape 695, 11:03:29-11:03:45
med, matrix material being poured
CG, SUPER: Polyester
Epoxy
Bismaleimide
Phenolic
Polyimide

NARRATION (VO):

THERMOSETS REQUIRE CURING TO DEVELOP THEIR FULL MECHANICAL PROPERTIES. ONCE CURED, OR SET, THERMOSETS CANNOT BE REPROCESSED. SOME OF THE PRIMARY THERMOSET MATRIX MATERIALS ARE:

POLYESTER,

EPOXY,

BISMALEIMIDE,

PHENOLIC,

AND POLYIMIDE.

SCENE 15.
CG, SUPER: Polyester
tape 693, 09:28:12-09:28:30
pan, polyester composite parts being manufactured

NARRATION (VO):

THE POLYESTER MATRIX MATERIALS ARE THE LEAST STRONG AND THE LEAST HEAT AND WEATHER RESISTANT. WITHIN THESE LIMITS, HOWEVER, THEY CAN BE QUITE VERSATILE. THEY ARE ALSO THE LEAST COSTLY, THUS ARE USED EXTENSIVELY IN COMMERCIAL APPLICATIONS.

SCENE 16.
CG, SUPER: Epoxy
Bismaleimide
Phenolic
Polyimide
tape 691, 07:04:32-07:04:52
advanced composites part being manufactured

NARRATION (VO):

THE EPOXY, BISMALEIMIDE, PHENOLIC, AND POLYIMIDE COMPOSITES PROVIDE SUPERIOR MECHANICAL PERFORMANCE AND HEAT RESISTANCE.

SCENE 17.
tape 697, 01:13:30-01:13:46
pan, fibers in pultrusion operation
CG, SUPER: Mechanical Properties
Strength
Rigidity

NARRATION (VO):

REINFORCEMENT MATERIAL CAN SIGNIFICANTLY IMPROVE MECHANICAL PROPERTIES, SUCH AS STRENGTH AND RIGIDITY. THESE IMPROVEMENTS ARE ESPECIALLY PRONOUNCED WHEN LONG ORIENTED FIBERS ARE USED.

SCENE 18.
tape 700, 13:04:15-13:04:34
composites manufacturing
CG, SUPER: Physical Properties
Density/Weight Per Unit Volume
Thermal Expansion
Electrical Conductivity
Thermal Conductivity
Vibration Dampening

NARRATION (VO):

PHYSICAL PROPERTIES, SUCH AS DENSITY, OR WEIGHT PER UNIT VOLUME, THERMAL EXPANSION, ELECTRICAL CONDUCTIVITY, THERMAL CONDUCTIVITY, AND VIBRATION DAMPENING ALSO ARE INFLUENCED BY THE REINFORCEMENT.

SCENE 19.
tape 688, 04:18:50-04:18:59
zoom out, e-glass being used in composite
CG, SUPER: E-Glass

NARRATION (VO):

SOME OF THE MOST COMMONLY USED FIBERS ARE:

tape 712, 20:00:40-20:00:50 aramid material CG, SUPER: Aramid **tape 689, 05:21:21-05:21:29** zoom out, carbon being used in composite CG, SUPER: Carbon/Graphite	E-GLASS..., ARAMID..., AND CARBON, WHICH IS ALSO REFERRED TO AS GRAPHITE.
SCENE 20. **tape 686, 02:01:56-02:02:09** fabric being cut **tape 703, 17:03:36-17:03:42** chopped strand **tape 700, 13:13:57-13:14:08** pan, tow being used **tape 712, 20:01:10-20:01:20** aramid fabric **tape 712, 20:01:40-20:01:50** aramid fabric 2 **tape 705, 20:33:43-20:33:53** freeze first frame, c.u. pan of tape fibers being used **tape 709, 01:23:55-01:24:25** foam preforms with reinforcement added **tape 712, 18:02:10-18:02:20** chopped fiber and resin preform	**NARRATION (VO):** THESE FIBERS COME IN MANY FORMS, WITH SOME OF THE MOST COMMON BEING: STRAND..., TOW, WHICH IS A CONTINUOUS BUNDLE OF UNTWISTED FILAMENTS..., FABRIC, WHICH IS A WOVEN CONSTRUCTION OF INTERLACED FIBERS, FILAMENTS OR YARNS IN SPECIFIC PATTERNS OR WEAVES..., PRE-IMPREGNATED, OR 'PREPREG' TAPE, WHICH IS A FLAT, THIN, NARROW AND LONG GROUPING OF PARALLEL FILAMENTS HELD TOGETHER BY THE MATRIX MATERIAL..., AND PREFORMS, WHICH ARE REINFORCEMENTS FORMED TO VARIOUS SHAPE PRIOR TO USE.
SCENE 21. **tape 687, 03:27:15-03:27:28** several kinds of reinforcement fibers being used in a single part	**NARRATION (VO):** SEVERAL DIFFERENT FIBER MATERIALS CAN BE USED IN THE PRODUCTION OF A SINGLE PART.
SCENE 22. **tape 385, 01:18:07-01:18:12** single fiber direction in part **tape 385, 01:16:16-01:16:25** fiber direction varied angularly through part **tape 692, 08:10:16-08:10:23** fiber direction varied randomly through part	**NARRATION (VO):** FIBER DIRECTION CAN BE THE SAME..., VARIED ANGULARLY..., OR VARIED RANDOMLY THROUGH PART THICKNESS.
SCENE 23. **tape 700, 13:29:01-13:29:05**	**NARRATION (VO):**

pan, large manufactured composite part
tape 692, 08:13:27-08:13:33
composite part being manufactured
tape 699, 03:07:06:00
still, manufactured composite part
tape 699, 03:05:55-03:06:00
manufactured composite part
tape 688, 04:05:11-04:05:28
zoom out, composite part being sprayed-up
tape 710, 06:03:02-06:03:10
jet fighter taking off
tape 363, 01:56:55-01:56:59
space shuttle launch
tape 712, 18:02:40-18:02:50
still, boat on water
tape 712, 19:07:50-19:07:58
snow boards
tape 712, 19:04:25-19:04:32
pan of corvette
tape 712, 20:02:10-20:02:20
composite medical device
tape 712, 18:03:40-18:03:50
still, electrical cable tray
tape 712, 18:03:10-18:03:20
still, construction site

FIBERS AND MATRIXES ARE COMBINED TO FORM A MULTITUDE OF COMPOSITE PRODUCTS, OFTEN AT A SIGNIFICANT WEIGHT SAVING AND SOMETIMES COSTS SAVING RELATIVE TO TRADITIONAL MATERIALS. FOR THESE REASONS, MANY MAJOR INDUSTRIES USE COMPOSITE MATERIALS, INCLUDING:

AIRCRAFT, ESPECIALLY IN MILITARY APPLICATIONS...,

AEROSPACE...,

MARINE...,

SPORTS EQUIPMENT...,

AUTOMOTIVE...,

MEDICAL...,

ELECTRICAL...,

AND CONSTRUCTION.

