

FUNDAMENTAL MANUFACTURING PROCESSES

Grinding

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

SCENE 2.
continue motion background
FMP02A, 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.
FMP SME, SME logo open, with music

SCENE 4.
FMP04A, FMP open, with music
GR04B, edited peter carey narration

MUSIC UP AND UNDER

NARRATION (VO):

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

SCENE 5.
continue FMP open
GR05A, CGS: Grinding
white text, centered on background
FMP05B, blue background
FMP05C, sound slug
FMP05D, half screen line

NARRATION (VO):

THIS PROGRAM EXPLORES THE BASICS OF GRINDING.

SCENE 6.
GR06A, SME4458, 01:26:02:00-01:26:22:00
zoom out, grinding operation

NARRATION (VO):

GRINDING IS AN ABRASIVE MATERIAL REMOVAL

PROCESS USED TO MACHINE HIGH-QUALITY, CLOSE TOLERANCE SURFACE FINISHES IN HARD MATERIALS, SUCH AS METALS AND CERAMICS.

SCENE 8.
GR08A, SME2585, 03:23:22:00-03:24:17:00
cylindrical grinding operation, edit at multiple points
GR08B, SME2661, 02:15:01:00-02:15:18:00
turning operation
GR08C, SME3339, 00:04:09:00-00:04:30:00
zoom out, end milling operation

NARRATION (VO):

IN GRINDING, AN ABRASIVE PRODUCT, MOST OFTEN A GRINDING WHEEL IS ROTATED AT HIGH SPEED AND THE WHEEL'S CIRCUMFERENTIAL SURFACE IS BROUGHT INTO CONTACT WITH THE MATERIAL BEING MACHINED. THE OBJECTIVE IS TO REMOVE MATERIAL QUICKLY, WHILE ACHIEVING THE REQUIRED WORKPIECE ACCURACY AND SURFACE FINISH. THIS MATERIAL REMOVAL METHOD SETS GRINDING APART FROM OTHER CHIP REMOVAL PROCESSES SUCH AS TURNING...,
AND MILLING.

SCENE 9.
GR09A, SME4112, 03:03:47:00-03:04:22:00
zoom out, grinding operation
GR09B, SME2673, 07:14:47:00-07:15:07:00
zoom in, tool being changed out of turning tool holder
GR09C, SME4355, 07:38:50:00-07:39:01:00
zoom in, grinding operation
GR09D, CGS: Part Size
Grind Position
Dress Position

NARRATION (VO):

ANOTHER SIGNIFICANT DIFFERENCE IN GRINDING IS THAT THE CUTTING 'TOOL', WHICH IS THE GRINDING WHEEL, IS CONSUMABLE. IT CHANGES SIZE DUE TO WEAR AND DRESSING. WHERE AS IN TURNING AND MILLING, THE TOOL IS A FIXED SIZE AND IS EASILY CHANGED AS NECESSARY. THE CONSTANTLY CHANGING GRINDING WHEEL SIZE AFFECTS PART SIZE, GRIND POSITION, AND DRESS POSITION.

SCENE 10.
GR10A, SME4313, 05:01:18:00-05:01:38:00
zoom out, tool room grinding

NARRATION (VO):

GR10B, SME4458, 01:14:40:00-01:15:54:00 zoom out, cnc grinding
GR10C, SME4415, 09:19:36:00-09:20:04:00 dedicated grinding machine
GR10D, SME4414, 08:09:45:00-08:10:09:00 dedicated grinding machine, alternative shot
GR10E, revised audio

GRINDING APPLICATIONS TYPICALLY FALL INTO THREE CATEGORIES:
TOOL ROOM GRINDING WHERE LOW-QUANTITY PARTS ARE PRODUCED ON MANUAL MACHINES,
'CNC' OR COMPUTER NUMERICALLY CONTROLLED MACHINES THAT ARE TYPICALLY UNIVERSAL IN NATURE, AND CAN BE SET UP TO GRIND MULTIPLE SURFACES ON MANY DIFFERENT PART TYPES.
AND SPECIALIZED MACHINES FOR SPECIFIC HIGH PRODUCTION APPLICATIONS.

SCENE 11.
GR11A, SME4414, 08:34:09:00-08:35:05:00 grinding operation
GR11B, SME4125, 16:10:24:00-16:11:02:00 zoom out, turning operation, half screen
GR11C, SME4354, 06:09:05:00-06:10:11:00 pocket milling operation, half screen
GR11D, SME4350, 02:55:06:00-02:55:16:00 wide, large roll being ground
GR11E, still, artificial knee
GR11F, still, odd shaped ground part on cylindrical grinder
GR11G, SME4350, 02:46:38:00-02:47:08:00 zoom out, large roll being ground, alternate shot

NARRATION (VO):

GRINDING CAN PRODUCE HIGH PRECISION PARTS AND EXCEPTIONAL SURFACE FINISHES--UP TO TEN TIMES THAT ACHIEVED IN TURNING OR MILLING, AND CAN ACHIEVE ACCURACIES OF ONE-TEN THOUSANDTH OF AN INCH, OR TWENTY FIVE-THOUSANDTHS OF A MILLIMETER, OR LESS.
PARTS MADE BY GRINDING RANGE WIDELY IN SIZE AND IN SHAPE.

--- FADE TO BLACK ---

SCENE 12.
GR12A, CGS: Abrasives & Grinding Wheels
white text, centered on background
FMP BKG, motion background

SCENE 13.
GR13A, SME2583, 01:15:21:00-01:15:37:00 pan of grinding wheel surface
GR13B, SME2589, 07:02:00:00-07:02:30:00 zoom in, grinding metal
GR13C, CGS: Abrasive Grains
Bond
Porosity

NARRATION (VO):

THE GRINDING WHEEL IS COMPOSED OF ABRASIVE GRAINS OR PARTICLES HELD IN A BINDER. EACH ABRASIVE GRAIN ON THE PERIPHERY OF THE WHEEL ACTS AS A CUTTING TOOL AND REMOVES A

TINY CHIP OF MATERIAL FROM THE WORK. ALL GRINDING WHEELS ARE COMPOSED OF THREE BASICS ELEMENTS:

ABRASIVE GRAINS,

A BOND,

AND POROSITY.

SCENE 14.
GR14A, still, ceramic abrasives
GR14B, still, silicon carbide abrasives
GR14C, still, aluminum oxide abrasives
GR14D, still, diamond abrasives
GR14E, still, cbn abrasives
GR14F, still, cbn powder abrasives
GR14G, **SME4458, 01:10:55:00-01:11:32:00**
zoom in, cylindrical grinding operation
GR14H, CGS: Hardness
Friability
Shape
GR14I, still, blocky diamond
GR14J, still, angular diamond
GR14K, revised audio

NARRATION (VO):

ABRASIVE GRAINS ARE A MANUFACTURED PRODUCT AND COME IN DIFFERENT MATERIALS AND SIZES. OTHER CHARACTERISTICS THAT COMPRISE ABRASIVE GRAINS INCLUDE:

HARDNESS, WHICH IS A MEASURE OF AN ABRASIVE GRAIN'S RESISTANCE TO WEAR.

FRIABILITY, WHICH REFERS TO THE ABILITY OF THE ABRASIVE TO FRACTURE AS IT WEARS, EXPOSING NEW, SHARP EDGES WHILE MACHINING.

AND SHAPE, EITHER BLOCKY OF ANGULAR. BLOCKY ABRASIVES ARE GENERALLY TOUGH AND LESS FRIABLE, WHILE ANGULAR-SHAPED ABRASIVES CUT SHARP AND AID GRINDING WITH LOW POWER.

SCENE 15.
GR15A, **SME4316, 10:48:25:00-10:48:54:00**
zoom in, grinding operation
GR15B, CGS: Aluminum Oxide
Ceramic
Silicon Carbide
Cubic Boron Nitride/CBN
Diamond

NARRATION (VO):

THE MOST COMMON GRINDING WHEEL ABRASIVES ARE:

ALUMINUM OXIDE,

CERAMIC,

SILICON CARBIDE,

CUBIC BORON NITRIDE OR 'CBN',

AND DIAMOND.

SCENE 16.
GR16A, CGS: Aluminum Oxide
GR16B, still, white aluminum oxide grains
GR16C, still, brown aluminum oxide grains
GR16D, SME4135, 06:17:35:00-06:17:47:00 aluminum oxide grinding operation

NARRATION (VO):

ALUMINUM OXIDE IS USED IN THREE-FOURTHS OF ALL GRINDING WHEELS, AND IS PRIMARILY USED TO GRIND FERROUS MATERIALS.

