FUNDAMENTALS OF TOOL DESIGN

Cutting Tool Design

SCENE 1.
CT49A, CGS: Multipoint Cutting-Tool Design
white text, centered on background
FTD01B, motion background

SCENE 2.
CT50A, tape FTD07, 06:53:37:00-06:54:00:00
milling cutter slowly turning
CT50B, tape FTD07, 06:54:13:00-06:54:23:00
same milling cutter milling cast iron

NARRATION (VO):

MULTIPOINT CUTTING TOOLS ARE A SERIES OF SINGLE-POINT CUTTING TOOLS MOUNTED IN OR INTEGRAL WITH A HOLDER OR BODY AND OPERATED IN SUCH A MANNER THAT ALL THE TEETH OR CUTTING EDGES FOLLOW ESSENTIALLY THE SAME PATH ACROSS THE WORKPIECE.

SCENE 3.
CT51A, tape FTD20, 21:05:24:00-21:05:46:00
c.u. drilling operation
CT51B, tape FTD01, 01:15:49:00-01:16:15:00
zoom out, milling operation

NARRATION (VO):

MOST MULTIPOINT CUTTING TOOLS CREATE DISCONTINUOUS CHIPS THAT ARE CARRIED FOR SOME DISTANCE BEFORE EJECTION. ADEQUATE CHIP SPACE MUST BE PROVIDED TO PREVENT JAMMING AND TOOL BREAKAGE. WHEN DESIGNING MULTIPOINT TOOLS, CARE MUST BE TAKEN TO PROVIDE SUFFICIENT CHIP SPACE WITHOUT LOSING TOO MUCH RIGIDITY IN THE TOOL. THE AMOUNT AND SHAPE OF THE CHIP SPACE NEEDED DEPENDS ON THE WORKPIECE MATERIAL AND TYPE OF CUT.

SCENE 4.
CT52A, tape FTD20, 21:11:23:00-21:11:38:00
milling operation

NARRATION (VO):

CT52B, tape FTD01, 01:18:40:00-01:18:58:00
zoom out, milling operation

FOR DISCONTINUOUS CHIPS, LESS ROOM AND CLOSER TOOTH SPACING CAN BE USED THAN FOR CONTINUOUS CHIPS. CHIPBREAKERS ARE OFTEN INCLUDED ON THE CUTTING FACE TO REDUCE CHIP SIZE AND ENHANCE THE TOOL'S ABILITY TO CONVEY CHIPS.

SCENE 5.
CT53A, tape FTD18, 18:29:21:00-18:29:32:00
broaching operation
CT53B, tape FTD01, 01:41:03:00-01:41:11:00
milling operation

NARRATION (VO):

CUTTING EDGES CAN BE STRAIGHT OR CONTOURED AND MAY BE EITHER LINEAR TRAVEL...,

OR ROTARY TRAVEL.

SCENE 6.
CT54A, tape FTD18, 18:08:22:00-18:08:36:00
zoom out, broaching operation

NARRATION (VO):

WITH THE LINEAR-TRAVEL, THE RELATIVE MOTION BETWEEN TOOL AND WORKPIECE IS ALONG A STRAIGHT LINE PATH.

SCENE 7.
CT55A, tape FTD13, 12:03:57:00-12:04:09:00
face mill turning slowly
CT55B, tape FTD02, 02:19:32:00-02:19:48:00
drilling operation
CT55C, tape FTD07, 06:02:13:00-06:02:25:00
milling operation
CT15C, tape 768, 04:22:30:00-04:22:42:00
shaping operation

NARRATION (VO):

WITH THE ROTARY-TRAVEL, THE TOOL TEETH REVOLVE ABOUT THE TOOL AXIS. THE RELATIVE MOTION BETWEEN THE TOOL AND WORKPIECE CAN BE AXIAL...,

OR IN A PLANE PERPENDICULAR TO THE TOOL AXIS...,

OR SOMETIMES A COMBINATION OF THE TWO AS WITH CERTAIN FORM-GENERATING TOOLS.

--- TOUCH BLACK ---

SCENE 8.
CT56A, tape FTD15, 15:36:46:00-15:37:07:00
milling operation
CT56B, CGS: Broach

NARRATION (VO):

THERE ARE NUMEROUS MULTITOOTH CUTTING

Twist Drill
Face Mill
CT56C, tape HSM06, 07:19:34:00-07:20:30:00
high speed milling operation

TOOLS. A FEW OF THE MOST COMMON INCLUDE:

THE BROACH,

THE TWIST DRILL,

AND FACE MILL.

