

FUNDAMENTALS OF TOOL DESIGN

Tool Materials

TRT: 30:46

SCENE 1.

TM01A, CGS: FBI warning
white text centered on black to
transparent gradient
TM01B, motion background

WARNING

Federal law provides severe civil and
criminal penalties for the unauthorized
reproduction, distribution or exhibition
of copyrighted media.

Copyright © 2008

Society of Manufacturing Engineers

SCENE 2.

continue motion background
TM02A, CGS: disclaimer
white text centered on black to
transparent gradient

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 3.

TM03A, SME logo open, with music
TM03B, revised SME logo open, with
music

SCENE 4.

TM04A, FTD open, with music
TM04B, peter carey narration

MUSIC UP AND UNDER

NARRATION (VO) :

THE FUNDAMENTALS OF TOOL DESIGN VIDEO SERIES,
EXAMINING THE DIVERSE FIELD OF TOOL DESIGN
MATERIALS AND TECHNOLOGIES.

SCENE 5.

continue FTD open
TM05A, CGS: Tool Materials
white text, centered on background
TM05B, blue background

NARRATION (VO) :

THIS PROGRAM EXPLORES THE FUNDAMENTALS OF TOOL
MATERIALS.

SCENE 6.

TM06A, tape FTD07, 06:18:48-06:18:59
c.u., cutting tool, turning
TM06B, tape 272, 02:14:01-02:14:12
pan, progressive die operation

NARRATION (VO) :

THERE IS A WIDE VARIETY OF TOOL MATERIALS USED

TM06C, tape 911, 06:09:20-06:09:28
part falling out of injection molding
machine

FOR CUTTING...,

FORMING...,

AND OTHER MANUFACTURING OPERATIONS.

SCENE 7.

TM07A, tape FTD06, 05:14:59-05:15:16
zoom out, forging operation

TM07B, tape 197, 01:21:21-01:21:34
zoom in, tapping operation

TM07C, tape 920, 03:15:52-03:16:14
thermoforming operation

NARRATION (VO) :

THE SELECTION OF A TOOL MATERIAL FOR ANY GIVEN
MANUFACTURING OPERATION IS NORMALLY DETERMINED
BY THE MECHANICAL PROPERTIES NECESSARY FOR
PROPER USE OF THE TOOL. MATERIAL SELECTION
SHOULD OCCUR ONLY AFTER CAREFUL EVALUATION OF
THE FUNCTION AND REQUIREMENTS OF THE PROPOSED
TOOL. FOR MOST APPLICATIONS, MORE THAN ONE
TYPE OF TOOL MATERIAL MAY BE SATISFACTORY,
WITH FINAL SELECTION GOVERNED BY MATERIAL
AVAILABILITY AND ECONOMIC CONSIDERATIONS.

SCENE 8.

TM08A, tape 273, 03:20:14-03:20:23
zoom in, female side of die

TM08B, CGS: Ferrous Metals

TM08C tape 226, 01:04:12-01:04:20
titanium nitride coated carbide tool,
cutting

TM08D CGS: Nonferrous Metals

TM08E tape 842, 12:23:51-12:24:16
rtv molding material poured around
pattern half

TM08F CGS: Nonmetallic Materials

NARRATION (VO) :

THE PRINCIPAL MATERIALS USED FOR TOOLS INCLUDE
FERROUS METALS...,
NONFERROUS METALS...,
AND NONMETALLIC MATERIALS.

SCENE 9.

TM09A, tape 772, 08:27:29-08:27:44
shaping of aluminum gear

NARRATION (VO) :

TO PROPERLY SELECT A TOOL MATERIAL, SEVERAL
PHYSICAL AND MECHANICAL PROPERTIES SHOULD BE
CONSIDERED TO DETERMINE HOW THE SELECTED
MATERIAL WOULD AFFECT THE TOOL'S PERFORMANCE
AND CAPABILITIES.

SCENE 10.

TM10A, CGS: Physical Properties

TM10B, tape 498, 07:18:28-07:19:00
induction heating operation

TM10C, tape 848, 04:07:23-04:07:50
ingots placed into wave soldering pot
for melting

TM10D, tape FTD02, 02:42:26-02:42:54
edm operation

TM10E, CGS: Density

Color

Electrical Conductivity

Thermal Conductivity

Thermal Expansion

Melting Point

NARRATION (VO):

THE PHYSICAL PROPERTIES OF A MATERIAL CONTROL
HOW THE MATERIAL WILL REACT UNDER CERTAIN
CONDITIONS. PHYSICAL PROPERTIES ARE NATURAL IN
THE MATERIAL AND CANNOT BE PERMANENTLY ALTERED
WITHOUT CHANGING THE COMPOSITION OF THE
MATERIAL ITSELF. THESE PHYSICAL PROPERTIES
INCLUDE:

DENSITY,

COLOR,

ELECTRICAL CONDUCTIVITY,

THERMAL CONDUCTIVITY,

THERMAL EXPANSION,

AND MELTING POINT.

--- TOUCH BLACK ---

SCENE 11.

TM11A, CGS: Density

TM11B, tape CM43, 15:14:02-15:14:30
mold opening, composite part pulled
from tooling

TM11C, tape 919, 02:09:38-02:09:51
zoom out, male mold

TM11D, tape 375, 17:14:36-17:14:48
mold dropped into machine

TM11E, tape 759, 06:12 31-06:12:52
hydroforming mold being moved

NARRATION (VO):

DENSITY IS A MATERIAL'S WEIGHT PER UNIT
VOLUME, SUCH AS POUNDS PER CUBIC FOOT OR
KILOGRAMS PER CUBIC METER. BESIDES INDICATING
EASE OR DIFFICULTY OF HANDLING, VARIOUS
MECHANICAL PROPERTIES ARE OFTEN EXPRESSED
RELATIVE TO DENSITY, SUCH AS THE EXPRESSION
STRENGTH-TO-WEIGHT RATIO.

--- TOUCH BLACK ---

SCENE 12.

TM12A, CGS: Color

TM12B, tape 829, 07:17:32-07:17:43
opening rapid prototype tooling

NARRATION (VO):

COLOR IS THE NATURAL TINT CONTAINED THROUGHOUT
A MATERIAL.

--- TOUCH BLACK ---

SCENE 13.

TM13A, CGS: Electrical Conductivity
TM13B, **tape 252**, **07:17:18-07:17:45**
wire edm tooling cutting part

NARRATION (VO) :

ELECTRICAL CONDUCTIVITY IS A MEASURE OF A
MATERIAL'S ABILITY TO PERMIT THE FLOW OF
ELECTRICAL CURRENT.

--- TOUCH BLACK ---

SCENE 14.

TM14A, CGS: Thermal Conductivity
TM14B, **tape 507**, **21:14:21-21:14:36**
torch heat treating

NARRATION (VO) :

THERMAL CONDUCTIVITY IS A FUNCTION OF HOW FAR
AND HOW FAST HEAT CAN FLOW THROUGH A MATERIAL.

--- TOUCH BLACK ---

SCENE 15.

TM15A, CGS: Thermal Expansion
TM15B, **tape 506**, **19:07:04-19:07:24**
parts pulled from heat, glowing, and
transferred to quench for cooling

NARRATION (VO) :

THERMAL EXPANSION IS A MEASURE OF THE
DIMENSIONAL CHANGES EXHIBITED BY A MATERIAL
WHEN EXPOSED TO HEAT, THUS AFFECTING ACCURACY.

--- TOUCH BLACK ---

SCENE 16.

TM16A, CGS: Melting Point
TM16B, **tape FTD09**, **08:24:23-08:24:38**
scrap being melted for casting

NARRATION (VO) :

THE MELTING POINT INDICATES THE TEMPERATURE AT
WHICH A MATERIAL CHANGES FROM THE SOLID STATE
TO THE LIQUID STATE. IT IS A ROUGH MEASURE OF
HEAT RESISTANCE.

--- TOUCH BLACK ---

SCENE 17.