--- FADE TO BLACK ---

SCENE 24.
CG: Composite Manufacturing Processes
white text centered on black
tape 713, 01:05:41-01:18:57
peter carey narration

SCENE 25.
tape 700, 13:08:47-13:08:55
filament winding operation
tape 686, 02:04:55-02:05:05
spray-up of composite
tape 697, 01:11:58-01:12:04
part coming out of pultrusion operation
tape 694, 10:10:23-10:10:33
hand lay-up operation
CG, SUPER: Manual Lay-Up
tape 705, 20:12:53-20:13:02
automated lay-up operation
CG, SUPER: Automated Lay-Up
tape 694, 10:00:40-10:00:47
spray-up operation
CG, SUPER: Spray-Up
tape 703, 17:00:55-17:01:05

NARRATION (VO):

THERE ARE NUMEROUS METHODS OF PRODUCING PARTS FROM FIBER-REINFORCED THERMOSET POLYMERS, WITH THE PRIMARY TYPES BEING:

MANUAL LAY-UP...,

AUTOMATED LAY-UP...,

SPRAY-UP...,

FILAMENT WINDING...,

PULTRUSION...,

filament winding operation
CG, SUPER: Filament Winding
tape 697, 01:01:17-01:01:25
pultrusion operation
CG, SUPER: Pultrusion
tape 687, 03:22:48-03:22:58
resin transfer molding operation
CG, SUPER: Resin Transfer
Molding

AND RESIN TRANSFER MOLDING.

--- TOUCH BLACK ---

SCENE 26.
CG, SUPER: Manual Lay-Up
tape 685, 01:01:07-01:01:17
hand lay-up of composite part
tape 692, 08:15:43-08:15:49
reinforcement being hand cut
tape 693, 09:17:37-09:17:53
reinforcement being cut up for lay-up
CG, SUPER: Knives
Scissors
Disk Cutters
Power Shears
Rotary Power Cutters
Saws
Lasers

NARRATION (VO):

MANUAL LAY-UP IS A WIDELY USED METHOD OF MANUFACTURING A WIDE RANGE OF COMPOSITE PARTS AND COMPONENTS. THE PROCESS BEGINS WITH CUTTING THE REINFORCEMENT MATERIAL TO SIZE. THIS MAY BE PERFORMED USING KNIVES, SCISSORS, DISK CUTTERS, POWER SHEARS, ROTARY POWER CUTTERS, SAWS, OR LASERS.

SCENE 27.
tape 692, 08:05:42-08:05:56
mold being coated with a release agent
tape 689, 05:03:33-05:03:41
metal mold
tape 693, 09:16:07-09:16:19
pan, composite material molds
CG, SUPER: Steel
Aluminum
Nickel
Copper
Polymer-Matrix
Composites

NARRATION (VO):

A MOLD HAVING THE DESIRED PART SHAPE IS THEN COATED WITH A RELEASE AGENT TO PERMIT SUBSEQUENT PART RELEASE. COMPOSITE MANUFACTURING MOLDS ARE COMMONLY MADE OF STEEL, ALUMINUM, NICKEL, COPPER OR POLYMER-MATRIX COMPOSITES.

SCENE 28.
tape 692, 08:07:24-08:07:36
gel-coat being applied to large mold
tape 685, 01:21:36-01:21:48
gel-coat being applied to small mold

NARRATION (VO):

ONCE COATED WITH A RELEASE AGENT, A LAYER OF RESIN CALLED A GEL-COAT, MAY BE APPLIED TO THE MOLD, AND ALLOWED TO CURE TO A TACKY STATE.

SCENE 29.
continue previous shot
tape 687, 03:07:38-03:08:06
resin applied impregnating the

NARRATION (VO):

AS THE GEL-COAT CURES, THE REINFORCEMENT MATERIAL

reinforcement

IS PREPARED FOR APPLICATION BY IMPREGNATION WITH WET RESIN, OR MATRIX MATERIAL.

SCENE 30.
tape 686, 02:24:48-02:25:08
reinforcement material on the coated mold surface
tape 686, 02:25:54-02:26:03
reinforcement material on the coated mold surface being hand-rolled

NARRATION (VO):

THE IMPREGNATED REINFORCEMENT MATERIAL IS THEN PLACED ON THE COATED MOLD SURFACE AND HAND-ROLLED FOR UNIFORM DISTRIBUTION AND REMOVAL OF ENTRAPPED AIR.

SCENE 31.
tape 688, 04:11:49-04:12:02
zoom out, additional reinforcement and resin being applied

NARRATION (VO):

MORE REINFORCEMENT MATERIAL AND RESIN ARE APPLIED AS NEEDED IN THIS MANNER UNTIL REQUIRED PART THICKNESS HAS BEEN BUILT-UP.

SCENE 32.
CG, SUPER: Wet Lay-Up
tape 687, 03:10:07-03:10:35
reinforcement material on the coated mold surface being hand-rolled

NARRATION (VO):

THIS SO-CALLED WET LAY-UP METHOD CAN BE USED WITH NEARLY ALL REINFORCEMENT MATERIALS, AND IS WIDELY USED TO PRODUCE GLASS-REINFORCED POLYESTER PRODUCTS AND SOMETIMES GLASS-REINFORCED EPOXY PRODUCTS. WET LAY-UP IS ALSO USED FOR MAKING COMPOSITE MOLDS.

SCENE 33.
CG, SUPER: Prepreg
tape 691, 07:05:16-07:05:35
hand lay-up using prepreg material
tape 691, 07:25:08-07:25:18
prepreg being pulled from refrigerated storage

NARRATION (VO):

LAY-UP CAN ALSO BE PERFORMED USING PREPREG MATERIAL. USE OF PREPREG ELIMINATES SEPARATE HANDLING OF THE REINFORCEMENT AND RESIN. PREPREG REDUCES RESIN CONSUMPTION, AND CAN IMPROVE PART QUALITY BY PROVIDING MORE CONSISTENT CONTROL OF REINFORCEMENT AND RESIN CONTENTS. HOWEVER, PREPREG MUST BE KEPT IN REFRIGERATED STORAGE UNTIL USE TIME TO PREVENT PRE-CURING.