SCENE 17.
GR17A, CGS: Ceramic
GR17B, still, ceramic grains
GR17C, SME4314, 06:02:10:00-06:02:48:00 zoom in, grinding using ceramic wheel

NARRATION (VO):

THE NEXT MOST COMMON MANUFACTURED ABRASIVE IS CERAMIC, WHICH IS USED FOR GRINDING HARD BRITTLE METALS. CERAMIC ABRASIVE GRAINS ARE COMMONLY MIXED WITH ALUMINUM OXIDE IN THE MANUFACTURE OF THE WHEEL TO PRODUCE BETTER GRINDING CHARACTERISTICS.

SCENE 18.
GR18A, CGS: Silicon Carbide
GR18B, still, medium silicon carbide grains
GR18C, still, coarse silicon carbide grains

NARRATION (VO):

SILICON CARBIDE IS USED FOR GRINDING SOFTER METALS, NON-FERROUS METALS, CAST IRON AND SOME HIGH DENSITY MATERIALS.

SCENE 19.
GR19A, still, cbn particles
GR19B, CGS: Cubic Boron Nitride
GR19C, still, block diamond particles
GR19D, CGS: Diamond
GR19E, SME4316, 10:52:39:00-10:52:51:00 zoom out, cbn grinding
GR19F, SME4123, 13:51:11:00-13:51:31:00 diamond grinding
GR19G, still, cbn particles, alternate shot

NARRATION (VO):

SUPERABRASIVES, SUCH AS CUBIC BORON NITRIDE,
AND DIAMOND, ARE THE HARDEST OF THE ABRASIVE MATERIALS.
CUBIC BORON NITRIDE IS USED TO GRIND HARD FERROUS MATERIALS...,
AND DIAMOND TO GRIND NON-FERROUS MATERIALS SUCH AS CARBIDE, GLASS, STONE, AND CERAMIC.

SCENE 20.
GR20A, SME4400, 08:04:41:00-08:05:08:00 zoom out, stored grinding wheels
GR20B, SME2604, 04:02:06:00-04:02:16:00 vitrified wheel stopping

NARRATION (VO):

THE ABRASIVE GRAINS ARE HELD TOGETHER USING

GR20C, CGS: Vitrified Bonds
GR20D, SME2583, 01:01:57:00-01:02:11:00
zoom out, organic grinding wheel
GR20E, CGS: Organic Bonds
GR20F, SME4450, 16:55:29:00-16:55:41:00
zoom in, metal bond powder metal operation
GR20G, CGS: Metal & Single Layer Bonds
GR20H, SME4453, 19:02:04:00-19:02:32:00
abrasive materials being mixed
GR20I, SME4453, 19:04:20:00-19:04:39:00
abrasive materials being mixed, alternate shot
GR20J, still, stored grinding wheels
GR20K, still, stored grinding wheels

A VARIETY OF DIFFERENT BOND SYSTEMS TO PRODUCE GRINDING WHEELS SUITED FOR VARIOUS APPLICATIONS. THESE BOND SYSTEMS INCLUDE:
VITRIFIED BONDS-- A GLASS-LIKE BOND FORMED OF FUSED CLAY OR FELDSPAR...,
ORGANIC BONDS-- FROM SYNTHETIC RESINS, RUBBER, OR SHELLAC...,
AND METAL BOND, USING POWDER METALLURGY OR SINGLE-LAYER BOND SYSTEMS.
WHILE VITRIFIED AND ORGANIC BONDS ARE USED FOR ALUMINUM OXIDE AND SILICON CARBIDE ABRASIVES, ALL FOUR BOND SYSTEMS ARE USED WITH SUPER ABRASIVES.

SCENE 21.
GR21A, SME4318, 12:04:48:00-12:05:05:00
grinding operation ending
GR21B, SME4353, 05:06:44:00-05:06:58:00
zoom out, hard bond wheel
GR21C, SME4313, 05:10:31:00-05:10:52:00
hard wheel operation
GR21D, SME4318, 12:01:56:00-12:02:16:00
zoom out, soft wheel operation

NARRATION (VO):

THE STRENGTH AND WEAR-RESISTANCE OF THE BOND DETERMINES THE GRADE OF A WHEEL. A 'HARD' WHEEL HAS A BOND THAT RESISTS THE BREAKING AWAY OF INDIVIDUAL GRAINS. IF THE WHEEL'S BOND IS TOO HARD, IT WILL WEAR SLOWLY, FAIL TO RELEASE DULL CUTTING EDGES, CUT INEFFICIENTLY AND CAUSE OVERHEATING THAT CAN AFFECT PART QUALITY. IF A WHEEL IS TOO SOFT FOR A GIVEN OPERATION, GRAINS ARE LOST TOO SOON AND THE WHEEL WEARS QUICKLY AND UNECONOMICALLY.

SCENE 22.
GR22A, SME2583, 01:06:28:00-01:06:35:00
c.u. dense wheel
GR22B, SME2583, 01:06:53:00-01:07:00:00
c.u. open wheel
GR22C, SME4458, 01:28:22:00-01:28:35:00
grinding with coolant

NARRATION (VO):

PORE STRUCTURE, OR DENSITY OF A GRINDING WHEEL REFERS TO THE POROSITY BETWEEN

GRAINS. THIS SEPARATION CREATES VOIDS IN THE BOND THAT PROVIDE COOLANT RETENTION AND CHIP CLEARANCE.

SCENE 23.
GR23A, still, closed pore structure
GR23B, CGS: Dense
GR23C, still, open pore structure
GR23D, CGS: Open
GR23E, SME2588, 06:26:10:00-06:26:22:00
open wheel operation
GR23F, SME4450, 16:15:41:00-16:16:18:00
zoom out, dense wheel, creep feed grinding operation

NARRATION (VO):

IF THE GRAIN SPACING IS CLOSE, THE WHEEL IS CALLED 'DENSE', IF THE SPACING IS FURTHER APART, IT IS CONSIDERED 'OPEN'...,
OPEN WHEELS ARE BEST FOR GRINDING SOFT MATERIALS AND LARGE WORK AREAS, AND FOR MINIMIZING HEAT...,
DENSE WHEELS ARE BEST FOR HARD MATERIALS AND FINER FINISHES.

SCENE 24.
GR24A, SME4316, 10:51:09:00-10:51:38:00
zoom out, grinding operation
GR13C, CGS: Abrasive Grains
Bond
Porosity

NARRATION (VO):

THE THREE ELEMENTS OF:
ABRASIVE GRAINS, THEIR SIZE, SHAPE, AND PROPERTIES...,
THE BOND TYPE, CONTENT, AND WEAR RESISTANCE...,
AND POROSITY, INCLUDING PORE SIZE, CONTENT, AND SPACING ARE CLOSELY RELATED, AND TOGETHER DETERMINE HOW WELL A WHEEL WILL PERFORM IN ANY GIVEN APPLICATION.

--- TOUCH BLACK ---

SCENE 25.
GR25A, SME4458, 01:28:56:00-01:29:12:00
zoom in, cylindrical grinding operation
GR25B, SME2583, 01:00:41:00-01:00:54:00
straight wheel
GR25C, SME2583, 01:01:06:00-01:01:16:00
straight wheel, alternate shot
GR25D, SME2583, 01:19:00:00-01:19:10:00
cylinder wheel

NARRATION (VO):

AMONG THE MANY CYLINDRICAL GRINDING WHEEL SHAPES ARE: THE STRAIGHT WHEEL...,
THE CYLINDER WHEEL...,

GR25E, SME2583, 01:04:00:00-01:04:10:00
straight cup wheel
GR25F, SME2583, 01:03:34:00-01:03:44:00
flaring cup wheel
GR25G, SME2583, 01:18:39:00-01:18:54:00
centerless wheel, zoom to internal wheel
GR25H, SME2583, 01:04:43:00-01:04:53:00
mounted points
GR25I, SME4408, 10:21:58:00-10:22:12:00
zoom cut-off wheel/disc

THE STRAIGHT CUP WHEEL...,

AND THE FLARED CUP WHEEL.

CENTERLESS GRINDING WHEELS ARE LARGE...,

WHILE INTERNAL DIAMETER GRINDING WHEELS ARE SMALL...,

OTHER COMMON WHEELS INCLUDE:

MOUNTED POINTS...,

AND CUT-OFF WHEELS OR DISCS.

--- TOUCH BLACK ---

SCENE 26.
GR26A, SME4398, 06:43:54:00-06:44:28:00
zoom out, dressing of wheel
GR26B, CGS: Dressing

NARRATION (VO):

DRESSING IS THE PROCESS OF RE-ESTABLISHING THE SHAPE AND CUTTING EFFICIENCY OF A GRINDING WHEEL, WHICH IN TURN, INFLUENCES THE SURFACE FINISH OF THE PART.

SCENE 27.
GR27A, SME2586, 04:21:39:00-04:21:50:00
dressing surface grinding wheel
GR27B, SME2587, 05:15:54:00-05:16:09:00
zoom out, single-point dresser, light passes

NARRATION (VO):

THE MOST COMMON DRESSING METHOD IS A STATIONARY SINGLE POINT DIAMOND TOOL. THE DIAMOND IS MOVED ACROSS THE FACE OF THE WHEEL AT A CONTROLLED DEPTH AND VELOCITY MUCH LIKE A TURNING TOOL ON A LATHE.