TM17A, CGS: Mechanical Properties
TM17B, **tape 799**, **17:17:29-17:18:01**
pan, coil plate processing
TM17C, CGS: Strength
Hardness
Wear Resistance

NARRATION (VO) :

UNLIKE PHYSICAL PROPERTIES, MECHANICAL
PROPERTIES CAN BE PERMANENTLY ALTERED BY

Toughness
Brittleness
Plasticity
Surface Finish

THERMAL OR MECHANICAL TREATMENT. THESE
MECHANICAL PROPERTIES INCLUDE:
STRENGTH,
HARDNESS,
WEAR RESISTANCE,
TOUGHNESS,
BRITTLENESS,
PLASTICITY,
AND SURFACE FINISH.

--- TOUCH BLACK ---

SCENE 18.

TM18A, CGS: Strength

TM18B, tape 895, 10:17:05-10:17:35
zoom out, indirect extrusion
operation

TM18C, tape MND16, 16:37:44-16:38:08
zoom out, tensile testing of rubber

TM18D, CGS: Tensile Strength
Compressive Strength
Yield Strength
Shear Strength
Fatigue Strength

NARRATION (VO) :

STRENGTH IS THE ABILITY OF A MATERIAL TO
RESIST DEFORMATION. IT IS COMMONLY DESIGNATED
IN UNITS OF POUNDS PER SQUARE INCH OR 'PSI'
AND MEGAPASCALS OR 'MPA'. COMMON TYPES OF
STRENGTH ARE TENSILE STRENGTH,
COMPRESSIVE STRENGTH,
YIELD STRENGTH,
SHEAR STRENGTH,
AND FATIGUE STRENGTH.

--- TOUCH BLACK ---

SCENE 19.

TM19A, CGS: Tensile Strength

TM19B, tape MND15, 15:53:33-15:53:54
specimen elongating and breaking

NARRATION (VO) :

TENSILE STRENGTH, ALSO CALLED ULTIMATE TENSILE
STRENGTH, IS THE RATIO OF THE MAXIMUM APPLIED
TENSILE LOAD TO CROSS-SECTIONAL AREA TO
RUPTURE A MATERIAL.

SCENE 20.

TM20A, CGS: Compressive Strength

NARRATION (VO) :

TM20B, tape MND15, 15:22:42-15:23:17
c.u. strain gage attached to specimen
TM20C, tape MND15, 15:25:02-15:25:13
strain gage removed
TM20D, CGS: compressive arrows
TM20E, CGS: compressive arrows
embedded into image

COMPRESSIVE STRENGTH IS THE RATIO OF THE
MAXIMUM APPLIED COMPRESSIVE LOAD TO CROSS-
SECTIONAL AREA TO RUPTURE A MATERIAL.

SCENE 21.

TM21A, CGS: Yield Strength
TM21B, tape MND15, 15:52:53-15:53:40
zoom in, specimen elongating
TM21C, tape MND15, 15:40:06-15:40:26
zoom in, specimen elongating
TM21D, CGS: yield strength arrows

NARRATION (VO):

YIELD STRENGTH IS THE STRESS REQUIRED TO
PERMANENTLY ELONGATE, OR DEFORM, A MATERIAL A
SPECIFIC AMOUNT, COMMONLY .2% OF TOTAL
ELONGATION. YIELD STRENGTH RATHER THAN
ULTIMATE TENSILE STRENGTH IN TENSION OR
COMPRESSION, IS OFTEN USED AS THE CRITICAL
STRENGTH FOR DESIGN OR STRUCTURAL PURPOSE.

SCENE 22.

TM22A, CGS: Shear Strength
TM22B, tape 795, 16:18:39-16:19:00
zoom out, shearing of sheet metal
TM22C, tape MND15, 15:15:24-15:15:41
shear testing of bolt

NARRATION (VO):

SHEER STRENGTH IS THE MAXIMUM AMOUNT OF SHEAR
LOAD A MATERIAL CAN WITHSTAND BEFORE FAILURE
OCCURS, DIVIDED BY ITS CROSS SECTIONAL AREA.

SCENE 23.

TM23A, CGS: Fatigue Strength
TM23B, tape MND06, 06:17:18-06:17:39
zoom out, fatigue test

NARRATION (VO):

FATIGUE STRENGTH IS THE MAXIMUM STRESS A
MATERIAL CAN SUSTAIN FOR A SPECIFIED NUMBER
OF CYCLES OF FULLY REVERSED TENSION TO EQUAL
COMPRESSION TO CAUSE RUPTURE. THE NUMBER OF
SUSTAINABLE STRESS CYCLES PRIOR TO FAILURE IS
THE MATERIAL'S FATIGUE LIFE.

--- TOUCH BLACK ---

SCENE 24.

TM24A, CGS: Hardness
TM24B, tape MND14, 14:24:19-14:24:52
zoom out, hardness testing
TM24C, CGS: Brinell Hardness Test
Rockwell Hardness Test

NARRATION (VO):

HARDNESS IS A MATERIAL'S RESISTANCE TO
INDENTATION AND IS A MEASURE OF ITS RESISTANCE

TO SCRATCHING OR ABRASION. MATERIAL HARDNESS IS DETERMINED USING A VARIETY OF TESTS, THE TWO MOST COMMON BEING:
THE BRINELL HARDNESS TEST,
AND THE ROCKWELL HARDNESS TEST.

SCENE 25.

TM25A, CGS: Brinell Hardness Test
TM25B, tape MND02, 02:06:08-02:07:02
c.u., brinell test, ball indenting specimen

NARRATION (VO):

IN THE BRINELL HARDNESS TEST, A KNOWN LOAD IS APPLIED FOR A GIVEN PERIOD OF TIME TO A SPECIMEN SURFACE USING A HARDENED STEEL OR TUNGSTEN-CARBIDE BALL, CAUSING A PERMANENT INDENTATION. STANDARD BALL DIAMETER IS 10 MILLIMETERS, OR APPROXIMATELY FOUR-TENTHS OF AN INCH.

SCENE 26.

TM26A, tape MND01, 01:44:02-01:44:31
zoom out, microscope used to read brinell specimen
TM26B, tape MND01, 01:49:17-01:49:36
zoom out, using microscope

NARRATION (VO):

THE DIAMETER OF THE RESULTING PERMANENT INDENTATION IS THEN MEASURED AND CONVERTED TO A BRINELL HARDNESS NUMBER. A MICROSCOPE ESPECIALLY DESIGNED FOR THE BRINELL HARDNESS TEST IS GENERALLY USED FOR DIAMETER-INDENTATION MEASUREMENTS.

SCENE 27.

TM27A, CGS: Rockwell Hardness Test
TM27B, tape MND03, 04:05:21-04:05:51
zoom out, rockwell harness test
TM27C, tape MND01, 01:26:12-01:26:32
rockwell harness test

NARRATION (VO):

THE ROCKWELL HARDNESS TEST INVOLVES THE USE OF AN INDENTOR FOR PENETRATING THE SURFACE OF A MATERIAL FIRST BY APPLYING A MINOR, OR INITIAL LOAD, AND THEN APPLYING A MAJOR, OR FINAL LOAD UNDER SPECIFIC CONDITIONS. THE DIFFERENCE BETWEEN THE MINOR AND MAJOR PENETRATION DEPTHS

IS THEN NOTED AS A HARDNESS VALUE DIRECTLY FROM A DIAL OR DIGITAL READOUT. THE HARDER THE MATERIAL THE HIGHER THE NUMBER.

SCENE 28.

TM28A, tape MND01, 01:30:50-01:30:58
zoom out, rockwell harness test

TM28B, tape MND01, 01:34:49-01:34:59
major load being changed

TM28C, tape MND01, 01:38:22-01:38:40
zoom out, rockwell hardened steel ball

TM28D, tape MND01, 01:30:14-01:30:35
rockwell spheroconical diamond

NARRATION (VO) :

THE MINOR LOAD APPLIED IS ALWAYS 10 KILOGRAMS...

AND THE MAJOR LOAD MAY BE 60, 100 OR 150

KILOGRAMS. THE MOST COMMON INDENTERS ARE EITHER A SMALL ONE-SIXTEENTH INCH HARDENED STEEL BALL...

