

FUNDAMENTAL MANUFACTURING PROCESSES

Tube Bending

SCENE 1.

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

WARNING

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criminal penalties for the unauthorized
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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 tube bending & end forming
equipment.

Make sure all machine guards are in place, and
follow all safety procedures when working with
or near tube bending & end forming equipment.

SCENE 3.

CG: AFFT screen A
white text centered on black to
blue gradient

TB03A, GRAPHIC: AFFT logo

This program was produced using the technical
resources of the Association for Forming &
Fabricating Technologies of the Society of
Manufacturing Engineers.

SCENE 4.

continue AFFT logo graphic
CG: AFFT screen B
white text centered on black to
blue gradient

For more information on tube bending, please
visit our website at:

www.sme.org/afft

SCENE 5.

TB05A, tape 40, 01:00:00-01:00:12

SME logo, with music

CG, SUPER: www.sme.org

SCENE 6.

TB06A, tape 25, 01:01:00-01:01:45

fundamental series open, with music

TB06B, 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.

CG: Tube Bending
white text centered on black

NARRATION (VO) :

THIS PROGRAM EXPLORES THE FUNDAMENTALS OF TUBE
BENDING.

SCENE 8.

TB08A, tape 823, 12:05:08-12:05:26
zoom out, metal tubing for wiring
TB08B, tape 821, 11:04:42-11:04:48
zoom out, tubes used as structural
light pole element
TB08C, tape 811, 03:11:55-03:12:05
zoom in, tube being bent
TB08D, tape 824, 01:17:21-01:17:28
automobiles on road
TB08E, tape 483, 11:04:12-11:04:19
jet taking off
TB08F, tape 823, 12:08:21-12:08:30
table with bent tubular supports
TB08G, tape 823, 13:00:54-13:01:03
coffee pot running

NARRATION (VO) :

METAL TUBING AND PIPES ARE USED FOR A VARIETY OF
APPLICATIONS SUCH AS CONDUITS FOR WIRING,
LIQUIDS, AND GASES...,
AND AS STRUCTURAL MEMBERS.
AS SUCH, TUBING CAN BE BENT AND FABRICATED INTO
VARIOUS SHAPES FOR USE AS COMPONENTS IN
AUTOMOBILES...,
AIRCRAFT...,
FURNITURE...,
APPLIANCES,
AND MORE.

SCENE 9.

TB09A, tape 795, 16:05:04-16:05:25
zoom out, steel tubing
CG, SUPER: Steel
Copper
Aluminum
Brass

NARRATION (VO) :

TUBING IS PRODUCED FROM VARIOUS METALS,
INCLUDING:
STEEL,
COPPER,
ALUMINUM,
AND BRASS.

SCENE 10.

continue previous shot
TB10A, tape 808, 08:05:47-08:05:51
zoom out, bending small tubing
TB10B, tape 813, 00:15:24-00:15:30
rectangular tube being bent
TB10C, GRAPHIC: round tubing
TB10D, GRAPHIC: square tubing

NARRATION (VO) :

ADDITIONALLY, TUBING IS AVAILABLE IN MANY SIZES,
AND IN SEVERAL CROSS-SECTIONAL SHAPES,
INCLUDING:

TB10E, GRAPHIC: rectangular tubing ROUND...,
TB10F, GRAPHIC: oval tubing SQUARE...,
TB10G, GRAPHIC: special shape RECTANGULAR...,
tubing OVAL...,
AND SPECIAL SHAPES.

SCENE 11.

TB11A, tape 795, 16:03:50-16:04:00
zoom out, tube shape being welded
TB11B, GRAPHIC: welded tube
TB11C, GRAPHIC: open seam tube
TB11D, GRAPHIC: lock-seam tubing
TB11E, GRAPHIC: seamless tube

NARRATION (VO) :

THESE TUBE SHAPES MAY HAVE A WELDED SEAM...,
AN OPEN SEAM...,
A LOCK-SEAM...,
OR BE SEAMLESS.

SCENE 12.

TB12A, tape 795, 16:03:17-16:03:39
pan of tube roll-forming
CG, SUPER: Roll-Forming
Extrusion
Drawing

NARRATION (VO) :

TUBES ARE PRODUCED USING VARIOUS PROCESSES WITH
THE PRIMARY TYPES BEING:
ROLL-FORMING,
EXTRUSION,
AND DRAWING.

SCENE 13.

TB13A, tape 811, 03:15:40-03:15:53
zoom out, tubes cut using shear
TB13B, tape 813, 00:17:49-00:17:59
tube being sawn
TB13C, tape 816, 05:12:12-05:12:23
zoom in, tube cut on lathe
CG, SUPER: Shearing
Sawing
Rotary Disc Cutting
Lathe Cutting
Laser Cutting

NARRATION (VO) :

AFTER BEING PRODUCED, TUBES ARE CUT TO LENGTH
USING A WIDE VARIETY OF CUTTING METHODS,
INCLUDING:
SHEARING,
SAWING,
ROTARY DISC CUTTING,
LATHE CUTTING,
AND LASER CUTTING.

SCENE 14.

TB14A, tape 817, 06:07:39-06:07:49
large tubing being bent
TB14B, tape 810, 02:01:36-02:01:49

NARRATION (VO) :

ONCE CUT, THESE TUBE BLANKS ARE TYPICALLY

end forming on tube

PROCESSED INTO COMPONENTS THROUGH BENDING...,
AND END FORMING.

