

FUNDAMENTAL MANUFACTURING PROCESSES

Extrusion Processes

SCENE 1.

EP01A, GRAPHIC: FBI warning
white text centered on black to blue
gradient

WARNING

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criminal penalties for the unauthorized
reproduction, distribution or exhibition
of copyrighted media.

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SCENE 2.

EP02A, GRAPHIC: disclaimer
white text centered on black to blue
gradient

Always read the operating manual and safety
information provided by the manufacturer before
operating any extrusion equipment.

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

SCENE 3.

EP03A, GRAPHIC: F&F/EMA/SME screen
white text centered on black to blue
gradient

This program was produced using the technical
resources of the Forming & Fabricating Community
of SME, and the Engineering Materials
Applications Community of SME.

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

www.sme.org

SCENE 4.

EP04A, SME logo open, with music

SCENE 5.

EP05A, tape 25, 01:01:00-01:01:45
fundamental series open, with music
EP05B, 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.

EP06A, GRAPHIC: Extrusion
Processes
white text centered on black

NARRATION (VO) :

THIS PROGRAM IS AN INTRODUCTION TO EXTRUSION

PROCESSES.

SCENE 7.

EP07A, tape 895, 10:14:20-10:14:31
extrusion of metal
EP07B, tape 890, 05:11:01-05:11:11
zoom out, extrusion of plastic

NARRATION (VO) :

EXTRUSION IS THE DEFORMATION OF EITHER METALS...,
OR PLASTICS FORCED UNDER PRESSURE THROUGH ONE OR
MORE DIE OPENINGS.

SCENE 8.

EP08A, tape 886, 01:15:58-01:16:09
wide, hot extrusion of metal
EP08B, tape 892, 07:03:37-07:03:49
zoom in, plastic profile extrusion
EP08C, tape 897, 12:17:45-12:17:54
extrusion slug
EP08D, tape 897, 12:17:10-12:17:18
stepped extrusion produced from slug

NARRATION (VO) :

THE RESULTING SHAPE IS CALLED AN EXTRUSION, AND
IS PRODUCED TYPICALLY HAVING A CONSTANT CROSS-
SECTION PROFILE DEFINED BY THE SHAPE, OR
GEOMETRY, OF THE DIE OPENING. WITH SPECIAL
TOOLING, STEPPED OR TAPERED EXTRUSIONS MAY ALSO
BE PRODUCED.

SCENE 9.

EP09A, tape 892, 07:06:17-07:06:26
zoom in, extrusion of thin plastic
part
EP09B, GRAPHIC: thick extruded part
EP09C, GRAPHIC: hollow extrusion
EP09D, GRAPHIC: solid extrusion
EP09E, tape 891, 06:15:21-06:15:35
plastic extrusion being cut into
part
CG, SUPER: Products
 Assembly Components
 Raw Stock

NARRATION (VO) :

ALMOST ANY THIN...,
OR THICK...,
HOLLOW...,
OR SOLID CROSS-SECTIONAL SHAPE MAY BE PRODUCED BY
EXTRUSION. THESE EXTRUSIONS ARE THEN TYPICALLY
CUT TO LENGTH FOR USE AS PRODUCTS,
ASSEMBLY COMPONENTS,
OR AS RAW STOCK FOR FURTHER PROCESSING INTO
DISCRETE PARTS.

SCENE 10.

EP10A, tape 896, 12:04:15-12:04:27
zoom in, extrusion being produced
EP10B, tape 824, 01:17:21-01:17:28
automobiles on road
EP10C, tape 483, 11:04:10-11:04:23
aircraft taking off
EP10D, tape 513, 02:20:06-02:20:14
construction site
EP10E, tape 823, 12:08:21-12:08:30

NARRATION (VO) :

EXTRUSIONS ARE USED FOR A VARIETY OF APPLICATIONS
WITHIN MANY INDUSTRIES, INCLUDING:
AUTOMOTIVE...,
AEROSPACE...,

office table
EP10F, tape 899, 14:06:49-14:06:59
pan, seamless tubing
EP10G, tape 899, 14:01:07-14:01:14
computer heat sink
EP10H, tape 899, 14:03:33-14:03:49
zoom out, aluminum ladder

BUILDING AND CONSTRUCTION...,
FURNITURE...,
UTILITY CONDUIT...,
ELECTRONICS...,
AND MANY CONSUMER PRODUCTS.

--- FADE TO BLACK ---

SCENE 11.
EP11A, GRAPHIC: Metal Extrusion
white text centered on black

SCENE 12.
EP12A02, peter carey narration
EP12B, tape 886, 01:11:19-01:11:28
zoom out, hot extrusion of part
CG, SUPER: Hot Extrusion
EP12C, tape 901, 01:06:05-01:06:15
warm extrusion of part
CG, SUPER: Warm Extrusion
EP12D, tape 896, 12:02:01-12:02:11
zoom in, cold extrusion of part
CG, SUPER: Cold Extrusion

NARRATION (VO):

METALS MAY BE EXTRUDED USING EITHER HOT
EXTRUSION...,
WARM EXTRUSION...,
OR COLD EXTRUSION PROCESSES.

--- TOUCH BLACK ---

SCENE 13.
CG, SUPER: Hot Extrusion
EP13A, tape 887, 02:04:12-02:04:33
heated billet placed in container,
beginning of heated billet being
extruded
EP13B, tape 887, 02:18:56-02:19:16
billet being extruded, camera view,
pan to extrusion

NARRATION (VO):

HOT EXTRUSION USES HEATED FEEDSTOCK, CALLED
BILLET, WHICH IS PLACED AND CONFINED IN A
CONTAINER...,
FORCE IS THEN APPLIED...,
AND THE BILLET IS EXTRUDED THROUGH THE DIE.