SCENE 28.
GR28A, SME2589, 07:15:21:00-07:15:45:00
c.u. dressing operation
GR28B, SME4377, 07:20:42:00-07:21:24:00
dressing of id wheel
GR28C, SME2594, 00:06:22:00-00:06:44:00
dressing of centerless grinding wheel
GR28D, CGS: 0.0005 inch/0.013 mm
GR28E, CGS: 0.002 inch/0.05 mm
GR28D, CGS: 0.0005 inch/0.013 mm
GR28F, CGS: 0.005 inch/0.13 mm

NARRATION (VO):

DRESSING PRODUCES A VERY FINE THREAD IN THE SURFACE OF THE WHEEL. THE DEPTH OF CUT IS REFERRED TO AS THE AMOUNT OF DRESS COMPENSATION, AND THE TRAVERSE RATE ACROSS THE WHEEL IS THE LEAD. A TYPICAL DEPTH OF CUT WILL VARY FROM FIVE TEN-THOUSANDTHS OF

AN INCH, OR APPROXIMATELY THIRTEEN-THOUSANDTHS OF A MILLIMETER, TO TWO-THOUSANDTHS OF AN INCH, OR APPROXIMATELY FIVE-HUNDREDTHS OF A MILLIMETER. THE LEAD CAN BE FROM FIVE TEN-THOUSANDTHS OF AN INCH, OR APPROXIMATELY THIRTEEN-THOUSANDTHS OF A MILLIMETER PER WHEEL REVOLUTION, TO FIVE-THOUSANDTHS OF AN INCH, OR APPROXIMATELY THIRTEEN-HUNDREDTHS OF A MILLIMETER.

SCENE 29.
GR29A, SME2587, 05:19:16:00-05:19:55:00
zoom in, dressing grinding wheel
GR29B, SME4377, 07:26:40:00-07:26:50:00
dressing to clean up wheel
GR29C, SME4410, 13:33:06:00-13:33:12:00
zoom in, loaded wheel, freeze last frame
GR29D, still, burn on workpiece

NARRATION (VO):

WITH CONVENTIONAL ABRASIVE WHEELS, DRESSING ALTERS THE WHEEL'S CUTTING ACTION BY RENEWING THE WHEEL SURFACE. THIS IS ACHIEVED BY REMOVING OR FRACTURING DULL GRAINS WITH THE DRESSING TOOL. DRESSING ALSO REMOVES TINY PIECES OF WORKPIECE MATERIAL FROM THE PORES OF THE WHEEL. THESE PARTICLES ‘LOAD’ THE WHEEL, MAKE IT CUT POORLY, AND CAN RESULT IN BURN AND CHATTER MARKS ON THE WORKPIECE.

SCENE 30.
GR30A, SME2587, 05:16:35:00-05:16:59:00
zoom in, slow zoom dressing wheel
GR30B, SME4377, 07:30:50:00-07:31:11:00
fast traverse dressing

NARRATION (VO):

DRESSING SPEED IS IMPORTANT. A TOO SLOW TRAVERSE DRESS CAN LEAVE THE WHEEL SURFACE IN A ‘CLOSED’ CONDITION, CAUSING PARTS TO BURN. CONVERSELY, A FAST TRAVERSE WILL ACHIEVE A MORE OPEN WHEEL FACE FOR MEDIUM OR ROUGH GRINDING.

SCENE 31.
GR31A, SME4450, 16:31:46:00-16:32:00:00
zoom out, stick used to dress wheel
GR31B, SME4415, 09:04:07:00-09:04:46:00
rotary diamond dresser being used

NARRATION (VO):

OTHER WHEEL DRESSING TOOLS INCLUDE

STICKS...,

AND ROTARY DRESSERS OF DIAMOND OR OTHER

MATERIAL.

SCENE 32.
GR32A, SME4458, 01:15:39:00-01:16:08:00
automatic dress cycle on grinder, then back to grinding

NARRATION (VO):

MOST GRINDERS ARE EQUIPPED WITH AUTOMATIC

DRESSING CYCLES TO PERIODICALLY DRESS THE

WHEEL AND AUTOMATICALLY ADJUST FOR THE

MATERIAL REMOVED FROM THE WHEEL.

--- FADE TO BLACK ---

SCENE 33.
GR33A, CGS: Grinding Safety
white text, centered on background
FMP BKG, motion background

SCENE 34.
GR34B, SME4400, 08:03:22:00-08:04:35:00
grinding wheel placed back in storage
GR34C, SME4400, 08:03:37:00-08:03:48:00
grinding wheel pulled from storage, alternate shot

NARRATION (VO):

A GRINDING WHEEL THAT HAS BEEN MISHANDLED

CAN BE DANGEROUS. GRINDING WHEELS ARE

EXTREMELY FRAGILE AND MUST BE HANDLED AND

STORED WITH CARE.

SCENE 35.
GR35A, SME4400, 08:10:00:00-08:10:23:00
zoom out, visual wheel inspection, installing
GR35B, SME2604, 05:04:34:00-05:04:43:00
ring test on good wheel with audio
GR35C, SME2604, 05:05:13:00-05:05:22:00
ring test on bad wheel with audio

NARRATION (VO):

WHEELS SHOULD BE VISUALLY INSPECTED BEFORE

USE. TO ASSURE THAT A WHEEL ISN'T CRACKED,

RING TEST IT USING A NON-METAL OBJECT. A

GOOD WHEEL WILL HAVE A CLEAR RINGING

SOUND...,

A CRACKED WHEEL WILL NOT.

SCENE 36.
GR34A, SME2583, 01:27:40:00-01:27:46:00
wheel dropped
GR36A, SME2583, 01:28:03:00-01:28:13:00
inspecting damaged wheel
GR36B, SME2584, 02:01:03:00-02:01:08:00
damaged wheel discarded

NARRATION (VO):

IF A WHEEL HAS BEEN DROPPED, OR APPEARS TO BE DAMAGED, RETURN IT TO THE MANUFACTURER OR DISCARD IT, BUT DON'T USE IT.

SCENE 37.
GR37A, ANI: speed indicated on wheel blotter
GR37B, SME2584, 02:02:20:00-02:02:30:00
speed indicated on wheel blotter, alternate shot

NARRATION (VO):

WHEEL SPEEDS ARE MARKED ON THE WHEEL OR BLOTTER AND MUST NOT BE EXCEEDED.

SCENE 38.
GR38A, SME2588, 06:04:20:00-06:04:30:00
wheel guards in place, door closed
GR38B, SME4399, 07:21:39:00-07:21:56:00
wheel guard secured on surface grinder

NARRATION (VO):

WHEEL GUARDS MUST ALWAYS BE IN PLACE BEFORE TURNING ON A GRINDING WHEEL TO AVOID INJURY SHOULD THE WHEEL FAIL.

SCENE 39.
GR39A, SME4400, 08:08:17:00-08:08:29:00
zoom out, safety glasses being worn

NARRATION (VO):

PROPER EYE PROTECTION SHOULD ALWAYS BE WORN DURING GRINDING OPERATIONS TO PROTECT AGAINST FLYING GRIT AND SPARKS.

SCENE 40.
GR40A, CGS: Balancing
GR42A, SME4399, 07:05:13:00-07:05:27:00
grinding operation with sparks
GR40B, SME2586, 04:07:00:00-04:07:14:00
surface grinding operation
GR40C, SME2584, 02:02:03:00-02:02:14:00
zoom out, bad surface on part

NARRATION (VO):

PROPER BALANCE OF THE GRINDING WHEEL IS ESSENTIAL TO PRODUCE HIGH QUALITY PARTS. OUT-OF-BALANCE WHEELS PRODUCE EXCESS VIBRATION, EARLY WHEEL FAILURE, AND CAN DESTROY WORKPIECE SURFACE FINISH.

SCENE 41.
GR41A, SME4458, 01:50:32:00-01:50:44:00
wheel on balance stand
GR41B, SME2587, 05:05:02:00-05:05:11:00
wheel balanced on grinding machine

NARRATION (VO):

GRINDING WHEELS MAY BE INITIALLY BALANCED ON A BALANCE STAND. MODERN MACHINES ARE SOMETIMES EQUIPPED WITH AN AUTOMATIC BALANCING DEVICE. WITH HIGHER WHEEL SPEEDS

AUTOMATIC BALANCING BECOMES A NECESSITY.

