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FUNDAMENTAL MANUFACTURING PROCESSES

Thermal & Abrasive Waterjet Cutting Processes- TWC

SCENE 1.
FMP01A, CGS: FBI warning
text centered on black to transparent gradient
FMP BKG, motion background

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SCENE 2.
continue motion background
FMP02A, CGS: DRL screen
text centered on black to transparent gradient

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SCENE 3.
continue motion background
FMP03A, CGS: disclaimer
white text, centered on background

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

SCENE 4.
FMP SME, SME logo open, with music

SCENE 5.
FMP05A, FMP open, with music
SD05B, edited peter carey narration

MUSIC UP AND UNDER

NARRATION (VO):

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

SCENE 6.
continue FMP open
SD06A, CGS: Thermal & Abrasive Waterjet

NARRATION (VO):

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Cutting Processes
white text, centered on background
FMP06B, blue background
FMP06C, sound slug

THIS PROGRAM IS AN INTRODUCTION TO THERMAL AND ABRASIVE WATERJET CUTTING PROCESSES.

SCENE 7.
laser cutting of part
oxy-fuel cutting of steel plate
plasma cutting of metal
laser cutting of metal

NARRATION (VO):

THERMAL CUTTING PROCESSES USE HEAT FOR CUTTING. THREE OF THE MOST COMMONLY USED THERMAL CUTTING PROCESSES ARE:

GAS OR OXY-FUEL...,

PLASMA...,

AND LASER.

SCENE 8.
waterjet cutting of part

NARRATION (VO):

ABRASIVE WATERJET CUTTING, USES NO HEAT, BUT CUTS BY ABRASIVE EROSION.

SCENE 9.
laser cutting of plastic
waterjet cutting diapers
plasma cutting external metal shape
waterjet cutting internal metal shape

NARRATION (VO):

THERMAL...,

AND ABRASIVE WATERJET CUTTING PROVIDE PRECISION NON-CONTACT CUTS IN A WIDE VARIETY OF MATERIALS, BUT THEY PRIMARILY CUT EXTERNAL...,

AND INTERNAL SHAPES OUT OF FLAT SHEET AND PLATE MATERIALS.

SCENE 10.
laser trimming stamped part

NARRATION (VO):

SECONDARILY, THESE PROCESSES ARE USED TO TRIM PREVIOUSLY FORMED SHAPES.

SCENE 11.
waterjet cutting metal plate
multiple laser heads cutting multiple shapes in metal

NARRATION (VO):

THERMAL AND ABRASIVE WATERJET CUTTING SEPARATE MATERIAL USING ONE CUT, RATHER

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THAN MULTIPLE PASSES, AND CAN UTILIZE

MULTIPLE CUTTING HEADS TO CUT MULTIPLE

SHAPES SIMULTANEOUSLY.

SCENE 12.
oxy-fuel cutting
plasma cutting
laser cutting
waterjet cutting
blue background
cg: WORKPIECE MATERIAL/THICKNESS
INTRICACY & QUALITY OF CUT
CUTTING SPEED
METALLURGICAL EFFECTS
ENVIRONMENTAL CONCERNS
COST OF SYSTEM
COST PER FOOT/METER OF CUT

NARRATION (VO):

CHOOSING THE MOST EFFECTIVE AMONG THESE

PROCESSES DEPENDS ON SEVERAL FACTORS,

SUCH AS:

THE WORK MATERIAL AND ITS THICKNESS,

CUT INTRICACY AND REQUIRED QUALITY,

DESIRED CUTTING SPEED,

METALLURGICAL EFFECTS,

ENVIRONMENTAL CONCERNS,

SYSTEM COST,

AND COST PER FOOT, OR METER OF CUT.

SCENE 13.
oxy-fuel cutting
plasma cutting
laser cutting
workholding for waterjet cutting
c.u. tip of plasma torch
c.u. abrasive particles used in waterjet cutting

NARRATION (VO):

THERE ARE ADVANTAGES COMMON TO THESE

METHODS OF CUTTING. UNLIKE MACHINING

METHODS USING MECHANICAL FORCE, THEY DO

NOT REQUIRE EITHER A VARIETY OF

PERISHABLE CUTTING TOOLS TO SHAPE PARTS

OR ELABORATE WORKHOLDING METHODS TO

CLAMP PARTS SECURELY. THEY DO, HOWEVER,

USE CONSUMABLES SUCH AS TORCH TIPS OR

GASES...,

OR ABRASIVE PARTICLES.

SCENE 14.
oxy-fuel cutting of part
ANI: photomicrography of thermal cut, arrows pointing out heat affected zone
ANI: another photomicrography of thermal

NARRATION (VO):

THERMAL CUTTING PROCESSES SHARE TWO

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cut, arrows pointing out heat affected zone
plasma cutting of part
laser cutting of part

DISADVANTAGES. FIRST, HEAT CHANGES THE STRUCTURE OF THE METAL IN A "HEAT-AFFECTED ZONE" ADJACENT TO THE CUT. THIS MAY DEGRADE SOME QUALITIES OF THE METAL'S CUT EDGE, REQUIRING PRE-TREATMENT OR TRIMMING. SECOND, TOLERANCES MAY BE LESS ACCURATE THAN A MACHINED CUT, EXCEPT WITH THE LASER.

SCENE 15.
c.u. plasma flames cutting
blue background
CG: FUEL GASES
CUTTING FLAMES
HOT SLAG
ELECTRICAL SHOCK
HIGH NOISE LEVELS
INTENSE ARC RADIATION
INTENSE LASER LIGHT
eye, ear, skin protection worn by worker using cutting process

NARRATION (VO):

THERE ARE ALSO SAFETY CONCERNS REGARDING FUEL GASES, FLAMES, HOT SLAG, ELECTRICAL SHOCK, HIGH NOISE LEVELS, AND INTENSE ARC RADIATION OR LASER LIGHT. ADDITIONALLY, EYE, EAR, OR SKIN PROTECTION IS ADVISABLE UNDER CERTAIN OPERATING CONDITIONS.