SCENE 14.
continue previous shot

NARRATION (VO):

HOT EXTRUSION IS PERFORMED AT TEMPERATURES MUCH
HIGHER THAN THE RECRYSTALLIZATION TEMPERATURE OF
THE MATERIAL TO BE EXTRUDED. AT THESE ELEVATED
TEMPERATURES, VIRTUALLY ALL METALS ARE
EXTRUDABLE.

SCENE 15.

EP15A, tape 886, 01:10:40-01:10:53

aluminum billet coming out of
preheat furnace

EP15B, tape 887, 02:26:35-02:26:58

zoom out, stacked billets

CG, SUPER: Carbon Steels
Stainless Steels
Tool Steels
Nickel Alloys
Magnesium Alloys
Copper Alloys
Titanium Alloys
Lead Alloys

NARRATION (VO) :

ALUMINUM IS THE MOST COMMON EXTRUDABLE METAL, AND
VIRTUALLY ALL ALUMINUM ALLOYS CAN BE EXTRUDED.
OTHER COMMON HOT EXTRUDED METALS INCLUDE:
CARBON STEELS,
STAINLESS STEELS,
TOOL STEELS,
NICKEL ALLOYS,
MAGNESIUM ALLOYS,
COPPER ALLOYS,
TITANIUM ALLOYS,
AND LEAD ALLOYS.

SCENE 16.

EP16A, tape 887, 02:10:16-02:10:34

zoom out, heated billet placed in
container

CG, SUPER: 200° To 2,300°
Fahrenheit

90° To 1,260° Celsius

NARRATION (VO) :

DEPENDING ON THE MATERIAL, TYPICAL BILLET
TEMPERATURES FOR HOT EXTRUSION RANGE FROM ABOUT
200 TO 2300 DEGREES FAHRENHEIT, OR 90 TO 1260
DEGREES CELSIUS.

SCENE 17.

EP17A, tape 887, 02:15:46-02:15:56

zoom out, aluminum being extruded
CG, SUPER: 575° To 1,100°

Fahrenheit
300° To 600° Celsius

NARRATION (VO) :

ALUMINUM BILLET TEMPERATURES RANGE FROM ABOUT 575
TO 1100 DEGREES FAHRENHEIT, OR 300 TO 600 DEGREES
CELSIUS.

SCENE 18.

EP18A, GRAPHIC: extruded shape

EP18B, GRAPHIC: circle appears
around extruded shape

NARRATION (VO) :

EXTRUSION SIZE IS OFTEN EXPRESSED AS CIRCLE SIZE,
WHICH IS THE DIAMETER OF THE SMALLEST CIRCLE THAT
ENCLOSES AN EXTRUSION'S CROSS-SECTION.

SCENE 19.

EP19A, tape 886, 01:21:22-01:21:30

zoom out, surface of hot extrusion
as it is being produced

NARRATION (VO) :

TYPICALLY, HOT EXTRUSIONS CAN BE PRODUCED TO

EP19B, tape 886, 01:16:35-01:16:50
pan, long extrusions cooling

EXTREMELY CLOSE-TOLERANCES, AS WELL AS SMOOTH,
FINE SURFACE FINISHES IN LENGTHS OF OVER 100
FEET, OR 30 METERS.

SCENE 20.

EP20A, tape 894, 09:03:24-09:03:41
zoom out, hot extrusion of long
shape

CG, SUPER: Improve Microstructures
Provide Close
Tolerances
Smooth Surface
Finishes

NARRATION (VO) :

DEPENDING ON THE MATERIAL, HOT EXTRUSION CAN
IMPROVE MICROSTRUCTURES AND PROVIDE CLOSE
TOLERANCES AND SMOOTH SURFACE FINISHES.

EP20B, tape 893, 08:19:39-08:19:51
zoom in, hot extrusion of long
complex shape

ADDITIONALLY, HOT EXTRUSION IS AN ECONOMICAL
PRODUCTION METHOD SINCE MOST OF THE MATERIAL
PROCESSED IS USABLE.

SCENE 21.

EP21A, tape 20, 00:04:18-00:04:30
machining of thin walled part

EP21B, tape 485, 11:16:52-11:17:02
forging operation

EP21C, tape 446, 13:17:23-13:17:32
casting operation

EP21D, tape 523, 10:11:20-10:11:33
welding operation

NARRATION (VO) :

AS A RESULT, THE PROCESS IS COMPETITIVE WITH
MACHINING...,
FORGING...,
CASTING...,
WELDING AND OTHER MEANS OF FABRICATING CERTAIN
METAL SHAPES OR PARTS.

SCENE 22.

EP22A, tape 796, 17:19:09-17:19:26
pan of tube mill line

NARRATION (VO) :

HOWEVER, HOT EXTRUSION IS NOT ALWAYS THE MOST
ECONOMICAL PRODUCTION METHOD. MOST CARBON-STEEL
TUBING, FOR EXAMPLE, IS MANUFACTURED BY ROLL
FORMING ON TUBE MILLS BECAUSE OF THEIR GREATER
PRODUCTION RATES.

SCENE 23.

EP23A, tape 893, 08:20:14-08:20:24
zoom in, direct extrusion process
CG, SUPER: Direct Extrusion

NARRATION (VO) :

THE PRIMARY TYPE OF HOT EXTRUSION IS DIRECT, OR
FORWARD, EXTRUSION.

SCENE 24.

EP24A, tape 886, 01:02:37-01:02:49

NARRATION (VO) :

zoom out, hot billet placed in container

EP24B, tape 886, 01:13:22-01:13:35
extrusion die with extrusion beginning

IN DIRECT EXTRUSION, THE HOT BILLET IS LOADED INTO A THICK-WALL CONTAINER..., AND FORCED THROUGH AN EXTRUSION DIE SECURED IN A HOLDER.

SCENE 25.