--- TOUCH BLACK ---

SCENE 42.
GR40D, SME4135, 06:14:20:00-06:14:35:00
zoom out, bad surface on part
GR42B, SME4116, 06:46:02:00-06:46:12:00
shoulder milling operation
GR42C, SME4130, 01:05:55:00-01:06:48:00
turning operation, edit at multiple points
GR42D, SME2589, 07:03:38:00-07:04:15:00
grinding, lots of sparks, fluid presented
GR42E, SME4350, 02:10:09:00-02:11:03:00
zoom out, grinding large part with a lot of coolant
GR42F, CGS: Lubricate the Process
Remove Heat & Swarf
Maintain Temperature in the Grinding Zone
GR42G, CGS: Abrasive Tool Choice
Grinding Cycle Design
Dressing Tools & Methods
Machine Tool Capabilities
Incoming Part Quality

NARRATION (VO):

GRINDING IS A BALANCING ACT BETWEEN CUTTING AND FRICTION.

IN MILLING...,

AND TURNING APPLICATIONS, LARGE CHIPS ARE PRODUCED WITH LITTLE ENERGY. GRINDING ON THE OTHER HAND, PRODUCES A LOT OF TINY CHIPS, WHILE GENERATING A SIGNIFICANT AMOUNT OF HEAT ENERGY. THIS COMBINED WITH OTHER FRICTIONAL INTERACTIONS REQUIRES CAREFUL ATTENTION TO THE THERMAL ASPECTS OF THE GRINDING PROCESS. CONSEQUENTLY, TO GRIND EFFICIENTLY, GRINDING FLUIDS ARE NEEDED TO LUBRICATE THE PROCESS, REMOVE HEAT AND GRINDING DEBRIS, OR SWARF, FROM THE GRINDING ZONE, AND MAINTAIN TEMPERATURE IN THE GRINDING ZONE. FRICTION CAN ALSO BE CONTROLLED BY THE ABRASIVE TOOL CHOICE, GRINDING CYCLE DESIGN, DRESSING TOOLS AND METHODS, MACHINE TOOL CAPABILITIES, INCOMING PART QUALITY, AND OTHER FACTORS.

SCENE 43.
GR43A, SME4235, 00:58:36:00-00:59:03:00
zoom out, od grinding with fluid
GR43B, SME2584, 02:01:49:00-02:01:55:00
heat damaged part
GR43C, SME2589, 07:13:20:00-07:13:40:00
zoom in, grinding with lubricants
GR43D, CGS: Emulsions
Synthetic Lubricants
Grinding Oils

NARRATION (VO):

EFFICIENT COOLING REDUCES THE GRINDING POWER REQUIREMENT, MAINTAINS WORK QUALITY, AND STABILIZES PART DIMENSIONS OVER LONG PRODUCTION RUNS. INSUFFICIENT FLUID

REACHING A WORK SURFACE MAY RESULT IN HEAT DAMAGE. GRINDING FLUIDS INCLUDE:

EMULSIONS,

SYNTHETIC LUBRICANTS,

AND GRINDING OILS.

SCENE 44.
GR44A, SME2588, 06:24:44:00-06:25:05:00
zoom out, flood coolant delivery
GR44B, SME2558, 01:11:28:00-01:11:41:00
high pressure coolant cleaning wheel during grind
GR44C, SME2558, 01:10:35:00-01:10:45:00
c.u. high pressure coolant cleaning wheel
GR44D, SME2558, 01:10:59:00-01:11:10:00
high pressure coolant cleaning wheel during grind

NARRATION (VO):

THE MOST COMMON COOLANT SUPPLY METHOD IS FLOOD COOLANT DELIVERED THROUGH ONE OR MORE NOZZLES TO THE WORK AREA. HIGH-EFFICIENCY COOLANT NOZZLES ARE USED IN PRODUCTION GRINDING THAT PROVIDES COOLANT DIRECTLY INTO THE GRINDING ZONE. THESE ARE ENGINEERED NOZZLES THAT ACCELERATE THE COOLANT TO MEET THE WHEEL VELOCITY. IN THIS MANNER, A SMALL AMOUNT OF COOLANT CAN BE USED VERY EFFECTIVELY TO IMPROVE GRINDING EFFICIENCY.

--- FADE TO BLACK ---

SCENE 45.
GR45A, CGS: The Grinding Process
white text, centered on background
FMP BKG, motion background

SCENE 46.
GR46A, SME4394, 04:52:38:00-04:53:33:00
zoom in, parts ground using thrufeed process

NARRATION (VO):

TO UNDERSTAND THE GRINDING PROCESS IT IS IMPORTANT TO UNDERSTAND THE PROCESS PARAMETERS AND THE RESULTING FORCE, FRICTION, AND HEAT RELATIONSHIPS.

SCENE 47.
GR47A, SME4399, 07:09:42:00-07:10:25:00
zoom in, surface grinding starting

NARRATION (VO):

GR47B, ANI: surface grinding wheel, sparking through grinding operation
GR47D, SME4399, 07:10:28:00-07:10:47:00 surface grinding operation
GR47E, ANI: normal force arrow
GR47F, ANI: tangential force arrow

TO INITIATE CUTTING IT IS NECESSARY TO EXERT A FORCE ON THE MATERIAL. THIS IS THE 'NORMAL' FORCE WHICH IS GENERATED BY FEEDING THE WHEEL INTO THE MATERIAL BEING GROUND. AS CUTTING IS INITIATED, A 'TANGENTIAL' FORCE IS CREATED CAUSING FRICTION BETWEEN THE WHEEL AND THE MATERIAL BEING GROUND. IT IS THIS TANGENTIAL FORCE THAT IS DIRECTLY RELATED TO POWER. THE HIGHER THE POWER, THE HIGHER THE HEAT.

SCENE 48.
GR48A, SME4301, 15:01:17:00-15:01:37:00 zoom out, fine wheel grinding
GR48B, SME4112, 03:01:35:00-03:01:56:00 coarse wheel grinding
GR48C, SME4450, 16:16:22:00-16:17:00:00 high speed creep feed grinding
GR48D, SME4311, 03:50:19:00-03:50:34:00 zoom in, high speed tool grinding, alternate shot

NARRATION (VO):

FINE HARD WHEELS CAUSE HIGHER NORMAL FORCES AND CONSEQUENTLY LOWER FRICTION. COARSE GRAINS CONVERSELY PRODUCE HIGHER FRICTION WHILE REDUCING THE NORMAL FORCE. THE HIGHER THE WHEEL SURFACE SPEED, THE LOWER THE FORCES, BUT HIGHER THE HEAT.

SCENE 49.
GR49A, SME4139, 10:32:33:00-10:33:05:00 surface grinding operation ending
GR49B, CGS: Coarse Feed/Rough Grind
Fine/Finish Feed
Dwell/Spark Out
GR49C, SME4398, 07:02:31:00-07:03:00:00 part going through entire grinding operation: coarse feed, finish feed, dwell, edit at multiple points

NARRATION (VO):

A TYPICAL GRIND CYCLE CONSISTS OF A COARSE FEED, OR ROUGH GRIND, THAT REMOVES WORKPIECE STOCK QUICKLY...,
A FINE, OR FINISH, FEED...,
AND A DWELL, SOMETIMES REFERRED TO AS SPARK-OUT.
THE MAJORITY OF STOCK IS QUICKLY REMOVED IN THE ROUGH GRIND, LEAVING A MINIMAL AMOUNT OF MATERIAL FOR FINISH GRINDING TO ACHIEVE PART ACCURACY IN A SHORT TIME. IN DWELL,

THE FINAL SURFACE FINISH AND PART ACCURACY IS ESTABLISHED.

--- FADE TO BLACK ---

SCENE 50.
GR50A, CGS: Precision Grinding Methods
white text, centered on background
FMP BKG, motion background

SCENE 51.
GR51A, SME4458, 01:30:52:00-01:31:15:00
part placed in grinding, zoom in, operator programming at machine
GR51B, SME4355, 07:38:09:00-07:38:19:00
cnc grinding operation starting
GR51C, SME4458, 01:16:08:00-01:16:24:00
zoom out, operator programming at cnc panel

NARRATION (VO):

PRECISION GRINDING IS MOST COMMONLY PERFORMED USING 'CNC', OR COMPUTER NUMERICAL CONTROLLED GRINDERS. THESE GRINDERS HAVE MACHINE CONTROLS AND DIGITAL SCALES WHICH GOVERN ALL AXIS MOTIONS. UNDER 'CNC' CONTROL, THE PART PROGRAM GOVERNS THE MOTIONS OF THE GRINDER AND PRODUCES THE PROGRAMMED SHAPE.

SCENE 52.
GR52A, SME4458, 01:27:19:00-01:27:29:00
zoom in, cnc part being ground
GR52B, SME4458, 01:03:18:00-01:03:33:00
zoom out, multiple parts

NARRATION (VO):

'CNC' GRINDERS REDUCE SETUP TIME, INCREASE FLEXIBILITY IN PRODUCTION, AND MAKE PARTS WHICH ARE MORE UNIFORM AND PREDICTABLE, FOR CONSISTENT QUALITY.