--- FADE TO BLACK ---

SCENE 15.

CG: Tube Bending

white text centered on black

SCENE 16.

TB16A, tape 815, 00:33:10-00:33:35

zoom out, tube bending

TB16B, peter carey narration

NARRATION (VO) :

TUBE BENDING IS A METHOD OF PRODUCING SHAPES BY HOLDING, OR CLAMPING THE TUBE WITH TOOLING AND APPLYING SUFFICIENT FORCE TO FORM THE TUBE TO A BEND RADIUS WHILE MAINTAINING THE TUBE'S CROSS-SECTIONAL SHAPE.

SCENE 17.

TB17A, tape 814, 00:18:05-00:18:32

wide, zoom in, bending operation

CG, SUPER: Yield Point

The Material's
Capability To Resist
Permanent Deformation

CG, SUPER: Tensile Strength

The Limit Of The
Material's Ability To
Resist Tearing

NARRATION (VO) :

FOR BENDING TO BE SUCCESSFUL, THE TUBE MATERIAL MUST BE BENT BEYOND ITS 'YIELD POINT', WHICH IS THE MATERIAL'S CAPABILITY TO RESIST PERMANENT DEFORMATION; BUT NOT PAST ITS ULTIMATE 'TENSILE STRENGTH', WHICH IS THE LIMIT OF THE MATERIAL'S ABILITY TO RESIST TEARING.

SCENE 18.

continue previous shot

TB18A, ANI: tube being bent

TB18B, ANI: c.u. cut away of tube

during bending, double arrow

appears within outside material,

distorting under tension, double

arrow appears within inside

material, distorting under

compression

NARRATION (VO) :

AS THE TUBE IS BENT, IT UNDERGOES A DISTORTION SO THAT THE MATERIAL OUTSIDE THE BEND IS FORCED TO STRETCH UNDER TENSION, AND THE MATERIAL INSIDE THE BEND IS FORCED TO COMPRESS.

SCENE 19.

TB19A, GRAPHIC: cutaway of tube

TB19B, GRAPHIC: cutaway of tube

with line indicating the neutral

axis

CG: Neutral Axis

NARRATION (VO) :

BETWEEN THE TENSION AND COMPRESSION ZONES IS A BOUNDARY LINE KNOWN AS THE 'NEUTRAL AXIS'. THE

TB19C, GRAPHIC: cutaway of tube with neutral axis line highlighted

NEUTRAL AXIS IS IMPORTANT SINCE BENDING OPERATIONS ARE CALCULATED FROM ITS LOCATION.

SCENE 20.

TB20A, tape 818, 07:06:32-07:06:50
zoom in, roll bending operation
CG, SUPER: Tube Outside Diameter
Tube Wall Thickness
Bend Radius
Bend Location

NARRATION (VO) :

FACTORS IMPORTANT TO THE SUCCESSFUL BENDING OF TUBES INCLUDE:
TUBE OUTSIDE DIAMETER,
TUBE WALL THICKNESS,
BEND RADIUS,
AND BEND LOCATION.

--- TOUCH BLACK ---

SCENE 21.

TB21A, tape 823, 11:05:40-11:05:48
manual tube bending operation
TB21B, tape 817, 06:08:33-06:08:41
zoom out, semi-automatic tube bending operation
TB21C, tape 814, 00:01:47-00:01:56
zoom in, cnc tube bending operation
TB21D, tape 822, 00:42:06-00:42:17
dedicated machine performing bending operation

NARRATION (VO) :

TUBE BENDING CAN BE PERFORMED MANUALLY...,
SEMI-AUTOMATICALLY...,
WITH CNC, OR COMPUTER NUMERICALLY CONTROLLED TUBE BENDERS...,
OR WITH DEDICATED BENDING MACHINERY.

SCENE 22.

TB22A, tape 823, 11:10:04-11:10:23
manual tube bending, operator placing tube into position, bending both ends
TB22B, tape 823, 11:11:56-11:12:04
c.u. operator placing tooling into position, bending tube

NARRATION (VO) :

IN MANUAL TUBE BENDING, AN OPERATOR PLACES THE WORKPIECE IN THE TOOLING AREA OF A HAND BENDER AT THE PROPER BEND POSITION,
THE TOOLING IS THEN MOVED INTO POSITION,
AND THE OPERATOR PHYSICALLY PULLS THE MECHANISM TO PRODUCE A BEND.

SCENE 23.

TB23A, tape 823, 11:07:38-11:08:13
zoom out, manual large tube bending operation

NARRATION (VO) :

WHILE MANUAL BENDING REQUIRES A MINIMUM INVESTMENT, IT IS NOT CONDUCIVE TO HIGHER PRODUCTION RATES, QUALITY OR REPEATABILITY.

ALTHOUGH MACHINES HAVE BEEN DESIGNED WITH ENOUGH LEVERAGE TO HANDLE LARGER DIAMETER TUBING, HAND BENDERS ARE GENERALLY LIMITED TO ONE-INCH, OR TWENTY FIVE MILLIMETER, DIAMETER TUBING.

SCENE 24.

