ISO TC 184/SC4/WG3 N 831 **Date: 99-11-8**

Supersedes ISO TC 184/SC4/WG_3

ISO/ [ballot stage] [standard number] - [part number] - [ballot cycle]

Document title: Proposal of Machining Process Model

ABSTRACT:

This document is a discussion paper for the proposal of Machining Process Model. We propose the detail investigation of Machining feature, which is core transform action between Design Process and Manufacturing Process. And we point out the further investigation of role concerning to Machining Feature among AP224,AP214,ISO14649 and Machining Process Model.

KEYWORDS:

Machining Process Model

AP224,AP214,ISO14649

Machining Feature

Form Feature

Process Planning

Workingstep

COMMENTS TO READER:

This document is a discussion paper for Machining Process.

And this document was presented at New Orleans ISO meeting.

OWNER: Yasumasa Oku

Address: Japan STEP Promotion Center

TIME24BLG 10Fl.,2-45,Aomi,Kotoho,

Tokyo135-8073,Japan

TEL: +81-3-5500-0521

FAX: +81-3-5500-0520

E-mail: oku@jecals.jipdec.or.jp

Editor: Takeshi Kishinami

Hokkaido University

E-mail: kisinami@coin.eng.hokudai.ac

Editor: Chiaki Sakamoto

Komatsu Engineering Co.Ltd.

E-mail: chiaki_sakamoto@KEG.komatsu.co.jp

ISO New Orleans Conference Proposal (1999/11/7-12)

The proposal of Machining Process Model

Proposer : JSTEP
Takeshi Kishinami (Graduate school of engineering, Hokkaido University)
Contributor : A05 committee (production design group)
Fumiki Tanaka (Hokkaido University)
Naosuke Toyama (Hokkaido University)
Chiaki Sakamoto (Komatsu Engineering Co.Ltd)
Noriaki Kojima (Komatsu Ltd.)
Yoshiki Muta (Toyota Motor Corporation)
Yasumasa Oku (JSTEP)
Seishiro Takeuchi (JSTEP)
Takamasa Ochiai (JSTEP)
Masaharu Tsuchiya (JSTEP)

1. Background/Purpose

JSTEP has analyzed activities to the production from the design of the machine product and proposed I-AAM (Integrated Application Activity Model) to clear the following. Whether STEP/Aps proposed until now can become Data Model of which activities, and activities to the production from the design, STEP, to support it, by which activities and what kind of Data Model is necessary.

From this analysis work, we have pointed out that Data Model which supports Process planning/Operation planning which interconnects the design and the machining is lacked. This Discussion paper is the material to examine Data Model which is necessary for Operation planning which ties the machining to the design about only one product. We think Operation planning to be the reverse problem of Machining Operation, and the mathematical background is explained here with modeling of Machining Process and necessary Data Model. Also we show that this Data Model is available as Data Model of Operation planning.

2. Scope

Machining Operation Information or List of Workingsteps should be inputted, and Machining Process Model until machining feature in the material is formed is made the target.

In Scope:

i. Machining Process Model

ii. Cutting Tool Model
iii. Functional Model of Machine Tools
iv. Functional constraints Model and Workingtool
v. Machining feature model

Out of Scope:

i. Process Plan
ii. Geometric Processing for generating NC data
iii. Machining technologies and Machine functions such as coolant and etc.

3. Why do we discuss a machining process model?

We showed the relations of the standard which relates to the relations of the input/output in Process planning or Operation planning and Machining feature being under consideration at present in ISO in Figure-1. Our understanding is arranged as follows.

1) We understand that machining feature that it is defined with AP224, AP214 is the standard to express the input data of the Process planning/Operation planning system mainly.(Contain an output data by the case, too)
2) On the other hand, we understand that ISO 14649 (ISO/TC184/SC1/WG7 : CNC Data Model) is the standard to prescribe the type of the output of Process planning/Operation planning or the input of the CNC device.

We hopes for the discussion which clears the part of the Machining feature definition of AP224, AP214 and ISO14649 first. We point out that the following examination is necessary in the case that if Machining Feature in each standard aims at the above-mentioned part.

1)You must be able to express the thing formed by given machine tools and tools and machining technologies with Machining feature in ISO14649 which is the output expression standard of Process planning/Operation planning.
2) Machining feature of AP224,AP214 which is the input data of Process planning/Operation planning must be converted into ISO14649 as an output of Process planning/Operation planning.
If we say conversely, machining feature of AP224, AP214 must be converted into Machining feature of ISO 14649 as an output.