SCENE 53.
GR53A, SME4355, 07:40:15:00-07:40:39:00
zoom out, multi-dimensional part being gaged in grinding machine

NARRATION (VO):

'CNC' HAS EXPANDED THE TYPES OF SHAPES THAT GRINDERS CAN GENERATE. A SINGLE PART MAY HAVE NUMEROUS OPERATIONS COMBINED IN A SINGLE SETUP.

--- TOUCH BLACK ---

SCENE 54.
GR54A, SME3522, 17:13:09:00-17:13:27:00
zoom out, grinding used as gear finishing process
GR54B, SME4235, 01:06:34:00-01:06:44:00
zoom in, abrasive belt grinding
GR54C, SME4123, 13:50:33:00-13:50:48:00
cutting tool grinding

NARRATION (VO):

THERE ARE MANY TYPES OF SPECIALIZED GRINDING, INCLUDING GEAR GRINDING...,
ABRASIVE BELT GRINDING...,
AND TOOL AND CUTTER GRINDING.

SCENE 55.
GR55A, SME2585, 03:18:55:00-03:19:15:00
zoom in, external cylindrical grinding operation
GR55B, CGS: Cylindrical Grinding
GR55C, SME4377, 07:24:00:00-07:24:28:00
internal cylindrical grinding operation
GR55D, SME4353, 05:06:27:00-05:06:35:00
centerless grinding operation
GR55E, CGS: Centerless Grinding
GR55F, SME4139, 10:19:12:00-10:19:24:00
zoom out, surface grinding operation
GR55G, CGS: Surface Grinding

NARRATION (VO):

HOWEVER, THE THREE PRIMARY CATEGORIES OF PRECISION GRINDING OPERATIONS ARE:
CYLINDRICAL GRINDING - BOTH EXTERNAL...,
AND INTERNAL...,
CENTERLESS GRINDING...,
AND SURFACE GRINDING.

--- TOUCH BLACK ---

SCENE 56.
GR56A, SME4458, 01:23:42:00-01:24:10:00
zoom in, cylindrical grinding operation
GR55B, CGS: Cylindrical Grinding
GR56B, SME4458, 01:14:48:00-01:15:04:00
zoom out, tapered part being ground
GR56C, SME4398, 06:50:18:00-06:50:32:00
zoom out, wheel forming operation

NARRATION (VO):

IN CYLINDRICAL GRINDING, THE WORKPIECE ROTATES ABOUT A FIXED AXIS AND THE SURFACES MACHINED ARE CONCENTRIC TO THAT AXIS OF ROTATION. ‘OD’ OR OUTSIDE DIAMETER CYLINDRICAL GRINDING PRODUCES AN EXTERNAL PART SURFACE THAT MAY BE STRAIGHT,
TAPERED,
OR SHAPED BY A CONTOUR IN THE WHEEL.

SCENE 57.
GR57A, SME2587, 05:06:20:00-05:06:36:00
wide, cylindrical grinder
GR57B, CGS: Wheelhead
GR57C, SME2587, 05:20:40:00-05:20:54:00
wheelhead swiveled

NARRATION (VO):

THE COMPONENTS MAKING UP THE CONVENTIONAL CYLINDRICAL GRINDER INCLUDE THE WHEELHEAD, WHICH INCORPORATES THE SPINDLE AND DRIVE MOTOR. THE WHEELHEAD IS ON A CROSS-SLIDE

AND SITS ATOP GRADUATED RINGS, SO THAT IT MAY BE SWIVELED FOR TAPER GRINDING.

SCENE 58.
GR58A, SME2585, 03:22:40:00-03:23:07:00
wheelhead moving into work
GR58B, SME2585, 03:25:42:00-03:27:16:00
wheelhead moving into work, grinding, sparking out, and retracting, edit at multiple points

NARRATION (VO):

THE CROSS FEED MOVES THE WHEELHEAD TO AND FROM THE WORK. SOMETIMES THIS IS CALLED 'INFEED' OR 'WHEEL INFEED'. THE 'INFEED' IS SET TO STOP AT THE POINT THAT WILL YIELD THE DESIRED FINAL DIMENSION. THE WHEEL THEN 'SPARKS OUT' OR FINISHES REMOVING MATERIAL, AND RETRACTS.

SCENE 59.
GR59A, SME2585, 03:19:57:00-03:20:27:00
headstock holding, driving work
GR59B, CGS: Headstock
GR59C, SME2585, 03:21:17:00-03:21:23:00
headstock driving work
GR59D, SME2587, 05:24:41:00-05:24:52:00
zoom out, headstock swiveled on swivel table

NARRATION (VO):

THE CYLINDRICAL GRINDER'S HEADSTOCK LOCATES THE WORK,

HOLDS IT,

AND DRIVES IT.

THE HEADSTOCK IS TYPICALLY ON A SWIVEL-BASE, WHICH MAY BE MOVED LONGITUDINALLY ON THE SWIVEL TABLE.

SCENE 60.
GR60A, SME2587, 05:09:36:00-05:09:47:00
zoom in, tailstock supporting work
GR60B, CGS: Tailstock
GR60C, SME2587, 05:24:57:00-05:25:06:00
zoom out, locking nut on tailstock

NARRATION (VO):

THE CYLINDRICAL GRINDER'S TAILSTOCK WITH DEAD CENTER APPLIES FORCE TO HOLD THE WORK AND ADJUSTS TO THE LENGTH OF THE WORKPIECE.

SCENE 61.
GR61A, SME2587, 05:07:00:00-05:07:12:00
machine table, zoom up to headstock
GR61B, SME2587, 05:07:41:00-05:07:53:00
pan of work on machine table
GR61C, CGS: Machine Table
GR61D, SME2585, 03:16:47:00-03:17:08:00
part placed between headstock and tailstock and rotated

NARRATION (VO):

THE MACHINE TABLE IS MOUNTED ON GUIDEWAYS ON THE BED AND SUPPORTS THE HEADSTOCK. THE HEADSTOCK'S LONGITUDINAL PLACEMENT ON THE TABLE POSITIONS THE WORK RELATIVE TO THE

WHEEL. THE LENGTH OF THE MACHINE TABLE DETERMINES THE MAXIMUM WORKPIECE LENGTH THE GRINDER CAN SUPPORT BETWEEN CENTERS.

--- TOUCH BLACK ---

SCENE 62.
GR62A, SME4398, 06:21:41:00-06:22:08:00
zoom in, internal grinding operation
GR62B, CGS: ID Grinding

NARRATION (VO):

INTERNAL DIAMETER OR 'ID' CYLINDRICAL GRINDING FINISHES THE INSIDE OF A ROUND HOLE PREVIOUSLY DRILLED, REAMED, OR BORED, REMOVING A SMALL AMOUNT OF STOCK. 'ID' GRINDING SPINDLES ARE OFTEN SMALL AND OF LIMITED STIFFNESS. INTERNAL GRINDING PRODUCES SURFACES FOR PRECISE CLEARANCES BETWEEN MATING OR BEARING SURFACES.

SCENE 63.
GR63A, SME4303, 03:32:15:00-03:32:32:00
zoom out, id grinding wheel grinding hole
GR63B, SME2585, 03:02:00:00-03:02:16:00
internal grinding operation

NARRATION (VO):

'ID' GRINDING REQUIRES THAT WHEELS SMALLER THAN THE DIAMETER OF THE HOLE BE BROUGHT INTO GRINDING POSITION INSIDE THE HOLE. BECAUSE THE WHEELS ARE SMALL THEY MUST BE ROTATED AT HIGH RPM TO REACH THE NECESSARY SURFACE SPEED TO CUT PROPERLY.

SCENE 64.
GR64A, SME4398, 06:17:42:00-06:18:22:00
wide, internal grinder, grinding, repositioning, grinding again
GR64B, CGS: Workhead
GR64C, CGS: Wheelhead

NARRATION (VO):

THE PRINCIPAL MACHINE COMPONENTS OF AN INTERNAL GRINDING MACHINE ARE THE WORKHEAD, WITH ITS OWN DRIVE, AND THE WHEELHEAD, WHICH IS THE INTERNAL GRINDING SPINDLE. ADDITIONALLY, 'ID' GRINDERS HAVE SEVERAL LINEAR MOTIONS THAT ARE USED TO POSITION

THE WHEEL AT A GRIND POSITION INSIDE THE WORK ZONE, AND MOVE THE WHEEL TO A DRESS OR LOAD POSITION.

SCENE 65.
GR65A, SME4377, 07:28:09:00-07:28:47:00
zoom out, reciprocating movement combined with wheel rotation

NARRATION (VO):

A RECIPROCATING OR OSCILLATION MOVEMENT IS USED IN COMBINATION WITH THE WHEEL ROTATION FOR BOTH THE WHEEL'S APPROACH TO THE WORK SURFACE AND FOR THE FEED MOVEMENT DURING GRINDING. THIS REMOVES STOCK FASTER AND MAINTAINS STRAIGHTNESS.