TB24A, tape 811, 03:01:23-03:01:43
semi-automatic tube bending
operation

NARRATION (VO) :

SEMI-AUTOMATIC TUBE BENDERS ARE USUALLY EITHER HYDRAULIC- OR ELECTRIC-MOTOR-POWERED BENDING MACHINES. MANY SEMI-AUTOMATIC TUBE BENDERS REQUIRE MANUAL POSITIONING OF TOOLING, ALTHOUGH SOME MACHINES HAVE POWERED POSITION OF TOOLING.

SCENE 25.

TB25A, tape 817, 06:09:13-06:09:40
manual placement of bent tube in
semi-automatic bending operation

NARRATION (VO) :

TYPICALLY, ONCE A BEND IS MADE ON A SEMI-AUTOMATIC TUBE BENDER, MANUAL POSITIONING OF THE TUBING IS REQUIRED FOR THE NEXT BEND. MANUAL POSITIONING IS PERFORMED ON THE TUBE UNTIL ALL BENDING OPERATIONS ARE COMPLETE.

SCENE 26.

TB26A, tape 811, 03:06:34-03:06:55
semi-automatic tube bending
operation

NARRATION (VO) :

WHILE SEMI-AUTOMATIC TUBE BENDERS OFFER MANY ADVANTAGES OVER MANUAL BENDING, ACCURACY AND REPEATABILITY CAN STILL BE AN ISSUE.

SCENE 27.

TB27A, tape 811, 03:14:37-03:14:54
cnc bending operation, pan to
controls

NARRATION (VO) :

COMPUTER NUMERICALLY CONTROLLED TUBE BENDERS CIRCUMVENT MANY OF THE PROBLEMS ASSOCIATED WITH MANUAL AND SEMI-AUTOMATIC BENDING BY INCORPORATING AN INTEGRAL COMPUTER PROCESSOR TO GOVERN THE TUBE BENDING OPERATION.

SCENE 28.

TB28A, tape 810, 02:16:23-02:17:14

NARRATION (VO) :

cnc bending operation
CG, SUPER: Increased Parts
Production Flexibility
Greater Bending Accuracy
& Repeatability
Programming Versatility
Complex Part Capability
Ability To Store &
Retrieve Part Programs

'CNC' TUBE BENDERS HAVE SERVO-DRIVES THAT
ACCURATELY CONTROL THE DISTANCE BETWEEN BENDS,
THE DEGREE OF BENDS, AND THE PLANE OF BENDS.
OTHER 'CNC' TUBE BENDER ADVANTAGES INCLUDE:
INCREASED PARTS PRODUCTION FLEXIBILITY,
GREATER BENDING ACCURACY AND REPEATABILITY,
PROGRAMMING VERSATILITY,
COMPLEX PART CAPABILITY,
AND THE ABILITY TO STORE AND RETRIEVE PART
PROGRAMS.

SCENE 29.

TB29A, tape 822, 00:24:49-00:25:08
zoom out, dedicated machine
performing bending operation

NARRATION (VO) :

DEDICATED BENDING MACHINES ARE GENERALLY CUSTOM-
BUILT FOR SPECIFIC PARTS OR FAMILIES OF PARTS.
DEDICATED BENDING MACHINERY CAN RANGE FROM
MANUALLY POWERED MACHINES TO FULLY AUTOMATED
WORK CELLS.

--- TOUCH BLACK ---

SCENE 30.

CG, SUPER: Rotary-Draw Bending
TB30A, tape 812, 04:05:58-04:06:34
multiple bend, rotary draw bending
operation
CG, SUPER: Compression Bending
TB30B, tape 822, 00:25:26-00:25:41
compression bending operation
CG, SUPER: Ram Bending
TB30C, tape 819, 08:05:01-08:05:17
ram bending operation
CG, SUPER: Press Bending
TB30D, tape 820, 09:07:52-09:07:58
press bending operation
CG, SUPER: Roll Bending
TB30E, tape 818, 07:02:38-07:02:53
zoom out, roll bending operation
TB30F, tape 819, 08:01:35-08:01:43
c.u. manual tube bending
TB30G, tape 820, 09:21:27-09:21:40
rotary draw bending operation

NARRATION (VO) :

THERE ARE SEVERAL METHODS OF TUBE BENDING IN ONE
OR MORE PLANES. THESE METHODS INCLUDE:
ROTARY-DRAW BENDING...,
COMPRESSION BENDING...,
RAM BENDING...,
PRESS BENDING...,
AND ROLL BENDING.
TUBE BENDING PROCESS SELECTION DEPENDS ON THE
TUBE MATERIAL,

CG, SUPER: Tube Material
Tube Diameter
Wall Thickness
Part Complexity
Minimum Bend Radius

TUBE DIAMETER,
WALL THICKNESS,
PART COMPLEXITY,
AND THE MINIMUM BEND RADIUS DESIRED.

--- TOUCH BLACK ---

SCENE 31.

CG, SUPER: Rotary-Draw Bending
TB31A, tape 814, 00:28:18-00:28:32
zoom out, rotary draw bending
operation

NARRATION (VO) :

ROTARY-DRAW BENDING IS THE MOST COMMON METHOD OF
TUBE BENDING AND IS PERFORMED ON ROTARY-TYPE
BENDING MACHINES.

SCENE 32.