--- TOUCH BLACK ---

SCENE 34.
CG, SUPER: Automated Lay-Up
tape 708, 01:05:29-01:05:47
continuous tape-laying machine, laying tape
tape 705, 20:20:28-20:20:50
fiber placement machine laying up part

NARRATION (VO):

THE AUTOMATED LAY-UP OF PREPREG MATERIAL IS USED PRIMARILY IN THE AEROSPACE INDUSTRY, AND IS ACCOMPLISHED USING TAPE-LAYING MACHINES..., AND FIBER PLACEMENT MACHINES HAVING COMPUTER NUMERICAL CONTROL.

SCENE 35.
tape 708, 01:01:14-01:01:21
automatic tape laying machine laying tape running on 'y' axis
tape 708, 01:01:59-01:02:08
automatic tape laying machine laying tape running on 'x' axis, head moving at end
tape 708, 01:06:34-01:06:57
med, tape laying machine laying tape with retrieval spool

NARRATION (VO):

AUTOMATIC TAPE LAYING MACHINES ARE PROGRAMMABLE GANTRY-STYLE MACHINES HAVING A 'Y'-AXIS CROSSMEMBER..., SLIDING ON 'X'-AXIS WAYS..., THAT SUPPORTS A MULTIAXIS TAPE-LAYING HEAD.

SCENE 36.
continue previous shot
tape 708, 01:04:36-01:05:10
c.u. head laying tape down

NARRATION (VO):

THE HEAD HAS A SPOOL OF PAPER-BACKED UNIDIRECTIONALLY REINFORCED TAPE AND CUTTERS TO CUT THE TAPE WITHOUT CUTTING THE PAPER, WHICH IS RETRIEVED ON ANOTHER SPOOL. THE HEAD ALSO CAN HEAT THE TAPE IF NECESSARY TO DEVELOP TACKINESS.

SCENE 37.
continue previous shot

NARRATION (VO):

THE HEAD DEPOSITS ROWS OF TAPE, BUTTING EACH ROW AGAINST THE EDGE OF THE PREVIOUS ONE..., AT THE END OF EACH ROW, THE HEAD CUTS THE TAPE AND MOVES INTO POSITION TO DEPOSIT THE NEXT ROW.

SCENE 38.
tape 708, 01:08:36-01:08:59
large part being tape rolled automatically

NARRATION (VO):

THERE IS ESSENTIALLY NO LIMIT TO THE SIZE OF

WORKPIECES THAT CAN BE TAPE-ROLLED, BUT THE SHAPE OF THE WORKPIECE HAS TO BE RELATIVELY FLAT TO BUTT EACH SUCCESSIVE ROW WITHOUT GAPS, OVERLAPS OR WRINKLES.

SCENE 39.
tape 705, 20:06:12-20:06:32
fiber-placement machine, head turning
tape 705, 20:25:59-20:26:16
fiber-placement machines dispensing individual strands or tows of material

NARRATION (VO):

TO OVERCOME THE LIMITATIONS OF TAPE LAYERS, AUTOMATIC, MULTIAXIS, FIBER-PLACEMENT MACHINES WERE INTRODUCED. THE MACHINES AUTOMATICALLY CONTROL DISPENSING NUMEROUS INDIVIDUAL NARROW TAPES OF MATERIAL, WHICH ARE COLLIMATED AS THEY ARE LAID ON THE MOLD SURFACES.

SCENE 40.
continue previous shot
tape 708, 01:16:29-01:16:39
tows being dispensed on curved mold

NARRATION (VO):

EACH TAPE CAN BE INDEPENDENTLY DISPENSED, CLAMPED, CUT, AND RESTARTED DURING FIBER PLACEMENT. AS A RESULT, PARTS OF COMPOUND CURVATURE WITH CONVEX AND CONCAVE SURFACES AND SMALL BEND RADII CAN BE PRODUCED.

--- TOUCH BLACK ---

SCENE 41.
CG, SUPER: Spray-Up
tape 686, 02:13:30-02:13:57
zoom out, spray-up using special spray gun

NARRATION (VO):

WITH THE SPRAY-UP METHOD, RESIN IS SPRAYED ONTO A PREPARED MOLD SURFACE USING A SPECIALIZED SPRAY-UP GUN.

SCENE 42.
continue previous shot
tape 685, 01:07:07-01:07:17
spray-up using woven roving

NARRATION (VO):

THE GUN SIMULTANEOUSLY CHOPS CONTINUOUS REINFORCEMENT INTO SUITABLE LENGTHS AS IT SPRAYS THE RESIN. FIBER REINFORCEMENT IS MAINLY CHOPPED E-GLASS, AND IT MAY BE ACCOMPANIED BY ADDITIONAL

REINFORCEMENT SUCH AS WOVEN ROVING.

SCENE 43.
tape 686, 02:04:39-02:04:52
zoom out, spray-up operation
tape 692, 08:09:08-08:09:16
spray-up gun used in spray up

NARRATION (VO):

SEVERAL STYLES OF GUNS ARE AVAILABLE. THE RESIN CAN BE MIXED EXTERNALLY, OR INTERNALLY WITHIN THE GUN CAVITY.

SCENE 44.
tape 692, 08:02:23-08:02:40
automated use of spray-up guns

NARRATION (VO):

SPRAY-UP GUNS CAN BE USED IN AUTOMATED SYSTEMS AND, CONSEQUENTLY, ALLOW HIGHER PRODUCTIVITY THAN MANUAL SPRAY-UP.

--- TOUCH BLACK ---

SCENE 45.
tape 687, 03:07:23-03:07:36
reverse pan, composite parts curing at room temperature
tape 692, 08:20:10-08:20:18
composite parts curing in room with heaters
tape 702, 16:14:38-16:14:50
composite parts being placed in heated-platen press for curing
tape 703, 17:16:27-17:16:46
cured composite parts coming out of oven
tape 706, 10:11:42-10:11:46
composite parts being placed in autoclave for curing

NARRATION (VO):

AFTER LAY-UP, COMPOSITE PARTS MAY BE ALLOWED TO CURE AT ROOM TEMPERATURE...,
OR WITH OPEN AIR HEAT ASSIST.
COMPOSITE PARTS ARE ALSO COMMONLY CONSOLIDATED AND CURED IN HEATED-PLATEN PRESSES...,
OVENS...,
OR AUTOCLAVES.