With this Paper, first, we pay attention to an examination item 1) and analyze the relations between shape of cutting edge,the functional model of machine tools and functional constraint

condition (constraint of rotational motion and translational motion) and volume surrounded by envelope, envelope of cutting edge due to the rotation/translation of tools, working edge mathematically, and then propose Machining Process Model. We explain potential Machining feature (Contain Machined Surface / Surface Texture) and the definition necessary condition by Shape of cutting edge (Contain a compound cutting edge) and the tool movement to use with this Machining Process Model .

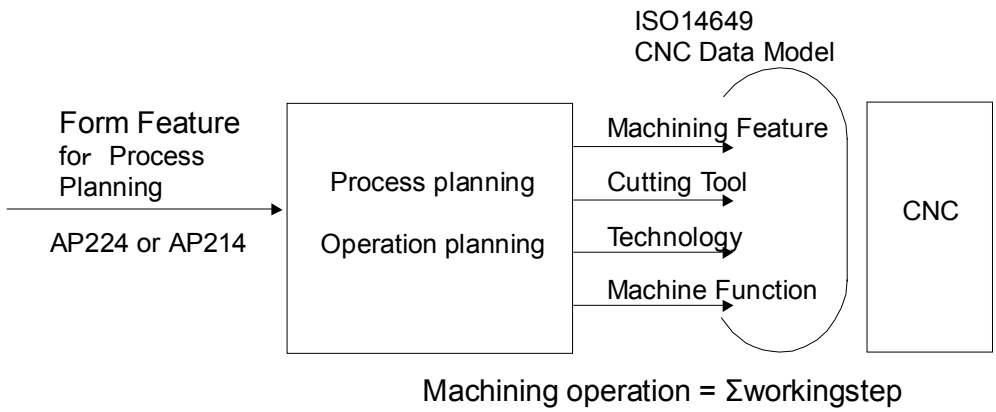


Figure-1. Roles of Machining Feature

4. Machining Process Model for 3axis milling

4.1.Mathematical model of milling process

$$\boldsymbol{r}_0 = A^1(x)A^2(y)A^3(z)A^6(\theta)\boldsymbol{r}_T \qquad 4.1)$$

where,

$\boldsymbol{r}_0$: Working tool or position of cutting edge on workpiece coordinate system

$\boldsymbol{r}_T$: Shape of cutting edge

$A^1(x)A^2(y)A^3(z)A^6(\theta)$: Functional model of milling machine

$A^1(x)$: X-axis translation	x : control parameter
$A^2(y)$: Y-axis translation	y : control parameter
$A^3(z)$: Z-axis translation	z : control parameter
$A^6(\theta)$: Z-axis rotation	θ : rotation control parameter

Control on motion of feed driving system:

$f(x, y, z) = 0$: Restriction equation between control parameters in Functional constraint

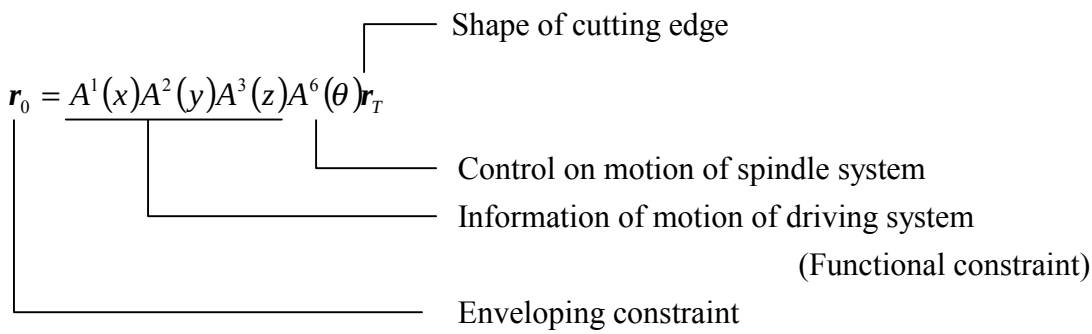
If x, y, and z are give as follows, they become to Toolpath.

$$\begin{aligned} x &= x(t) \\ y &= y(t) \\ z &= z(t) \end{aligned} \qquad 4.2)$$

Control on motion of main driving system:

$$\theta = \begin{cases} \theta(t) : \text{primary motion} \\ const. : \text{primary motion stopped} \end{cases} \qquad 4.3)$$