TB32A, tape 814, 00:26:25-00:26:31
zoom out, rotary bending machine
TB32B, tape 808, 08:14:46-08:15:12
zoom out, tube bending
TB32C, tape 818, 07:07:59-07:08:46
zoom out, rotary bending machine
CG, SUPER: Rotary Bending
Form/Bending Die
GRAPHIC: add arrow showing bending
die
CG, SUPER: Clamping Die
GRAPHIC: add arrow showing clamping
die
CG, SUPER: Pressure Die
GRAPHIC: add arrow showing pressure
die
CG, SUPER: Wiper Die
GRAPHIC: add arrow showing wiper
die

NARRATION (VO) :

ALL ROTARY-TYPE BENDING MACHINES AND BENDING
OPERATIONS USE A VARIETY OF TUBE-BENDING
TOOLING, WITH THE ESSENTIAL COMPONENTS BEING:
A ROTARY BENDING FORM, OR BENDING DIE...,
A CLAMPING DIE...,
A PRESSURE DIE...,
AND A WIPER DIE.

SCENE 33.

CG, SUPER: Rotary Bending Form
TB33A, tape 818, 07:09:17-07:09:38
c.u., rotary bending form, tube
placed in for bending, operation
beginning

NARRATION (VO) :

THE ROTARY BENDING FORM HAS A TUBE GROOVE THAT
FITS THE OUTSIDE PROFILE OF THE WORKPIECE. THIS
BENDING FORM ROTATES DURING BENDING AND
DETERMINES THE RADIUS TO WHICH THE WORKPIECE IS
BENT.

SCENE 34.

CG, SUPER: Clamping Die
TB34A, tape 818, 07:11:22-07:11:44

NARRATION (VO) :

zoom out, clamp die moving with rotary bending form during bending

THE CLAMPING DIE MATES AND MOVES WITH THE CLAMPING SECTION OF THE ROTARY BENDING FORM TO PRODUCE THE HOLDING FORCE NEEDED TO KEEP THE TUBE FROM SLIPPING DURING BENDING.

SCENE 35.

CG, SUPER: Pressure Die

TB35A, tape 818, 07:15:05-07:15:24

c.u., zoom out pressure die, locating tube for bending, moving with tube during bending operation

NARRATION (VO) :

THE PRESSURE DIE LOCATES THE TUBE IN THE BENDING POSITION AND HOLDS IT AGAINST THE ROTARY BENDING FORM DURING THE BENDING OPERATION. THE PRESSURE DIE MAY MOVE WITH THE TUBE DURING DRAWING, OR REMAIN FIXED.

SCENE 36.

CG, SUPER: Wiper Die

TB36A, tape 818, 07:12:05-07:12:31

static, wiper die during bending
GRAPHIC: add arrow to show tangent point of bend

NARRATION (VO) :

THE STATIONARY WIPER DIE PROVIDES SUPPORT FOR THE TUBE BEHIND THE TANGENT POINT OF THE BEND, WHICH IS THE POINT WHERE THE STRAIGHT SECTION OF THE TUBE ENDS AND THE RADIUS OF THE BEND BEGINS.

SCENE 37.

TB37A, tape 812, 04:20:32-04:20:44

rotary-draw bending making single 180 degree bend

TB37B, tape 820, 09:02:57-09:03:08

rotary-draw bending of multiple bends using special tooling

NARRATION (VO) :

ROTARY-DRAW BENDING IS USED TO MAKE BENDS UP TO 180 DEGREES USING STANDARD TOOLING..., AND MULTIPLE OR COMPOUND BENDS USING SPECIAL TOOLING.

SCENE 38.

TB38A, tape 816, 05:15:49-05:16:24

zoom out, bending operation using mandrel

TB38B, tape 811, 03:12:53-03:13:11

zoom out, tube bent around inserted mandrel

NARRATION (VO) :

DURING BENDING, AN INTERNAL MANDREL MAY BE NECESSARY TO SUPPORT THE WALL OF THE WORKPIECE AS IT IS PULLED AROUND THE BENDING FORM. MANDRELS ARE ALSO USED TO REDUCE THE AMOUNT OF FLATTENING IN THE BEND, AND TO HELP PREVENT WRINKLES FROM FORMING ON THE INNER WALL OF THE

BEND.

SCENE 39.

TB39A, tape 818, 07:16:32-07:16:49

zoom out, mandrels on shelf

TB39B, GRAPHIC: plug mandrel

CG: Plug Mandrel

TB39C, GRAPHIC: form mandrel

CG: Form Mandrel

TB39D, GRAPHIC: single-ball mandrel

CG: Single-Ball Mandrel

TB39E, GRAPHIC: multi-ball mandrel

CG: Multi-Ball Mandrel

NARRATION (VO) :

THERE ARE SEVERAL DIFFERENT TYPES OF MANDRELS,

INCLUDING:

THE PLUG MANDREL...,

THE FORM MANDREL...,

THE SINGLE-BALL MANDREL...,

AND THE MULTI-BALL MANDREL.

SCENE 40.

TB40A, tape 810, 02:21:51-02:22:46

zoom out, c.u. tube placed over

mandrel, bending of tube

NARRATION (VO) :

THE TUBE IS INSERTED OVER THE MANDREL...,

AND THEN POSITIONED SO THAT THE MANDREL IS

LOCATED IN THE REGION OF THE BEND TANGENT. THE

MANDREL IS TYPICALLY ATTACHED TO A ROD ANCHORED

AT THE REAR OF THE BENDING MACHINE. THIS ROD HAS

BOTH LATERAL AND LONGITUDINAL ADJUSTMENT

CAPABILITY TO POSITION THE MANDREL PROPERLY FOR

BENDING.