SCENE 66.
continue previous shot
GR66A, ANI: cut away, straight cylindrical hole
GR66B, ANI: cut away, straight cylindrical hole with shoulder
GR66C, SME4430, 01:14:05:00-01:14:15:00
ball bearing races being assembled
GR66D, ANI: bar stock exterior

NARRATION (VO):

SOME OF THE SHAPES FINISHED BY INTERNAL GRINDING ARE:
STRAIGHT CYLINDRICAL HOLES...,
FLAT SURFACES AT RIGHT ANGLES TO THE HOLE AXIS, SUCH AS INTERNAL SHOULDERS AND RECESSED CYLINDRICAL HOLES...,
AND RADIUSED PROFILES, SUCH AS BALL BEARING RACES.

--- TOUCH BLACK ---

SCENE 67.
GR55E, CGS: Centerless Grinding
GR67A, SME2594, 00:04:43:00-00:05:01:00
c.u. centerless grinding operation
GR67B, SME4419, 10:11:01:00-10:11:36:00
zoom out, centerless grinding operation
GR67C, SME2594, 00:03:25:00-00:03:38:00
work rest blade supporting workpieces

NARRATION (VO):

IN CENTERLESS GRINDING, THE WORKPIECE IS LOCATED BETWEEN TWO WHEELS,
THE GRINDING WHEEL,
AND THE REGULATING WHEEL.
BOTH WHEELS ROTATE IN THE SAME DIRECTION BUT AT DIFFERENT SPEEDS. THE WORK IS

SUPPORTED FROM BELOW BY A FIXED WORK-REST BLADE.

SCENE 68.
GR68A, CGS: Regulating Wheel
GR68B, SME2594, 00:01:58:00-00:02:15:00 centerless grinding operation
GR68C, SME4395, 05:01:12:00-05:01:33:00 zoom in, parts being ground in centerless grinder

NARRATION (VO):

THE REGULATING WHEEL IS SLOWER THAN THE GRINDING WHEEL, AND CAUSES THE WORKPIECE TO ROTATE AT A DESIRED PERIPHERAL SPEED FOR GRINDING. AS THE GAP BETWEEN THE TWO WHEELS IS REDUCED, THE DIAMETER OF THE ROTATING WORKPIECE IS GROUND TO A UNIFORM OUTSIDE DIAMETER. THE CHANGE IN THE WORKPIECE DIAMETER IS EQUAL TO THE DISTANCE BY WHICH ONE OF THE WHEELS IS ADVANCED.

SCENE 69.
GR69A, SME4415, 09:28:03:00-09:28:26:00 zoom out, thrufeed centerless grinding operation
GR69B, CGS: Thrufeed Grinding
GR69C, SME2594, 00:07:31:00-00:07:47:00 infeed centerless grinding operation
GR69D, CGS: Infeed/Plunge Grinding

NARRATION (VO):

THE TWO MOST COMMON CENTERLESS GRINDING PROCESSES ARE:
THRUFEED GRINDING...,
AND INFEED, OR PLUNGE, GRINDING.

SCENE 70.
GR69B, CGS: Thrufeed Grinding
GR70B, SME4394, 04:51:36:00-04:52:11:00 zoom out, parts ground using thrufeed process

NARRATION (VO):

IN THRUFEED GRINDING, WORKPIECES TRAVERSE CONTINUOUSLY IN THE AXIAL DIRECTION BETWEEN THE GRADUALLY NARROWING GAP BETWEEN THE TWO WHEELS. WORKPIECES ARE ADVANCED BY THE AXIAL FORCE ON THE SURFACE OF THE REGULATING WHEEL. THIS IS ACHIEVED BY SETTING THE REGULATING WHEEL'S AXIS AT A SPECIFIC ANGLE OF INCLINATION TO THE GRINDING WHEEL AXIS.

SCENE 71.
GR71A, SME4353, 05:03:26:00-05:03:46:00
zoom out, thrufeed parts being ground

NARRATION (VO):

THRUFEED GRINDING IS USED FOR PARTS HAVING A STRAIGHT CYLINDRICAL SURFACE. THESE PARTS ARE GROUND CONSECUTIVELY, TYPICALLY WITH SEVERAL BETWEEN THE WHEELS SIMULTANEOUSLY.

SCENE 72.
GR69D, CGS: Infeed/Plunge Grinding
GR72B, SME4390, 22:36:53:00-22:37:30:00
zoom out, infeed centerless grinding operation

NARRATION (VO):

INFEED, OR PLUNGE, GRINDING IS USED FOR WORKPIECES WITH HEADS UNSUITABLE FOR THRUFEEDING. A WORKPIECE IS PLACED ON THE WORK-REST BLADE AND FED TO AN END STOP WHILE ONE WHEEL IS RETRACTED. ONCE THAT WHEEL IS BROUGHT BACK, THE GAP BETWEEN THE WHEELS IS REDUCED BY A FEED MOVEMENT, AND THE PART DIAMETER IS GROUND.

--- TOUCH BLACK ---

SCENE 73.
GR55G, CGS: Surface Grinding
GR73A, SME4139, 10:19:55:00-10:20:18:00
surface grinding with traverse movement
GR73B, SME2588, 06:25:51:00-06:26:05:00
zoom in, surface grinding with rotating workpiece movement
GR73C, SME4135, 06:12:01:00-06:12:19:00
zoom out, surface grinding using the grinder's periphery
GR73D, SME4316, 10:45:35:00-10:45:50:00
surface grinding using the grinder's face

NARRATION (VO):

SURFACE GRINDING PRODUCES FLAT, ANGULAR, OR CONTOURED SURFACES BY FEEDING THE WORKPIECE IN A HORIZONTAL PLANE BENEATH A ROTATING WHEEL. A FLAT SURFACE MAY BE GROUND BY EITHER A TRAVERSING MOVEMENT...,
OR A ROTATING MOVEMENT OF THE WORKPIECE OR WORKPIECES...,
AND BY USING EITHER THE PERIPHERY...,
OR THE FACE OF A GRINDING WHEEL.

SCENE 74.
GR74A, SME2588, 06:12:56:00-06:13:16:00
zoom out, surface grinding surface with contoured form

NARRATION (VO):

STRAIGHT SURFACES WITH CONTOURED FORMS MAY

GR74B, still, form dresser with surface grinding wheel
GR74C, SME2588, 06:01:27:00-06:02:20:00 c.u. dressing device, dressing, alternate shot

BE GROUND, PROVIDED THE WIDTH OF THE FORM FITS WITHIN THE WIDTH OF THE WHEEL. AN APPROPRIATE DRESSING DEVICE WITH THE SPECIFIC FORM PERIODICALLY DRESSES THE WHEELS CONTOUR.

SCENE 75.
GR75A, SME4311, 03:47:09:00-03:47:36:00 zoom in, surface grinding using horizontal spindle

NARRATION (VO):

THE MOST COMMON METHOD OF SURFACE GRINDING USES A HORIZONTAL SPINDLE, THE PERIPHERY OF THE WHEEL, AND A RECIPROCATING RECTANGULAR TABLE. THE WORKPIECE IS MOUNTED ON A MAGNETIC TABLE AND MOVES BACK AND FORTH IN A STRAIGHT LINE, AND AT RIGHT ANGLES TO THE GRINDING WHEEL AXIS.

SCENE 76.
GR76A, SME2586, 04:06:03:00-04:06:17:00 surface grinder table, on saddle, on base
GR76B, CGS: Table
GR76C, CGS: Saddle
GR76D, CGS: Base
GR76E, SME2586, 04:12:56:00-04:13:09:00 surface grinder column, wheelhead
GR76F, CGS: Column
GR76G, CGS: Wheelhead

NARRATION (VO):

THE TABLE IS MOUNTED ON A SADDLE...,
WHICH IN TURN SITS ON THE BASE...,
THE COLUMN, AT THE BACK, SUPPORTS THE SPINDLE AND WHEELHEAD.

SCENE 77.
GR77A, SME2604, 04:06:19:00-04:06:31:00 downfeed of grinder
GR77B, SME2586, 04:10:25:00-04:10:38:00 zoom in, crossfeed grinding
GR77C, SME2588, 06:09:17:00-06:09:28:00 downfeed, reciprocation of surface grinder

NARRATION (VO):

VERTICAL DOWNFEED OF THE WHEEL IS GOVERNED BY THE WHEEL FEED HANDWHEEL, TO CONTROL DEPTH OF CUT. THE CROSSFEED, OR TRANSVERSE MOVEMENT BETWEEN STROKES, IS SET BY THE CROSS-FEED HANDWHEEL OR POWER CROSSFEED CONTROL. ON CNC MODELS, DOWNFEED AND CROSSFEED, AS WELL AS TABLE RECIPROCATION, ARE AUTOMATED.