--- TOUCH BLACK ---

SCENE 9.
CT57A, tape 766, 02:05:35:00-02:05:49:00
c.u. pan of broach
CT57B, tape 781, 20:20:34:00-20:20:50:00
c.u. broaching operation

NARRATION (VO):

THE BROACH IS THE MOST COMMON MULTIPOINT, LINEAR-TRAVEL CUTTING TOOL AND IS USED FOR PRODUCING EITHER EXTERNAL OR INTERNAL SURFACES IN A VARIETY OF PROFILES.

SCENE 10.
CT58A, tape FTD20, 22:12:12:00-22:12:46:00
zoom out, broaching operation
CT58B, CGS: Face Angle
Back-Off Angle
Face-Angle Radius
Back-Of-Tooth Radius
Land
Tooth Depth
Chip Space
Pitch

NARRATION (VO):

BROACH TEETH ARE MADE UP OF SEVERAL ANGLES AND GEOMETRIES TO SUCCESSFULLY CUT SHAPES, INCLUDING:

THE FACE ANGLE,

BACK-OFF ANGLE,

FACE-ANGLE RADIUS,

BACK-OF-TOOTH RADIUS,

LAND,

TOOTH DEPTH,

CHIP SPACE,

AND PITCH.

SCENE 11.
CT59A, CGS: Face Angle
CT59B, ANI: c.u. broach tooth
CT59C, ANI: face angle lines

NARRATION (VO):

THE FACE ANGLE, WHICH IS ALSO CALLED THE HOOK ANGLE, IS THE ANGLE OF THE CUTTING EDGE OF A BROACH TOOTH.

SCENE 12.
continue graphic
CT60A, CGS: Back-Off Angle
CT60B, ANI: back-off angle lines

NARRATION (VO):

THE BACK-OFF ANGLE IS THE RELIEF CLEARANCE IN BACK OF THE CUTTING EDGE OF THE BROACH TOOTH. BACK-OFF ANGLES ARE QUITE LOW, TYPICALLY ONE-HALF TO THREE-AND-A-HALF DEGREES.

SCENE 13.
continue graphic
CT61A, CGS: Face-Angle Radius
CT61B, ANI: face angle radius arrow

NARRATION (VO):

THE FACE-ANGLE RADIUS IS THE RADIUS JUST BELOW THE CUTTING EDGE OF THE TOOTH.

SCENE 14.
continue graphic
CT62A, CGS: Back-Of-Tooth Radius
CT62B, ANI: back-of-tooth radius arrow

NARRATION (VO):

THE BACK-OF-TOOTH RADIUS IS THE RADIUS ON THE BACK OF THE CUTTING EDGE OF THE TOOTH.

SCENE 15.
continue graphic
CT63A, CGS: Land
CT63B, ANI: land lines

NARRATION (VO):

THE LAND IS THE THICKNESS OF THE BROACH TOOTH AT IT'S TOP.

SCENE 16.
continue graphic
CT64A, CGS: Tooth Depth
CT64B, ANI: root reference line
CT64C, ANI: tooth depth line

NARRATION (VO):

THE TOOTH DEPTH IS THE HEIGHT OF THE TOOTH FROM THE ROOT TO THE CUTTING EDGE.

SCENE 17.
continue graphic
CT65A, CGS: Chip Space
CT65B, ANI: chip space highlight

NARRATION (VO):

THE CHIP SPACE, WHICH IS ALSO REFERRED TO AS THE CHIP GULLET, IS THE SPACE BETWEEN BROACH TEETH WHICH ACCOMMODATES CHIPS DURING CUTTING.

SCENE 18.
continue graphic
CT66A, CGS: Pitch

NARRATION (VO):

CT66B, ANI: pitch lines

THE PITCH IS THE MEASUREMENT FROM THE CUTTING EDGE OF ONE TOOTH TO THE CORRESPONDING POINT ON THE NEXT TOOTH.