--- TOUCH BLACK ---

SCENE 16.
plasma cutting on "x-y" table
waterjet cutting on "x-y" table
laser cutting with articulated-arm robots or 5-axis gantry system
robot carrying plasma head
robot carrying waterjet head

NARRATION (VO):

THERMAL AND ABRASIVE WATERJET CUTTING PROCESSES TYPICALLY CUT MATERIAL ON A TWO-AXIS "X-Y" TABLE, BUT HAVE ALSO BEEN TEAMED WITH ARTICULATED-ARM ROBOTS OR 5-AXIS GANTRY SYSTEMS. MANY TYPES OF ROBOTS CAN CARRY A PLASMA TORCH, LASER, OR ABRASIVE WATERJET CUTTING HEAD FOR A WIDE RANGE OF CUTTING APPLICATIONS.

SCENE 17.
nesting, third mazak tape, 39 to 43

NARRATION (VO):

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minutes
part being laser cut from single sheet
nesting software being used to maximize
use of stock material

TYPICALLY, MULTIPLE PARTS ARE CUT FROM A SHEET OF STEEL OR OTHER MATERIAL. ARRANGING THE PARTS ON THE SHEET IS CALLED NESTING. NESTING SOFTWARE IS AVAILABLE TO HELP PROGRAMMERS ARRANGE PARTS ON THE COMPUTER SCREEN TO MAXIMIZE USE OF THE STOCK MATERIAL.

--- FADE TO BLACK ---

SCENE 18.
, CGS: Oxy-Fuel Cutting
white text, centered on background
FMP BKG, motion background

SCENE 19.
montage of stills from henry ford museum,
or oxy-fuel cutting of steel plate.

NARRATION (VO):

OXYGEN-FUEL OR OXY-FUEL CUTTING WAS ONCE THE ONLY FORM OF THERMAL CUTTING.

SCENE 20.
ANI: two-part torch, preheating exterior
oxy-fuel flame & jet of oxygen at the
center
c.u. oxy-fuel flame cutting of steel plate

NARRATION (VO):

THE OXY-FUEL CUTTING PROCESS USES A TWO-PART TORCH -- A PREHEATING EXTERIOR OXY-FUEL FLAME AND JET OF OXYGEN WITH A PURITY OF 99.5% OR BETTER, AT THE CENTER. THE CUTTING RELIES ON A CHEMICAL REACTION BETWEEN OXYGEN AND IRON OR CARBON STEEL IN THE PRESENCE OF HEAT.

SCENE 21.
pan from flame to tanks of gas
c.u. oxy-fuel flame preheating metal

NARRATION (VO):

THE EXTERIOR FLAME, PRODUCED BY A MIXTURE OF OXYGEN AND A COMBUSTIBLE GAS SUCH AS ACETYLENE, PROPANE, METHANE, OR OTHER GAS, PREHEATS THE OXIDIZABLE METAL

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TO ITS "KINDLING TEMPERATURE", WHICH IS AROUND 900 DEGREES CENTIGRADE. THIS IS THE TEMPERATURE AT WHICH THE METAL REACTS QUICKLY WITH OXYGEN.

SCENE 22.
c.u. red hot metal, compressed oxygen turned on
oxy-fuel cutting beginning

NARRATION (VO):

ONCE THE STARTING AREA REACHES THE KINDLING TEMPERATURE, THE OPERATOR TURNS ON THE JET OF COMPRESSED CUTTING OXYGEN. THE OXYGEN STREAMS FROM THE TORCH TIP INTO THE GLOWING-RED, PREHEATED METAL, CAUSING A FAST COMBUSTION REACTION BETWEEN THE STEEL AND THE OXYGEN.

SCENE 23.
oxy-fuel cutting of metal

NARRATION (VO):

THE RESULTING MOLTEN MATERIAL, OR SLAG, IS BLOWN THROUGH THE METAL BY THE STREAM OF CUTTING OXYGEN. THIS EXPOSES FRESH METAL TO THE CUTTING STREAM.

SCENE 24.
oxy-fuel cutting operation
blue background
CG: OXYGEN PURITY
OXYGEN SUPPLY RATE
TORCH TIP SIZE
TORCH TIP TYPE
DISTANCE FROM THE WORK
FUEL GAS TYPE
GAS FLOW RATES
CUTTING SPEED

NARRATION (VO):

MANY VARIABLES AFFECT THE OXY-FUEL CUT QUALITY, INCLUDING OXYGEN PURITY, RATE OF OXYGEN SUPPLY, TORCH TIP SIZE, TYPE, DISTANCE FROM THE STEEL PLATE, FUEL GAS TYPE, GAS FLOW RATES, AND CUTTING SPEED.

SCENE 25.
oxy-fuel cutting operation
blue background
CG: MATERIAL TYPE
CONDITION OF SURFACE
ANGLE OF THE CUT

NARRATION (VO):

OTHER MAJOR FACTORS IN CUT QUALITY ARE THE MATERIAL TYPE, ITS SURFACE CONDITION, AND THE ANGLE OF THE CUT, IF

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IT IS OTHER THAN STRAIGHT.

SCENE 26.
pan of oxy-fuel torch, preheating metal, dissolve to through cutting

NARRATION (VO):

OXY-FUEL CUTTING TORCHES SUPPLY THE PROPER FUEL GAS-OXYGEN MIXTURE FOR PREHEATING THE METAL, AND SUPPLY A STEADY FLOW OF OXYGEN FOR THE THROUGH CUTTING.

SCENE 27.
c.u. changing cutting tip of oxy-fuel torch
c.u. changing gas pressure
torch tip/nozzle
another torch tip/nozzle
another torch tip/nozzle
another torch tip/nozzle
another torch tip/nozzle
another torch tip/nozzle
split screen, two different diameters in relation to thick & thin depth of cut

NARRATION (VO):

CHANGING TORCH CUTTING TIPS AND REGULATING GAS PRESSURE ALTER THE OXY-FUEL'S CUTTING ACTION. CUTTING TIPS OR NOZZLES COME IN A VARIETY OF DESIGNS TO SERVE DIFFERENT CUTTING FUELS. THE DIAMETER OF THE CENTRAL JET OF OXYGEN MUST BE SELECTED IN PROPORTION TO THE DEPTH OF THE STOCK BEING CUT.