EP25A, tape 886, 01:01:09-01:01:20
zoom out, ram with dummy block loading billet, add arrow to show dummy block

EP25B, tape 886, 01:19:38-01:19:50
extrusion coming out of die

NARRATION (VO) :

THE FORCE FOR EXTRUDING IS APPLIED BY A RAM, ALONG WITH AN INTERMEDIATE, REUSABLE DUMMY BLOCK. METAL FLOW FROM THE DIE IS IN THE SAME DIRECTION AS THE FORWARD MOTION OF THE RAM.

SCENE 26.

EP26A, tape 886, 01:25:21-01:25:44
zoom in, ram going into extrusion machine

CG, SUPER: Friction Between the Billet Length & the Container Material

NARRATION (VO) :

SINCE THE SURFACE OF THE BILLET LENGTH SLIDES ALONG THE WALL OF THE CONTAINER, EXTRUSION FORCE DEPENDS ON FRICTION BETWEEN THE BILLET LENGTH AND THE CONTAINER, AND THE MATERIAL. THE FRICTION PORTION OF THE FORCE CAN BE REDUCED BY USING LUBRICATION.

SCENE 27.

EP27A, ANI: ram pushed forward along with dummy block, flattening billet within container, force arrow appears, growing larger as breakthrough force is needed, after breakthrough, force arrow decreases for most of extrusion length, force arrow rapidly rising as billet becomes disk, ram continues to push

NARRATION (VO) :

FORCE INCREASES RAPIDLY AS THE BILLET IS UPSET TO FILL THE CONTAINER, THEN INCREASES FURTHER AS BREAKTHROUGH FORCE BEFORE EXTRUSION BEGINS. UPON BREAKTHROUGH, THE FORCE DECLINES AS BILLET LENGTH DECREASES UNTIL A MINIMUM FORCE IS REACHED. AS THE BILLET THINS, THE FORCE RAPIDLY RISES AGAIN TO CONTINUE METAL FLOW RADially TOWARD THE DIE OPENING.

SCENE 28.

EP28A, tape 887, 02:07:08-02:07:35
press opens exposing end of billet extrusion

NARRATION (VO) :

RESISTANCE TO DEFORMATION, OR FORCE REQUIREMENTS,

INCREASE MARKEDLY AS THE THICKNESS OF THE BUTT,
OR UNUSED BILLET PORTION, DECREASES.

--- TOUCH BLACK ---

SCENE 29.

EP29A, tape 887, 02:12:39-02:12:49
pan, hot extrusion performed on
horizontal press

NARRATION (VO) :

HOT EXTRUSION IS MOST COMMONLY PERFORMED ON
HORIZONTAL HYDRAULIC PRESSES.

SCENE 30.

EP30A, tape 893, 08:27:19-08:27:48

wide, hot extrusion press, zoom in
to extrusion operation

CG, SUPER: Billet Material &
Temper
Cross-Section &
Complexity
Length & Temperature
Extrusion Speed
Reduction/Extrusion
Ratio

EP30B, GRAPHIC: cross-section of hot
extrusion container and die areas,
lines indicating container liner and
die opening

NARRATION (VO) :

HOT EXTRUSION PRESSES ARE USUALLY RATED IN FORCE
CAPACITY, WHICH TRANSLATES TO THE AMOUNT OF
PRESSURE APPLIED TO THE BILLET. THAT PRESSURE
DEPENDS ON BILLET MATERIAL AND TEMPER; ITS CROSS-
SECTION AND COMPLEXITY, LENGTH AND TEMPERATURE;
EXTRUSION SPEED AND REDUCTION, OR EXTRUSION,
RATIO. THE EXTRUSION RATIO EQUALS THE CROSS-
SECTIONAL AREA OF THE CONTAINER LINER DIVIDED BY
THE CROSS-SECTIONAL AREA OF THE DIE OPENINGS.

SCENE 31.

EP31A, tape 893, 08:24:17-08:24:43

lubrication added to ram during
aluminum extrusion operation

CG, SUPER: Copper Alloys
Titanium Alloys
Alloy Steels
Carbon Steels
Stainless Steels
Tool Steels

NARRATION (VO) :

LUBRICANTS MAY BE USED FOR THE HOT EXTRUSION OF
ALUMINUM AND ALUMINUM ALLOYS, BUT THEY ARE MORE
COMMONLY NEEDED WHEN EXTRUDING COPPER ALLOYS,
TITANIUM ALLOYS, ALLOY STEELS, CARBON STEELS,
STAINLESS STEELS AND TOOL STEELS.

--- TOUCH BLACK ---

SCENE 32.

CG, SUPER: Warm extrusion

EP32A, tape 901, 01:06:02-01:06:25

warm extrusion operation

CG, SUPER: Cold extrusion

EP32B, tape 896, 12:05:19-12:05:36

cold extrusion operation

NARRATION (VO) :

WARM EXTRUSION REFERS TO EXTRUSION WITH THE
BILLET, OR SLUG OF FEEDSTOCK AS IT'S MORE

COMMONLY CALLED, AT A TEMPERATURE GREATER THAN ROOM TEMPERATURE BUT WELL BELOW THE MATERIALS RECRYSTALLIZATION TEMPERATURE.

COLD EXTRUSION REFERS TO EXTRUSION WITH THE SLUG AT ROOM TEMPERATURE.

SCENE 33.

EP33A, tape 901, 01:06:56-01:07:21
warm extrusion operation

NARRATION (VO) :

BECAUSE THE SLUG IS AT A LOWER TEMPERATURE THAN IN HOT EXTRUSION, NO RECRYSTALLIZATION OR MICROSTRUCTURAL CHANGES OCCUR IN THE MATERIAL DURING EXTRUSION.

SCENE 34.

EP34A, tape 898, 13:14:53-13:15:10
zoom out, cold extrusion operation
CG, SUPER: Strength & Hardness of
the Material
Provide Precision
Extrusions
EP34B, tape 898, 13:21:37-13:22:00
zoom out, cold extrusion operation

NARRATION (VO) :

WARM AND COLD EXTRUSION PROCESSES CAN INCREASE STRENGTH AND HARDNESS OF THE MATERIAL AND PROVIDE PRECISION EXTRUSIONS. ADDITIONALLY, EXTRUDING AT LOWER TEMPERATURES, ELIMINATES OR REDUCES POLLUTION CONCERNS CAUSED BY GREATER HEATING, AND AVOIDS THE COST OF HIGH-TEMPERATURE TOOLING.