SCENE 19.
CT67A, tape FTD20, 22:10:57:00-22:11:12:00
zoom in, broaching operation
CT67B, tape 781, 20:20:34:00-20:20:50:00
c.u. broaching operation
CT67C, tape 766, 02:06:58:00-02:07:25:00
c.u. broaching operation

NARRATION (VO):

IN OPERATION, EACH TOOTH ON THE BROACH IS GENERALLY HIGHER THAN THE PRECEDING TOOTH. AS A RESULT, THE DEPTH OF CUT, OR CHIP LOAD, INCREASES WITH EACH TOOTH AS THE BROACHING OPERATION PROGRESSES.

TOOTH SHAPE AND CHIP SPACE DEPEND ON WORKPIECE LENGTH, CHIP THICKNESS PER TOOTH AND TYPE OF CHIP MADE.

SCENE 20.
CT68A, ANI: standard broach
CT68B, CGS: Roughing Teeth
CT68C, ANI: standard broach, roughing teeth highlighted
CT68D, CGS: Semifinishing Teeth
CT68E, ANI: standard broach, semifinishing teeth highlighted
CT68F, CGS: Finishing Teeth
CT68G, ANI: standard broach, finishing teeth highlighted

NARRATION (VO):

BROACHES TEETH ARE TYPICALLY GROUPED INTO THREE DISTINCT REGIONS:

ROUGHING TEETH, WHICH MAKE THE FIRST, GENERALLY HEAVIER CUTS IN A BROACHING OPERATION,

SEMIFINISHING TEETH, WHICH TAKE SMALLER, SEMIFINISHING CUTS,

AND FINISHING TEETH, WHICH ARE ARRANGED AT A CONSTANT SIZE FOR FINISHING.

SCENE 21.
CT69A, tape FTD18, 18:06:21:00-18:06:38:00
zoom out, broaching operation

NARRATION (VO):

BROACHES ARE COMMONLY PRODUCED FROM HIGH-SPEED STEEL OR MAY EMPLOY INDEXABLE CARBIDE INSERTS.

--- TOUCH BLACK ---

SCENE 22.
CT70A, tape FTD02, 02:26:17:00-02:26:38:00
zoom out, drilling operation
CT70B, tape 33, 02:27:45:00-02:28:15:00
holemaking on lathe

NARRATION (VO):

THE TWIST DRILL IS A ROUGHING TOOL AND IS THE MOST COMMON AXIALLY-FED ROTARY TOOL USED IN HOLEMAKING OPERATIONS. EITHER THE ROTATING DRILL IS FED INTO A STATIONARY WORKPIECE, OR A STATIONARY DRILL IS FED INTO A ROTATING WORKPIECE.

SCENE 23.
CT71A, tape 80, 03:01:40:00-03:01:58:00
twist drill tilt, shank to drill point
CT71B, CGS: Shank
CT71C, CGS: Flutes
CT71D, CGS: Drill Point

NARRATION (VO):

THE THREE ELEMENTAL PARTS OF THE TWIST DRILL INCLUDE THE SHANK...,

FLUTES...,

AND DRILL POINT.

SCENE 24.
CT72A, CGS: Shank
CT72B, tape 80, 03:21:39:00-03:21:43:00
straight shank twist drill put in collet, dissolve to freeze frame
CT72C, tape 80, 03:22:21:00-03:22:21:01
freeze frame, straight shank in collet
CT72D, tape 698, 02:26:33:00-02:33:56:00
twist drills used to machine composites

NARRATION (VO):

THE SHANK IS THE MEANS BY WHICH THE DRILL IS HELD AND DRIVEN. TWIST DRILL SHANKS MAY BE STRAIGHT OR TAPERED.

SCENE 25.
CT73A, CGS: Flutes
CT73B, tape FTD02, 02:25:31:00-02:25:56:00
zoom in, drilling with coolant

NARRATION (VO):

FLUTES LET COOLANT INTO AND CARRY CHIPS OUT OF THE HOLE BEING PRODUCED. BOTH OF THESE FUNCTIONS ARE ESSENTIAL FOR THE DRILL POINT TO CONTINUE CUTTING UNDER THE SEVERE CONDITIONS OF ROTATING AT HIGH SPEED IN AN ENCLOSED SPACE.