SCENE 28.
c.u. torch tip to work, cutting
thin material being cut using oxy-fuel process
thick material being cut using oxy-fuel process

NARRATION (VO):

THE TORCH TIP-TO-WORK STANDOFF DISTANCE IS ALSO DEPENDENT ON THE WORKPIECE THICKNESS. FOR THINNER MATERIAL THE TIP IS KEPT CLOSE TO THE WORK AND MOVED RAPIDLY, WHILE FOR THICKER WORK, THE STANDOFF DISTANCE IS INCREASED.

SCENE 29.
continue previous shot
kerf of thick stock/part after oxy-fuel cutting

NARRATION (VO):

ADDITIONALLY, THE THICKER THE CUT, THE MORE DIFFICULT IT BECOMES TO MAINTAIN CUT QUALITY. LARGER TORCH TIPS WITH

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GREATER OXYGEN FLOW ARE USED TO CUT THICK STOCK, CREATING A LARGER KERF OR WIDTH OF THE CUT.

SCENE 30.

NARRATION (VO):

BUT BY ADJUSTING THE CUTTING PARAMETERS IT IS POSSIBLE TO ACHIEVE A FAIRLY SMOOTH EDGE AND A FAIRLY NARROW KERF. THE DEPTH OF THE HEAT-AFFECTED ZONE DEPENDS ON THE WORK MATERIAL AND THICKNESS.

SCENE 31.
oxy-fuel cutting using manual/portable unit
oxy-fuel cutting using gigantic automated machine with numerous cutting torches

NARRATION (VO):

MACHINE TOOLS FOR OXY-FUEL CUTTING RANGE FROM MANUAL AND PORTABLE UNITS..., TO GIGANTIC AUTOMATED MACHINES WITH A MOTOR-DRIVEN CARRIAGE WITH NUMEROUS CUTTING TORCHES.

SCENE 32.
continue previous shot
blue background
CG: TORCH PLACEMENT
IGNITION
FUEL PRESSURE
CUTTING SPEED

NARRATION (VO):

MACHINES TYPICALLY HAVE ADJUSTMENTS FOR TORCH PLACEMENT, IGNITION, FUEL PRESSURE, AND CUTTING SPEED.

--- FADE TO BLACK ---

SCENE 33.
, CGS: Plasma Cutting
white text, centered on background
FMP BKG, motion background

SCENE 34.
plasma cutting of metal

NARRATION (VO):

PLASMA CUTTING USES AN EXTREMELY HIGH TEMPERATURE, HIGH-VELOCITY STREAM OF

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IONIZED GAS OR PLASMA, TO CUT METAL.

SCENE 35.
c.u. plasma cutting of metal

NARRATION (VO):

THIS PLASMA JET IS FORMED BY AN ARC AND A GAS OR GAS MIXTURE, AND HAS A TEMPERATURE BETWEEN 10,000 AND 50,000 DEGREES FAHRENHEIT.

SCENE 36.
ANI: jet concentrated as a vortex in a narrow spot, melting metal, and blowing it out of cut

NARRATION (VO):

THE JET IS CONCENTRATED AS A VORTEX IN A NARROW SPOT WHERE IT MELTS THE METAL, AND BLOWS IT OUT OF THE CUT.

SCENE 37.
plasma cutting of part

NARRATION (VO):

THE PLASMA CUTTING PROCESS OPERATES WITH HIGHER ENERGY THAN OXY-FUEL, SO IT CUTS FASTER, AND REQUIRES NO PREHEATING.

SCENE 38.
continue previous shot
ANI: full frame, plasma, fourth state of matter, goes to quarter screen, exposing other three states, all of which are highlighted when introduced

NARRATION (VO):

TO BETTER UNDERSTAND THIS CUTTING PROCESS, LET'S EXAMINE WHAT CONSTITUTES A PLASMA. PLASMA IS SOMETIMES DESCRIBED AS THE FOURTH STATE OF MATTER; WITH THE THREE PRIMARY STATES OF MATTER BEING SOLID, LIQUID, AND GAS. THE DIFFERENCE BETWEEN THESE STATES IS THEIR ENERGY LEVELS.

SCENE 39.
ice cube in pan, stove element heats up, dissolve,
ice cube melted to water, dissolve,
water turned to steam
ANI: gas heated up, becoming ionized, electrically conductive

NARRATION (VO):

WHEN ENERGY IN THE FORM OF HEAT IS ADDED TO ICE, A SOLID, IT FORMS WATER, A LIQUID. WHEN ADDITIONAL ENERGY IS ADDED,

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THE WATER EVAPORATES AND FORMS STEAM—IF HIGH ENERGY WERE ADDED TO THESE GASES, THEY WOULD BECOME IONIZED AND ELECTRICALLY CONDUCTIVE. THIS CONDUCTIVE, IONIZED GAS IS CALLED A PLASMA.

SCENE 40.
hand held plasma cutting using shop air
c.u. mechanical plasma system cutting of part
gas mixture plasma cutting of stainless steel or aluminum part

NARRATION (VO):

HAND HELD PLASMA CUTTERS UTILIZE SHOP AIR. MECHANICAL SYSTEMS FOR CUTTING STEEL OFTEN USE OXYGEN AS THE CUTTING GAS, WITH A SHIELD OF EITHER AIR, WATER, OR CARBON DIOXIDE. GAS MIXTURES SUCH AS ARGON AND HYDROGEN, OR NITROGEN AND HYDROGEN ARE USED WHEN CUTTING STAINLESS STEEL AND ALUMINUM.