OR A SPHEROCONICAL DIAMOND, WHICH IS ALSO REFERRED TO AS A BRALE INDENTER.

--- TOUCH BLACK ---

SCENE 29.

TM29A, CGS: Wear Resistance

TM29B, tape 216, 01:12:11-01:12:33
cutting tool insert machining cast iron

NARRATION (VO) :

WEAR RESISTANCE IS THE MATERIAL'S RESISTANCE TO ABRASION BY RUBBING, GRINDING OR OTHER FRICTIONAL MEANS. THE HARDER THE MATERIAL SURFACE, THE GREATER THE WEAR OR ABRASION RESISTANCE.

--- TOUCH BLACK ---

SCENE 30.

TM30A, CGS: Toughness

TM30B, tape MND15, 15:44:15-15:44:23
c.u. specimen set up

TM30C, tape MND15, 15:44:43-15:44:53
wide, pendulum released, reset after fracture

TM30D, tape MND16, 16:14:40-16:14:52
wide, plastic container impact tested

TM30E, tape MND16, 16:15:32-16:15:49
c.u. impact testing of plastic part with crack initiation

TM30F, tape MND03, 03:03:59-03:04:19
wide, charpy impact test

NARRATION (VO) :

TOUGHNESS IS THE MATERIAL'S ABILITY TO ABSORB IMPACT ENERGY AND DEFORM PLASTICALLY BEFORE FRACTURING. TOUGHNESS IS OFTEN MEASURED BY USING TWO BASIC TYPES OF IMPACT TESTS: DROP WEIGHT...

AND PENDULUM, SUCH AS THE CHARPY NOTCHED-BAR

TM30G, tape MND16, 16:23:39-16:24:06
izod specimen supported, broken by
blow from pendulum

IMPACT TEST...,
AND THE IZOD NOTCHED-BAR IMPACT TEST.

--- TOUCH BLACK ---

SCENE 31.

TM31A, CGS: Brittleness
TM31B, tape 125, 01:27:30-01:27:36
grinding wheel being dropped, slow
motion

NARRATION (VO):

BRITTLENESS IS THE PROPERTY OF A MATERIAL THAT
CAUSES IT TO BREAK OR FRACTURE EASILY WITH
LITTLE OR NO DEFORMATION WHEN A SUDDEN LOAD IS
APPLIED.

--- TOUCH BLACK ---

SCENE 32.

TM32A, CGS: Plasticity
TM32B, tape 898, 13:21:37-13:22:00
zoom out, cold extrusion operation
TM32C, CGS: Ductility
Malleability

NARRATION (VO):

PLASTICITY IS THE MATERIAL'S ABILITY TO DEFORM
NONELASTICALLY WITHOUT FRACTURE OR RUPTURE.
TWO GENERAL CATEGORIES OF PLASTICITY ARE:
DUCTILITY,
AND MALLEABILITY.

SCENE 33.

TM33A, CGS: Ductility
TM33B, tape 748, 03:27:40-03:29:14
deep draw stamping operation

NARRATION (VO):

DUCTILITY IS THE PROPERTY OF A MATERIAL THAT
ALLOWS IT TO BE STRETCHED OR DRAWN USING A
TENSIONAL FORCE WITHOUT FRACTURE OR RUPTURE.

SCENE 34.

TM34A, CGS: Malleability
TM34B, tape 364, 01:09:08-01:09:24
zoom out, repressing of powder metal
part

NARRATION (VO):

MALLEABILITY IS THE PROPERTY OF A MATERIAL
THAT PERMITS PLASTIC DEFORMATION IN
COMPRESSION WITHOUT FRACTURE.

--- TOUCH BLACK ---

SCENE 35.

TM35A, CGS: Surface Finish
TM35B, tape 963, 11:01:31-11:01:49

NARRATION (VO):

zoom out, set of carbide rolls
TM35C, tape 967, 15:02:43-15:02:58
zoom out, roll forming of painted
surface stock

SURFACE FINISH IS THE SURFACE ROUGHNESS OF A
MATERIAL. SURFACE FINISH INFLUENCES A TOOL'S
QUALITY AND SERVICE LIFE LONGEVITY AND
DIRECTLY AFFECTS THE QUALITY OF PARTS PRODUCED
FROM THE TOOL.

--- TOUCH BLACK ---

SCENE 36.

TM36A, tape 226, 01:07:32-01:07:50
coated carbide tool, cutting
TM36B, tape FTD17, 17:02:14-17:02:26
zoom in, tool being heat treated

NARRATION (VO) :

TOOL MATERIALS ARE OFTEN COATED...,
AND OR HEAT TREATED TO IMPROVE THEIR
PERFORMANCE.

SCENE 37.

TM37A, tape FTD14, 13:59:34-13:59:58
zoom out, coated cutting tools
TM37B, CGS: Surface Hardness
Wear Resistance
Friction Coefficient
Thermal Conductivity

NARRATION (VO) :

THIN-FILM COATINGS ARE USED ON A WIDE VARIETY
OF TOOL MATERIALS AND IMPROVE CHARACTERISTICS
NOT OBTAINABLE USING THE TOOL MATERIAL ALONE.
THESE CHARACTERISTICS INCLUDE SURFACE
HARDNESS, WEAR RESISTANCE, FRICTION
COEFFICIENT AND THERMAL CONDUCTIVITY.

SCENE 38.

TM38A, tape 235, 02:07:33-02:07:43
photomicrograph of multilayers
TM38B, tape 235, 02:11:50-02:12:00
photomicrograph of multilayers
TM38C, tape 235, 02:09:12-02:09:22
photomicrograph of multilayers

NARRATION (VO) :

MOST COATINGS ARE UNDER ONE-THOUSANDTH OF AN
INCH, OR TWENTY-FIVE-HUNDREDTHS OF A
MILLIMETER THICK, AND MAY HAVE SEVERAL LAYERS.

SCENE 39.

TM39A, tape 507, 21:18:18-21:18:38
zoom out, torch heat treating
TM39B, tape 501, 12:09:18-12:09:36
through hardening heat treating
TM39C, tape FTD17, 17:08:54-17:09:08
ionitriding surface hardening of
tooling
TM39D, tape 497, 05:20:03-05:20:20
zoom out, stress relieving operation

NARRATION (VO) :

HEAT TREATING PROCESSES USE CONTROLLED HEATING
AND COOLING CYCLES TO OBTAIN DESIRED
METALLURGICAL STRUCTURES AND MECHANICAL
PROPERTIES OF METAL OR ALLOY TOOL MATERIALS.
HEAT TREATING PROCESSES CAN BE CLASSIFIED AS

EITHER:

THROUGH-HARDENING PROCESSES THAT INCREASE THE
STRENGTH AND HARDNESS THROUGHOUT AN ALLOY'S
CROSS-SECTION,

SURFACE HARDENING PROCESSES THAT CREATE
DIFFERENT PROPERTIES AT THE SURFACE THAN AT
THE CENTER OF A METAL STRUCTURE,

OR SOFTENING PROCESSES THAT DECREASE THE
HARDNESS OF METALS AND ALLOYS.

--- FADE TO BLACK ---

SCENE 40.

TM40A, CGS: Ferrous Tool Materials
white text, centered on background
TM01B, motion background

SCENE 41.

TM41A, peter carey narration
TM41B, tape **FTD03**, **03:14:42-03:15:13**
zoom out, milling of tool steel
TM41C, CGS: Carbon Steels
Alloy Steels
Tool Steels
Cast Irons

NARRATION (VO) :

FERROUS TOOL MATERIALS HAVE IRON AS A BASE
METAL AND ARE WIDELY USED FOR JIGS, FIXTURES,
DIES, MOLDS AND MANY OTHER SPECIAL TOOLS. THE
PRIMARY TYPES OF FERROUS TOOL MATERIALS
INCLUDE:

CARBON STEELS,

ALLOY STEELS,

TOOL STEELS,

AND THE CAST IRONS.

SCENE 42.