Structure of milling process



4.2.IDEF0 Model of milling process

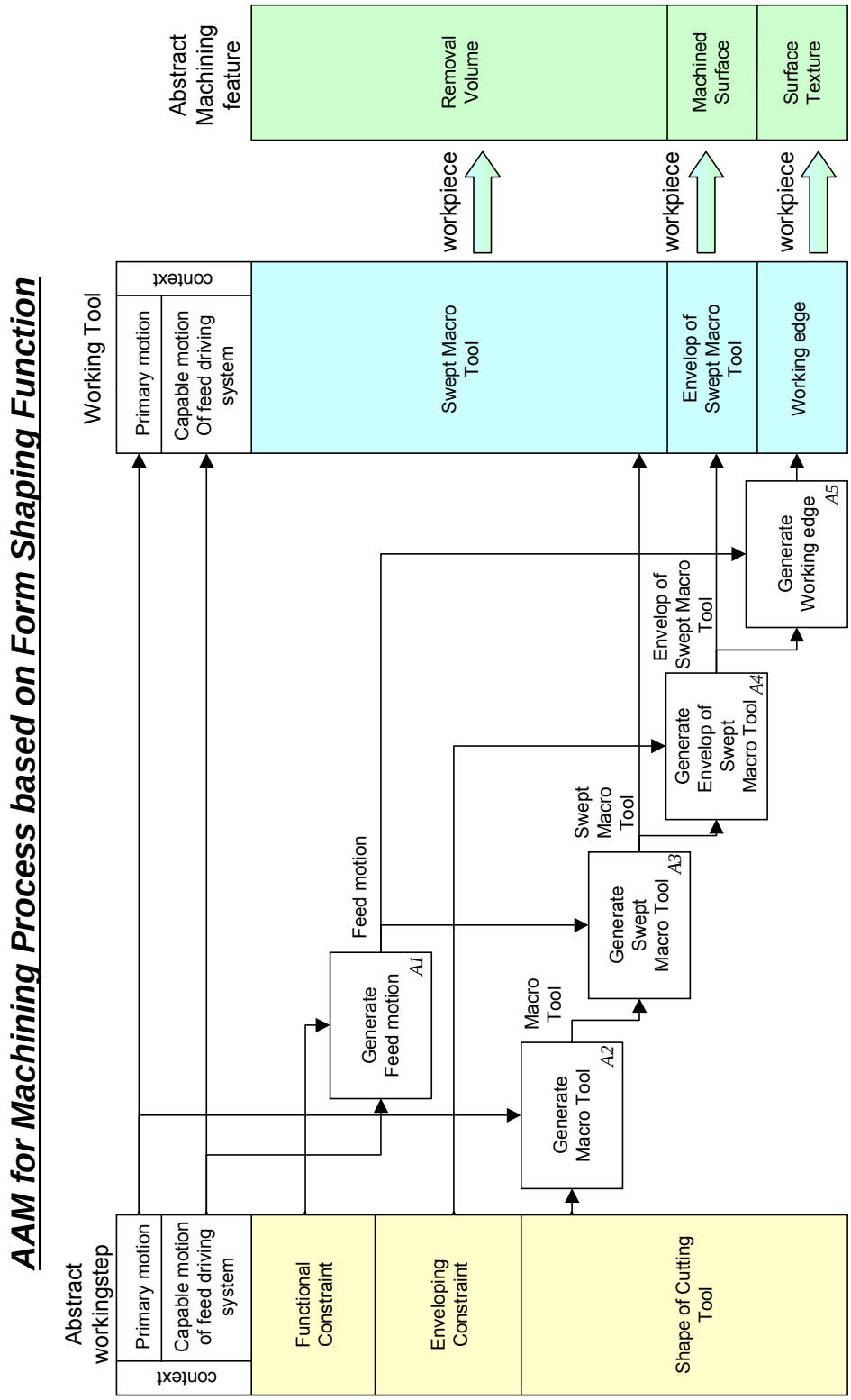


Figure-4.1. AAM for Machining Process