

FUNDAMENTAL MANUFACTURING PROCESSES

Workholding - WH

SCENE 1.

WH12A, CGS: Principles of Workholding
white text, centered on background
FMP BKG, motion background

SCENE 2.

WH13A, part on blue background
WH13B, part with datum plane highlighted
WH13C, part with datum lines highlighted
WH13D, part with datum hole highlighted
WH13E, CGS: Datums

NARRATION (VO) :

A MACHINED PART HAS CERTAIN PLANES,
LINES, AND/OR HOLES FROM WHICH OTHER
POINTS ARE MEASURED. THESE REFERENCE
POINTS OR PLANES ARE CALLED DATUMS.

SCENE 3.

WH14A, **SME2638**, **01:18:12:00-01:18:22:00**
part released from workholding, freeze
last frame
WH14B, **SME2638**, **01:18:23:00-01:18:35:00**
new part secured onto workholding
WH14C, **SME4026**, **11:55:59:00-11:56:10:00**
alternate shot, zoom out, multiples of the
same part

NARRATION (VO) :

TO CORRECTLY MACHINE A PART, IT MUST BE
HELD IN A SETUP THAT GUARANTEES A
DEFINITE LOCATION, OR POSITION AND
ORIENTATION IN SPACE, WITH RESPECT TO
THE PART'S DATUM POINTS OR SURFACES.
THIS MUST BE REPEATABLE, PART-AFTER-
PART.

SCENE 4.

WH15A, **SME4132**, **03:22:12:00-03:22:43:00**
clamped part being machined

NARRATION (VO) :

SECONDLY, THE WORKHOLDING DEVICE MUST
HOLD THE PART SECURELY IN POSITION WHILE
CUTTING FORCES, VIBRATIONS, CENTRIFUGAL
FORCE, AND GRAVITY ACT TO DISLODGE IT.

SCENE 5.

WH16A, **SME2638**, **01:04:38:00-01:05:10:00**
clamped part being machined

NARRATION (VO) :

IN THEORY, THE LOCATION AND CLAMPING OF
WORKPIECES ARE CONSIDERED SEPARATE

ISSUES. BUT IN WORKHOLDING PRACTICE,
LOCATING AND CLAMPING ARE INTEGRATED AS
PART OF THE SAME PROCESS.

SCENE 6.

WH17A, SME4315, 09:30:27:00-09:30:53:00
zoom out, machining part
WH17B, SME2648, 21:02:18:00-21:02:30:00
over tightening work in vise

NARRATION (VO) :

THE HOLDING ACTION ENSURES THE WORKPIECE
IS STABLE FOR MACHINING, ONCE LOCATED.
IF IT IS NOT RESTRAINED ADEQUATELY, THE
WORKPIECE WILL MOVE AND BECOME SCRAP.
CONVERSELY, THE CLAMPING FORCE MUST NOT
BE INAPPROPRIATELY EXCESSIVE, SO AS TO
DISTORT, GOUGE, OR BREAK THE WORKPIECE.

--- TOUCH BLACK ---

SCENE 7.

WH18A, SME4383, 14:20:18:00-14:20:27:00
rectangular workpiece secured on fixture
WH18B, CGS: Six Degrees of Freedom
WH18C, solid object on blue background
WH18D, X axis appears
WH18E, Y axis appears
WH18F, Z axis appears
WH18G, clockwise rotation of axes appears
WH18H, counterclockwise rotation of axes
appears

NARRATION (VO) :

WORKHOLDING STARTS FROM VISUALIZING THE
COORDINATE SYSTEM REPRESENTING A SOLID
OBJECT IN SPACE, KNOWN AS THE SIX
DEGREES OF FREEDOM. THESE SIX
COORDINATES CONSIST OF THE PLUS AND
MINUS MOVEMENT IN THE "X"...,
"Y"...,
AND "Z" AXES,
AND THE CLOCKWISE...,
AND COUNTERCLOCKWISE ROTATION AROUND
EACH OF THESE THREE AXES.

SCENE 8.

continue previous shot
WH18G, counterclockwise vanishes
WH18F, clockwise vanishes
WH18E, Z axis disappears
WH18D, Y axis disappears

NARRATION (VO) :

THERE ARE TWELVE DIRECTIONS OF MOVEMENT
THAT MAKE-UP THESE SIX DEGREES OF

WH18C, X axis disappears, solid object on blue background

FREEDOM. TO ACCURATELY LOCATE A WORKPIECE FOR MACHINING, IT MUST BE SECURED TO RESTRICT MOVEMENT IN THESE TWELVE DIRECTIONS.

SCENE 9.

WH20A, SME4395, 05:15:27:00-05:15:42:00
zoom out, part located on threaded locator
WH20B, SME4383, 14:42:00:00-14:42:15:00
alternate shot, part located on circular surface
WH20C, CGS: Circular
 Irregular
 Plane

NARRATION (VO) :

LOCATING MAY BE DONE FROM CIRCULAR, IRREGULAR OR PLANE SURFACES.