TM42A, tape **957**, **05:09:13-05:09:40**
zoom in, c.u. roll forming
TM42B, CGS: Cast
Hot Rolled
Cold Rolled
Ground

NARRATION (VO) :

FERROUS TOOL MATERIALS ARE USED IN THE CAST,
HOT-ROLLED,
COLD-ROLLED,

OR GROUND CONDITION.

SCENE 43.

TM43A, tape 418, 14:06:18-14:06:41

zoom out, casting of mold

TM43B, tape 667, 00:04:18-00:04:32

machining of casting

TM43C, tape 439, 05:03:42-05:04:04

casting

NARRATION (VO) :

CASTING IS COMMONLY USED TO CREATE BLANKING AND FORMING DIES, AND SOMETIMES INJECTION MOLDS. TYPICALLY, THE CASTING IS POURED TO A ROUGH OVER-SIZED FORM AND THEN IS MACHINED TO THE DESIRED FINAL SHAPE.

SCENE 44.

TM44A, tape FTD09, 08:47:05-08:47:17

zoom out, hot rolling operation

NARRATION (VO) :

HOT ROLLING LEAVES A LAYER OF DECARBURIZED SLAG ON THE SURFACE OF STEEL, WHICH MUST BE REMOVED BY MACHINING IF THE STEEL IS TO BE HARDENED.

SCENE 45.

TM45A, tape 607, 15:06:08-15:06:32

zoom out, edge rolling of sheared stock

NARRATION (VO) :

COLD-ROLLED STEELS HAVE A BRIGHT SCALE-FREE SURFACE AND ARE RATHER ACCURATE OR CLOSE TO SIZE. HOWEVER, THE INTERNAL STRESSES DEVELOPED IN COLD ROLLING MAY CAUSE DISTORTION IF EXTENSIVE MACHINING OR WELDING IS REQUIRED.

SCENE 46.

TM46A, tape FTD03, 03:03:46-03:04:22

zoom out, steel being ground

TM46B, tape FTD03, 03:05:11-03:05:32

zoom out, steel being ground

NARRATION (VO) :

GROUND STEELS ARE HELD TO VERY CLOSE TOLERANCES. THEY ARE USUALLY USED WHEN A FINISHED SURFACE IS REQUIRED WITHOUT ADDITIONAL MACHINING. THEY ARE AVAILABLE GROUND 'TO SIZE' OR 'OVERSIZE' BY FIFTEEN THOUSANDTHS OF AN INCH, OR THIRTY EIGHT HUNDREDTHS OF A MILLIMETER, ABOVE A STANDARD SIZE.

--- TOUCH BLACK ---

SCENE 47.

TM47A, CGS: Carbon Steels

TM47B, tape 813, 00:18:38-00:19:40
zoom out, sawing operation

TM47C, tape 11, 01:22:21-011:22:48
fixturing 01

TM47D, tape 11, 01:18:13-011:18:38
fixturing 02

NARRATION (VO) :

CARBON STEELS CONTAIN MOSTLY IRON AND CARBON,
WITH SMALL AMOUNTS OF OTHER ALLOYING ELEMENTS
AND ARE USED EXTENSIVELY IN TOOL AND JIG
CONSTRUCTION.

SCENE 48.

TM48A, tape 813, 00:14:19-00:14:54
sawing operation

TM48B, CGS: Low-Carbon
.05%-.3% Carbon
Medium-Carbon
.3%-.7% Carbon
High-Carbon
.7%-1.5% Carbon

NARRATION (VO) :

CARBON STEEL GRADES ARE DESIGNATED AS LOW-
CARBON, CONTAINING BETWEEN .05 AND .3%
CARBON...,
MEDIUM-CARBON, CONTAINING BETWEEN .3 AND .7%
CARBON...,
AND HIGH-CARBON, CONTAINING BETWEEN .7 AND
1.5% CARBON.

--- TOUCH BLACK ---

SCENE 49.

TM49A, CGS: Alloy Steels

TM49B, tape 908, 03:08:00-03:08:21
zoom out, machining of plastic
injection mold

TM49C, tape FTD02, 02:45:28-02:45:50
zoom out, edming of plastic injection
mold

TM49D, CGS: Manganese
Silicon
Nickel
Molybdenum
Chromium

NARRATION (VO) :

ALLOY STEELS ARE BASICALLY CARBON STEELS WITH
ADDITIONAL ELEMENTS ADDED TO ALTER THEIR
CHARACTERISTICS AND BRING ABOUT PREDICTABLE
CHANGE IN MECHANICAL PROPERTIES. THE ALLOYING
ELEMENTS USED MOST OFTEN IN STEELS ARE
MANGANESE,
SILICON,
NICKEL,
MOLYBDENUM,
AND CHROMIUM.

SCENE 50.

TM50A, tape FTD02, 02:55:10-02:55:29
zoom out, injection mold tooling
TM50B, tape 908, 03:20:24-03:20:36
pulling inserts from injection mold

NARRATION (VO) :

ALLOY STEELS INCLUDE THE CORROSION-RESISTANT
STAINLESS STEELS, WHICH ARE HIGH-CHROMIUM AND
NICKEL-CHROMIUM STEELS. SOME HIGH-CHROMIUM
STAINLESS STEELS CAN BE HARDENED BY HEAT
TREATING AND ARE USED FOR TOOLS REQUIRING
RESISTANCE TO HIGH TEMPERATURE, WEAR, ABRASION
AND CORROSION, SUCH AS PLASTIC INJECTION
MOLDS.

--- TOUCH BLACK ---

SCENE 51.

TM51A, CGS: Tool Steels
TM51B, tape 967, 15:09:36-15:09:59
zoom out, roll forming operation
TM51C, CGS: Heat Resistance
Abrasion Resistance
Shock Resistance
Dimensional Stability in
Hardening
Cutting Ability
TM51D, tape 492, 21:06:49-21:07:11
forgings being produced
TM51E, tape 272, 02:23:19-02:23:30
pan, progressive die

NARRATION (VO) :

TOOL STEELS ARE GENERALLY HIGH-CARBON, HIGH-
STRENGTH ALLOYS MODIFIED WITH OTHER ALLOYING
ELEMENTS TO PRODUCE STEELS HAVING VARYING
DEGREES OF:
HEAT RESISTANCE,
ABRASION RESISTANCE,
SHOCK RESISTANCE,
DIMENSIONAL STABILITY IN HARDENING,
AND CUTTING ABILITY.
BECAUSE NO SINGLE STEEL CAN OPTIMALLY POSSESS
ALL OF THESE PROPERTIES, HUNDREDS OF DIFFERENT
TOOL STEELS HAVE BEEN DEVELOPED TO MEET THE
VAST RANGE OF SERVICE DEMANDS.

SCENE 52.

TM52A, CGS: steel classification
text, fly in
TM52B, tape 478, 05:22:56-05:23:18
zoom out, open die forging
TM52C, tape 820, 09:04:28-09:04:58

NARRATION (VO) :

THE AMERICAN IRON AND STEEL INSTITUTE TOOL
STEEL CLASSIFICATION SYSTEM USES A LETTER AND

zoom out, bending of tube
TM52D, tape 791, 10:01:26-10:01:58
flying shear operation
TM52E, CGS: Water-Hardening Steels
Cold-Work Steels
Shock-Resisting Steels
High-Speed Steels
Hot-Work Steels
Plastic Mold Steels
Special-Purpose Steels

NUMBER DESIGNATION TO IDENTIFY AND CLASSIFY
THE MATERIALS IN THE SEVEN MAJOR FAMILIES OF
TOOL STEELS:
WATER-HARDENING STEELS,
COLD-WORK STEELS,
SHOCK-RESISTING STEELS,
HIGH-SPEED STEELS,
HOT-WORK STEELS,
PLASTIC MOLD STEELS,
AND SPECIAL-PURPOSE STEELS.