SCENE 46.
tape 693, 09:10:05-09:10:25
zoom out, composite parts curing in room with heaters
tape 703, 17:08:00-17:08:10
zoom in, parts pulled out of heated-platen press
tape 707, 10:03:28-10:03:34
parts going into autoclave

NARRATION (VO):

CURING CYCLES FOR COMPOSITES CAN BE LENGTHY, RANGING FROM AN HOUR, TO HALF A DAY OR LONGER. THE PROCESS IS TYPICALLY FASTER IN PRESSES THAN IN OVENS OR AUTOCLAVES, BUT OVENS AND AUTOCLAVES CAN ACCOMMODATE MUCH LARGER PARTS OR MANY SMALL ONES.

SCENE 47.
CG, SUPER: Vacuum Bag Molding
tape 691, 07:19:18-07:19:26
vacuum bag molding operation

NARRATION (VO):

LAY-UPS MAY ALSO BE CONSOLIDATED AND CURED USING

VACUUM BAG MOLDING.

SCENE 48.
tape 691, 07:17:23-07:17:34
vacuum bag molding operation, film sealed around mold
tape 691, 07:17:45-07:17:57
air valve added to plastic film

NARRATION (VO):

IN VACUUM BAG MOLDING, A NON-ADHERING PLASTIC FILM, TYPICALLY POLYESTER, IS SEALED AROUND THE MOLD PLATE AND LAY-UP MATERIAL...,

AN AIR VALVE OR VALVES IS THEN ADDED TO THE PLASTIC FILM FOR VACUUM CONNECTIONS.

SCENE 49.
tape 691, 07:19:59-07:20:19
vacuum created, flattening the bag against the reinforcement fibers

NARRATION (VO):

ONCE READY, A VACUUM IS SLOWLY CREATED UNDER THE BAG FORMED BY THE FILM. THIS VACUUM FORCES THE BAG AGAINST THE LAY-UP, DRAWING OUT ENTRAPPED AIR AND ELIMINATING VOIDS. ADDITIONALLY, IT ALSO DRAWS OUT EXCESS RESIN.

SCENE 50.
tape 694, 10:02:47-10:02:57
large vacuum mold curing at room temperature
tape 691, 07:23:12-07:23:26
vacuum mold transferred to an oven for curing

NARRATION (VO):

ONCE FULL VACUUM IS APPLIED, THE MOLD IS ALLOWED TO CURE AT ROOM TEMPERATURE...,

OR TRANSFERRED TO AN OVEN OR AUTOCLAVE FOR CURING.

VACUUM IS USUALLY MAINTAINED DURING THE ENTIRE HEATING AND COOLING CYCLE.

SCENE 51.
tape 694, 10:03:32-10:03:44
zoom out, large vacuum mold part

NARRATION (VO):

VACUUM BAG MOLDING IS EFFECTIVE IN PRODUCING RELATIVELY LARGE AND COMPLEX SHAPED PARTS, INCLUDING THOSE HAVING COMPOUND CONTOURS.

--- TOUCH BLACK ---

SCENE 52.
CG, SUPER: Filament Winding
tape 695, 11:17:01-11:17:18
filament winding operation
tape 696, 12:03:48-12:03:53

NARRATION (VO):

FILAMENT WINDING INVOLVES WRAPPING A NARROW FIBER

mandrel being removed from filament wound pipe

TOW OR BAND OF TOWS OF RESIN-IMPREGNATED FIBER AROUND A MANDREL OF THE SHAPE TO BE PRODUCED..., WHEN THE MANDREL IS REMOVED, A HOLLOW SHAPE IS THE RESULT.

SCENE 53.
tape 700, 13:17:35-13:18:00
wide, filament winding operation
CG, SUPER: Pipes, Tubes & Fittings
Springs
Cylindrical, Oblong & Spherical Pressure Vessels
Storage Tanks
Drive Shafts
Rocket Motor Cases
Helicopter Blades

NARRATION (VO):

USES FOR FILAMENT WINDING INCLUDE PIPES, TUBES AND FITTINGS; SPRINGS; CYLINDRICAL, OBLONG AND SPHERICAL PRESSURE VESSELS; STORAGE TANKS; DRIVE SHAFTS; ROCKET MOTOR CASES; AND HELICOPTER BLADES.

SCENE 54.
tape 700, 13:11:52-13:12:08
wet winding operation
CG, SUPER: Wet Winding
tape 707, 10:04:23-10:04:33
dry winding operation
CG, SUPER: Dry Winding

NARRATION (VO):

FILAMENT WINDING CAN USE EITHER WET OR DRY MATERIAL. IN 'WET WINDING', THE RESIN IS APPLIED AT THE TIME OF WINDING BY DRAWING THE MATERIAL THROUGH A RESIN BATH. IN 'DRY WINDING' PREPREG MATERIAL IS USED.

SCENE 55.
tape 702, 16:19:42-16:19:53
filament winding operation using hoop winding technique
CG, SUPER: Hoop Winding
tape 700, 13:09:06-13:09:12
filament winding operation using helical winding technique
CG, SUPER: Helical Winding

NARRATION (VO):

THE TOW IS TYPICALLY APPLIED BY:

HOOP WINDING...,

OR HELICAL WINDING.

SCENE 56.
CG, SUPER: Hoop Winding
tape 702, 16:26:55-16:27:17
zoom in, hoop winding operation

NARRATION (VO):

IN HOOP WINDING, THE TOW PATH IS ALMOST PERPENDICULAR TO THE MANDREL AXIS. EACH MANDREL ROTATION ADVANCES THE MATERIAL-DELIVERY SUPPORTING CARRIAGE ONE BAND WIDTH, BUTTING THE EDGE OF ONE

BAND NEXT TO THE PREVIOUS BAND.

SCENE 57.
CG, SUPER: Helical Winding
tape 700, 13:27:47-13:28:12
wide, helical winding operation

NARRATION (VO):

IN HELICAL WINDING, MATERIAL IS DEPOSITED IN A HELICAL PATH IN ONE DIRECTION, THEN TURNS AROUND ON END AND RETURNS IN A HELICAL PATH IN THE OPPOSITE DIRECTION. THIS ROUTINE CONTINUES UNTIL PART THICKNESS HAS BEEN BUILT UP.

SCENE 58.
tape 385, 01:16:49-01:16:59
wide, filament winding operation
tape 385, 01:15:18-01:15:25
c.u., zoom out, filament winding operation using hoop and helical winding

NARRATION (VO):

TO PROVIDE THE DESIRED MECHANICAL PROPERTIES OF A PART, COMBINATIONS OF HOOP AND HELICAL WINDING CAN ALSO BE PERFORMED.