SCENE 35.

EP35A, tape 901, 01:06:29-01:06:52
warm extrusion operation

NARRATION (VO) :

LIKE HOT EXTRUSION, VIRTUALLY ALL METALS CAN BE WARM OR COLD EXTRUDED, BUT THOSE HAVING HIGH DUCTILITY ARE EASIEST TO PROCESS.

SCENE 36.

continue previous shot
EP36A, tape 895, 10:17:05-10:17:35
zoom out, indirect extrusion
operation
CG, SUPER: Indirect Extrusion
EP36B, tape 896, 12:07:07-12:07:26
combination extrusion operation
CG, SUPER: Combination Extrusion
EP36C, tape 902, 18:01:37-18:01:45
impact extrusion operation
CG, SUPER: Impact Extrusion

NARRATION (VO) :

WARM... ,
AND COLD EXTRUSION ARE COMMONLY INTEGRATED INTO CONTINUOUS OR SEMI-CONTINUOUS MANUFACTURING OPERATIONS, WITH THE THREE PRINCIPAL METHODS INCLUDING:

INDIRECT EXTRUSION...,
COMBINATION EXTRUSION...,
AND IMPACT EXTRUSION.

--- TOUCH BLACK ---

SCENE 37.
CG, SUPER: Indirect Extrusion
EP37A, tape 895, 10:18:53-10:19:28
zoom out, indirect extrusion

NARRATION (VO) :

WARM OR COLD INDIRECT, OR BACKWARD, EXTRUSION IS INTENDED MAINLY FOR HOLLOW SHAPES. THE INSIDE DIAMETER IS CONTROLLED BY A PUNCH, WHILE THE OUTSIDE DIAMETER IS CONTROLLED BY THE DIE.

SCENE 38.
continue previous shot

NARRATION (VO) :

INDIRECT EXTRUSION IS USED TO PRODUCE A MULTITUDE OF PARTS, SUCH AS THOSE WITH RECTANGULAR, OVAL OR UNUSUAL SHELLS, AND PARTS HAVING HIGH SHELL LENGTH TO DIAMETER RATIOS.

--- TOUCH BLACK ---

SCENE 39.
CG, SUPER: Combination Extrusion
EP39A, tape 896, 12:06:14-12:06:45
combination extrusion operation
producing complex part

NARRATION (VO) :

COMBINATION EXTRUSION COMBINES VARIOUS TYPES OF EXTRUSION, SUCH AS DIRECT AND INDIRECT, IN THE SAME PRESS STROKE, PERMITTING MORE COMPLEX SHAPES TO BE PRODUCED.

--- TOUCH BLACK ---

SCENE 40.
CG, SUPER: Impact Extrusion
EP40A, tape 902, 18:13:20-18:14:10
zoom out, impact extrusion operation

NARRATION (VO) :

IMPACT EXTRUSION IS SIMILAR TO DIRECT, INDIRECT, AND COMBINATION EXTRUSION BUT TYPICALLY EMPLOYS FASTER SPEEDS, SHORTER STROKES AND SHALLOWER DIES. DEPENDING ON THE OPERATION, PUNCH IMPACT

CAUSES THE FEEDSTOCK SLUG TO MOVE EITHER UPWARD,
DOWNWARD OR IN BOTH DIRECTIONS WITHOUT BEING
COMPLETELY CONFINED BY THE PUNCH OR DIE WALLS.

SCENE 41.

EP41A, tape 902, 18:05:58-18:06:11
large reduction impact extrusion
EP41B, tape 902, 18:19:52-18:20:10
zoom out, high production impact
extrusion operation

NARRATION (VO) :

BECAUSE OF THE HIGH IMPACT FORCE, LARGE METAL
REDUCTIONS ARE POSSIBLE. WITH AUTOMATIC SLUG
FEED, PRODUCTION RATES AS HIGH AS 18,000 PARTS
PER HOUR CAN BE ACHIEVED.

SCENE 42.

EP42A, tape 902, 18:17:33-18:18:01
zoom in, impact extrusion operation
CG, SUPER: Tin
Aluminum
Zinc
Copper
Brass
Lead
Steel

NARRATION (VO) :

DUCTILE, LOW-MELTING-POINT METALS AND ALLOYS SUCH
AS TIN, ALUMINUM, ZINC, COPPER, BRASS, LEAD AND
STEEL ARE USED MOST COMMONLY FOR IMPACT-EXTRUSION
APPLICATIONS.

--- FADE TO BLACK ---

SCENE 43.

EP43A, GRAPHIC: Plastic Extrusion
white text centered on black

SCENE 44.

EP44A, peter carey narration
EP44B, tape 890, 05:28:23-05:28:43
zoom out, extruder extruding plastic
profile, pan to extruder

NARRATION (VO) :

PLASTICS EXTRUSION IS A CONTINUOUS PROCESS IN
WHICH THERMOPLASTIC FEEDSTOCK MATERIAL IN AN
EXTRUDER IS TRANSFORMED INTO A MOLTEN, VISCOUS
FLUID USING HEAT AND MECHANICAL SHEARING.

SCENE 45.

EP45A, tape 890, 05:01:12-05:01:27
zoom out, plastic profile coming out
of die
EP45B, tape 900, 15:02:41-15:02:49
zoom out, plastic rod stock
EP45C, tape 900, 15:05:33-15:05:42
zoom out, plastic tube stock
EP45D, tape 890, 05:07:12-05:07:25
zoom out, plastic angle profile
being extruded

NARRATION (VO) :

THIS THERMOPLASTIC FLUID IS THEN FORCED THROUGH A
DIE OPENING WHERE IT IS SHAPED AND COOLED INTO
SOLID FORM. THESE FORMS INCLUDE:
BAR AND ROD...