SCENE 53.
TM53A, CGS: Water-Hardening Tool
Steels
TM53B, tape 293, 02:01:12-02:01:37
forming operation
TM53C, tape 508, 22:01:04-22:01:28
water quench heat treating operation
TM53D, tape 799, 18:02:28-18:02:51
blanking die operation
TM53E, CGS: Blanking Dies
Forming Dies
Drills
Countersinks
Reamers
Taps
Files

NARRATION (VO) :
WATER-HARDENING TOOL STEELS ARE ESSENTIALLY
HIGH-CARBON PLAIN-CARBON STEELS, AND ACCOUNT
FOR A LARGE PERCENTAGE OF ALL TOOL STEELS
USED. WATER-HARDENING TOOL STEELS ARE
AVAILABLE AS SHALLOW, MEDIUM OR DEEP-HARDENED,
AND ARE CAPABLE OF ROCKWELL C-65 TO C-67
SURFACE HARDNESS. THEY ARE THE LEAST EXPENSIVE
AND MOST READILY MACHINABLE TOOL STEELS.
APPLICATIONS INCLUDE BLANKING DIES, FORMING
DIES, DRILLS, COUNTERSINKS, REAMERS, TAPS, AND
FILES.

SCENE 54.
TM54A, CGS: Cold-Work Tool Steels
TM54B, tape 813, 00:12:04-00:12:26
zoom in, roll bending tooling

NARRATION (VO) :
COLD-WORK TOOL STEELS INCORPORATE VARIOUS
AMOUNTS OF MANGANESE, SILICON, MOLYBDENUM AND
CHROMIUM ALLOYING ELEMENTS, AND ARE USED IN
APPLICATIONS WHERE IMPROVED TOUGHNESS IS
REQUIRED.

SCENE 55.

TM55A, tape 966, 14:09:09-14:09:33

zoom out, roll formed parts being produced

TM55B, CGS: Oil-Hardening
Air-Hardening Medium-Alloy
High-Carbon, High-Chromium

NARRATION (VO) :

THERE ARE THREE BASIC KINDS OF COLD-WORK TOOL STEELS:
THE OIL-HARDENING,
THE AIR-HARDENING MEDIUM-ALLOY,
AND THE HIGH-CARBON, HIGH-CHROMIUM GRADES.

SCENE 56.

TM56A, tape 507, 21:03:58-21:04:18

heat treating of bar stock in oil

TM56B, tape 507, 21:05:09-21:05:38

heat treating of tooling in oil

TM56C, tape 794, 15:14:46-15:15:03

zoom out, slitting of foil stock

NARRATION (VO) :

BECAUSE OF THEIR ALLOY ADDITIONS, THE OIL- AND AIR-HARDENING TOOL STEELS MAINTAIN HIGH HARDENABILITY WHILE PROVIDING THE BEST FREEDOM FROM DISTORTION AND CRACKING DURING HEAT TREATING. THIS IS DUE IN PART TO THEIR SLOW COOLING RATES. APPLICATIONS INCLUDE COLD-FORMING, COINING AND BURNISHING TOOLS AS WELL AS MOLDS, SHEARING KNIVES AND BLADES, AND ROTARY CUTTING KNIVES.

SCENE 57.

TM57A, tape 476, 03:22:58-03:23:27

forging operation

TM57B, tape 450, 17:25:51-17:26:12

zoom out, die casting operation

NARRATION (VO) :

THE HIGH-CARBON, HIGH-CHROMIUM TOOL STEELS CONTAIN BETWEEN 10 AND 18% CHROMIUM. WHEN HEAT TREATED, THESE STEELS ARE BEST IN HOT HARDNESS AND WEAR RESISTANCE APPLICATIONS, SUCH AS FORGING DIES, DIE-CASTING DIE BLOCKS AND DRAWING DIES.

SCENE 58.

TM58A, CGS: Shock-Resisting Tool Steels

TM58B, tape FTD06, 05:26:58-05:27:18

zoom out, impact forging operation

NARRATION (VO) :

SHOCK-RESISTING TOOL STEELS CONTAIN LESS CARBON AND PROVIDE HIGHER TOUGHNESS FOR BOTH HOT AND COLD IMPACT APPLICATIONS. CARBIDE-

FORMING ALLOYS PROVIDE THE NECESSARY HOT-WORK,
ABRASION RESISTANT, AND HARDENABILITY
CHARACTERISTICS.

SCENE 59.

TM59A, CGS: High-Speed Tool Steels
TM59B, tape 238, 01:03:03-01:03:10
hss machining

TM59C, tape 234, 02:02:21-02:02:30
hss drill being milled

TM59D, tape 234, 01:12:52-01:12:59
hss form tool being ground

NARRATION (VO) :

THE HIGH-SPEED TOOL STEELS ARE USED FOR
CUTTING TOOLS AND OTHER APPLICATIONS REQUIRING
STRENGTH AND HARDNESS AT SUSTAINED
TEMPERATURES UP TO OR EXCEEDING 1400 DEGREES
FAHRENHEIT, OR 760 DEGREES CELSIUS.

SCENE 60.

TM60A, tape 238, 01:02:32-01:02:42
hss machining part

TM60B, CGS: Tungsten
Molybdenum

TM60C, tape 13, 03:05:58-03:06:24
hss end milling operation

TM60D, tape 13, 03:07:22-03:07:43
hss end milling operation

NARRATION (VO) :

THERE ARE TWO PRIMARY GRADES OF HIGH-SPEED
TOOL STEELS:
TUNGSTEN,
AND MOLYBDENUM.

ALL ARE HIGH-ALLOY STEELS, HARDENABLE TO AT
LEAST ROCKWELL C-63, SOME TO ROCKWELL C-70,
AND POSSESS FINE GRAIN SIZE AND UNIFORM DEEP
HARDENING. ALL HIGH-SPEED TOOL STEELS CONTAIN
SOME TUNGSTEN, CHROMIUM AND VANADIUM; MOST
ALSO CONTAIN SUBSTANTIAL COBALT.

SCENE 61.

TM61A, CGS: Hot-Work Tool Steels

TM61B, tape 488, 00:06:30-00:06:56
open die forging operation

TM61C, tape 893, 08:27:19-08:27:48
wide, hot extrusion press, zoom in to
extrusion operation

TM61D, tape 484, 15:21:46-15:22:36
ring rolling operation

NARRATION (VO) :

HOT-WORK TOOL STEELS PROVIDE GOOD WEAR
RESISTANCE, SHOCK RESISTANCE AND HIGH HARDNESS
DURING PROLONGED USE AT ELEVATED TEMPERATURE.
ALL HOT-WORK TOOL STEELS EMPLOY SUBSTANTIAL
CARBIDE-FORMING ALLOY ADDITIONS OF CHROMIUM,
TUNGSTEN, AND/OR MOLYBDENUM. THESE STEELS ARE

GENERALLY PREFERRED FOR EXTRUSION TOOLS, DIE
CASTING DIES AND FORGING DIES.

SCENE 62.

TM62A, CGS: Plastic Mold Tool Steels
TM62B, tape **CM47**, 19:13:28-19:13:48
zoom out, milling of compression mold
TM62C, tape **CM42**, 14:14:13-14:14:25
compression mold opening

NARRATION (VO) :

PLASTIC MOLD TOOL STEELS ARE TOUGH OIL-
HARDENING GRADES THAT ARE RATHER LOW IN CARBON
CONTENT AND WEAR RESISTANCE. THESE STEELS ARE
DESIGNED TO MEET THE REQUIREMENTS OF ZINC DIE-
CASTING, PLASTIC INJECTION AND COMPRESSION
MOLDING.

SCENE 63.

TM63A, CGS: Special-Purpose Tool
Steels
TM63B, tape **356**, 00:04:10-00:04:22
nibbling operation
TM63C, tape **197**, 01:26:24-01:26:38
tapping operation

NARRATION (VO) :

SPECIAL-PURPOSE TOOL STEELS ARE LIMITED IN
USE, BUT FEATURE GOOD TOUGHNESS AND
MACHINABILITY. SPECIAL-PURPOSE TOOL STEEL USES
INCLUDE PRESS-BRAKE DIES, PUNCHES AND TAPS.

--- TOUCH BLACK ---

SCENE 64.