SCENE 59.
tape 702, 16:23:44-16:24:08
metal filament winding mandrel
CG, SUPER: Steel
Aluminum
Copper
Nonmetallics
CG, SUPER: Eutectic & Soluble Salts
Sand with Water-Soluble Polyvinyl Alcohol Binder
Low-Temperature-Melting Alloys
Plaster
Thermoplastic Foams

NARRATION (VO):

FILAMENT WINDING MANDRELS MAY BE MADE OF STEEL, ALUMINUM, COPPER, OR NONMETALLICS, AND DESIGNED TO COLLAPSE OR BE DISSOLVABLE FOR REMOVAL FROM THE PART AFTER CURING. DISSOLVABLE MATERIALS INCLUDE EUTECTIC AND SOLUBLE SALTS, SAND WITH WATER-SOLUBLE POLYVINYL ALCOHOL BINDER, LOW-TEMPERATURE-MELTING ALLOYS, PLASTER OR THERMOPLASTIC FOAMS.

--- TOUCH BLACK ---

SCENE 60.
CG, SUPER: Pultrusion
tape 698, 02:02:14-02:02:26
wide, pultrusion operation, pan to die
tape 698, 02:14:43-02:14:56
caterpillar system pulling pultrusion

NARRATION (VO):

PULTRUSION IS A CONTINUOUS PROCESS USED PRIMARILY TO PRODUCE LONG, STRAIGHT SHAPES OF CONSTANT CROSS-SECTION...,
THE PROCESS IS SIMILAR TO EXTRUSION, EXCEPT THAT THE MATERIAL IS PULLED, RATHER THAN PUSHED, THROUGH A DIE.

SCENE 61.
tape 697, 01:14:05-01:14:23
pan, pultrusion roving and mat transverse reinforcement
tape 697, 01:17:43-01:17:53
med, mat transverse reinforcement

NARRATION (VO):

PULTRUSIONS ARE PRODUCED USING CONTINUOUS REINFORCING FIBERS CALLED 'ROVING' THAT PROVIDE LONGITUDINAL REINFORCEMENT...,

TRANSVERSE REINFORCEMENT ALSO IS INCORPORATED IN THE PULTRUSION USING MAT OR CLOTH MATERIALS.

SCENE 62.
tape 697, 01:25:23-01:25:38
reinforcement being drawn through resin bath
tape 697, 01:23:36-01:23:44
surfacing material added to pultrusion, pan to preforming system
tape 697, 01:28:16-01:28:24
pan, preforming system to die
tape 698, 02:00:31-02:00:45
med, die with pultrusion coming out
tape 697, 01:08:05-01:08:13
pultrusion fabrication being saw-cut to length

NARRATION (VO):

THE REINFORCEMENT IS GENERALLY RESIN IMPREGNATED BY DRAWING IT THROUGH A RESIN WET-OUT STATION...,

A SURFACING MATERIAL IS TYPICALLY ADDED AFTERWARDS...,

THE SATURATED REINFORCEMENTS ARE THEN GENERALLY SHAPED WITHIN A GUIDING, OR PREFORMING, SYSTEM...,

AND SUBSEQUENTLY SHAPED,

AND CURED THROUGH A PREHEATED DIE OR SET OF DIES...,

ONCE CURED, THE PULTRUSION IS SAW-CUT TO LENGTH.

SCENE 63.
tape 697, 01:27:47-01:28:00
pan down, resin squeezed out at die, returning to the bath

NARRATION (VO):

MATERIAL WASTE FOR PULTRUSION IS LOW BECAUSE EXCESS RESIN IS SQUEEZED OFF THE FIBERS AND RETURNED TO THE WET-OUT STATION.

SCENE 64.
tape 697, 01:10:35-01:10:41
pultrusion operation producing hollow shape
tape 699, 03:05:11-03:05:17
pultrusion operation producing solid shape

NARRATION (VO):

PULTRUSIONS CAN BE HOLLOW...,

OR SOLID.

SCENE 65.
tape 712, 21:00:40-21:00:50
GRAPHIC: fixed pultrusion die
tape 712, 21:01:05-21:01:25

NARRATION (VO):

PULTRUSION DIES MAY BE FIXED, OR ONE MAY FLOAT,

GRAPHIC: floating pultrusion die
tape 698, 02:01:16-02:01:29
zoom out, pultrusion die producing hollow part

SUCH AS INTERNAL MANDRELS USED IN MAKING HOLLOW PARTS. THE PRESSURE APPLIED CAN BE HYDRAULIC OR MECHANICAL. ALTHOUGH PART CROSS-SECTION IS TYPICALLY CONSTANT, FLOATING MANDRELS CAN PERMIT SOME VARIATION.

SCENE 66.
tape 699, 03:05:41-03:05:47
solid pultrusion parts
tape 699, 03:05:54-03:06:04
pultrusion support parts
tape 699, 03:04:26-03:04:32
zoom out, pultrusion parts
CG, SUPER: Bar
Rod
Pipe
Tubing
Profiles
Ladder Rails & Rungs
Truck & Building Panels
Sheet & Panel Stiffeners
Supports

NARRATION (VO):

PULTRUSION APPLICATIONS INCLUDE BAR AND ROD, PIPE, TUBING, PROFILES, LADDER RAILS AND RUNGS, TRUCK AND BUILDING PANELS, SHEET AND PANEL STIFFENERS, AND SUPPORTS OF MANY KINDS.

--- TOUCH BLACK ---

SCENE 67.
CG, SUPER: Resin Transfer Molding
tape 703, 17:23:19-17:23:26
mold being closed
tape 704, 18:05:39-18:05:47
part coming out of resin transfer mold

NARRATION (VO):

RESIN TRANSFER MOLDING, OR 'RTM', IS AN EFFICIENT METHOD OF PRODUCING LARGE AND COMPLEX COMPOSITE PARTS AT FASTER RATES THAN BY OTHER COMPOSITE MANUFACTURING METHODS.

SCENE 68.
tape 704, 18:01:44-18:01:58
mold loaded with reinforcement material
tape 703, 17:24:18-17:24:28
mold halves clamped together
tape 703, 17:25:43-17:25:54
resin pumped into a hole at the base of the mold
tape 703, 17:26:43-17:26:55
zoom out, air vents at top of mold, resin spilling from these vents
tape 703, 17:27:38-17:27:45
fill hole being plugged
tape 704, 18:01:09-18:01:16

NARRATION (VO):

IN ONE SUCH METHOD, A MATCHED MOLD IS LOADED WITH THE PROPER AMOUNT OF REINFORCEMENT MATERIAL..., AND THE MOLD HALVES ARE CLAMPED TOGETHER..., RESIN IS THEN PUMPED OR GRAVITY FED INTO THE MOLD, INFUSING THE ENCLOSED REINFORCEMENT MATERIAL..., AIR WITHIN THE MOLD IS VENTED AS IT IS DISPLACED BY THE RESIN...,

tilt up, part curing

ONCE THE RESIN FILLS THE MOLD, THE FILL HOLE AND VENTS ARE PLUGGED...,

THE PART IS THEN ALLOWED TO CURE.