SCENE 10.

WH21A, SME4394, 04:32:02:00-04:32:23:00
zoom out, rectangular parts being secured
WH21B, six locators on blue background
WH21C, translucent part faces over locators
WH21D, solid part resting on locators
WH18H, 12 directions of movement
WH21E, remaining 3 directions of movement not cancelled with locators
WH21F, CGS: 3-2-1 Locational Method

NARRATION (VO) :

THE 3-2-1 LOCATIONAL METHOD IS SUITED FOR RECTANGULAR PARTS LOCATED BY THEIR OUTER EDGES. WITH THIS METHOD, SIX POINTS OF CONTACT, OR LOCATORS, ON THE FACES OF AN OBJECT COLLECTIVELY CANCEL NINE OF THE TWELVE DIRECTIONS OF MOVEMENT.

SCENE 11.

WH21B, six locators on blue background
WH22A, 3 primary locators highlighted
WH22B, CGS: 3 Primary Locators
WH22C, 2 secondary locators highlighted
WH22D, CGS: 2 Secondary Locators
WH22E, 1 tertiary locator highlighted
WH22F, CGS: 1 Tertiary Locator

NARRATION (VO) :

THESE SIX CONTACT POINTS INCLUDE: THREE PRIMARY LOCATORS..., TWO SECONDARY LOCATORS..., AND A SINGLE TERTIARY LOCATOR.

SCENE 12.

WH22B, CGS: 3 Primary Locators
WH23B, 3 primary locators on blue background
WH23C, translucent plane over 3 locators
WH18H, 12 directions of movement
WH23D, -Z axis restrained
WH23E, X rotary axes restrained
WH23F, Y rotary axes restrained

NARRATION (VO) :

THE THREE PRIMARY LOCATORS ESTABLISH THE PLANE UPON WHICH THE PART RESTS. THESE LOCATORS RESTRAIN FIVE OF THE TWELVE DIRECTIONS OF MOVEMENT: THE DOWN

DIRECTION OR MINUS "Z" AXIS, AND THE
CLOCKWISE AND COUNTERCLOCKWISE ROTARY
MOTIONS AROUND THE "X" AND "Y" AXES.

SCENE 13.

WH22D, CGS: 2 Secondary Locators
WH24B, 2 secondary locators on blue
background
WH24C, translucent plane over 2 locators
WH23F, 5 of 12 directions restrained
WH24D, +Y axis restrained
WH24E, Z rotary axes restrained

NARRATION (VO) :

THE TWO SECONDARY LOCATORS ARE 90
DEGREES TO THE PRIMARIES, AND IN THE
ESTABLISHED PLANE. THESE LOCATORS
RESTRICT THREE ADDITIONAL DIRECTIONS OF
MOVEMENT: THE PLUS "Y" AXIS, AND THE
CLOCKWISE AND COUNTERCLOCKWISE ROTARY
MOTIONS AROUND THE "Z" AXIS.

SCENE 14.

WH22F, CGS: 1 Tertiary Locator
WH25B, single tertiary locator on blue
background
WH25C, translucent plane over tertiary
locator
WH24E, 8 of 12 movements restrained
WH25D, -X axis is restrained

NARRATION (VO) :

THE FINAL, TERTIARY LOCATOR IS FOUND 90
DEGREES TO THE SECONDARY LOCATORS. IT
RESTRICTS THE MINUS "X" AXIS. TOGETHER,
THESE SIX LOCATORS ABSORB THE PRIMARY
MACHINING FORCES.

SCENE 15.

WH26A, **SME4024**, **09:20:56:00-09:21:11:00**
rectangular parts secured for machining
WH25D, 9 of 12 directions restrained
WH26B, +X axis restrained
WH26C, +Z axis restrained
WH21D, block of steel, all directions of
movement restrained

NARRATION (VO) :

WHEN A CLAMPING DEVICE IS ADDED, THE
THREE AXES THAT REMAIN -- THE PLUS "X",
THE PLUS "Z", AND THE MINUS "Y" AXES,
ARE SECURED FOR MACHINING.

SCENE 16.

WH21C, translucent part faces over
locators
WH27A, additional locator added to primary
locator set
WH27B, additional locator added to
secondary locator set
WH27C, additional locator added to

NARRATION (VO) :

ADDING ADDITIONAL, REDUNDANT LOCATORS
ONLY RISKS MAGNIFYING ANY WORKPIECE
VARIATIONS, COMPROMISING MACHINING

tertiary set

ACCURACY, AS WELL AS INCREASING
WORKHOLDING COSTS.

--- TOUCH BLACK ---

SCENE 17.