EP45E, tape 720, 06:02:47-06:03:08
flat plastic plate
EP45F, tape 889, 04:04:17-04:04:27
flexible bags winding up
EP45G, tape 900, 17:01:20-17:01:30
c.u., mono-filament fish line
EP45H, tape 900, 16:01:30-16:01:40
c.u. wire with plastic casing

TUBE AND PIPE...,
OR PROFILES SUCH AS ANGLES AND OTHER CROSS
SECTIONS...,
FLAT PRODUCTS SUCH AS SHEET AND PLATE...,
FLEXIBLE FILM FOR BAGS AND PACKAGING...,
MONO-FILAMENTS...,
AND WIRING INSULATION.

SCENE 46.

EP46A, tape 408, 10:03:23-10:03:41
zoom out, plastic being sucked
EP46B, tape 888, 03:17:24-03:17:46
zoom out, extrusion of plastic film
CG, SUPER: Acetyl Copolymers
Acrylonitrile Butadiene
Styrene
Nylon
Polycarbonate
Polyethylene
Polyvinyl Chloride

NARRATION (VO) :

FEEDSTOCK FOR PLASTIC EXTRUSION IS TYPICALLY IN
THE FORM OF PELLETS. THE MOST COMMONLY EXTRUDED
THERMOPLASTICS INCLUDE:
ACETYL COPOLYMERS,
ACRYLONITRILE BUTADIENE STYRENE,
NYLON,
POLYCARBONATE,
POLYETHYLENE,
AND POLYVINYL CHLORIDE.

SCENE 47.

EP47A, tape 888, 03:07:02-03:07:18
pan, extruder extruding plastic film

NARRATION (VO) :

THE EXTRUSION OF PLASTICS IS MOST COMMONLY
PERFORMED USING A SCREW EXTRUSION MACHINE.

SCENE 48.

EP48A, tape 891, 06:26:24-06:26:35
wide, screw extrusion machine, zoom
to hopper
EP48B, tape 891, 06:27:31-06:27:40
pan, externally heated feed barrel
EP48C, tape 891, 06:19:23-06:19:37
zoom out, screw being pushed into a
screw extruder machine
EP48D, tape 891, 06:27:43-06:27:51
zoom in, die assembly

NARRATION (VO) :

THE MAIN COMPONENTS OF A TYPICAL SCREW EXTRUSION
MACHINE ARE THE HOPPER...,
AN EXTERNALLY HEATED FEED BARREL...,
THAT HOLDS A HELICALLY FLUTED EXTRUDER SCREW...,
AND THE DIE ASSEMBLY.

SCENE 49.

EP49A, tape 889, 04:16:10-04:16:20

NARRATION (VO) :

tilt down, hopper with plastic being fed to feed barrel
EP49B, tape 890, 05:05:35-05:05:53
zoom out, plastic being vacuum fed automatically

THERMOPLASTIC FEEDSTOCK IS FED TO THE FEED BARREL FROM THE HOPPER. HOPPERS ARE TYPICALLY VACUUM FED AUTOMATICALLY, BUT MAY BE FILLED MANUALLY.

SCENE 50.
EP50A, ANI: cutaway, resin entering feed barrel, driven forward by rotating screw

NARRATION (VO) :
AS THE FEEDSTOCK ENTERS THE FEED BARREL IT IS DRIVEN FORWARD BY THE ROTATION OF THE SCREW.

SCENE 51.
continue animation

NARRATION (VO) :
THE FEEDSTOCK PLASTISIZES, OR MELTS, AS THE ROTATING SCREW "DRAGS" IT FORWARD. THIS IS REFERRED TO AS DRAG FLOW. DRAG FLOW CAUSES THE THERMOPLASTIC MOLECULES TO SLIDE OVER EACH OTHER CREATING FRICTIONAL HEAT WHICH MELTS THE MATERIAL.

SCENE 52.
EP52A, tape 888, 03:13:51-03:14:06
pan, heating bands on feed barrel

NARRATION (VO) :
EXTERNAL HEATING BANDS PROVIDE ADDITIONAL HEAT TO THE FEED BARREL, BRINGING THE MATERIAL TO ITS FINAL TEMPERATURE.

SCENE 53.
EP53A, GRAPHIC: extruder screw
CG, SUPER: Feed Zone
EP53B, GRAPHIC: extruder screw, feed zone highlighted
CG, SUPER: Transition Zone
EP53C, GRAPHIC: extruder screw, transition zone highlighted
CG, SUPER: Mixing Zone
EP53D, GRAPHIC: extruder screw, mixing zone highlighted
CG, SUPER: Metering Zone
EP53E, GRAPHIC: extruder screw, metering zone highlighted

NARRATION (VO) :
TYPICAL EXTRUDER SCREWS CONSIST OF FOUR ZONES. THESE ZONES INCLUDE:
THE FEED ZONE...,
THE TRANSITION ZONE...,
THE MIXING ZONE...,
AND THE METERING ZONE.

SCENE 54.
CG, SUPER: Feed Zone
EP54A, ANI: feed zone, screw turning, plastic being mixed together

NARRATION (VO) :
THE FEED ZONE HAS A CONSTANT FLIGHT DEPTH, WHICH

EP54B, ANI: c.u. feed zone, screw turning, plastic being mixed together,
EP54C, GRAPHIC: bring up translucent green rectangle, then single black arrow, and finally double black arrow

FORCES THE MATERIAL TOGETHER AND RIDS IT OF AIR.
FLIGHT DEPTH IS THE DISTANCE BETWEEN THE MAJOR DIAMETER OF THE SCREW AT THE TOP OF THE FLIGHT, AND THE MINOR DIAMETER OF THE SCREW AT THE BASE OF THE FLIGHT.