SCENE 41.

TB41A, tape 812, 04:18:18-04:18:51

tube bending operation

TB41B, tape 812, 04:17:35-04:18:03

pan from bending operation to

extraction mechanism

NARRATION (VO) :

DURING BENDING, THE METAL ON THE OUTSIDE OF THE

BEND STRETCHES ACROSS THE FORMED TIP OF THE

MANDREL, MAKING IT IMPRACTICAL IF NOT IMPOSSIBLE

TO REMOVE THE BENT PIECE FROM THE DIES.

THEREFORE AN EXTRACTION MECHANISM IS USED TO

REMOVE THE MANDREL FROM THE BEND AREA.

--- TOUCH BLACK ---

SCENE 42.

CG, SUPER: Compression Bending

TB42A, tape 822, 00:22:45-00:23:10

c.u. compression bending operation,

NARRATION (VO) :

COMPRESSION BENDING TOOLING IS SIMILAR TO THAT

zoom out

USED IN ROTARY-DRAW BENDING, EXCEPT THE BENDING FORM IS STATIONARY AND A MOVABLE WIPING SHOE REPLACES THE CLAMP DIE. THE WORKPIECE IS CLAMPED TO THE STATIONARY BENDING FORM AND THE WIPING SHOE ROTATES AROUND THE FORM, WRAPPING THE MATERIAL AGAINST THE BENDING FORM.

SCENE 43.

TB43A, tape 822, 00:14:42-00:15:02
zoom in, compression bending operation

TB43B, tape 822, 00:37:05-00:37:15
zoom in, compression bending operation

NARRATION (VO) :

COMPRESSION BENDING WORKS WELL FOR APPLICATIONS IN WHICH LITTLE CLAMPING DISTANCE IS AVAILABLE BETWEEN BENDS. HOWEVER, COMPRESSION BENDING DOES NOT CONTROL METAL FLOW AS WELL AS DRAW BENDING, AND THE PROCESS IS IMPRACTICAL FOR PRODUCING BENDS REQUIRING A MANDREL WHEN THERE IS MORE THAN ONE BEND IN A WORKPIECE.

SCENE 44.

TB44A, tape 823, 11:14:16-11:14:25
zoom out, manual compression bending

TB44B, tape 822, 00:31:43-00:31:58
wide, powered compression bending

NARRATION (VO) :

COMPRESSION BENDERS CAN BE MANUALLY OPERATED... , OR POWERED.

--- TOUCH BLACK ---

SCENE 45.

CG, SUPER: Ram Bending

TB45A, tape 819, 08:06:51-08:07:10
ram bending of tube

NARRATION (VO) :

IN RAM BENDING, TWO SUPPORTING DIES HOLD THE TUBE WHILE FORCE IS APPLIED BY MEANS OF A HYDRAULIC RAM TO THE CENTER OF THE WORKPIECE. THIS PROCESS BENDS THE TUBE TO THE DESIRED ANGLE AND BEND RADIUS.

SCENE 46.

TB46A, tape 819, 08:06:25-08:06:44
c.u. ram bender with forming shoe,
zoom out, bending

NARRATION (VO) :

THE RAM BENDER USES A DIE OR FORMING SHOE MOUNTED TO THE HYDRAULIC PISTON ROD OF THE

MACHINE. THE GROOVE IN THE DIE IS MACHINED TO THE DESIRED CONTOUR OF THE TUBE AND TO THE BEND RADIUS OF THE PROPOSED BEND SECTION.

SCENE 47.

TB47A, tape 819, 08:16:46-08:17:14
wide, supporting dies, bending operation beginning, zoom into dies swiveling, two bends

NARRATION (VO) :

THE SUPPORTING DIES ARE ALSO CONTOURED TO MATCH THE OUTSIDE SURFACE OF THE TUBE. THESE DIES SWIVEL OR ROTATE ON THEIR MOUNTING PINS SO THAT THEY FOLLOW THE TUBE AND MAINTAIN EXTERNAL SUPPORT THROUGHOUT THE BENDING OPERATION. RAM BENDING REQUIRES NO CLAMPING DURING BENDING.

--- TOUCH BLACK ---

SCENE 48.

CG, SUPER: Press Bending
TB48A, tape 820, 09:08:31-09:08:45
tube bending using vertical hydraulic bending press

NARRATION (VO) :

PRESS BENDING USING A VERTICAL HYDRAULIC BENDING PRESS IS A MODIFICATION OF RAM BENDING, BUT IS CONSIDERABLY FASTER AND MORE FLEXIBLE.

SCENE 49.

TB49A, tape 821, 10:03:04-10:03:38
zoom in, tube placed on dies of vertical hydraulic bending press, bending operation, two cycles
TB49B, tape 820, 09:09:21-09:09:32
cushion cylinder moving during bending
TB49C, tape 821, 10:03:51-10:04:13
zoom in, bending of tube

NARRATION (VO) :

THE TUBE IS PLACED ON TOP OF ADJACENT WING-TYPE DIES. THESE DIES SIMULTANEOUSLY SEPARATE AND ROTATE WITH THE TUBE AS IT DEFLECTS AND BENDS FROM PRESSURE APPLIED BY THE DESCENDING RAM DIE. CUSHION CYLINDERS MAINTAIN CONSTANT TORQUE ON THE WING DIES. THE NEARLY CONSTANT CUSHIONING FORCE IS KEY TO PREVENTING WRINKLES AND PRODUCING ACCURATE BENDS WITH MINIMUM DISTORTION OF THE TUBE CROSS SECTION.