SCENE 41.
continue previous shot
blue background
CG: PLASMA ARC CUTTING SYSTEM
INCLUDES:
TORCH
POWER SUPPLY
ARC STARTING CIRCUIT

NARRATION (VO):

A PLASMA ARC CUTTING SYSTEM CONSISTS OF A TORCH, A POWER SUPPLY, AND AN ARC STARTING CIRCUIT.

SCENE 42.
zoom into torch, cutting
c.u. torch providing water or gas to cool cut

NARRATION (VO):

THE TORCH SERVES AS THE HOLDER FOR THE CONSUMABLE NOZZLE AND ELECTRODE WHICH CONSTRICT AND MAINTAIN THE PLASMA JET IN A VORTEX.

SCENE 43.
pan from cutting to plasma power supply
plasma cutting part
high power plasma cutting

NARRATION (VO):

THE PLASMA CUTTING POWER SUPPLY IS A CONSTANT CURRENT "DC" POWER SOURCE. THE

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OUTPUT CURRENT, OR AMPERAGE, DETERMINES THE SPEED AND CUT THICKNESS CAPABILITY.

SCENE 44.
ANI: arc starter producing a high "ac" voltage which ionizes the cutting gas, allowing it to become conductive
hypertherm and komatsu diagrams

NARRATION (VO):

THE ARC STARTER IS A HIGH FREQUENCY GENERATOR CIRCUIT THAT PRODUCES A HIGH "AC" VOLTAGE WHICH IONIZES THE CUTTING GAS, ALLOWING IT TO BECOME CONDUCTIVE.

SCENE 45.
ANI: plasma cutting process, pilot arc created
CG, SUPER: ELECTRODE/CATHODE

NARRATION (VO):

WHEN A GAS IS FED TO THE TORCH, PART OF THE GAS IS IONIZED BY THE HIGH-VOLTAGE ARC STARTER BETWEEN THE ELECTRODE, OR CATHODE, IN THE TORCH, AND THE TORCH TIP. WHEN THE POWER SUPPLY'S SMALL "DC" CURRENT MEETS THIS HIGH VOLTAGE GAS, IT CREATES A PILOT ARC. THIS PILOT ARC LEAVES THE TORCH TIP AS A PLASMA JET AND BECOMES THE PATH FOR THE MAIN PLASMA ARC.

SCENE 46.
ANI: pilot arc contacting anode surface, forming main arc, pilot arc shutting off

NARRATION (VO):

ONCE THE PILOT ARC CONTACTS THE METAL'S SURFACE, OR ANODE, THE MAIN ARC FORMS. THE PILOT ARC THEN SHUTS OFF, AND THE CUTTING TORCH BEINGS OPERATION.

SCENE 47.
height adjustment backing plasma torch off from beginning of cut, cutting process continuing

NARRATION (VO):

THE TORCH HAS AN AUTOMATIC HEIGHT CONTROL WHICH RAISES IT UP SLIGHTLY FOR CLEARANCE WHEN THE FIRST PUDDLE OF

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MOLTEN MATERIAL FORMS. ONCE THE METAL IS PIERCED, THE AUTOMATIC HEIGHT CONTROL RETURNS THE TORCH TO ITS INITIAL HEIGHT.

SCENE 48.
molten metal blown through cut
c.u dross hanging from bottom of cut
dross-free oxygen cut

NARRATION (VO):

THE HEATED METAL BECOMES MOLTEN AND IS BLOWN THROUGH THE CUT BY THE PLASMA STREAM. SOME SLAG OR DROSS MAY COLLECT ON THE BOTTOM SURFACE, ADJACENT TO THE CUT.

SCENE 49.
ANI: kerf width of plasma cut
c.u. fast plasma cutting operation

NARRATION (VO):

PLASMA CUTTING'S KERF WIDTH IS ROUGHLY EQUAL TO THE TORCH ORIFICE DIAMETER. IT'S HEAT-AFFECTED ZONE IS ALSO NARROWER THAN IN THE OXY-FUEL PROCESS BECAUSE OF THE FASTER CUTTING SPEED.

SCENE 50.
continue previous shot
ANI: beveled kerf & top-edge rounding

NARRATION (VO):

THE JET REMOVES MORE METAL FROM THE TOP OF THE KERF THAN FROM THE BOTTOM. THIS RESULTS IN SLIGHTLY BEVELED OR TAPERED CUTS. SOMETIMES THERE IS ALSO TOP-EDGE ROUNDING.

SCENE 51.
plasma cutting operation
plasma cutting using oxygen

NARRATION (VO):

DEPENDING ON THE CUTTING GAS AND MATERIAL TYPE, KERF ANGLES WILL RANGE FROM 1 TO ABOUT 8 DEGREES.

SCENE 52.
continue previous shot
plasma cutting of non-ferrous metals, and non-oxidizing materials which cannot be

NARRATION (VO):

PLASMA CUTTING MAY BE USED ON ALL

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cut by oxy-fuel cutting

METALS, BUT IS ESPECIALLY EFFECTIVE ON STAINLESS STEEL, ALUMINUM AND OTHER NON-FERROUS METALS, AND NON-OXIDIZING MATERIALS WHICH CANNOT BE CUT BY OXY-FUEL CUTTING.

SCENE 53.
ANI: air, gas or water being used to shield the plasma jet
ANI: water injected inside the torch, swirling around the plasma jet
plasma cutting operation

NARRATION (VO):

WHEN PLASMA CUTTING, AIR, WATER OR A GAS MAY BE USED TO SHIELD THE PLASMA JET. THIS REDUCES SMOKE AND IMPROVES THE CUT.

SCENE 54.
plasma torch being used on cnc turret punch press
c.u. plasma torch being used on cnc turret punch press
turret punch press punching holes
w.a. whitney 3400 rtc machine

NARRATION (VO):

A PLASMA CUTTING TORCH IS SOMETIMES COMBINED WITH A CNC, OR COMPUTER NUMERICAL CONTROL, PUNCH PRESS FOR A VERSATILE AND PRODUCTIVE COMBINATION. SUCH MACHINES CAN CUT CONTOURS WITH THE PLASMA TORCH AS WELL AS PUNCH INTERNAL HOLES WITH THE INTERCHANGEABLE PUNCHES AND DIES. THIS IS MUCH FASTER THAN UTILIZING PLASMA CUTTING ALONE.