SCENE 55.
CG, SUPER: Transition Zone
EP55A, ANI: transition zone, screw turning, lines indicate decreasing flight depth, plastic compacted together at start of zone, completely melted by end of zone

NARRATION (VO) :
THE TRANSITION ZONE HAS A DECREASING FLIGHT DEPTH WHICH REDUCES THE PLASTIC VOLUME. THIS COMPRESSION CAUSES THE THERMOPLASTIC MOLECULES TO RUB HARDER AGAINST EACH OTHER, PLASTISIZING THE MATERIAL.

SCENE 56.
CG, SUPER: Mixing Zone
continue animation, mixing zone, screw turning, with special mixing element, mixing plastisized material, arrow indicates length of special mixing element

NARRATION (VO) :
THE MIXING ZONE HAS A CONSTANT FLIGHT DEPTH AND MAY BE EQUIPPED WITH A SPECIAL MIXING ELEMENT TO ENSURE THAT THE FEEDSTOCK IS COMPLETELY PLASTISIZED AND MIXED INTO A HOMOGENEOUS BLEND.

SCENE 57.
CG, SUPER: Metering Zone
continue animation, metering zone, screw turning, pumping out plastic through die
EP57B, tape 891, 06:05:15-06:05:33
c.u., plastic extruded out of die

NARRATION (VO) :
THE METERING ZONE HAS A CONSTANT FLIGHT DEPTH MUCH SMALLER THAN THAT OF THE FEED ZONE. THIS SECTION ACTS AS A PUMP FORCING THE PRESSURIZED HOMOGENEOUS FEEDSTOCK THROUGH THE EXTRUDER'S DIE ASSEMBLY, WHICH FORMS THE CROSS-SECTIONAL SHAPE OF THE EXTRUSION.

SCENE 58.
EP58A, tape 890, 05:05:04-05:05:12
zoom out, die assembly extruding part
EP58B, still, twin screw extruded
EP58C, still, twin screws

NARRATION (VO) :
SCREW EXTRUDERS COMMONLY USE A SINGLE, HELICAL FEED SCREW FOR PLASTISIZING AND MIXING THE FEEDSTOCK MATERIAL, BUT FOR MORE THOROUGH

PROCESSING, TWIN SCREW EXTRUDERS HAVING TWO
SCREWS MAY BE USED.

SCENE 59.

EP59A, tape 891, 06:10:56-06:11:18

zoom out, profile extrusion
operation

CG, SUPER: Profile Extrusion

EP59B, tape 889, 04:27:03-04:27:13

zoom out, blown film extrusion
operation

CG, SUPER: Blown Film Extrusion

NARRATION (VO) :

TWO OF THE PRINCIPAL PLASTIC EXTRUSION PROCESSES
ARE PROFILE EXTRUSION...,
AND BLOWN FILM EXTRUSION.

--- TOUCH BLACK ---

SCENE 60.

CG, SUPER: Profile Extrusion

EP60A, tape 890, 05:11:43-05:12:02

zoom out, profile extrusion
operation

NARRATION (VO) :

PROFILE EXTRUSION IS A HORIZONTAL PROCESS USED TO
MAKE LONG, CONTINUOUS SHAPES HAVING A CONSTANT
CROSS SECTION, OR PROFILE.

SCENE 61.

EP61A, tape 890, 05:24:28-05:24:56

zoom out, profile coming out of die
and into a cooling tank

NARRATION (VO) :

THE PROFILE IS EXTRUDED INTO A LONG HORIZONTAL
COOLING TANK OR TROUGH FILLED WITH WATER. THIS
WATER COOLS AND SOLIDIFIES THE EXTRUDED PLASTIC
AS IT EXITS THE DIE.

SCENE 62.

EP62A, tape 890, 05:20:40-05:20:50

haul-off rolls pulling profile out
of cooling tank

EP62B, tape 890, 05:21:48-05:22:03

cutter separating profile into
lengths

NARRATION (VO) :

AT THE END OF THE COOLING TANK, HAUL-OFF ROLLS
PULL THE PROFILE AWAY FROM THE DIE AT A UNIFORM,
CONTROLLED SPEED...,
AS THE PROFILE IS PULLED THROUGH THE HAUL-OFF
ROLLS, A CUTTER SHEARS IT TO THE REQUIRED LENGTH
FOR FURTHER PROCESSING.

SCENE 63.

EP63A, tape 892, 07:02:05-07:02:14

zoom out, die producing extruded
profile

EP63B, tape 891, 06:12:14-06:12:24

zoom in, die producing extruded
profile

NARRATION (VO) :

SOME PROFILES ARE DIFFICULT TO EXTRUDE BECAUSE OF
SHRINKAGE AND THE FLOW CHARACTERISTICS OF THE

EP63C, tape 890, 05:24:56-05:25:10
zoom in, sizing operation on profile
extrusion

PLASTIC. TYPICALLY, GENEROUS INTERNAL AND/OR
EXTERNAL CORNER RADII ARE USED TO MINIMIZE THESE
CONCERNS. ADDITIONALLY, SOME PROFILE EXTRUSIONS
MAY ALSO REQUIRE IN-LINE SIZING TO ACHIEVE
DIMENSIONAL TOLERANCES.

--- TOUCH BLACK ---

SCENE 64.
CG, SUPER: Blown-Film Extrusion
EP64A, tape 888, 03:02:49-03:03:07
tilt up, blown-film extrusion
operation
EP64B, tape 888, 03:18:38-03:18:54
tilt up, blown-film extrusion
operation, clear plastic

NARRATION (VO) :

THE BLOWN-FILM EXTRUSION PROCESS USES AN EXTRUDER
TO PUMP MOLTEN PLASTIC VERTICALLY UP THROUGH A
DIE HAVING A 360-DEGREE ANNULAR OPENING ON ITS
TOP. THIS PRODUCES A TUBULAR FILM EXTRUSION WHICH
IS SUBSEQUENTLY FILLED WITH AIR.