TM64A, CGS: Cast Iron
TM64B, tape **FTD01**, 01:13:21-01:13:55
zoom out, machining of cast iron

NARRATION (VO) :

CAST IRON IS ESSENTIALLY AN ALLOY OF IRON,
CONTAINING FROM 2 TO 4% CARBON, .5 TO 3%
SILICON, .4 TO 1% MANGANESE, PLUS PHOSPHORUS
AND SULFUR. OTHER ALLOYING ELEMENTS MAY BE
ADDED DEPENDING ON THE PROPERTIES DESIRED.

SCENE 65.

continue previous shot
TM65A, CGS: Graphite/Free Carbon
Iron Carbide/Cementite
TM65B, tape **438**, 04:27:10-04:27:40
pouring cast iron casting

NARRATION (VO) :

THE CARBON IN CAST IRON OCCURS IN TWO FORMS:
GRAPHITE OR FREE CARBON AND IRON CARBIDE OR
CEMENTITE. THE HIGH CARBON CONTENT MAKES
MOLTEN IRON FLUID, EASING CASTABILITY.
GRAPHITE INCREASES CASTING SOUNDNESS,

MACHINABILITY, DAMPING QUALITY AND LUBRICITY.

SCENE 66.

TM66A, tape FTD01, 01:15:43-01:16:17
zoom out, machining of cast iron
tooling

TM66B, CGS: Gray Iron
Ductile/Nodular Iron
Compacted Graphite Iron
Malleable Iron
White Iron
Alloy Iron

NARRATION (VO) :

CAST IRONS ARE NOT USUALLY SPECIFIED BY
COMPOSITION BUT BY GRADES CLASSIFIED BY
MINIMUM TENSILE STRENGTH. THE PRINCIPAL GRADES
OF CAST IRON INCLUDE:

GRAY IRON,

DUCTILE OR NODULAR IRON,

COMPACTED GRAPHITE IRON,

MALLEABLE IRON,

WHITE IRON,

AND ALLOY IRON.

--- FADE TO BLACK ---

SCENE 67.

TM67A, CGS: Nonferrous Tool Materials
white text, centered on background
TM01B, motion background

SCENE 68.

TM68A, peter carey narration
TM68B, tape 925, 08:14:12-08:14:24
zoom out, 2-up multiple cavity mold
TM68C, tape 522, 09:06:01-09:06:39
laser welding operation with aluminum
fixture
TM68D, tape FTD13, 12:16:04-12:16:17
carbide milling operation

NARRATION (VO) :

NONFERROUS TOOL MATERIALS HAVE A BASE METAL
OTHER THAN IRON. THESE TOOL MATERIALS ARE
UTILIZED TO SOME DEGREE IN MOLD AND DIE MAKING
APPLICATIONS, AND FIND COMMON USE IN JIG AND
FIXTURE DESIGN WHERE MAGNETISM AND TOOL WEIGHT
ARE FACTORS. NONFERROUS MATERIALS AND THEIR
ALLOYS ARE ALSO EXTENSIVELY USED FOR CUTTING
TOOLS TO MACHINE HIGH-STRENGTH MATERIALS.

SCENE 69.

TM69A, tape FTD12, 11:05:25-11:05:43
turning operation with uncoated
carbide
TM69B, CGS: Aluminum

NARRATION (VO) :

THE THREE MOST COMMON NONFERROUS TOOL

Carbide
Cermet

MATERIALS ARE:

ALUMINUM,

CARBIDE,

AND CERMET.

--- TOUCH BLACK ---

SCENE 70.

TM70A, CGS: Aluminum

TM70B, **tape 930**, **13:29:05-13:29:18**
pan, thermoforming mold

TM70C, **tape 925**, **08:10:05-08:10:18**
tilt down, female mold, freeze frame
at end if necessary

TM70D, **tape 931**, **14:13:20-14:13:42**
pan, plastic heated up, thermoformed

TM70E, **tape 927**, **10:11:21-10:11:42**
pan of family mold

TM70F, **tape 920**, **03:05:56-03:06:07**
aluminum jig being used

NARRATION (VO) :

ALUMINUM HAS LONG BEEN USED FOR SPECIAL TOOLING, SUCH AS THERMOFORMING MOLDS. THE PRINCIPAL ADVANTAGES TO USING ALUMINUM ARE ITS HIGH STRENGTH-TO-WEIGHT RATIO, NONMAGNETIC PROPERTIES, AND RELATIVE EASE IN MACHINING AND FORMING. PURE ALUMINUM IS CORROSION RESISTANT BUT NOT WELL SUITED FOR TOOLING. ALUMINUM ALLOYS, WHILE NOT AS CORROSION RESISTANT AS PURE ALUMINUM ARE MUCH STRONGER AND COMMONLY USED FOR TOOLING APPLICATIONS.

--- TOUCH BLACK ---

SCENE 71.

TM71A, CGS: Carbide

TM71B, **tape FTD07**, **06:55:51-06:56:01**
carbide cutting tool

TM71C, **tape FTD14**, **13:31:44-13:32:06**
powder metal carbide inserts being
produced

TM71D, CGS: Tungsten Carbide
Titanium Carbide
Tantalum Carbide
Niobium Carbide

TM71E, **tape FTD14**, **13:24:45-13:25:16**
powder metal carbide inserts being
produced

NARRATION (VO) :

CARBIDE, WHICH IS ALSO REFERRED TO AS CEMENTED CARBIDE, IS A POWDER METALLURGY PRODUCT MADE OF FINELY BALL-MILLED OR PROCESSED HARD CARBIDE PARTICLES, BONDED TOGETHER BY A METAL BINDER. THE HARD CARBIDES INCLUDE TUNGSTEN CARBIDE, TITANIUM CARBIDE, TANTALUM CARBIDE, AND NIOBIUM CARBIDE. THE HARD CARBIDE PARTICLES ARE SUBMICRON TO TEN MICRONS IN SIZE AND MAKE UP FROM 60 TO 97% OF THE MATERIAL.

THE BINDER IS MOSTLY COBALT.

SCENE 72.

TM72A, tape 225, 01:12:03-01:12:18

coated carbide tools

TM72B, tape 226, 01:08:54-01:09:06

coated carbide tool, turning

TM72C, tape FTD13, 12:08:02-12:08:16

coated carbide tool, milling

NARRATION (VO) :

TWO-THIRDS OF ALL CARBIDE TOOLS USED ARE COATED. IN GENERAL, A COATED CARBIDE TOOL MAY HAVE OVER THREE TIMES THE TOOL LIFE OF AN UNCOATED GRADE, OR MAY BE USED AT CUTTING SPEEDS TWO TO FOUR TIMES FASTER FOR THE SAME TOOL LIFE.

SCENE 73.

TM73A, tape FTD14, 13:58:46-13:59:03

zoom out, coated cutting tools

TM73B, CGS: Titanium Carbide

Titanium Nitride

Aluminum Oxide

Titanium Carbonitride

Titanium-Aluminum Nitride

NARRATION (VO) :

THE PRIMARY CUTTING-TOOL COATING MATERIALS ARE TITANIUM CARBIDE, TITANIUM NITRIDE, ALUMINUM OXIDE, TITANIUM CARBONITRIDE, TITANIUM-ALUMINUM NITRIDE, AND COMBINATIONS OF SOME OF THESE.

SCENE 74.

TM74A, tape FTD08, 07:03:43-07:04:02

carbide milling operation

TM74B, tape FTD12, 11:23:34-11:23:50

carbide finish turning operation

TM74C, tape FTD12, 11:41:42-11:41:58

zoom out, inconel turning with carbide

NARRATION (VO) :

TOUGH, SHOCK-RESISTANT CARBIDE GRADES ARE NEEDED FOR INTERRUPTED CUTTING..., HARDER AND CHEMICALLY-STABLE GRADES ARE NEEDED FOR FINISHING STEEL AT HIGH SPEED..., TOUGH AND HEAT-RESISTANT GRADES ARE NEEDED FOR MACHINING THE SUPERALLOYS, SUCH AS INCONEL AND HASTELLOY.

SCENE 75.