SCENE 55.
material handling on cnc turret punch press
scrap handling on cnc turret punch press
toolchanging on cnc turret punch press
rapid work positioning cnc turret punch press

NARRATION (VO):

SUCH FLEXIBLE CNC COMBINATION MACHINES INCORPORATE MATERIAL HANDLING...,
SCRAP HANDLING...,
TOOLCHANGING...,
AND RAPID WORK POSITIONING.

--- FADE TO BLACK ---

SCENE 56.
, CGS: Laser Cutting

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white text, centered on background
FMP BKG, motion background

SCENE 57.
laser cutting part, zoom into cut

NARRATION (VO):

LASER CUTTING USES A BEAM OF LASER LIGHT TO GENERATE HEAT FOR CUTTING METALS AND OTHER MATERIALS.

SCENE 58.
laser performing narrow cut
c.u. laser cutting of part
contour cutting with laser
holemaking with laser

NARRATION (VO):

LASERS' ADVANTAGES OVER OTHER THERMAL CUTTING PROCESSES INCLUDE A NARROWER KERF, NARROWER HEAT-AFFECTED ZONE, AND FINER EDGE. CUTS ACHIEVABLE WITH A LASER ARE SMOOTHER THAN WITH THE OTHER THERMAL PROCESSES AND MAY REQUIRE NO SECONDARY EDGE FINISHING. SHEET METAL MAY BE CONTOUR-CUT RAPIDLY AND SMALL HOLES CAN BE DRILLED IN UNDER A SECOND.

SCENE 59.
continue previous shot
laser cutting workpiece

NARRATION (VO):

LASER CUTTING ALSO HAS LIMITATIONS. IT IS EXPENSIVE, AND GENERALLY COST-EFFECTIVE ONLY FOR MATERIALS UP TO 1/2 INCH OR 13 MILLIMETERS THICK, THOUGH THICKER MATERIALS MAY BE CUT.

SCENE 60.
blue background
CG: LIGHT AMPLIFICATION BY THE STIMULATED EMISSION OF RADIATION, highlight first letter of each word, LASER
ANI: coherent vs. ordinary random light

NARRATION (VO):

THE TERM LASER IS AN ACRONYM FOR LIGHT AMPLIFICATION BY THE STIMULATED EMISSION OF RADIATION. A LASER PRODUCES AN INTENSE BEAM OF COHERENT LIGHT, AS

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OPPOSED TO ORDINARY RANDOM LIGHT.

SCENE 61.
ANI: principle of how a laser works, electrons generated, flowing through tube of gas
CG, SUPER: POWER SUPPLY
CATHODE
ELECTRONS
ANODE

NARRATION (VO):

LET'S EXAMINE HOW A LASER BEAM IS PRODUCED. WHEN A LASER'S HIGH VOLTAGE POWER SUPPLY IS ACTIVATED, THE CATHODE IN THE LASER GENERATES ELECTRONS WHICH FLOW THROUGH A TUBE OR ENCLOSED CAVITY TOWARD THE ANODE. THE TUBE CONTAINS CO2 GAS OR ANOTHER LASER SOURCE.

SCENE 62.
ANI: continue, principle of how a laser works, electrons colliding with gas atoms, raising, then falling, producing photon, process continuing
CG, SUPER: PHOTON

NARRATION (VO):

WHEN AN ELECTRON COLLIDES WITH A GAS ATOM, ONE OF THE ELECTRONS FROM THAT ATOM ABSORBS ENERGY AND JUMPS TO A HIGHER ORBIT. WHEN THAT ELECTRON FALLS BACK TO ITS EARLIER ORBIT, IT LOSES THIS EXTRA ENERGY IN THE FORM OF A PHOTON OF LIGHT. WHEN THIS PHOTON HITS OTHER ENERGIZED ATOM IN THE CO2 GAS, THAT ATOM GIVES OFF ITS OWN PHOTON, WITH THE SAME WAVELENGTH AND IN THE SAME DIRECTION AND PHASE AS THE FIRST PHOTON.

SCENE 63.
ANI: continue, principle of how a laser works, photons bouncing between two mirrors, becoming intense, beam bursts through one end of mirror

NARRATION (VO):

AS INCREASING NUMBER OF PHOTONS ARE EMITTED FROM EXCITED ATOMS, THEY BOUNCE BETWEEN TWO MIRRORS, BECOMING INCREASINGLY INTENSE. A FRACTION OF THE BEAM BURSTS THROUGH A PARTIALLY

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REFLECTIVE AND PARTIALLY TRANSMISSIVE MIRROR AT ONE END -- THIS IS THE LIGHT THAT FORMS THE LASER BEAM.

SCENE 64.
ANI: continuous laser beam wave, pulsed laser beam wave
c.u. laser beam cutting part

NARRATION (VO):

A LASER BEAM CAN BE IN A CONTINUOUS WAVE OR IN A SERIES OF BURSTS OR PULSES. A BEAM CAN ALSO BE FOCUSED INTO A SPOT ONE-HUNDREDTH (0.010) OF AN INCH, OR ONE QUARTER (0.25) MILLIMETER DIAMETER OR LESS TO HEAT, MELT, OR VAPORIZE THE WORKPIECE MATERIAL.

SCENE 65.
laser cutting workpiece

NARRATION (VO):

A LASER'S PERFORMANCE CAN BE ENHANCED BY USING ASSIST GASES OR LIQUIDS.