--- TOUCH BLACK ---

SCENE 50.

CG, SUPER: Roll Bending

TB50A, tape 819, 08:15:28-08:15:42

zoom out, roll bending of tube

TB50B, tape 813, 00:09:46-00:09:57

zoom in, three forming rolls on vertical roll bender

TB50C, tape 818, 07:02:55-07:03:03

horizontal roll bender

NARRATION (VO) :

ROLL BENDING TUBE STOCK IS PERFORMED ON A ROLL BENDER. ROLL BENDERS HAVE THREE FORMING ROLLS OF APPROXIMATELY THE SAME DIAMETER. THESE ARE ARRANGED IN A PYRAMID IN EITHER A VERTICAL..., OR HORIZONTAL PLANE.

SCENE 51.

TB51A, tape 819, 08:10:04-08:10:32

zoom out, third roll being

adjusted, roll bending of tube

NARRATION (VO) :

TWO OF THE FORMING ROLLS ARE FIXED AND OPPOSE THE THIRD, ADJUSTABLE CENTER ROLL. ALL THE ROLLS ARE ACCURATELY CONTOURED TO MATCH THE CROSS-SECTIONAL SHAPE OF THE WORKPIECE AND PROVIDE SUPPORT DURING THE BENDING OPERATION.

SCENE 52.

TB52A, tape 818, 07:03:56-07:04:31

zoom out, roll bending operation

NARRATION (VO) :

IN OPERATION, THE TUBE STOCK IS PASSED THROUGH THE ROLLS WITH THE POSITION OF THE ADJUSTABLE CENTER ROLL CONTROLLING THE BEND RADIUS.

SCENE 53.

TB53A, tape 813, 00:07:13-00:07:29

zoom out, roll bending operation

TB53B, tape 819, 08:11:07-08:11:28

wide, roll bending operation

NARRATION (VO) :

ROLL BENDING IS USED TO PRODUCE LARGE RADIUS BENDS, BUT IS LIMITED TO PROCESSING HEAVY-WALL MATERIAL SINCE IT PRODUCES A HIGH DEGREE OF WALL THINNING. THE PROCESS IS CAPABLE OF PRODUCING TUBES IN FULL CIRCLES, HELIXES, AND MULTIPLE-RADIUS PARTS, AS WELL AS, BENDING PIPE, SOLID BAR AND EXTRUSIONS.

--- FADE TO BLACK ---

SCENE 54.

CG: Tube End Forming

white text on black

SCENE 55.

TB55A, tape 816, 05:10:12-05:10:34

zoom out, tube ends being expanded

TB55B, tape 808, 08:09:36-08:09:52

zoom out, tubes being brazed together

TB55C, tape 823, 13:03:01-13:03:15

zoom out, tubes fitted together in automotive fluid-handling system

TB55D, peter carey narration

NARRATION (VO) :

TUBE END FORMING METHODS ARE USED TO ALTER A TUBE AT ITS END. TUBE END FORMS ARE REQUIRED FOR MANY APPLICATIONS, INCLUDING: CREATING A CONNECTION TO ANOTHER COMPONENT, SUCH AS A TUBE OR FITTING..., OR TO ACHIEVE A CLOSE-TOLERANCE FIT FOR CERTAIN FLUID-HANDLING SYSTEMS.

SCENE 56.

TB56A, tape 810, 02:02:51-02:03:02

zoom in, tube being expanded

CG, SUPER: Reduction

TB56B, GRAPHIC: reduced tube end

CG, SUPER: Expansion

TB56C, GRAPHIC: expanded tube end

CG, SUPER: Flaring

TB56D, GRAPHIC: flared tube end

CG, SUPER: Beading

TB56E, GRAPHIC: tube end with beading

NARRATION (VO) :

THERE ARE MANY BASIC FORMS THAT CAN BE APPLIED TO THE END OF A TUBE, WITH THE PRIMARY TYPES INCLUDING: REDUCTION..., EXPANSION..., FLARING..., AND BEADING.

--- TOUCH BLACK ---

SCENE 57.

CG, SUPER: Reduction

TB57A, tape 816, 05:03:36-05:04:02

zoom in, stationary tubes on ram-forming machine being reduced

NARRATION (VO) :

IN TUBE END REDUCTION, THE TUBE IS TYPICALLY HELD STATIONARY ON A RAM-FORMING MACHINE WHILE A REDUCTION PUNCH IS FORCED AXIALLY OVER THE END OF THE TUBE TO REDUCE THE DIAMETER.

SCENE 58.

TB58A, tape 816, 05:02:12-05:02:42

c.u. stationary tubes on ram-forming machine being reduced

NARRATION (VO) :

THIS REDUCTION IN DIAMETER PLACES THE TUBE END SECTION UNDER PREDOMINATELY COMPRESSIVE STRESSES. ADDITIONALLY, THERE IS AN INCREASE IN

TUBE WALL THICKNESS AND TUBE END LENGTH.

--- TOUCH BLACK ---

SCENE 59.