based on Form Shaping Function

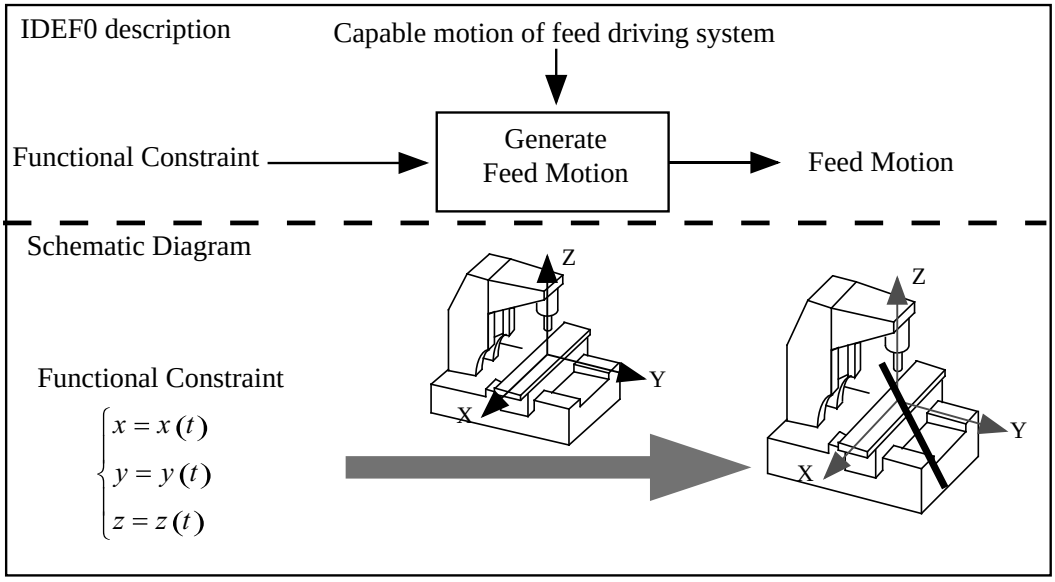


Figure-4.2.

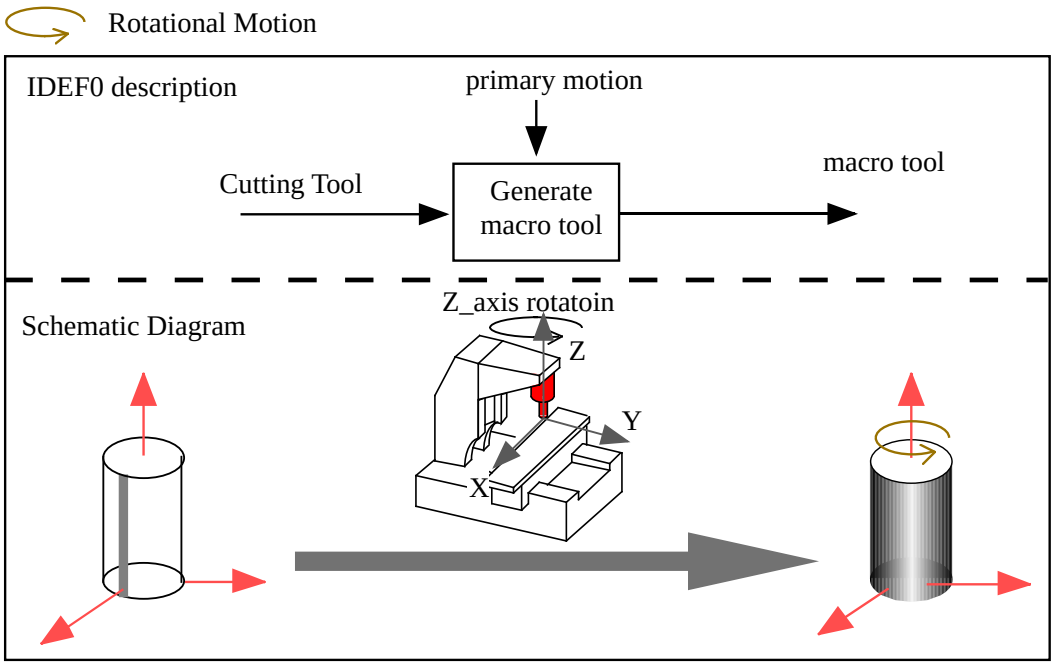


Figure-4.3.