SCENE 26.
CT74A, ANI: blue background with drill helix angles
CT74B, tape 80, 03:06:19:00-03:06:27:00
drill with standard helix angle
CT74C, tape 80, 03:05:07:00-03:05:15:00

NARRATION (VO):

THE HELIX ANGLE OF A DRILL'S FLUTES CAN VARY DEPENDING ON THE MATERIAL TO BE

drill with high helix angle
CT74D, tape 80, 03:06:39:00-03:06:48:00
drill with low helix angle

DRILLED. A STANDARD HELIX ANGLE OF 25 TO 33 DEGREES IS OPTIMAL FOR STEELS AND CAST IRONS...,

A HIGH HELIX OR FAST SPIRAL ANGLE OF 35 TO 40 DEGREES IS USED FOR LOW-STRENGTH MATERIALS LIKE ALUMINUM...,

AND A LOW-HELIX OR SLOW-SPIRAL ANGLE OF 15 TO 20 DEGREES IS USED FOR DRILLING BRASS AND PLASTICS.

SCENE 27.
CT75A, CGS: Drill Point
CT75B, tape 78, 01:25:46:00-01:25:55:00
c.u. twist drill point entering work

NARRATION (VO):

THE DRILL POINT, WHICH DOES THE WORK OF METAL CUTTING, IS FORMED BY TWO CUTTING LIPS AND A CHISEL EDGE.

SCENE 28.
CT76A, ANI: drill, showing cutting lips, chisel edge
CT76B, ANI: arrow 1
CT76C, ANI: arrow 2
CT76D, CGS: Cutting Lips
CT76E, CGS: Chisel Edge
CT76F, ANI: drill
CT76G, ANI: chisel edge arrow
CT76H, ANI: drill web
CT76I, ANI: drill web arrow 1
CT76J, ANI: drill web arrow 2
CT76K, CGS: Drill Web

NARRATION (VO):

THE CUTTING LIPS, WHEN THE DRILL IS CORRECTLY GROUND, FORM TWO STRAIGHT LINES CONNECTED BY THE CHISEL EDGE. THE LENGTH OF THE CHISEL EDGE DEPENDS ON THE ANGLE IT MAKES WITH THE CUTTING LIPS AND THE THICKNESS OF THE DRILL WEB OR CORE.

SCENE 29.
CT77A, ANI: drill web
CT77B, tape 728, 15:15:00:00-15:15:22:00
holemaking operation
CT77C, tape FTD19, 20:15:53:00-20:16:10:00
holemaking operation

NARRATION (VO):

THE WEB THICKNESS AT THE DRILL POINT IS A COMPROMISE BETWEEN THICKNESS FOR RIGIDITY AND THINNESS FOR RAPID PENETRATION RATES, LARGER FLUTE SPACE, AND GOOD CHIP CLEARANCE.

SCENE 30.
CT78A, ANI: standard drill point
CT78B, ANI: standard drill point lines

NARRATION (VO):

CT78C, ANI: 118°
CT78D, ANI: standard drill point
CT78E, ANI: clearance reference arrow

THE STANDARD DRILL POINT COMMONLY HAS A 118 DEGREE POINT ANGLE, SYMMETRICAL CUTTING LIPS, AND A CLEARANCE ANGLE TYPICALLY BETWEEN 10 AND 20 DEGREES.

--- TOUCH BLACK ---

SCENE 31.
CT79A, tape FTD23, 03:07:43:00-03:08:15:00
face milling cutter, cutting surface, ending
CT79B, tape 232, 04:13:38:00-04:13:47:00
c.u. insert place in face mill pocket, freeze last frame

NARRATION (VO):

FACE MILLING CUTTERS EFFECTIVELY GENERATE FLAT SURFACES WITH THE SPINDLE PERPENDICULAR TO THE WORK SURFACE. THE CUTTER BODY HAS MULTIPLE POCKETS TO ACCEPT A VARIETY OF INDEXABLE INSERT TYPES.

SCENE 32.
CT80A, tape FTD03, 03:14:41:00-03:15:12:00
zoom out, milling with chips

NARRATION (VO):

AS THE CUTTER ROTATES, EACH INSERT EDGE ALTERNATELY ENTERS AND LEAVES THE CUT, REMOVING A SMALL AMOUNT OF MATERIAL IN A SHORT, DISCONTINUOUS CHIP. THE CHIP THICKNESS AT THE START OF THE CUT IS CALLED THE UNDEFORMED CHIP THICKNESS. AT LEAST ONE TOOTH SHOULD ALWAYS BE IN CONTACT WITH THE WORKPIECE. KEEPING THE MILLING CUTTER AND WORKPIECE CONSTANTLY UNDER LOAD AVOIDS VIBRATION AND SHOCK LOADS.