SCENE 78.
GR78A, CGS: Creep-Feed Grinding
GR78B, SME4450, 16:19:35:00-16:20:46:00 creep grinding operation
GR78C, SME2587, 05:02:04:00-05:02:16:00 wheel dressing

NARRATION (VO):

CREEP-FEED GRINDING IS A FORM OF SURFACE GRINDING THAT REMOVES MATERIAL IN A SINGLE DEEP AND SLOW PASS. IT REQUIRES A VERY RIGID MACHINE AND IS USED IN HIGH-PRODUCTION. THE WHEEL IS TYPICALLY DRESSED BETWEEN EACH PIECE OR CONTINUOUSLY DURING THE GRIND.

SCENE 79.
GR79A, SME4299, 13:10:00:00-13:10:22:00 zoom out, vertical spindle surface grinder

NARRATION (VO):

ON THE VERTICAL SPINDLE SURFACE GRINDER WITH ROTARY TABLE, THE FACE OF THE WHEEL, RATHER THAN THE PERIPHERY, DOES THE GRINDING. IT REMOVES MATERIAL RAPIDLY FOR PRODUCTION GRINDING OF PLAIN, FLAT SURFACES.

SCENE 80.
GR80A, SME4414, 08:02:33:00-08:02:46:00 zoom out, grinding wheels in double disk surface grinder
GR80B, SME4414, 08:14:04:00-08:14:41:00 zoom out, parts going into double disk grinding operation, parts coming out
GR80C, still, double disk grinding wheels inside machine

NARRATION (VO):

THE DOUBLE-DISC GRINDER USES OPPOSED FACES OF TWO DISC-SHAPED WHEELS TO SIMULTANEOUSLY GRIND OPPOSITE SIDES OF THE WORKPIECE AS THE WORK IS FED BETWEEN THE WHEELS. THIS PROCESS IS EFFECTIVE FOR HIGH PRODUCTION APPLICATIONS IN WHICH BOTH SIDES OF A WORKPIECE NEED TO BE GROUND FLAT WITH A FIXED WORK THICKNESS.

--- FADE TO BLACK ---

SCENE 81.
GR81A, CGS: Workpiece Surface Finish
white text, centered on background
FMP BKG, motion background

SCENE 82.
GR82A, SME2589, 07:13:10:00-07:13:46:00
zoom in, rough grinding operation
GR82B, CGS: Workpiece Material
Wheel Type
Wheel's Condition
Dressing Procedure
Feed Rate
Machine's Rigidity
Grinding Lubricant
Cleanliness
Surface Integrity

NARRATION (VO):

IN GRINDING, WORKPIECE SURFACE FINISH IS INFLUENCED BY SEVERAL FACTORS:

THE WORKPIECE MATERIAL,

THE WHEEL TYPE,

THE WHEEL'S CONDITION,

THE DRESSING PROCEDURE,

THE FEED RATE,

THE MACHINE'S RIGIDITY,

GRINDING LUBRICANT CLEANLINESS,

AND SURFACE INTEGRITY.

SCENE 83.
GR83A, CGS: Workpiece Material
GR83B, SME4398, 06:49:43:00-06:50:05:00
zoom in, part being ground

NARRATION (VO):

A FINER FINISH CAN BE PRODUCED ON HARDENED MATERIALS, SUCH AS HARDENED STEELS, THAN ON SOFTER MATERIALS SUCH AS CAST IRON OR ALUMINUM, SINCE THE SOFTER MATERIALS CAN CAUSE LOADING OF THE WHEEL.

SCENE 84.
GR84A, CGS: Wheel Type
GR84B, SME4398, 06:52:46:00-06:52:59:00
grinding operation
GR84C, still, c.u., closed, fine grain wheel
GR84D, still, c.u., closed, coarse grain wheel

NARRATION (VO):

THE PRIMARY FACTOR AFFECTING SURFACE FINISH IS GRAIN SIZE OF THE WHEEL. A FINE-GRIT, WHEEL PRODUCES A SMOOTHER FINISH THAN A COARSE-GRIT.

SCENE 85.
GR85A, CGS: Wheel's Condition
GR85B, SME2558, 01:09:00:00-01:09:10:00
clogged wheel surface

NARRATION (VO):

IF THE WHEEL BECOMES DULL AND LOADED WITH GRINDING DEBRIS IT WILL GRIND INEFFECTIVELY AND PRODUCE A POOR SURFACE FINISH.

SCENE 86.
GR86A, CGS: Dressing Procedure
GR86B, SME4377, 07:14:39:00-07:15:10:00 zoom in, fast dressing of wheel
GR86C, SME2587, 05:18:13:00-05:18:32:00 zoom out, slow dressing of wheel
GR86D, SME4399, 07:24:09:00-07:24:49:00 c.u. dressing of surface grinding wheel

NARRATION (VO):

DRESSING AFFECTS SURFACE FINISH AS WELL AS THE WHEELS ABILITY TO REMOVE MATERIAL. A FASTER TRAVERSE RATE WILL PRODUCE A MORE AGGRESSIVE CUTTING ACTION AND A COARSER FINISH. A SLOW TRAVERSE RATE WILL CREATE LESS AGGRESSIVE CUTTING ACTION AND A FINER FINISH.

SCENE 87.
GR87A, CGS: Feed Rate
GR87B, SME2589, 07:02:46:00-07:02:55:00 high speed grinding
GR87C, SME2588, 06:33:29:00-06:33:40:00 slow speed grinding

NARRATION (VO):

HIGH FEED RATES PRODUCE A ROUGH FINISH, WHILE SLOWER FEED RATES CREATE FINER FINISHES.

SCENE 88.
GR88A, CGS: Machine Rigidity
GR88B, SME4398, 06:03:26:00-06:04:06:00 zoom out, automated grinding machine

NARRATION (VO):

HIGH MACHINE RIGIDITY, OR STIFFNESS, AND THE OVERALL CONDITION OF THE MACHINE IS A PREREQUISITE TO COST EFFECTIVE GRINDING. A MACHINE IN POOR CONDITION IS PRONE TO PRODUCE CHATTER AND POOR QUALITY PARTS.

SCENE 89.
GR89A, CGS: Grinding Lubricant Cleanliness
GR89B, SME4415, 09:32:14:00-09:32:40:00 zoom out, coolant being filtered
GR89C, SME4415, 09:41:19:00-09:41:34:00 coolant being filtered, alternate shot

NARRATION (VO):

GRINDING LUBRICANT CLEANLINESS AFFECTS SURFACE FINISH AND WHEEL CONDITION. GOOD COOLANT FILTRATION REMOVES THE PROCESS WASTE THAT COULD DAMAGE WORKPIECE SURFACE FINISH.

SCENE 90.
GR90A, CGS: Surface Integrity
GR90B, still, part with nice surface
GR90C, still, part with surface integrity problems
GR90D, movie of part with nice surface

NARRATION (VO):

SURFACE INTEGRITY IS THE CONDITION OF THE SURFACE BELOW THE APPARENTLY SMOOTH FINISH.

dissolving to part with poor surface
GR90E, SME4458, 01:32:45:00-01:32:58:00
zoom out, part with microcracking, bad surface integrity
GR90F, SME4458, 01:33:20:00-01:33:33:00
zoom in, part with microcracking, bad surface integrity
GR90G, SME4458, 01:35:27:00-01:35:42:00
zoom out, part with microcracking, bad surface integrity
GR90H, CGS: Viewed Under Ultraviolet Light

MICRO-CRACKING, MICROSTRUCTURAL CHANGES, OR OTHER DAMAGE, TYPICALLY DUE TO EXCESS HEAT OR EXCESS FORCE IN THE PROCESS, MAY BE HIDDEN UNDER A CLEAN, SMOOTH-LOOKING SURFACE.

SCENE 91.
GR91A, SME4135, 06:11:46:00-06:11:58:00
finish surface grinding operation

NARRATION (VO):

CAREFUL FINISH GRINDING CAN SOMETIMES REMOVE DAMAGE TO SURFACE INTEGRITY CREATED BY TOO-VIGOROUS ROUGH GRINDING.

--- FADE TO BLACK ---

SCENE 92.
FMP RVW, CGS: Review
white text, centered on background
FMP BKG, motion background
FMP RVM, review music

MUSIC UP AND UNDER

NARRATION (VO):

LET'S REVIEW THE MATERIAL CONTAINED IN THIS PROGRAM.

SCENE 93.
GR06A, SME4458, 01:26:02:00-01:26:22:00
zoom out, grinding operation

NARRATION (VO):

GRINDING IS AN ABRASIVE MATERIAL REMOVAL PROCESS USED TO MACHINE HIGH-QUALITY, CLOSE TOLERANCE SURFACE FINISHES IN HARD MATERIALS, SUCH AS METALS AND CERAMICS.