SCENE 65.
EP65A, tape 888, 03:11:24-03:11:37
zoom out, plastic bubble having
diameter larger than diameter of die
opening

NARRATION (VO) :

AS A RESULT, THE TUBE EXPANDS OUT INTO A BUBBLE
HAVING A DIAMETER LARGER THAN THE DIAMETER OF THE
ANNULAR OPENING OF THE DIE.

SCENE 66.
EP66A, tape 888, 03:25:50-03:26:01
tilt up, from die opening to
collapsing frame
EP66B, tape 888, 03:15:49-03:16:06
tilt down, nip rolls as plastic is
pulled through

NARRATION (VO) :

THE TUBULAR BUBBLE COOLS AS IT IS PULLED UP. WHEN
SUFFICIENTLY COOL, THE BUBBLE IS FLATTENED WITHIN
A COLLAPSING FRAME. THE FLATTENED PLASTIC IS THEN
PULLED THROUGH A SERIES OF ROLLS, COMMONLY
REFERRED TO AS NIP ROLLS.

SCENE 67.
continue previous shot
EP67A, tape 889, 04:19:56-04:20:12
zoom out, following plastic as it is
guided to a winder

NARRATION (VO) :

NIP ROLLS HELP TO MAINTAIN TENSION ON THE
FLATTENED PLASTIC FILM AS IT IS GUIDED TO A
WINDER...,
AND WOUND ONTO A CORE FOR LATER USE.

--- FADE TO BLACK ---

SCENE 68.

EP68A, GRAPHIC: Review
white text on black
EP68B, peter carey narration
EP68C, **tape 63**, **12:00:15-12:03:49**
review music

MUSIC UP AND UNDER

NARRATION (VO) :

LET'S REVIEW THE MATERIAL CONTAINED IN THIS
PROGRAM.

SCENE 69.

EP69A, **tape 895**, **10:14:20-10:14:31**
extrusion of metal
EP69B, **tape 890**, **05:11:01-05:11:11**
zoom out, extrusion of plastic

NARRATION (VO) :

EXTRUSION IS THE DEFORMATION OF EITHER METALS...,
OR PLASTICS FORCED UNDER PRESSURE THROUGH ONE OR
MORE DIE OPENINGS.

SCENE 70.

EP70A, **tape 886**, **01:15:58-01:16:09**
wide, hot extrusion of metal
EP70B, **tape 892**, **07:03:37-07:03:49**
zoom in, plastic profile extrusion
EP70C, **tape 897**, **12:17:45-12:17:54**
extrusion slug
EP70D, **tape 897**, **12:17:10-12:17:18**
stepped extrusion produced from slug

NARRATION (VO) :

THE RESULTING SHAPE IS CALLED AN EXTRUSION, AND
IS PRODUCED TYPICALLY HAVING A CONSTANT CROSS-
SECTION PROFILE DEFINED BY THE SHAPE, OR
GEOMETRY, OF THE DIE OPENING. WITH SPECIAL
TOOLING, STEPPED OR TAPERED EXTRUSIONS MAY ALSO
BE PRODUCED.

SCENE 71.

EP71A, **tape 892**, **07:06:17-07:06:26**
zoom in, extrusion of thin plastic
part
EP71B, GRAPHIC: thick extruded part
EP71C, GRAPHIC: hollow extrusion
EP71D, GRAPHIC: solid extrusion
EP71E, **tape 891**, **06:15:21-06:15:35**
plastic extrusion being cut into
part
CG, SUPER: Products
Assembly Components
Raw Stock

NARRATION (VO) :

ALMOST ANY THIN...,
OR THICK...,
HOLLOW...,
OR SOLID CROSS-SECTIONAL SHAPE MAY BE PRODUCED BY
EXTRUSION. THESE EXTRUSIONS ARE THEN TYPICALLY
CUT TO LENGTH FOR USE AS PRODUCTS,
ASSEMBLY COMPONENTS,
OR AS RAW STOCK FOR FURTHER PROCESSING INTO
DISCRETE PARTS.

--- TOUCH BLACK ---

SCENE 72.

EP72A, tape 886, 01:11:19-01:11:28
zoom out, hot extrusion of part
CG, SUPER: Hot Extrusion
EP72B, tape 901, 01:06:05-01:06:15
warm extrusion of part
CG, SUPER: Warm Extrusion
EP72C, tape 896, 12:02:01-12:02:11
zoom in, cold extrusion of part
CG, SUPER: Cold Extrusion

NARRATION (VO) :

METALS MAY BE EXTRUDED USING EITHER HOT
EXTRUSION...,
WARM EXTRUSION...,
OR COLD EXTRUSION PROCESSES.

--- TOUCH BLACK ---

SCENE 73.

CG, SUPER: Hot Extrusion
EP73A, tape 887, 02:04:12-02:04:33
heated billet placed in container,
beginning of heated billet being
extruded
EP73B, tape 887, 02:18:56-02:19:16
billet being extruded, camera view,
pan to extrusion

NARRATION (VO) :

HOT EXTRUSION USES HEATED FEEDSTOCK, CALLED
BILLET, WHICH IS PLACED AND CONFINED IN A
CONTAINER...,
FORCE IS THEN APPLIED...,
AND THE BILLET IS EXTRUDED THROUGH THE DIE.

SCENE 74.

continue previous shot

NARRATION (VO) :

HOT EXTRUSION IS PERFORMED AT TEMPERATURES MUCH
HIGHER THAN THE RECRYSTALLIZATION TEMPERATURE OF
THE MATERIAL TO BE EXTRUDED.

SCENE 75.

EP75A, tape 893, 08:20:14-08:20:24
zoom in, direct extrusion process
CG, SUPER: Direct Extrusion

NARRATION (VO) :

THE PRIMARY TYPE OF HOT EXTRUSION IS DIRECT, OR
FORWARD, EXTRUSION.