SCENE 33.
CT81A, tape 232, 04:14:23:00-04:14:34:00
coarse pitch cutter, milling wide cut
CT81B, ANI: climb milling mode insert biting thick to thin chip
CT81C, ANI: climb milling mode, chip

NARRATION (VO):

MOST MILLING WITH INDEXABLE-INSERT MILLING CUTTERS IS PERFORMED USING THE

highlighted
CT81D, CGS: Climb Milling Mode

'CLIMB MILLING MODE', WITH THE INSERT BITING INTO THE THICKEST PORTION OF THE CHIP FIRST AND THEN THINNING TOWARDS ZERO UPON EXIT.

SCENE 34.
CT82A, CGS: Conventional Milling Mode
CT82B, ANI: conventional milling mode insert biting thick to thin chip
CT82C, ANI: conventional milling mode, chip highlighted

NARRATION (VO):

THIS IS THE REVERSE OF THE 'CONVENTIONAL MILLING MODE' IN WHICH THE MILLING CUTTER BITES INTO THE MINIMUM CHIP THICKNESS AT THE START OF THE CUT AND EXITS AT THE MAXIMUM CHIP THICKNESS.

SCENE 35.
CT83A, tape 232, 04:21:03:00-04:21:19:00
milling with chips
CT83B, tape 232, 04:19:38:00-04:19:50:00
face milling shoulder
CT83C, tape 233, 05:08:49:00-05:09:19:00
small face mill, ramping into part, milling pocket
CT83D, tape FTD19, 20:06:12:00-20:06:48:00
face milling shoulder

NARRATION (VO):

THE MILLED SURFACE RESULTS FROM THE COMBINED ACTION OF CUTTING EDGES LOCATED ON THE PERIPHERY AND FACE OF THE CUTTER. THE FLAT MILLED SURFACE HAS NO RELATION TO THE CONTOUR OF THE INDIVIDUAL TEETH, EXCEPT WHEN MILLING A SHOULDER. NOT ALL FACE MILLS ARE USED FOR LARGE, STRAIGHT CUTS. SOME SMALL DIAMETER FACE MILLS ARE USED TO RAMP INTO A SURFACE, THEN PLUNGE TO A DEPTH, AND INTERPOLATE OUTWARDS TO MILL A LARGE POCKET MORE EFFICIENTLY THAN AN END MILL COULD.

--- TOUCH BLACK ---

SCENE 36.
CT84A, tape FTD13, 12:05:30:00-12:05:57:00
zoom out, milling operation
CT84B, CGS: Effective Diameter
Cutter Hand
Cutter Geometry

NARRATION (VO):

SOME OF THE VARIABLES NEEDING CONSIDERATION IN THE DESIGN OF FACE

Insert Pocket Design
Cutter Pitch

MILLING CUTTERS INCLUDE:

THE CUTTER'S EFFECTIVE DIAMETER,

CUTTER HAND,

CUTTER GEOMETRY,

INSERT POCKET DESIGN,

AND CUTTER PITCH.

SCENE 37.
CT85A, CGS: Effective Diameter
CT85B, tape FTD13, 12:22:53:00-12:23:03:00
face mill cutting, wide in cut
CT85C, ANI: milling cutter
CT85D, ANI: lines showing effective diameter of cutter
CT85E, ANI: arrow indicating effective diameter

NARRATION (VO):

FOR CUTTING, THE 'EFFECTIVE DIAMETER' IS THE MOST SIGNIFICANT CONCERN. THE EFFECTIVE DIAMETER IS MEASURED FROM THE HIGHEST POINT ON AN INSERT ON ONE SIDE TO THE HIGHEST POINT ON AN INSERT ON THE OPPOSITE SIDE.

SCENE 38.
CT86A, tape FTD03, 03:13:41:00-03:14:06:00
face mill, cutting, end overhanging cut

NARRATION (VO):

FOR PROPER POSITIONING, THE FACE MILLING CUTTER'S EFFECTIVE DIAMETER SHOULD BE ABOUT ONE-AND-A-HALF TIMES THE WIDTH OF THE CUT DESIRED. THIS ALLOWS A QUARTER TO ONE THIRD OF THE CUTTER TO OVERHANG THE EDGES OF THE WORKPIECE, PROVIDING OPTIMAL CHIP FORMATION.