SCENE 69.
tape 704, 18:05:13-18:05:18
mold halves separating
tape 704, 18:05:33-18:05:38
part removed from mold

NARRATION (VO):

ONCE CURED, THE MOLD HALVES ARE SEPARATED...,

AND THE PART IS REMOVED.

SCENE 70.
tape 709, 01:23:30-01:23:47
resin transfer mold opening with finished preforms

NARRATION (VO):

RESIN TRANSFER MOLDING CAN ALSO BE DONE USING PREFORMS, AND MAY BE ACCOMPANIED BY A VACUUM ASSIST.

SCENE 71.
tape 687, 03:20:50-03:21:10
resin transfer molding using nonmetallic mold
tape 709, 01:21:56-01:22:10
resin transfer molding using metal mold

NARRATION (VO):

MOLDS MAY BE EITHER NONMETALLIC, OR METAL. NONMETALLIC MOLDS ARE TYPICALLY FIBER-REINFORCED POLYMERS. THEIR USE DEPENDS LARGELY ON CURING TEMPERATURE AND PRODUCTION VOLUME OF THE MANUFACTURING OPERATION. METAL MOLDS ARE USED FOR HIGH-TEMPERATURE PROCESSING AND TO PROVIDE LONGER SERVICE LIFE.

SCENE 72.
tape 687, 03:22:48-03:23:16
resin transfer molding operation
CG, SUPER: Automotive Parts
Aircraft Parts
Bath & Shower Enclosures
Ventilation Components
Machine Cabinets

NARRATION (VO):

APPLICATIONS FOR RESIN TRANSFER MOLDING INCLUDE AUTOMOTIVE AND AIRCRAFT PARTS, BATH AND SHOWER ENCLOSURES, VENTILATION COMPONENTS AND MACHINE CABINETS.

--- FADE TO BLACK ---

SCENE 73.
CG: Composite Fabrication & Joining Methods
white text centered on black
tape 713, 01:19:00-01:23:45

peter carey narration

SCENE 74.
tape 687, 03:02:24-03:02:35
composite part being sawed
tape 696, 12:12:59-12:13:05
composite part being machined
tape 686, 02:19:32-02:19:44
composite part being drilled

NARRATION (VO):

AFTER CURING, POLYMER-MATRIX COMPOSITES CAN BE CUT...,

MACHINED...,

DRILLED, AND OTHERWISE FABRICATED BY MANY OF THE SAME METHODS USED FOR METALS.

SCENE 75.
tape 693, 09:12:23-09:12:59
sharp tool cutting composite part

NARRATION (VO):

HOWEVER, BECAUSE THE MATERIALS ARE ABRASIVE AND BRITTLE, THE NEED TO MAINTAIN SHARP TOOLS TO PREVENT DELAMINATION CANNOT BE OVER-STRESSED.

SCENE 76.
tape 696, 12:16:41-12:17:00
zoom out, drill with coolant being used to cut composite part

NARRATION (VO):

ALTHOUGH HIGH-SPEED-STEEL TOOLS CAN SUFFICE, TUNGSTEN CARBIDE AND DIAMOND-TIPPED TOOLS ARE OFTEN PREFERRED. ALSO, COOLANT IS OFTEN RECOMMENDED TO MINIMIZE HEAT BUILDUP AND TO PROLONG TOOL LIFE.

SCENE 77.
tape 699, 03:08:29-03:08:40
composite part being secured to workholding fixture, being machined

NARRATION (VO):

WORKHOLDING FIXTURES SHOULD PROVIDE PROPER PART BACKUP TO PREVENT BACKSIDE MATERIAL BREAKOUT IN VARIOUS OPERATIONS.

SCENE 78.
tape 689, 05:05:41-05:05:49
bandsaw used to cut composite part
tape 696, 12:06:13-12:06:19
circular saw used to cut composite part
tape 688, 04:13:23-04:13:26
saber saw used to cut composite part

NARRATION (VO):

POLYMER-MATRIX COMPOSITES ARE TYPICALLY CUT WITH BANDSAWS...,

CIRCULAR SAWS...,

AND SABER SAWS.

SCENE 79.
tape 689, 05:04:17-05:04:32
zoom out, bandsaw used to cut composite part
tape 694, 10:18:02-10:18:14
zoom out, circular saw used to cut composite part
tape 688, 04:13:01-04:13:10
zoom out, saber saw used to cut composite part

NARRATION (VO):

BANDSAWING SPEEDS WITH HIGH-SPEED-STEEL BLADES RANGE FROM 4000 TO 6500 FEET PER MINUTE AT FEEDS OF 6 TO 12 INCHES PER MINUTE...,
WITH CIRCULAR SAWS, THE SPEED RANGE IS BROADER STILL: 2000 TO 10,000 FEET PER MINUTE...,
BLADE SPEEDS OF 2500 STROKES PER MINUTE ARE SUGGESTED WITH SABER SAWS.

SCENE 80.
tape 692, 08:26:39-08:27:04
zoom in, manual routing of composite part

NARRATION (VO):

MANUAL AND MACHINE ROUTING HAVE BEEN EFFECTIVE WITH FLUTED CARBIDE MILLING CUTTERS AND CARBIDE OPPOSED-HELICAL ROUTER BITS.

SCENE 81.
tape 696, 12:10:53-12:11:09
turning of composite part
tape 696, 12:15:08-12:15:18
zoom in, c.u. drilling of composite material

NARRATION (VO):

IN MACHINING OPERATIONS, SUCH AS TURNING...,
AND DRILLING, SPEEDS SHOULD BE SOMEWHAT GREATER AND FEEDS SOMEWHAT LESS THAN FOR METALS.

SCENE 82.
tape 698, 02:26:33-02:26:56
holemaking operation
tape 703, 17:11:47-17:11:58
composite part with hole being reamed
tape 686, 02:19:49-02:19:59
composite part with hole being threaded

NARRATION (VO):

FOR DRILLING, LARGE, POSITIVE RAKE ANGLES ARE RECOMMENDED TO REDUCE THE PENETRATING FORCE AND, THUS, HEAT BUILDUP. DRILL FLUTES SHOULD BE WIDE AND POLISHED TO EASE CHIP REMOVAL. SECONDARY OPERATIONS SUCH AS REAMING...,
AND THREADING CAN ALSO BE PERFORMED ON COMPOSITE PARTS.