--- TOUCH BLACK ---

SCENE 76.

CG, SUPER: Warm extrusion
EP76A, tape 901, 01:06:02-01:06:25
warm extrusion operation
CG, SUPER: Cold extrusion
EP76B, tape 896, 12:05:19-12:05:36
cold extrusion operation

NARRATION (VO) :

WARM EXTRUSION REFERS TO EXTRUSION WITH THE
BILLET, OR SLUG OF FEEDSTOCK AS IT IS MORE
COMMONLY CALLED, AT A TEMPERATURE GREATER THAN

ROOM TEMPERATURE BUT WELL BELOW THE MATERIALS
RECRYSTALLIZATION TEMPERATURE.
COLD EXTRUSION REFERS TO EXTRUSION WITH THE SLUG
AT ROOM TEMPERATURE.

SCENE 77.

EP77A, tape 901, 01:06:29-01:06:52

warm extrusion

EP77B, tape 895, 10:17:05-10:17:35

zoom out, indirect extrusion
operation

CG, SUPER: Indirect Extrusion

EP77C, tape 896, 12:07:07-12:07:26

combination extrusion operation

CG, SUPER: Combination Extrusion

EP77D, tape 902, 18:01:37-18:01:45

impact extrusion operation

CG, SUPER: Impact Extrusion

NARRATION (VO) :

WARM...,

AND COLD EXTRUSION ARE COMMONLY INTEGRATED INTO

CONTINUOUS OR SEMI-CONTINUOUS MANUFACTURING

OPERATIONS, WITH THE THREE PRINCIPAL METHODS

INCLUDING:

INDIRECT EXTRUSION...,

COMBINATION EXTRUSION...,

AND IMPACT EXTRUSION.

--- TOUCH BLACK ---

SCENE 78.

EP78A, tape 890, 05:28:23-05:28:43

zoom out, extruder extruding plastic
profile, pan to extruder

NARRATION (VO) :

PLASTICS EXTRUSION IS A CONTINUOUS PROCESS IN

WHICH THERMOPLASTIC FEEDSTOCK MATERIAL IN AN

EXTRUDER IS TRANSFORMED INTO A MOLTEN, VISCOUS

FLUID USING HEAT AND MECHANICAL SHEARING.

SCENE 79.

EP79A, tape 890, 05:01:12-05:01:27

zoom out, plastic profile coming out
of die

EP79B, tape 900, 15:02:41-15:02:49

zoom out, plastic rod stock

EP79C, tape 900, 15:05:33-15:05:42

zoom out, plastic tube stock

EP79D, tape 890, 05:07:12-05:07:25

zoom out, plastic angle profile

being extruded

EP79E, tape 720, 06:02:47-06:03:08

flat plastic plate

EP79F, tape 889, 04:04:17-04:04:27

flexible bags winding up

EP79G, tape 900, 17:01:20-17:01:30

NARRATION (VO) :

THIS THERMOPLASTIC FLUID IS THEN FORCED THROUGH A

DIE OPENING WHERE IT IS SHAPED AND COOLED INTO

SOLID FORM. THESE FORMS INCLUDE:

BAR AND ROD...,

TUBE AND PIPE...,

OR PROFILES SUCH AS ANGLES AND OTHER CROSS

SECTIONS...,

c.u., mono-filament fish line
EP79H, tape 900, 16:01:30-16:01:40
c.u. wire with plastic casing

FLAT PRODUCTS SUCH AS SHEET AND PLATE...,
FLEXIBLE FILM FOR BAGS AND PACKAGING...,
MONO-FILAMENTS...,
AND WIRING INSULATION.

SCENE 80.
EP80A, tape 888, 03:07:02-03:07:18
pan, extruder extruding plastic film

NARRATION (VO) :
THE EXTRUSION OF PLASTICS IS MOST COMMONLY
PERFORMED USING A SCREW EXTRUSION MACHINE.

SCENE 81.
EP81A, tape 891, 06:26:24-06:26:35
wide, screw extrusion machine, zoom
to hopper
EP81B, tape 891, 06:27:31-06:27:40
pan, externally heated feed barrel
EP81C, tape 891, 06:19:23-06:19:37
zoom out, screw being pushed into a
screw extruder machine
EP81D, tape 891, 06:27:43-06:27:51
zoom in, die assembly

NARRATION (VO) :
THE MAIN COMPONENTS OF A TYPICAL SCREW EXTRUSION
MACHINE ARE THE HOPPER...,
AN EXTERNALLY HEATED FEED BARREL...,
THAT HOLDS A HELICALLY FLUTED EXTRUDER SCREW...,
AND THE DIE ASSEMBLY.

SCENE 82.
EP82A, tape 890, 05:05:04-05:05:12
zoom out, die assembly extruding
part
EP82B, still, twin screw extruded
EP82C, still, twin screws

NARRATION (VO) :
SCREW EXTRUDERS COMMONLY USE A SINGLE, HELICAL
FEED SCREW FOR PLASTISIZING AND MIXING THE
FEEDSTOCK MATERIAL, BUT FOR MORE THOROUGH
PROCESSING, TWIN SCREW EXTRUDERS HAVING TWO
SCREWS MAY BE USED.

SCENE 83.
EP83A, tape 891, 06:10:56-06:11:18
zoom out, profile extrusion
operation
CG, SUPER: Profile Extrusion
EP83B, tape 889, 04:27:03-04:27:13
zoom out, blown film extrusion
operation
CG, SUPER: Blown Film Extrusion

NARRATION (VO) :
TWO OF THE PRINCIPAL PLASTIC EXTRUSION PROCESSES
ARE PROFILE EXTRUSION...,
AND BLOWN FILM EXTRUSION.

--- FADE TO BLACK ---

SCENE 84.
EP84A, CG, ROLL: credits
white text on black, fade up mid-
screen

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SCENE 85.

EP85A, GRAPHIC: 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 86.

EP86A, ANI: SME logo, with music