WH28A, SME4094, 09:13:00:00-09:14:10:00
parts being machined using various cutting
tools, edit at various points
WH28B, SME4379, 10:55:21:00-10:55:34:00
zoom out, part being machined,

NARRATION (VO) :

FOR OPTIMUM ACCURACY AND PRODUCTIVITY,
THE WORKHOLDING SHOULD ALLOW AS MANY
OPERATIONS AS POSSIBLE TO BE DONE IN A
SINGLE CLAMPING. RECLAMPING OR
RECHUCKING HAVE TWO NEGATIVE IMPACTS.

SCENE 18.

WH29A, SME4379, 10:53:02:00-10:53:10:00
part removed from first operation
WH29B, SME4379, 10:51:42:00-10:51:54:00
part moved to second location
WH29C, SME4380, 11:07:41:00-11:07:55:00
zoom out, part machined in a different
location,
WH29D, SME4380, 11:17:50:00-11:18:00:00
zoom in, back of part clamped into fixture

NARRATION (VO) :

FIRST, WHEN THE WORKPIECE IS MOVED, THE
LOCATION OF THE WORKPIECE IN RELATION TO
THE MACHINE TOOL IS LOST. THAT
COMPROMISES THE ACCURACY OF THE PART.
SECONDLY, THE TIME REQUIRED TO SET UP A
PART FOR MACHINING IS "NON-VALUE-ADDED
TIME" -- ADDING COSTS AND WASTE TO AN
OPERATION WITH EACH UNCLAMP/CLAMP CYCLE.

SCENE 19.

WH30A, SME4120, 10:12:15:00-10:13:07:00
machined part being reclamped
WH30B, CGS: Datum Surfaces must be
Machined First
A Through-Hole has Steps on
Both Sides
A Part has Blind Holes on
Opposite Sides

NARRATION (VO) :

ALTHOUGH A SINGLE CLAMPING CYCLE IS
IDEAL, TWO OR MORE CLAMPINGS OR
CHUCKINGS MAY BE REQUIRED WHEN:
DATUM SURFACES MUST BE MACHINED
FIRST...,
OR A THROUGH-HOLE HAS STEPS ON BOTH
SIDES...,
OR A PART HAS BLIND HOLES ON OPPOSITE

SIDES.

SCENE 20.

WH31A, SME4022, 07:18:20:00-07:19:06:00
intense rough milling
WH31B, SME4022, 07:21:40:00-07:22:16:00
intense rough milling
WH31C, SME4359, 11:39:04:00-11:39:24:00
rough milling

NARRATION (VO) :

ACCURACY CAN ALSO BE AFFECTED BY PART DEFLECTION, DEPENDING ON THE PART GEOMETRY AND CUTTING OPERATIONS. SO THE WORKHOLDING MUST GRIP THE WORKPIECE STRONGLY ENOUGH TO PREVENT PARTS DEFLECTING FROM THE CUTTING FORCES OF MACHINING. ACCORDINGLY, THE WORKHOLDING CAN INFLUENCE WHAT SPEEDS AND FEEDS ARE POSSIBLE IN A MACHINING PROCESS.

SCENE 21.

WH32A, SME4394, 04:25:30:00-04:25:53:00
zoom out, parts mounted to tombstone being machined
WH32B, SME4383, 14:11:47:00-14:12:05:00
zoom in, small cluster of parts mounted to tombstone

NARRATION (VO) :

THE CHOICE OF WORKHOLDING ALSO INFLUENCES WHAT CUTTING TOOL PATH CAN BE PROGRAMMED INTO A CNC MACHINE TOOL. AND HIGHLY CLUSTERED PART SETUPS MAY LIMIT THE SIZE AND SHAPE OF THE CUTTING TOOLS THAT CAN BE USED.

SCENE 22.

WH33A, SME4352, 04:10:46:00-04:11:10:00
zoom in, multiple parts being machined
WH33B, SME4352, 04:16:15:00-04:16:30:00
c.u., multiple parts being drilled
WH33C, SME4352, 04:43:42:00-04:43:53:00
c.u., multiple parts being tapped
WH33D, SME4352, 04:44:00:00-04:44:15:00
wide, multiple parts being rotated and milled

NARRATION (VO) :

WHEN MULTIPLE PARTS ARE MOUNTED AND MACHINED IN A SINGLE SET-UP, TIME AND COST SAVINGS CAN BE SIGNIFICANT. THE AVERAGE TIME PER PART FOR LOADING AND UNLOADING MAY BE REDUCED. AND SINCE EACH CUTTING-TOOL MACHINES MULTIPLE PARTS BEFORE BEING CHANGED, THE AVERAGE TIME FOR EACH CUTTING-TOOL CHANGE IS REDUCED

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IN THE PIECE COST. MULTI-PART SETUPS
ALLOW THESE SAVINGS UP TO THE POINT AT
WHICH THEY ARE OFFSET BY INCREASED
FIXTURE COSTS.

--- FADE TO BLACK ---