--- TOUCH BLACK ---

SCENE 83.
tape 698, 02:29:11-02:29:22
adhesive being applied to

NARRATION (VO):

composite element
CG, SUPER: Adhesive Bonding
tape 703, 17:13:26-17:13:30
mechanical fastening of composite elements
CG, SUPER: Mechanical Fastening

THERE ARE TWO PRINCIPAL JOINING METHODS FOR ASSEMBLING POLYMER-MATRIX COMPOSITE PARTS:

ADHESIVE BONDING...,

AND MECHANICAL FASTENING.

SCENE 84.
CG, SUPER: Adhesive Bonding
tape 690, 06:24:07-06:24:25
composite part being laid on another
tape 690, 06:25:04-06:25:12
c.u. composite parts being bonded together

NARRATION (VO):

ADHESIVE BONDING JOINS SURFACES TOGETHER BY USING A LIQUID OR SOLID ADHESIVE THAT RESISTS INTERFACIAL SEPARATION BETWEEN THE TWO SURFACES OF CONTACT...,

ADHESIVE BONDING FORMS PERMANENT JOINTS.

SCENE 85.
tape 690, 06:25:54-06:26:11
composite part elements being cleaned for bonding
tape 698, 02:11:05-02:11:15
pultrusion being abraded before bonding

NARRATION (VO):

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

SCENE 86.
continue previous shot
CG, SUPER: Single Lap
tape 711, 00:01:30-00:01:35
ANI: single lap joint
CG, SUPER: Double Lap
tape 711, 00:02:00-00:02:05
ANI: double lap joint
CG, SUPER: Stepped Lap
tape 711, 00:02:30-00:02:35
ANI: stepped lap joint
CG, SUPER: Single Overlay
tape 711, 00:03:00-00:03:05
ANI: single overlay joint
CG, SUPER: Double Overlay
tape 711, 00:03:30-00:03:35
ANI: double overlay joint
CG, SUPER: Scarf
tape 711, 00:04:00-00:04:05
ANI: scarf joint

NARRATION (VO):

JOINT TYPES FOR ADHESIVE BONDING INCLUDE:

SINGLE LAP...,

DOUBLE LAP...,

STEPPED LAP...,

SINGLE OVERLAY...,

DOUBLE OVERLAY...,

AND SCARF.

SCENE 87.
tape 693, 09:01:40-09:02:25
adhesive being applied to composite elements
CG, SUPER: Epoxies
Bismaleimides
Acrylics
Polyimides
Polysulfides
Epoxy-Phenolics
Urethanes

NARRATION (VO):

COMPOSITE BONDING ADHESIVES ARE NUMEROUS AND INCLUDE:

EPOXIES,

BISMALEIMIDES,

ACRYLICS,

POLYIMIDES,

POLYSULFIDES,

EPOXY-PHENOLICS,

AND URETHANES.

SCENE 88.
continue previous shot
tape 693, 09:04:16-09:04:25
workpieces placed in fixture after the adhesive is applied
tape 693, 09:04:43-09:04:56
workpieces pressed together in fixture

NARRATION (VO):

AFTER THE ADHESIVE IS APPLIED, THE WORKPIECES MAY BE PLACED IN A FIXTURE...,

AND THEN PRESSED TOGETHER TO REMOVE TRAPPED AIR AND CURE...,

SOME ADHESIVES CURE AT ROOM TEMPERATURE BUT MANY REQUIRE ELEVATED TEMPERATURE.

SCENE 89.
tape 702, 16:09:35-16:09:47
zoom out, adhesive bonding of bushing

NARRATION (VO):

ADHESIVE BONDING CAN ALSO BE USED TO BOND SURFACE-MOUNTED FASTENERS AND BUSHINGS, THUS COMBINING ADHESIVE BONDING AND MECHANICAL FASTENING.

SCENE 90.
CG, SUPER: Mechanical Fastening
tape 688, 04:15:33-04:15:41
mechanical fastening using rivets
tape 702, 16:10:16-16:10:21
mechanical fastening using pins
tape 703, 17:14:52-17:15:00
zoom out, mechanical fastening using bolts

NARRATION (VO):

MECHANICAL FASTENING INVOLVES THE USE OF RIVETS...,

PINS...,

BOLTS AND OTHER FASTENER TYPES TO JOIN COMPOSITE ELEMENTS TOGETHER.

SCENE 91.
tape 698, 02:25:52-02:26:00
zoom in, holes being drilled for mechanical fasteners

NARRATION (VO):

MECHANICAL FASTENING REQUIRES PRECISION HOLEMAKING.

SCENE 92.
tape 698, 02:19:11-02:19:22
zoom in, metal fastener holding part together
tape 686, 02:21:55-02:22:04
use of polymer-matrix composite fasteners

NARRATION (VO):

TITANIUM ALLOY, SUPERALLOY, AND STAINLESS STEEL FASTENERS ARE OFTEN USED, BUT POLYMER-MATRIX COMPOSITE FASTENERS ARE ALSO AVAILABLE.

SCENE 93.
tape 703, 17:15:40-17:15:52
mechanical fasteners being tightened

NARRATION (VO):

MECHANICAL FASTENING CLAMPING LOADS SHOULD BE SUFFICIENT TO CLOSE GAPS BUT NOT SO MUCH AS TO CAUSE DISTORTION OR BREAKAGE.

--- FADE TO BLACK ---

SCENE 94.
CG: Review
white text on black
tape 713, 01:23:47-01:26:40
peter carey narration
tape 63, 12:00:15-12:03:49
review music

MUSIC UP AND UNDER

NARRATION (VO):

LET'S REVIEW THE MATERIAL CONTAINED IN THIS VIDEOTAPE.

SCENE 95.
tape 692, 08:10:21-08:10:35
zoom out, part being produced using fiber-reinforced polymers
CG, SUPER: Matrix
tape 695, 11:02:39-11:02:50
c.u. matrix material being mixed
CG, SUPER: Reinforcement
tape 695, 11:12:39-11:12:45
reinforcement material

NARRATION (VO):

COMPOSITES ARE MADE-UP OF AT LEAST TWO DISTINCT INTENDED MATERIALS:

A MATRIX, OR BASE MATERIAL...,

AND A REINFORCEMENT MATERIAL.