SCENE 39.
CT87A, CGS: Cutter Hand
CT87B, tape FTD13, 12:17:20:00-12:17:50:00
face mill, rotating counterclockwise, flip image to simulate cutter rotating clockwise
CT87C, tape 233, 05:09:45:00-05:10:18:00
face mill, rotating counterclockwise, flip image to simulate cutter rotating clockwise

NARRATION (VO):

THE CUTTER HAND IS DETERMINED BY EXAMINING THE CUTTER'S FACE WHILE RUNNING ON A MACHINE TOOL. A RIGHT-HAND CUTTER ROTATES COUNTERCLOCKWISE...,

AND A LEFT-HAND CUTTER ROTATES

CLOCKWISE.

SCENE 40.
CT88A, CGS: Cutter Geometries
CT88B, tape FTD07, 06:06:47:00-06:07:10:00
inserts being tighten into milling cutter
CT88C, CGS: Radial Rake
Axial Rake

NARRATION (VO):

CUTTER GEOMETRIES OR 'RAKE' ANGLES ARE DETERMINED BY THE CUTTER BODY AND THE INSERT. TWO 'RAKE' ANGLES, THE 'RADIAL' RAKE, AND THE 'AXIAL' RAKE ARE DETERMINED BY THE POSITION OF THE INSERT POCKETS IN THE CUTTER BODY.

SCENE 41.
CT89A, CGS: Radial Rake
CT89B, ANI: positive radial rake milling cutter
CT89C, ANI: positive radial rake milling cutter with insert line
CT89D, ANI: positive radial rake milling cutter with reference line
CT89E, CGS: Positive Radial Rake
CT89F, ANI: negative radial rake with lines
CT89G, CGS: Negative Radial Rake

NARRATION (VO):

THE 'RADIAL' RAKE IS THE ANGLE MEASURED BETWEEN THE INSERT FACE AND A RADIAL LINE DRAWN FROM THE CUTTER AXIS TO THE CUTTING EDGE, HENCE THE NAME RADIAL RAKE. IF THE INSERT TILTS 'TOWARD' THE CHIP GULLET, IT HAS A 'POSITIVE' RADIAL RAKE...,

IF THE INSERT TILTS 'AWAY' FROM THE CHIP GULLET, IT HAS A 'NEGATIVE' RADIAL RAKE.

SCENE 42.
CT90A, CGS: Axial Rake
CT90B, ANI: positive axial rake milling cutter
CT90C, ANI: positive axial rake milling cutter with insert line
CT90D, ANI: positive axial rake milling cutter with reference line
CT90E, CGS: Positive Axial Rake
CT90F, ANI: negative axial rake with lines
CT90G, CGS: Negative Axial Rake

NARRATION (VO):

THE AXIAL RAKE IS THE ANGLE MEASURED BETWEEN THE INSERT FACE AND AN AXIAL LINE OR PLANE. IT MAY ALSO BE POSITIVE...,

OR NEGATIVE.

SCENE 43.
CT91A, tape FTD15, 15:33:10:00-15:33:25:00
zoom out, milling operation
CT91B, CGS: Negative Radial & Axial
CT91C, ANI: lines forming negative radial/axial

NARRATION (VO):

THE COMBINATION OF 'AXIAL' AND 'RADIAL' RAKE ANGLES YIELD THREE GEOMETRIES OF

CT91D, CGS: Positive Radial & Axial
CT91E, ANI: lines forming positive radial/axial
CT91F, CGS: Negative Radial & Positive Axial
CT91G, ANI: lines forming negative radial/positive axial

MILLING CUTTERS: 'NEGATIVE RADIAL AND AXIAL'-- WHICH OFFERS THE STRONGEST EDGES BUT GENERATES THE GREATEST CUTTING FORCES...,

'POSITIVE RADIAL AND AXIAL'--WHICH PROVIDES THE FREEST CUTTING...,

AND 'NEGATIVE RADIAL' AND 'POSITIVE AXIAL'--WHICH PRESENTS A STRONG EDGE TO THE WORKPIECE, BUT PULLS THE CHIP UP.