TM75A, tape FTD02, 02:27:29-02:27:46

zoom out, carbide drill being used

TM75B, tape FTD12, 11:10:26-11:10:34

cutting tool insert being replaced

NARRATION (VO) :

CARBIDE IS USED FOR SOLID ROUND TOOLS, SUCH AS DRILLS AND END MILLS..., OR IN THE FORM OF CUTTING-TOOL INSERTS.

SCENE 76.

TM76A, CGS: Cermet

TM76B, tape 226, 01:13:20-01:13:45
c.u. cermets being used in machining

TM76C, tape 226, 01:11:48-01:12:04
cermet used in machining

TM76D, tape 226, 01:14:40-01:14:58
zoom in, cermets being used in rough
turning

TM76E, tape 233, 05:12:43-05:13:04
cermets being used in milling

NARRATION (VO) :

A CERMET CONSISTS OF HARD MATERIAL, SUCH AS
TITANIUM CARBIDE OR TITANIUM NITRIDE, AND A
NICKEL OR COBALT BINDER. THE SOLID CERMET
CUTTING-TOOL INSERT OFFERS EXCELLENT SURFACE
FINISH. INITIALLY USED ONLY FOR SEMI-FINISH
AND FINISH TURNING AND BORING, SOME CERMET
GRADES ARE NOW TOUGH ENOUGH TO HANDLE ROUGH
TURNING AS WELL AS MILLING APPLICATIONS ON
CARBON STEELS, STAINLESS STEELS AND SOME
DUCTILE IRONS.

--- FADE TO BLACK ---

SCENE 77.

TM77A, CGS: Nonmetallic Tool
Materials

white text, centered on background

TM01B, motion background

NARRATION (VO) :

NONMETALLIC TOOL MATERIALS ARE USED MAINLY FOR
LIMITED PARTS PRODUCTION AND WHERE THE COST OF
USING TOOL STEELS AND OTHER MATERIALS ARE NOT
ECONOMICALLY PRACTICAL. NONMETALLIC TOOL
MATERIALS CAN BE USED BY THEMSELVES TO CREATE
SPECIAL TOOLS, BUT COMMONLY INCORPORATE
METALLIC ELEMENTS.

SCENE 79.

TM79A, tape 828, 06:08:53-06:09:37
pouring rtv material in mold

TM79B, CGS: Wood

Composites

Rubber

Ceramics

Diamond

NARRATION (VO) :

SOME OF THE PRINCIPAL NONMETALLIC TOOL
MATERIALS INCLUDE:
WOOD,

Cubic Boron Nitride

COMPOSITES,

RUBBER,

CERAMICS,

DIAMOND,

AND CUBIC BORON NITRIDE.

--- TOUCH BLACK ---

SCENE 80.

TM80A, CGS: Wood

TM80B, tape 921, 04:26:20-04:26:36
pan, wood mold

TM80C, tape 918, 01:03:07-01:03:27
zoom out, steel rule die,
thermoformed part placed on it

TM80D, tape 918, 01:07:57-01:08:16
zoom out, steel rule die being used
to trim thermoformed parts

TM80E, CGS: Hardboard,
Densified Wood
Particleboard
Plywood

NARRATION (VO) :

WOOD IS OFTEN USED IN LOW-COST, LIMITED-

PRODUCTION TOOLS. SOME COMMON APPLICATIONS

INCLUDE SHORT RUN OR PROTOTYPE THERMOFORMING

MOLDS, STEEL-RULE DIES IN WHICH WOOD SUPPORTS

THE RULE, AND JIG PLATES WITH INSERTED STEEL

BUSHINGS. THERE ARE SEVERAL VARIETIES OF WOOD

PRODUCTS USED IN TOOLING APPLICATIONS,

INCLUDING:

HARDBOARD,

DENSIFIED WOOD,

PARTICLEBOARD,

AND PLYWOOD.

--- TOUCH BLACK ---

SCENE 81.

TM81A, CGS: Composites

TM81B, tape 687, 03:07:38-03:07:58
reinforcement, matrix poured and
spread on it

TM81C, tape 687, 03:10:23-03:11:08
composite tooling being produced

TM81D, tape 692, 08:06:13-08:06:25
zoom out, gel coating of composite
mold

TM81E, tape 692, 08:02:14-08:02:40
robotic spray up of gel coated mold

TM81F, tape CM06, 06:12:08-06:12:30
reinforcement, matrix poured and

NARRATION (VO) :

COMPOSITE TOOL MATERIALS CONSIST OF A

REINFORCING MATERIAL...,

AND A MATRIX, OR BASE MATERIAL. THE MATRIX

FUNCTIONS AS A BINDER FOR THE REINFORCEMENT,

AND CONTROLS THE PHYSICAL SHAPE AND DIMENSIONS

OF THE TOOLING. SPECIAL COMPOSITE TOOLING

spread on it

MATERIALS ARE USED AS ECONOMICAL ALTERNATIVES TO METAL TOOLING FOR COMPOSITES MANUFACTURING. ADDITIONALLY, COMPOSITE TOOLING IS DESIRABLE SINCE IT CAN HAVE THE SAME THERMAL EXPANSION CHARACTERISTICS AS THE COMPOSITE PARTS BEING MANUFACTURED AND CURED.

SCENE 82.

TM82A, tape CM09, 09:09:02-09:09:20

zoom out, composite boat hull mold supported with steel tubing

TM82B, tape CM07, 07:13:36-07:13:46

part pulled from reinforced composite mold

NARRATION (VO) :

COMPOSITE MOLDS ARE USUALLY BACKED BY STIFFENERS TO GIVE ADDITIONAL RIGIDITY TO THE CRITICAL MOLD DIMENSIONS. THESE STIFFENERS CAN BE METAL, COMPOSITE OR EVEN WOOD.

--- TOUCH BLACK ---

SCENE 83.

TM83A, CGS: Rubber

TM83B, tape 761, 10:28:25-10:28:40

zoom in, rubber diaphragm forming operation ending, emphasizing the rubber diaphragm

NARRATION (VO) :

RUBBER IS USED IN SPECIAL DRAWING, BLANKING, AND BULGING DIE OPERATIONS, AS WELL AS FOR PROTECTIVE ELEMENTS AND OTHER SPECIAL TOOLS.

SCENE 84.

TM84A, CGS: Silicone Rubber

TM84B, tape 828, 06:11:17-06:11:56

pouring of rtv material into mold

TM84C, tape 829, 07:03:35-07:03:49

mold being pulled apart after curing

TM84D, tape 829, 07:06:14-07:06:24

molding of parts using rtv mold

TM84E, tape 829, 07:08:17-07:08:27

mold put together

TM84F, tape 829, 07:12:21-07:13:12

molding of parts using rtv mold

NARRATION (VO) :

SILICONE RUBBER, SPECIFICALLY 'RTV' OR ROOM TEMPERATURE VULCANIZING SILICONE, IS USED AS A RAPID MEANS OF PRODUCING SOFT TOOLING FOR LOW-PRESSURE MOLDING. A PATTERN IS USED TO CREATE THE 'RTV' MOLD HALVES AND PATTERN CAVITY. ONCE PREPARED, THIS TOOLING CAN BE USED TO MOLD SMALL TO MEDIUM QUANTITIES OF PARTS FROM VARIOUS URETHANE, EPOXY OR OTHER POLYMER MATERIALS. 'RTV' TOOLING CAN TYPICALLY BE USED TO MOLD SEVERAL PARTS BEFORE REPLACEMENT

BECOMES NECESSARY. THE NUMBER OF PARTS PRODUCED DEPENDS ON ACCURACY AND FINISH REQUIREMENTS AND THE COMPLEXITY OF PART GEOMETRY.

--- TOUCH BLACK ---

SCENE 85.