SCENE 96.
CG, SUPER: Matrix
tape 694, 10:09:03-10:09:09
matrix material sprayed onto reinforcement
tape 694, 10:06:37-10:06:45
matrix/reinforcement material used in lay-up
tape 698, 02:17:18-02:17:26

NARRATION (VO):

THE MATRIX FUNCTIONS AS A BINDER FOR THE REINFORCEMENT, AND CONTROLS THE PHYSICAL SHAPE AND DIMENSIONS OF THE PART. THE PRIMARY PURPOSE OF THE

zoom in, matrix material put under load
tape 711, 00:00:50-00:00:59
ANI: part matrix transferring load exerted upon it to the reinforcement
tape 712, 19:02:38-19:02:52
matrix protecting reinforcement from adverse environmental effects

MATRIX IS TO TRANSFER THE LOAD, OR STRESS, APPLIED TO THE COMPOSITE TO THE REINFORCEMENT. THE MATRIX ALSO PROTECTS THE REINFORCEMENT FROM ADVERSE ENVIRONMENTAL EFFECTS.

SCENE 97.
tape 695, 11:03:29-11:03:45
med, matrix material being poured
CG, SUPER: Polyester
Epoxy
Bismaleimide
Phenolic
Polyimide

NARRATION (VO):

SOME OF THE PRIMARY MATRIX MATERIALS INCLUDE:

POLYESTER,

EPOXY,

BISMALEIMIDE,

PHENOLIC,

AND POLYIMIDE.

SCENE 98.
CG, SUPER: Reinforcement
tape 700, 13:23:16-13:23:34
pan, reinforcement fibers being added to composite lay-up
tape 701, 14:02:01-14:02:07
composite reinforcement particles being used

NARRATION (VO):

THE REINFORCEMENT'S FUNCTION IS TO IMPROVE THE MECHANICAL PROPERTIES OF THE COMPOSITE, AND IS TYPICALLY THE MAIN LOAD-BEARING ELEMENT.

REINFORCEMENT IS USUALLY IN THE FORM OF FIBERS...,

OR PARTICLES.

SCENE 99.
tape 688, 04:18:50-04:18:59
zoom out, e-glass being used in composite
CG, SUPER: E-Glass
tape 712, 20:00:40-20:00:50
aramid composite material
CG, SUPER: Aramid
tape 689, 05:21:21-05:21:29
zoom out, carbon being used in composite
CG, SUPER: Carbon/Graphite

NARRATION (VO):

SOME OF THE MOST COMMONLY USED FIBERS ARE:

E-GLASS...,

ARAMID...,

AND CARBON, WHICH IS ALSO REFERRED TO AS GRAPHITE.

SCENE 100.
tape 686, 02:01:56-02:02:09
fabric being cut
tape 703, 17:03:36-17:03:42

NARRATION (VO):

THESE FIBERS COME IN MANY FORMS, INCLUDING:

chopped strand
tape 697, 01:13:30-01:13:46
pan, tow being used
tape 701, 14:03:24-14:03:46
zoom out, fabric
tape 705, 20:34:00-20:34:10
freeze first frame, c.u. pan of tape fibers being used
tape 709, 01:23:55-01:24:25
foam preforms with reinforcement added

STRAND...,

TOW...,

FABRIC...,

PRE-IMPREGNATED, OR 'PREPREG' TAPE...,

AND PREFORMS.

SCENE 101.
tape 700, 13:08:47-13:08:55
filament winding operation
tape 686, 02:04:55-02:05:05
spray-up of composite
tape 697, 01:11:58-01:12:04
part coming out of pultrusion operation
tape 691, 07:05:16-07:05:35
hand lay-up using prepreg material
CG, SUPER: Manual Lay-Up
tape 705, 20:20:28-20:20:50
fiber placement machine laying up part
CG, SUPER: Automated Lay-Up
tape 694, 10:00:40-10:00:47
spray-up operation
CG, SUPER: Spray-Up
tape 703, 17:00:55-17:01:05
filament winding operation
CG, SUPER: Filament Winding
tape 697, 01:01:17-01:01:25
pultrusion operation
CG, SUPER: Pultrusion
tape 687, 03:22:48-03:22:58
resin transfer molding operation
CG, SUPER: Resin Transfer Molding

NARRATION (VO):

THERE ARE NUMEROUS METHODS OF PRODUCING COMPOSITE

PARTS, WITH THE PRIMARY TYPES BEING:

MANUAL LAY-UP...,

AUTOMATED LAY-UP...,

SPRAY-UP...,

FILAMENT WINDING...,

PULTRUSION...,

AND RESIN TRANSFER MOLDING.

SCENE 102.
tape 687, 03:07:23-03:07:36
reverse pan, composite parts curing at room temperature
tape 692, 08:20:10-08:20:18
composite parts curing in room with heaters
tape 702, 16:14:38-16:14:50
composite parts being placed in heated-platen press for curing
tape 703, 17:16:27-17:16:46
cured composite parts coming out of oven
tape 707, 10:03:28-10:03:34

NARRATION (VO):

AFTER PRODUCTION, COMPOSITE PARTS MAY BE ALLOWED

TO CURE AT ROOM TEMPERATURE...,

OR WITH OPEN AIR HEAT ASSIST.

COMPOSITE PARTS ARE ALSO COMMONLY CONSOLIDATED AND

CURED IN HEATED-PLATEN PRESSES...,

OVENS...,

composite parts being placed in autoclave for curing

OR AUTOCLAVES.

SCENE 103.
tape 687, 03:02:24-03:02:35
composite part being sawed
tape 696, 12:12:59-12:13:05
composite part being machined
tape 699, 03:08:29-03:08:40
composite part being drilled
tape 698, 02:29:11-02:29:22
adhesive being applied to composite element
tape 703, 17:15:47-17:15:52
mechanical fastening of composite elements

NARRATION (VO):

AFTER CURING, COMPOSITE PARTS CAN BE CUT...,

MACHINED...,

DRILLED, AND OTHERWISE FABRICATED BY MANY OF THE SAME METHODS USED FOR METALS.

ADDITIONALLY, COMPOSITE PARTS MAY BE JOINED AND ASSEMBLED USING ADHESIVE BONDING...,

AND MECHANICAL FASTENING.

--- FADE TO BLACK ---

SCENE 104.
CG, ROLL: credits
white text on black, fade up mid-screen
tape 712, 18:01:10-18:01:50
GRAPHIC: CMA logo

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Society of Manufacturing Engineers

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Communicore

SCENE 105.
CG: 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 106.
tape 40, 01:00:00-01:00:12
SME logo, with music
CG, SUPER: www.sme.org