CG, SUPER: Expansion

TB59A, tape 816, 05:05:30-05:05:47
zoom in, tube end being expanded

NARRATION (VO) :

IN TUBE END EXPANSION, THE EXPANDED TUBULAR DIAMETER IS PLACED UNDER PREDOMINATELY TENSILE STRESSES, RESULTING IN A DECREASE IN TUBE WALL THICKNESS AND TUBE END LENGTH.

SCENE 60.

TB60A, tape 821, 10:08:52-10:09:04
tube end being expanded on ram forming machine

NARRATION (VO) :

THERE ARE SEVERAL METHODS USED FOR TUBE END EXPANSION, WITH ONE OF THE MOST COMMON BEING RAM FORMING.

SCENE 61.

TB61A, tape 816, 05:08:11-05:08:36
tube end being expanded on ram forming machine

NARRATION (VO) :

AS WITH TUBE END REDUCTION, RAM FORMING IS PERFORMED ON A RAM-FORMING MACHINE USING AN AXIALLY-FORCED EXPANSION PUNCH THAT MATCHES THE DESIRED INSIDE DIAMETER OF THE TUBE.

--- TOUCH BLACK ---

SCENE 62.

CG, SUPER: Flaring

TB62A, tape 809, 01:02:50-01:03:11
zoom in, flaring of multiple tube ends

NARRATION (VO) :

TUBE END FLARING IS THE OPENING, OR EXPANDING OUTWARD, OF THE END OF A TUBE.

SCENE 63.

continue previous shot

TB63A, tape 823, 12:03:53-12:04:03
single flare on tube

TB63B, tape 819, 08:21:35-08:21:50
single flare tube end forming operation

TB63C, tape 823, 12:02:48-12:02:58
inside double flare on tube

TB63D, tape 819, 08:19:16-08:19:33
inside double flare tube end forming operation

NARRATION (VO) :

THERE ARE SEVERAL TYPES OF TUBE END FLARES, INCLUDING:
SINGLE FLARES...,
WHICH CAN BE PERFORMED IN A SINGLE SET-UP...,
AND INSIDE DOUBLE FLARES...,

WHICH USE A TWO-FLARE PUNCH OPERATION WITHIN THE
SAME TOOLING.

--- TOUCH BLACK ---

SCENE 64.

CG, SUPER: Beading

TB64A, tape 810, 02:06:11-02:06:26

zoom out, beading on tubes

NARRATION (VO) :

BEADING IS A PROJECTION OR PROJECTIONS USED
AROUND A TUBE END TO PROVIDE STRENGTH. BEADING
IS COMMONLY USED FOR CLOSE-TOLERANCE
CONNECTIONS.

SCENE 65.

TB65A, tape 811, 03:23:02-03:23:29

zoom out, beading of tube end using
rolling

NARRATION (VO) :

BEADS CAN BE GENERATED USING A VARIETY OF
METHODS, WITH BEAD ROLLING BEING ONE OF THE MOST
COMMON.

SCENE 66.

continue previous shot

TB66A, GRAPHIC: tube end with
external beading

TB66B, GRAPHIC: tube end with
groove

NARRATION (VO) :

BEADS PRODUCED ARE OF TWO TYPES:
EXTERNAL TUBE BEADS...,
AND INTERNAL TUBE BEADS, WHICH ARE ALSO REFERRED
TO AS 'GROOVES'.

--- FADE TO BLACK ---

SCENE 67.

CG: Review

white text on black

TB67A, tape 63, 12:00:15-12:03:49

review music

TB67B, peter carey narration

MUSIC UP AND UNDER

NARRATION (VO) :

LET'S REVIEW THE MATERIAL CONTAINED IN THIS
PROGRAM.

SCENE 68.

TB68A, tape 823, 12:05:08-12:05:26

zoom out, metal tubing for wiring

TB68B, tape 821, 11:04:42-11:04:48

zoom out, tubes used as structural
light pole element

TB68C, tape 817, 06:07:39-06:07:49

large tubing being bent

NARRATION (VO) :

METAL TUBING AND PIPES ARE USED FOR A VARIETY OF
APPLICATIONS SUCH AS CONDUITS FOR WIRING,
LIQUIDS, AND GASES...,

TB68D, tape 810, 02:01:36-02:01:49
end forming on tube

AND AS STRUCTURAL MEMBERS.

THESE TUBES ARE TYPICALLY PROCESSED INTO

COMPONENTS THROUGH BENDING...,

AND END FORMING.

--- TOUCH BLACK ---

SCENE 69.

TB69A, tape 815, 00:33:10-00:33:35
zoom out, tube bending

NARRATION (VO) :

TUBE BENDING IS A METHOD OF PRODUCING SHAPES BY HOLDING, OR CLAMPING THE TUBE WITH TOOLING AND APPLYING SUFFICIENT FORCE TO FORM THE TUBE TO A BEND RADIUS WHILE MAINTAINING THE TUBE'S CROSS-SECTIONAL SHAPE.

SCENE 70.

TB70A, tape 814, 00:18:05-00:18:32
wide, zoom in, bending operation
CG, SUPER: Yield Point

The Material's
Capability To Resist
Permanent Deformation

CG, SUPER: Tensile Strength

The Limit Of The
Material's Ability To
Resist Tearing

NARRATION (VO) :

FOR BENDING TO BE SUCCESSFUL, THE TUBE MATERIAL MUST BE BENT BEYOND ITS 'YIELD POINT', WHICH IS THE MATERIAL'S CAPABILITY TO RESIST PERMANENT DEFORMATION; BUT NOT PAST ITS ULTIMATE 'TENSILE STRENGTH', WHICH IS THE LIMIT OF THE MATERIAL'S ABILITY TO RESIST TEARING.