TM85A, CGS: Ceramics

TM85B, tape 227, 02:02:21-02:02:36
machining with ceramic tool

TM85C, tape HSM06, 07:18:20-07:18:52
ceramic tool cutting inconel

TM85D, CGS: Alumina-Based
Silicon Nitride-Based

NARRATION (VO) :

CERAMIC TOOLS HAVE HIGH COMPRESSIVE STRENGTH, HIGH HOT HARDNESS, HIGH RESISTANCE TO ABRASION AND GALLING, AND LOW HEAT CONDUCTIVITY. THEY ARE USED PRIMARILY AS HIGH SPEED CUTTING TOOLS TO MACHINE EXTREMELY HARD OR HIGHLY ABRASIVE MATERIALS. CERAMIC CUTTING TOOLS CAN BE DIVIDED INTO ALUMINA-BASED CERAMICS, AND SILICON NITRIDE-BASED CERAMICS.

SCENE 86.

TM86A, tape FTD12, 11:45:25-11:45:44
alumina-based high speed finishing
operation

TM86B, tape 239, 07:01:18-07:01:37
alumina-based turning operation

NARRATION (VO) :

STANDARD ALUMINA-BASED CERAMICS ARE USED FOR HIGH SPEED SEMI-FINISHING AND FINISHING OF FERROUS AND SOME NONFERROUS MATERIALS. THESE TOOLS ARE NOT GOOD WITH ALUMINUM BECAUSE OF AN AFFINITY BETWEEN THE MATERIALS. ALUMINA-BASED CERAMICS OFFER GOOD MECHANICAL AND CHEMICAL WEAR RESISTANCE, BUT LACK TOUGHNESS AND THERMAL SHOCK RESISTANCE. THUS THEY ARE GENERALLY NOT USED FOR MILLING, ROUGH TURNING, OR FOR INTERRUPTED CUTTING.

SCENE 87.

TM87A, tape FTD12, 11:51:38-11:51:58
silicon nitride-based machining

TM87B, tape 226, 01:25:14-01:25:25

NARRATION (VO) :

SILICON NITRIDE-BASED CERAMICS, SOMETIMES

silicon nitride-based machining of
grey cast iron
TM87C, tape HSM06, 07:14:36-07:14:55
zoom out, hard milling machining
operation

CALLED SIALONS, OFFER GREATER TOUGHNESS AND
THERMAL SHOCK RESISTANCE THAN MOST ALUMINA-
BASED CERAMICS. THEY ARE USED IN HIGH-SPEED
ROUGHING APPLICATIONS WHERE EXCELLENT ABRASION
RESISTANCE IS REQUIRED. SILICON NITRIDE-BASED
CERAMICS ARE USED FOR HIGH-SPEED MACHINING OF
GRAY CAST IRON, AS WELL AS SUPERALLOYS SUCH AS
NICKEL AND COBALT-BASED MATERIALS.

SCENE 88.

TM88A, zoom out, photomicrograph of
whisker-reinforced ceramics
TM88B, zoom in, photomicrograph of
whiskers
TM88C, tape FTD12, 11:45:45-11:45:56
zoom out, inconel turning with
whisker reinforced ceramic insert

NARRATION (VO) :

WHISKER-REINFORCED CERAMICS, WITH SILICON
CARBIDE REINFORCING 'WHISKERS' IN AN ALUMINUM
OXIDE MATRIX, ARE STRONGER THAN THE BRITTLE
CERAMIC MATRIX ALONE. THE WHISKERS ACT LIKE
REBAR IN CONCRETE, ADDING MECHANICAL STRENGTH
AND THERMAL SHOCK RESISTANCE.

--- TOUCH BLACK ---

SCENE 89.

TM89A, CGS: Diamond
TM89B, tape FTD14, 13:41:18-13:41:45
zoom out, diamond grinding wheel
TM89C, tape FTD07, 06:08:30-06:08:40
milling with diamond insert
TM89D, tape FTD14, 13:40:38-13:40:49
diamond grinding wheel
TM89E, tape 125, 01:12:53-01:13:02
cluster diamond dresser
TM89F, tape 125, 01:13:23-01:13:32
single point diamond dresser
TM89G, tape 909, 04:03:15-04:03:37
zoom in, polishing operation

NARRATION (VO) :

DIAMOND, SYNTHETIC OR NATURAL, IS THE HARDEST
OF MATERIALS AND FINDS LIMITED USE AS A TOOL
MATERIAL. IT IS USED FOR TURNING AND MILLING
TOOLS...,
GRINDING WHEELS...,
AND GRINDING-WHEEL DRESSERS.
DIAMOND POWDER COATED TOOLS ARE USED FOR
LAPPING AND POLISHING OPERATIONS, AND CAN
PROVIDE VERY SMOOTH AND LUSTROUS FINISHES.

SCENE 90.

TM90A, CGS: Polycrystalline Diamond

NARRATION (VO) :

TM90B, tape 226, 01:27:52-01:28:03 POLYCRYSTALLINE DIAMOND, OR 'PCD', BLANKS
pcd insert
TM90C, tape FTD07, 06:04:28-06:04:38 CONSIST OF MICRO-SIZED DIAMOND PARTICLES IN A
pcd insert on mill
TM90D, tape 227, 02:07:52-02:08:10 METALLIC BINDER, AND IS MORE THAN 50 TIMES
pcd insert machining non-ferrous
metal
TM90E, tape 232, 04:24:49-04:25:03 HARDER THAN COMMON CARBIDE. POLYCRYSTALLINE
pcd insert milling DIAMOND BLANKS ARE USED EITHER AS INDEXABLE
INSERTS OR ARE BRAZED TO A CUTTING TOOL. THEY
MACHINE NONFERROUS AND NONMETALLIC MATERIALS
BUT, BECAUSE OF THEIR HIGH CHEMICAL AFFINITY
TO CARBON, CANNOT BE USED ON FERROUS
MATERIALS.

--- TOUCH BLACK ---

SCENE 91.

TM91A, CGS: Cubic Boron Nitride
TM91B, tape 227, 02:23:47-02:24:27
cbn machining alloy steels
TM91C, tape 228, 03:04:51-03:05:13
machining with round cbn insert
TM91D, tape 771, 07:17:44-07:18:05
zoom out, 'cbn' wheel
TM91E, tape 771, 07:19:23-07:19:36
'cbn' wheel grinding operation ending
TM91F, peter carey narration
TM91G, credit music

NARRATION (VO) :

CUBIC BORON NITRIDE, OR 'CBN', IS THE SECOND
HARDEST MATERIAL AFTER DIAMOND. IT HAS A
COMPRESSIVE STRENGTH OF 700,000 'PSI' OR 4,830
MEGA PASCALS, TWICE THE THERMAL CONDUCTIVITY
OF COPPER, AND IS THERMALLY STABLE AND
OXIDATION RESISTANT IN AIR TO ABOUT 3500
DEGREES FAHRENHEIT OR 1925 DEGREES CELSIUS.
USED FOR GRINDING WHEELS AND CUTTING TOOLS,
'CBN' IS USED TO MACHINE FERROUS AND
NONFERROUS METALS THAT CANNOT BE READILY CUT
BY MORE COMMON MATERIALS.

--- FADE TO BLACK ---

SCENE 92.

continue music, up and under
TM92A, CGS, ROLL: credits
white text, fade up mid-screen
TM92B, extended motion background

Produced By:
Society of Manufacturing Engineers

Executive Producer:

Copyright © 2008 Society of Manufacturing Engineers

Steven R. Bollinger

Producer/Director/Cameraman:

Jerome T. Cook

Written By:

John A. Vaccari

Graphics By:

Jerome T. Cook

Equipment Access Provided By:

Greenleaf Corporation

Ingersoll Cutting Tools

Macsteel

Master Precision Mold Technology

Pioneer Forge

Quality Rolls

Riviera Tool Company

Roll-Kraft

Sun Steel Treating Inc.

Tri-County Precision Grinding, Inc.

Technical & Editorial Consulting:

William Greenleaf,

Dale Hill,

Dr. Choll Jun,

David Rydbom,

Greenleaf Corporation

Jon Brouwer,

Riviera Tool Company

Production Assistance Provided By:

Lance Rosol

Video Editing:

Jerome T. Cook

SCENE 93.
continue motion background
TM93A, 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 94.
TM03B, revised SME logo open, with
music