SCENE 66.
inert gas used with laser to blow away molten material
reactive gas used with laser to increase cutting ability
liquid spray used with laser, cooling part

NARRATION (VO):

FOR EXAMPLE, A HIGH-PRESSURE GAS JET CAN BE USED TO BLOW MOLTEN MATERIAL AWAY FROM THE CUT. THE GAS MAY BE EITHER AN INERT GAS -- TO PROVIDE A CLEAN OXIDE-FREE CUT, OR A REACTIVE GAS SUCH AS OXYGEN, TO INCREASE THE CUTTING SPEED. A LIQUID SPRAY MAY ALSO BE USED TO CONTROL THE TEMPERATURE OF MATERIAL NEAR THE CUT.

SCENE 67.
co2 laser cutting part
yag laser cutting part

NARRATION (VO):

LASER TYPES ARE BASED ON THEIR LASING MEDIUMS. THE TWO MOST COMMONLY USED

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LASERS FOR MATERIAL PROCESSING ARE: THE

CO2 GAS LASER...,

AND THE NEODYMIUM-DOPED YTTRIUM-ALUMINUM

GARNET, OFTEN CALLED SIMPLY "YAG",

SOLID-STATE LASER.

SCENE 68.
wide, laser cutting machine
c.u laser that begins to cut
motion control system moving beam and workpiece
enclosure being closed before cutting
pan up from cutting to fume exhaust system

NARRATION (VO):

ALL LASER CUTTING MACHINES ARE

CONSTRUCTED OF CERTAIN COMPONENTS, THOSE

INCLUDE:

A LASER,

A BEAM DELIVERY SYSTEM,

A MOTION CONTROL SYSTEM--TYPICALLY CNC--

FOR THE BEAM AND WORKPIECE,

AN ENCLOSURE,

AND SOMETIMES PROVISION FOR FUME

EXHAUST.

SCENE 69.
wide, co2 laser cutting of flat material

NARRATION (VO):

THERE ARE FOUR STYLES OF CO2 LASER

CUTTERS FOR FLAT MATERIAL.

SCENE 70.
ball-transfer machine, laser cutting part

NARRATION (VO):

BALL-TRANSFER MACHINES MOVE THE WORK

MATERIAL UNDER THE FIXED LASER BEAM. THE

SHEET IS MOVED OVER BALLS MOUNTED IN THE

TABLE.

SCENE 71.
moving-table machine, laser cutting part

NARRATION (VO):

MOVING-TABLE MACHINES HAVE A SUPPORT

TABLE OF ALUMINUM PINS OR AN EGG-CRATE-

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LIKE METAL GRID; THE ENTIRE SUPPORT TABLE MOVES UNDER THE FIXED LASER HEAD.

SCENE 72.
hybrid machine, laser cutting part

NARRATION (VO):

HYBRID MACHINES COMBINE PART MOTION WITH LASER BEAM MOTION.

SCENE 73.
flying optic/moving beam laser machine, laser moving in two axes, cutting part

NARRATION (VO):

FLYING OPTIC OR MOVING BEAM LASER MACHINES MOVES THE LASER BEAM IN TWO AXES, WHILE THE PART REMAINS STATIONERY.

SCENE 74.
yag laser utilizing 5 or 6 axis machine, cutting previously formed shape

NARRATION (VO):

"YAG" LASERS WITH A FIBER-OPTIC BEAM DELIVERY MAY BE PAIRED WITH A FIVE OR SIX-AXIS ROBOT FOR CONTOUR CUTTING OR DRILLING ON PREVIOUSLY FORMED SHAPES. THE ROBOT-GUIDED LASER BEAM CAN OPERATE AT ANY ANGLE TO THE WORK.

SCENE 75.
laser being used on cnc turret punch press

NARRATION (VO):

LIKE PLASMA CUTTING, A LASER SYSTEM CAN BE COMBINED WITH A CNC TURRET PUNCH PRESS FOR HIGHLY VERSATILE FUNCTIONALITY.

SCENE 76.
laser holemaking
drill bit breaking in cut

NARRATION (VO):

BECAUSE OF ITS SPEED, EASE OF AUTOMATION, AND ABILITY TO PENETRATE VERY HARD MATERIALS, LASER DRILLING IS A NON-CONTACT ALTERNATIVE TO CONVENTIONAL DRILLING PROCESSES -- WITH THE ADVANTAGE

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OF HAVING NO BROKEN DRILL BITS.

SCENE 77.
small hole laser drilling

NARRATION (VO):

LASER DRILLING OF SMALL HOLES IN THIN MATERIALS USES HIGH POWER PULSES FOR SHORT TIMES TO DRILL HOLES WITH SINGLE OR MULTIPLE PULSES; THIS IS CALLED PERCUSSION DRILLING. "YAG" LASERS ARE GENERALLY USED FOR PERCUSSION DRILLING.

SCENE 78.
zoom in, laser drilling small holes
laser drilling in inaccessible location
laser drilling of non-metal material

NARRATION (VO):

PERCUSSION DRILLING IS PARTICULARLY SUITED TO HOLE DIAMETERS UNDER A TWO-HUNDREDTH (0.020) OF AN INCH, OR ONE-HALF (0.5) MILLIMETER. HOLES CAN BE LASER DRILLED IN OTHERWISE INACCESSIBLE LOCATIONS AND IN A VARIETY OF NON-METALS, AS WELL AS METALS.

SCENE 79.
laser trepanning hole

NARRATION (VO):

LARGER HOLES ARE CUT BY TREPANNING, WHICH USUALLY SWEEPS THE FOCUSED LASER BEAM IN A CIRCLE. TREPANNING IS USED TO PRODUCE HOLE DIAMETERS ABOVE ONE-HUNDREDTH (0.010) OF AN INCH, OR ONE QUARTER (0.25) MILLIMETER.

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SCENE 80.
, CGS: Abrasive Waterjet Cutting
white text, centered on background
FMP BKG, motion background

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SCENE 81.
c.u., pull back to wide of abrasive waterjet cutting of material

NARRATION (VO):

THE ABRASIVE WATERJET EROSION PROCESS USES ABRASIVE PARTICLES SUSPENDED IN A HIGH-PRESSURE STREAM OF WATER TO CUT A WIDE RANGE OF MATERIALS.