SCENE 94.
GR08A, SME2585, 03:23:22:00-03:24:17:00
cylindrical grinding operation, edit at multiple points
GR09A, SME4112, 03:03:47:00-03:04:22:00
zoom out, grinding operation

NARRATION (VO):

IN GRINDING, AN ABRASIVE PRODUCT, MOST OFTEN A GRINDING WHEEL IS ROTATED AT HIGH SPEED AND THE WHEEL'S CIRCUMFERENTIAL SURFACE IS BROUGHT INTO CONTACT WITH THE MATERIAL BEING MACHINED. THE OBJECTIVE IS

TO REMOVE MATERIAL QUICKLY, WHILE ACHIEVING THE REQUIRED WORKPIECE ACCURACY AND SURFACE FINISH.

SCENE 95.
GR13A, SME2583, 01:15:21:00-01:15:37:00
pan of grinding wheel surface
GR14G, SME4458, 01:10:55:00-01:11:32:00
zoom in, cylindrical grinding operation

NARRATION (VO):

THE GRINDING WHEEL IS COMPOSED OF ABRASIVE GRAINS AND A BOND MATERIAL WITH POROSITY TO CREATE SPACE FOR COOLANT AND CHIP CLEARANCE.

SCENE 96.
GR15A, SME4316, 10:48:25:00-10:48:54:00
zoom in, grinding operation
GR16A, CGS: Aluminum Oxide
GR16B, still, white aluminum oxide grains
GR17A, CGS: Ceramic
GR17B, still, ceramic grains
GR18A, CGS: Silicon Carbide
GR18C, still, coarse silicon carbide grains
GR19A, still, cbn particles
GR19B, CGS: Cubic Boron Nitride
GR19C, still, block diamond particles
GR19D, CGS: Diamond

NARRATION (VO):

THE MOST COMMON GRINDING WHEEL ABRASIVES ARE:

ALUMINUM OXIDE...,

CERAMIC...,

SILICON CARBIDE...,

AND THE SUPERABRASIVES, SUCH AS CUBIC BORON NITRIDE OR ‘CBN’...,

AND DIAMOND.

SCENE 97.
GR21B, SME4353, 05:06:44:00-05:06:58:00
zoom out, hard bond wheel
GR21D, SME4318, 12:01:56:00-12:02:16:00
zoom out, soft wheel operation

NARRATION (VO):

AN ABRASIVE MUST BE HARDER THAN THE MATERIAL IT IS CUTTING, SHOCK RESISTANT, HEAT RESISTANT AND CAPABLE OF FRACTURING WHEN THE CUTTING EDGES BECOME DULL.

SCENE 98.
GR41A, SME4458, 01:50:32:00-01:50:44:00
wheel on balance stand
GR26A, SME4398, 06:43:54:00-06:44:28:00
zoom out, dressing of wheel

NARRATION (VO):

WHEEL BALANCING...,

AND DRESSING PROCEDURES PREPARE AND MAINTAIN THE WHEEL FOR PROPER USE.

SCENE 99.
GR34C, SME4400, 08:03:37:00-08:03:48:00

NARRATION (VO):

grinding wheel pulled from storage,
GR35A, SME4400, 08:10:00:00-08:10:23:00
zoom out, visual wheel inspection, installing
GR38B, SME4399, 07:21:39:00-07:21:56:00
wheel guard secured on surface grinder
GR39A, SME4400, 08:08:17:00-08:08:29:00
zoom out, safety glasses being worn

SAFE GRINDING OPERATIONS REQUIRE THAT
WHEELS BE PROPERLY STORED...,
INSPECTED FOR CRACKS...,
AND CORRECTLY INSTALLED...,
THE MACHINE MUST BE GUARDED...,
AND THE OPERATOR MUST WEAR EYE PROTECTION
AT ALL TIMES.

SCENE 100.
GR49C, SME4398, 07:02:31:00-07:03:00:00
part going through entire grinding operation
GR55B, CGS: Cylindrical Grinding
GR55C, SME4377, 07:24:00:00-07:24:28:00
internal cylindrical grinding operation
GR55D, SME4353, 05:06:27:00-05:06:35:00
centerless grinding operation
GR55E, CGS: Centerless Grinding
GR55F, SME4139, 10:19:12:00-10:19:24:00
zoom out, surface grinding operation
GR55G, CGS: Surface Grinding

NARRATION (VO):
THE THREE PRIMARY CATEGORIES OF PRECISION
GRINDING OPERATIONS ARE:
CYLINDRICAL GRINDING - BOTH EXTERNAL...,
AND INTERNAL...,
CENTERLESS GRINDING...,
AND SURFACE GRINDING.

SCENE 101.
GR56A, SME4458, 01:23:42:00-01:24:10:00
zoom in, cylindrical grinding operation
GR55B, CGS: Cylindrical Grinding
GR56B, SME4458, 01:14:48:00-01:15:04:00
zoom out, tapered part being ground
GR56C, SME4398, 06:50:18:00-06:50:32:00
zoom out, wheel forming operation

NARRATION (VO):
IN CYLINDRICAL GRINDING, THE WORKPIECE
ROTATES ABOUT A FIXED AXIS AND THE SURFACES
MACHINED ARE CONCENTRIC TO THAT AXIS OF
ROTATION. 'OD' OR OUTSIDE DIAMETER
CYLINDRICAL GRINDING PRODUCES AN EXTERNAL
PART SURFACE THAT MAY BE STRAIGHT...,
TAPERED...,
OR SHAPED BY A CONTOUR IN THE WHEEL.

SCENE 102.
GR62A, SME4398, 06:21:41:00-06:22:08:00
zoom in, internal grinding operation
GR62B, CGS: ID Grinding
GR65A, SME4377, 07:28:09:00-07:28:47:00
zoom out, reciprocating movement combined with wheel rotation

NARRATION (VO):
INTERNAL OR 'ID' CYLINDRICAL GRINDING
ACHIEVES ACCURATE INTERNAL FITS AND PRECISE
CLEARANCES. INTERNAL SHAPES AND SURFACES
MAY BE GROUND BY SMALL WHEELS ROTATING AT

HIGH RPM'S WHILE RECIPROCATING.

SCENE 103.
GR55E, CGS: Centerless Grinding
GR67A, SME2594, 00:04:43:00-00:05:01:00
c.u. centerless grinding operation
GR70B, SME4394, 04:51:36:00-04:52:11:00
zoom out, parts ground using thrufeed process

NARRATION (VO):

IN CENTERLESS GRINDING, THE WORKPIECE IS LOCATED BETWEEN TWO WHEELS,
THE GRINDING WHEEL,
AND THE REGULATING WHEEL.
BOTH WHEELS ROTATE IN THE SAME DIRECTION BUT AT DIFFERENT SPEEDS. THE WORK IS SUPPORTED FROM BELOW BY A FIXED WORK-REST BLADE.

SCENE 104.
GR55G, CGS: Surface Grinding
GR73A, SME4139, 10:19:55:00-10:20:18:00
surface grinding with traverse movement
GR73B, SME2588, 06:21:19:00-06:21:30:00
zoom in, surface grinding with rotating workpiece movement
GR73C, SME4135, 06:12:01:00-06:12:19:00
zoom out, surface grinding using the grinder's periphery
GR73D, SME4316, 10:45:35:00-10:45:50:00
surface grinding using the grinder's face

NARRATION (VO):

SURFACE GRINDING PRODUCES FLAT, ANGULAR, OR CONTOURED SURFACES BY FEEDING THE WORKPIECE IN A HORIZONTAL PLANE BENEATH A ROTATING WHEEL. A FLAT SURFACE MAY BE GROUND BY EITHER A TRAVERSING MOVEMENT...,
OR A ROTATING MOVEMENT OF THE WORKPIECE OR WORKPIECES...,
AND BY USING EITHER THE PERIPHERY...,
OR THE FACE OF A GRINDING WHEEL.

--- FADE TO BLACK ---

SCENE 105.
continue music, up and under
GR CRX, CGS, ROLL: credits
white text, fade up mid-screen
FMP EXM, extended motion background

Produced By:
Society of Manufacturing Engineers

Executive Producer:
Kristine Nasiatka

Producer/Director/Cameraman:

Jerome T. Cook

Written By:
James Greenwood

Equipment Access Provided By:
C & A Tool Engineering, Inc.
Cinetic Landis Corp.
Cinetic Gardner Abrasives
Milan Tool Corp.
Pacific Bearing Company
Saint-Gobain High-Performance Materials

Visual Materials Provided By:
Cinetic Landis Corp.
Saint-Gobain High-Performance Materials

Graphics:
Jerome T. Cook
Dennis Summers,
Quantum Dance Works

Production Assistance:
Patrick Fitzpatrick,
n-code Inc.
Lance Rosol,
Pixel Perfect Photography

Video Editing:
Jerome T. Cook

SCENE 106.
continue motion background
FMP DIS, CGS: disclaimer
white text, centered on background

Some machinery in this program had safety equipment removed to allow better recording of certain processes.
Always read the safety information provided in the manufacturers' manual before machine

operation.

SCENE 107.
FMP SME, SME logo open, with music