SCENE 71.

continue previous shot
TB71A, ANI: tube being bent
TB71B, ANI: c.u. cut away of tube during bending, double arrow appears within outside material, distorting under tension, double arrow appears within inside material, distorting under compression

NARRATION (VO) :

AS THE TUBE IS BENT, IT UNDERGOES A DISTORTION SO THAT THE MATERIAL OUTSIDE THE BEND IS FORCED TO STRETCH UNDER TENSION, AND THE MATERIAL INSIDE THE BEND IS FORCED TO COMPRESS.

SCENE 72.

TB72A, GRAPHIC: cutaway of tube
TB72B, GRAPHIC: cutaway of tube with line indicating the neutral axis
CG: Neutral Axis
TB72C, GRAPHIC: cutaway of tube

NARRATION (VO) :

BETWEEN THE TENSION AND COMPRESSION ZONES IS A BOUNDARY LINE KNOWN AS THE 'NEUTRAL AXIS'. THE

with neutral axis line highlighted NEUTRAL AXIS IS IMPORTANT SINCE BENDING
OPERATIONS ARE CALCULATED FROM ITS LOCATION.

SCENE 73.

TB73A, tape 818, 07:06:32-07:06:50
zoom in, roll bending operation
CG, SUPER: Tube Outside Diameter
Tube Wall Thickness
Bend Radius
Bend Location

NARRATION (VO) :

FACTORS IMPORTANT TO THE SUCCESSFUL BENDING OF
TUBES INCLUDE:
TUBE OUTSIDE DIAMETER,
TUBE WALL THICKNESS,
BEND RADIUS,
AND BEND LOCATION.

--- TOUCH BLACK ---

SCENE 74.

TB74A, tape 823, 11:05:40-11:05:48
manual tube bending operation
TB74B, tape 817, 06:08:33-06:08:41
zoom out, semi-automatic tube
bending operation
TB74C, tape 814, 00:01:47-00:01:56
zoom in, cnc tube bending operation
TB74D, tape 822, 00:42:06-00:42:17
dedicated machine performing
bending operation

NARRATION (VO) :

TUBE BENDING CAN BE PERFORMED MANUALLY...,
SEMI-AUTOMATICALLY...,
WITH CNC, OR COMPUTER NUMERICALLY CONTROLLED
TUBE BENDERS...,
OR WITH DEDICATED BENDING MACHINERY.

SCENE 75.

CG, SUPER: Rotary-Draw Bending
TB75A, tape 812, 04:05:58-04:06:34
multiple bend, rotary draw bending
operation
CG, SUPER: Compression Bending
TB75B, tape 822, 00:25:26-00:25:41
compression bending operation
CG, SUPER: Ram Bending
TB75C, tape 819, 08:05:01-08:05:17
ram bending operation
CG, SUPER: Press Bending
TB75D, tape 820, 09:07:52-09:07:58
press bending operation
CG, SUPER: Roll Bending
TB75E, tape 818, 07:02:38-07:02:53
zoom out, roll bending operation

NARRATION (VO) :

THERE ARE SEVERAL METHODS OF TUBE BENDING IN ONE
OR MORE PLANES. THESE METHODS INCLUDE:
ROTARY-DRAW BENDING...,
COMPRESSION BENDING...,
RAM BENDING...,
PRESS BENDING...,
AND ROLL BENDING.

--- TOUCH BLACK ---

SCENE 76.

TB76A, tape 816, 05:08:11-05:08:36
tube end being expanded on ram

NARRATION (VO) :

forming machine

TB76B, tape 808, 08:09:36-08:09:52

zoom out, tubes being brazed together

TB76C, tape 823, 13:03:01-13:03:15

zoom out, tubes fitted together in automotive fluid-handling system

TUBE END FORMING METHODS ARE USED TO ALTER A

TUBE AT ITS END. TUBE END FORMS ARE REQUIRED FOR

MANY APPLICATIONS, INCLUDING:

CREATING A CONNECTION TO ANOTHER COMPONENT, SUCH

AS A TUBE OR FITTING...,

OR TO ACHIEVE A CLOSE-TOLERANCE FIT FOR CERTAIN

FLUID-HANDLING SYSTEMS.

SCENE 77.

TB77A, tape 810, 02:02:51-02:03:02

zoom in, tube being expanded

CG, SUPER: Reduction

TB77B, GRAPHIC: reduced tube end

CG, SUPER: Expansion

TB77C, GRAPHIC: expanded tube end

CG, SUPER: Flaring

TB77D, GRAPHIC: flared tube end

CG, SUPER: Beading

TB77E, GRAPHIC: tube end with beading

NARRATION (VO):

THERE ARE MANY BASIC FORMS THAT CAN BE APPLIED

TO THE END OF A TUBE, WITH THE PRIMARY TYPES

INCLUDING:

REDUCTION...,

EXPANSION...,

FLARING...,

AND BEADING.

--- FADE TO BLACK ---

SCENE 78.

CG, ROLL: credits

white text on black, fade up mid-screen

TB78A, GRAPHIC: AFFT logo

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SCENE 79.

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 80.

TB80A, tape 40, 01:00:00-01:00:12

SME logo, with music

CG, SUPER: www.sme.org