SCENE 82.
abrasive waterjet cutting steel
abrasive waterjet cutting of part

NARRATION (VO):

ABRASIVE WATERJET CUTTING GENERATES NO HEAT, AND LEAVES NO HEAT-AFFECTED ZONE, MAKING IT AN ALTERNATIVE TO THERMAL CUTTING. IN ADDITION, THERE ARE NO TOXIC FUMES, TOXIC WASTES, OR CHEMICALS TO CAUSE PROBLEMS. DUST IS ALSO NONEXISTENT.

SCENE 83.
abrasive waterjet cutting of problematic material
abrasive waterjet cutting of laminate
abrasive waterjet cutting thick steel

NARRATION (VO):

ABRASIVE WATERJET SYSTEMS CUT MATERIALS THAT GUM UP SAWS OR SUFFER UNSATISFACTORY HEAT DAMAGE IN THERMAL PROCESSES. IT IS GOOD AT CUTTING LAMINATES OF DIFFERENT MATERIALS, INCLUDING COMPOSITE MIXTURES OF METALS AND NON-METALS. THICK MATERIALS MAY ALSO BE CUT USING THE ABRASIVE WATERJET PROCESS.

SCENE 84.
c.u. waterjet cutting of part
c.u. water coming out of hose while washing car

NARRATION (VO):

THE WATER PRESSURE FOR WATERJET CUTTING IS BETWEEN 30,000 TO 60,000 PSI OR POUNDS PER SQUARE INCH. BY COMPARISON,

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ORDINARY HOUSEHOLD WATER NORMALLY RUNS AT 40 TO 50 PSI.

SCENE 85.
wide, abrasive waterjet cutting of part
med, intensifier pump, pan to waterjet cutting
med, plumbing and tank, handling water
med, gantry or robot delivery system guiding the cutting head
c.u. waterjet nozzle assembly, forming waterjet

NARRATION (VO):

THE COMPONENTS OF AN ABRASIVE WATERJET SYSTEM INCLUDES A HIGH-PRESSURE INTENSIFIER PUMP TO PROVIDE THE STREAM OF WATER,

THE PLUMBING AND TANK, OR CATCHER UNIT TO HANDLE THE WATER,

A GANTRY, ROBOT, OR OTHER DELIVERY SYSTEM TO GUIDE THE CUTTING HEAD,

AND THE NOZZLE ASSEMBLY UNIT, WHICH FORMS THE JET.

SCENE 86.
hopper, abrasive material dumped into it
c.u. metering valve
med, abrasive waterjet mixing unit

NARRATION (VO):

THE ABRASIVE DELIVERY SYSTEM INCLUDES A HOPPER TO HOLD THE ABRASIVE MATERIAL,

A METERING VALVE,

AND A MIXING CHAMBER, WHICH MIXES THE ABRASIVE PARTICLES INTO THE WATER STREAM.

SCENE 87.
ANI: incoming water passing through filter and booster pump to pressurize water. then to intensifier pump to increase the water pressure to cutting levels, circle appears with close-up of water fed into mixing chamber

NARRATION (VO):

INCOMING WATER FIRST PASSES THROUGH A FILTER AND A BOOSTER PUMP TO PRESSURIZE IT. THEN THE INTENSIFIER PUMP, A HYDRAULICALLY DRIVEN DOUBLE-ACTING RECIPROCATING-TYPE PUMP, INCREASES THE PRESSURE TO CUTTING LEVELS. THE WATER IS

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THEN FORCED THROUGH A JEWEL ORIFICE INTO THE MIXING CHAMBER LOCATED WITHIN THE CUTTING HEAD.

SCENE 88.
ANI: continue animation above, dry abrasive added to mixing chamber, accelerated then forced down focusing tube. waterjet exiting cutting head, cutting material

system diagram, frederick mason will provide drawing as start point.

NARRATION (VO):

DRY GARNET ABRASIVE IS FED INTO THE MIXING CHAMBER. THERE THE WATER ACCELERATES THE PARTICLES TO SUPERSONIC VELOCITIES. THE HIGH-SPEED SLURRY IS FOCUSED IN A FOCUSING TUBE AND EXITS THE NOZZLE IN A JET STREAM. THE GARNET ABRASIVE SUSPENDED IN THE WATERJET DOES OVER NINETY PERCENT OF THE CUTTING.

SCENE 89.
c.u. waterjet cutting, emphasis on cut & kerf

NARRATION (VO):

WATERJET CUTTING'S KERF IS APPROXIMATELY EQUAL TO THE NOZZLE DIAMETER, AND RELATIVELY SMOOTH. THERE IS A SLIGHT TAPER IN THE KERF WALL WHEN CUTTING MATERIAL THICKER THAN 2 INCHES OR 50 MILLIMETERS.

SCENE 90.
rough waterjet cutting to separate material
fine, finished part cut with waterjet process

NARRATION (VO):

THE CUT FINISH IS PROPORTIONAL TO THE FEEDRATE, AND CAN VARY FROM A ROUGH CUT EDGE MADE MERELY TO ACHIEVE SEPARATION, TO A FAIRLY FINE, FINISHED EDGE.

SCENE 91.
continue previous shot
blue background
CG: SURFACE CHARACTERISTICS VARIABLES OF WATERJET CUTS
WATERJET PRESSURE

NARRATION (VO):

THE CUT'S SURFACE CHARACTERISTICS VARY WITH WATERJET PRESSURE AND DIAMETER; THE

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WATERJET DIAMETER
ABRASIVE MATERIAL SIZE
ABRASIVE MATERIAL TYPE
ABRASIVE MATERIAL FLOW RATE
TRAVERSE SPEED
THE CUTTING ANGLE

SIZE, TYPE AND FLOW RATE OF THE ABRASIVE MATERIAL; TRAVERSE SPEED; AND THE CUTTING ANGLE.