SCENE 44.
CT92A, ANI: insert rake angle
CT92B, ANI: insert rake angle lines appear
CT92C, ANI: insert rake angle along with radial & axial rake forming milling cutter's
CT92D, CGS: Effective Rake

NARRATION (VO):

THE 'RAKE' ANGLE ON FACE-MILLING CUTTER INSERTS IN CONJUNCTION WITH THE CUTTER BODY'S 'RADIAL' AND 'AXIAL' RAKE ANGLES CONTRIBUTES TO THE CUTTER'S 'EFFECTIVE' RAKE.

SCENE 45.
CT93A, CGS: Lead Angle
CT93B, tape FTD03, 03:18:36:00-03:18:54:00 zoom out, c.u. milling operation
CT93C, ANI: milling cutter having zero degree lead angle
CT93D, ANI: reference line appear indicating zero degree lead angle
CT93E, ANI: milling cutter having 15 degree lead angle
CT93F, ANI: milling cutter having 30 degree lead angle
CT93G, ANI: milling cutter having 45 degree lead angle

NARRATION (VO):

THE CUTTERS 'LEAD ANGLE' INFLUENCES CUTTING FORCES AND CHIP THICKNESS. THE GREATER THE LEAD ANGLE, THE GREATER THE AXIAL FORCE AND THE LONGER, BUT THINNER, THE CHIP. STANDARD MILLING CUTTERS COME IN ZERO-, 15-, 30-, AND 45-DEGREE LEAD ANGLES.

SCENE 46.
CT94A, tape 232, 04:16:32:00-04:16:40:00 c.u. insert with chip gullet
CT94B, tape 233, 05:07:20:00-05:07:30:00 modular face mill with no insert cartridge in pocket
CT94C, tape 233, 05:06:54:00-05:07:04:00 modular face mill with square insert in cartridge pocket

NARRATION (VO):

MOST FACE MILLS ARE DESIGNED WITH INSERT POCKETS THAT ARE FIXED. OTHER CUTTERS ARE MODULAR AND ACCEPT A VARIETY OF

CT94D, tape 233, 05:08:03:00-05:08:13:00
modular face mill with round insert in cartridge pocket

INTERCHANGEABLE INSERT CARTRIDGES THAT HOLD VARIOUS INSERT DESIGNS AND SEAT THE INSERTS AT DIFFERENT ANGLES.

SCENE 47.
CT95A, CGS: Cutter Pitch
CT95B, tape FTD23, 03:06:58:00-03:07:10:00
milling operation
CT95C, ANI: underneath cutter
CT95D, ANI: underneath cutter, lines appear
CT95E, ANI: underneath cutter with lines, double arrow appears
CT95F, tape FTD23, 03:17:53:00-03:18:20:00
milling operation

NARRATION (VO):

THE CUTTER PITCH IS DETERMINED BY THE NUMBER OF INSERTS RELATIVE TO THE CUTTER DIAMETER AND CAN BE DEFINED AS THE DISTANCE FROM A POINT ON ONE EDGE TO THE CORRESPONDING POINT ON THE NEXT EDGE.

THE COARSER THE PITCH, THE LARGER THE CHIP GULLET.

SCENE 48.
CT96A, tape 233, 05:18:04:00-05:18:08:00
c.u. milling insert, different shape
CT96B, tape 233, 05:16:50:00-05:16:54:00
c.u. milling insert, different shape
CT96C, tape 233, 05:17:25:00-05:17:29:00
c.u. milling insert, different shape
CT96D, tape 233, 05:17:32:00-05:17:36:00
c.u. milling insert, different shape
CT96E, tape 233, 05:17:47:00-05:17:54:00
c.u. milling insert, different shape
CT96F, tape 239, 07:22:39:00-07:22:50:00
milling insert with radius
CT96G, tape 239, 07:23:32:00-07:23:40:00
milling insert with wiper flat
FTD CXM, credit music

NARRATION (VO):

MILLING INSERTS ARE AVAILABLE WITH VARIOUS GRADES AND SHAPES.

IN ADDITION, MILLING INSERTS HAVE THEIR OWN CORNER GEOMETRIES, INCLUDING THE RADIUS...,

AND THE WIPER FLAT.

--- FADE TO BLACK ---