SCENE 92.
water collected under "xy" table
water collected in mobile unit on 5-axis system

NARRATION (VO):

ONCE USED, THE WATER-ABRASIVE STREAM IS COLLECTED IN A TANK UNDER THE "X-Y" TABLE...,

OR IN A MOBILE CATCHER IN A FIVE-AXIS CONTOURING SYSTEM.

SCENE 93.
waterjet system using multiple cutting heads
waterjet cutting underneath the water

NARRATION (VO):

ABRASIVE WATERJET SYSTEMS UTILIZE MULTIPLE CUTTING HEAD CONFIGURATIONS FOR CERTAIN PRODUCTION APPLICATIONS.

ADDITIONALLY, SINCE THE WATERJET JET STREAM CAN BE NOISY, SOME CUTTING APPLICATION ARE BEING PERFORMED UNDER WATER, ELIMINATING THE PROBLEM.

SCENE 94.
worker wearing proper protection around waterjet cutting
pan from shielding over system tubing to safety system control panel

NARRATION (VO):

AN ABRASIVE JET CAN EASILY CUT PEOPLE.

SHOULD A TUBING BURST OCCUR, SHIELDING PREVENTS THE DISCHARGE OF HIGH-PRESSURE WATER AND SAFETY SYSTEMS SHUTDOWN THE PRESSURE.

--- FADE TO BLACK ---

SCENE 95.
FMP RVW, CGS: Review
white text, centered on background
FMP BKG, motion background

NARRATION (VO):

LET'S REVIEW THE MATERIAL CONTAINED IN THIS PROGRAM.

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SCENE 96.

NARRATION (VO):

THE PRINCIPAL NON-CONTACT CUTTING PROCESSES INCLUDE:

OXY-FUEL...,

PLASMA...,

LASER...,

AND ABRASIVE WATERJET CUTTING.

SCENE 97.

NARRATION (VO):

THE SIMILARITIES AMONG THESE PROCESSES ARE:

THEY CUT IN ONE PASS,

THEY USE NO CUTTING TOOLS,

THEY CUT ANY SHAPE A CNC MACHINE OR ROBOT CAN FOLLOW,

AND PART EDGES MAY REQUIRE SECONDARY FINISHING.

SCENE 98.

NARRATION (VO):

OXY-FUEL CUTTING RELIES ON A CHEMICAL COMBUSTION BETWEEN OXYGEN AND IRON OR CARBON STEEL IN THE PRESENCE OF HIGH HEAT. TORCHES SUPPLY AN OUTER PRE-HEATING FLAME AND AN INNER STREAM OF HIGH-PRESSURE PURE OXYGEN.

SCENE 99.

NARRATION (VO):

PLASMA CUTTING USES AN EXTREMELY HIGH TEMPERATURE, HIGH-VELOCITY JET OF ELECTRICALLY CONDUCTIVE GAS--CALLED A

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PLASMA--CONCENTRATED IN A SMALL SPOT TO MELT METAL INSTANTANEOUSLY.

SCENE 100.

NARRATION (VO):

THE HOT PLASMA STREAM IS FORMED BY AN ELECTRICAL ARC IN AN INERT GAS MIXTURE.

SCENE 101.

NARRATION (VO):

LASER CUTTING USES A CONCENTRATED BEAM OF LASER LIGHT TO GENERATE HEAT. THE BEAM DIAMETER FROM A LASER MAY BE ONLY ONE-HUNDREDTH (0.010) OF AN INCH, OR ONE QUARTER (0.25) MILLIMETER.

SCENE 102.

NARRATION (VO):

LASERS PRODUCE A NARROWER KERF, A NARROWER HEAT-AFFECTED ZONE, AND A FINER EDGE THAN OTHER THERMAL CUTTING PROCESSES. LASER CUTTING IS MOST EFFECTIVE ON THINNER MATERIAL.

SCENE 103.

NARRATION (VO):

THE MAIN TYPES OF LASERS FOR CUTTING ARE THE GAS-BASED CO2 LASER, WHICH IS PREFERRED FOR CONTOUR CUTTING, AND THE SOLID-CRYSTAL-BASED "YAG" LASER, WHICH MAY BE PREFERRED FOR PERCUSSION DRILLING.

SCENE 104.

NARRATION (VO):

PERCUSSION DRILLING REFERS TO DRILLING SMALL-DIAMETER HOLES WITH SINGLE OR

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MULTIPLE HIGH POWER PULSES OF SHORT DURATION.

SCENE 105.

NARRATION (VO):

LASER TREPANNING PRODUCES MID-SIZE HOLES BY SWEEPING THE OPTICS IN A CIRCULAR PATH OVER THE WORK SURFACE.

SCENE 106.

NARRATION (VO):

THERE ARE SEVERAL STYLES OF MACHINES FOR LASER CUTTING FLAT MATERIAL, AS WELL AS SUCCESSFUL PAIRINGS OF LASERS WITH MULTI-AXIS ROBOTS.

SCENE 107.

NARRATION (VO):

ABRASIVE WATERJET CUTTING USES GARNET ABRASIVE SUSPENDED IN A HIGH-PRESSURE STREAM OF WATER, TO CUT BY ABRASIVE EROSION.

SCENE 108.

NARRATION (VO):

AN INTENSIFIER PUMP PROVIDES THE STREAM OF HIGH-PRESSURE WATER. THE GANTRY OR ROBOT DELIVERY SYSTEM INCLUDES THE HIGH-PRESSURE HOSES, ABRASIVE DELIVERY AND MIXING SYSTEM, NOZZLE, AND CATCHER UNIT.

SCENE 109.

NARRATION (VO):

ABRASIVE WATERJET CAN CUT VERY THICK MATERIALS AS WELL AS SHEET MATERIALS. IT LEAVES NO HEAT- AFFECTED ZONE.

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--- FADE TO BLACK ---

SCENE 110.
continue music, up and under
SD CRX, CGS, ROLL: credits
white text, fade up mid-screen
FMP EXM, extended motion background

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SCENE 111.
continue motion background
FMP DIS, CGS: disclaimer
white text, centered on background

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 112.
FMP SME, SME logo open, with music