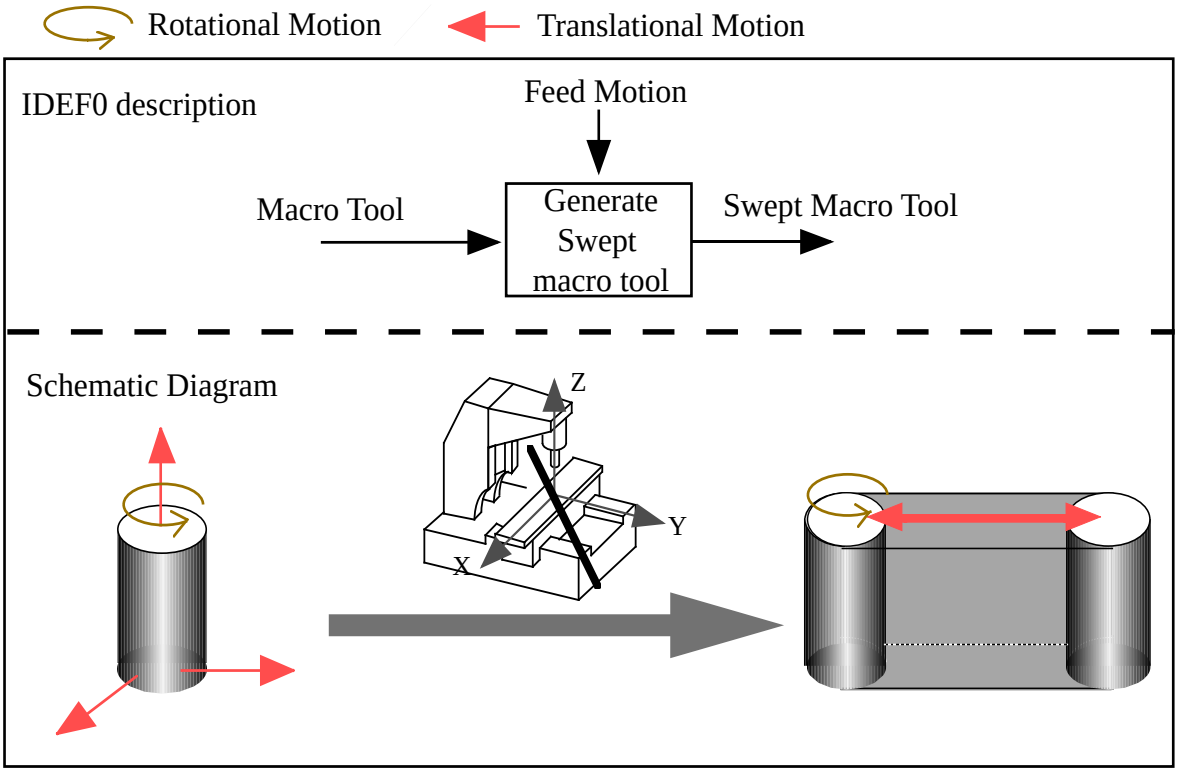


Figure-4.4.

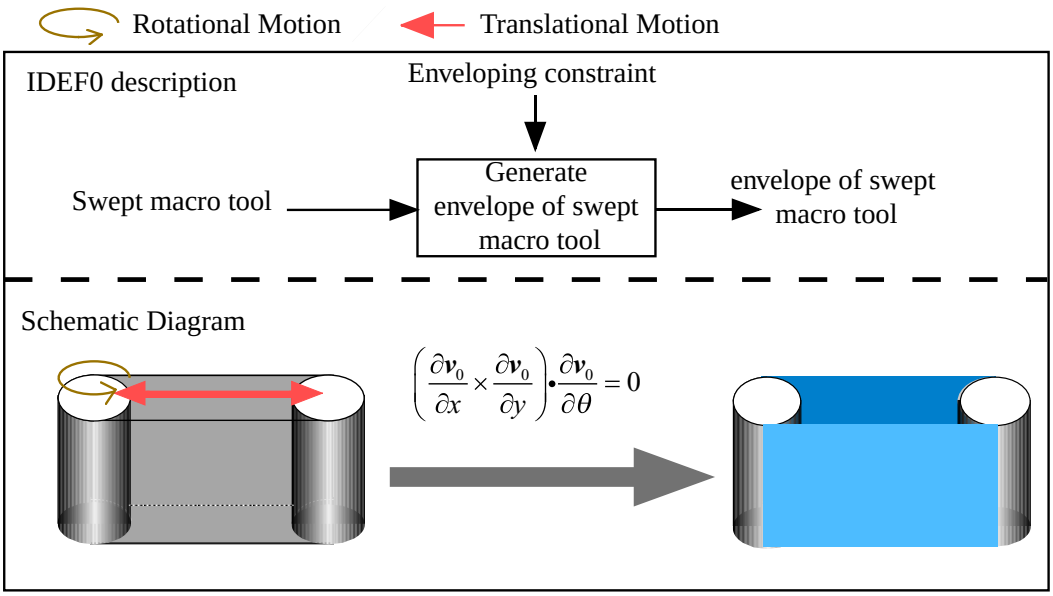


Figure-4.5.

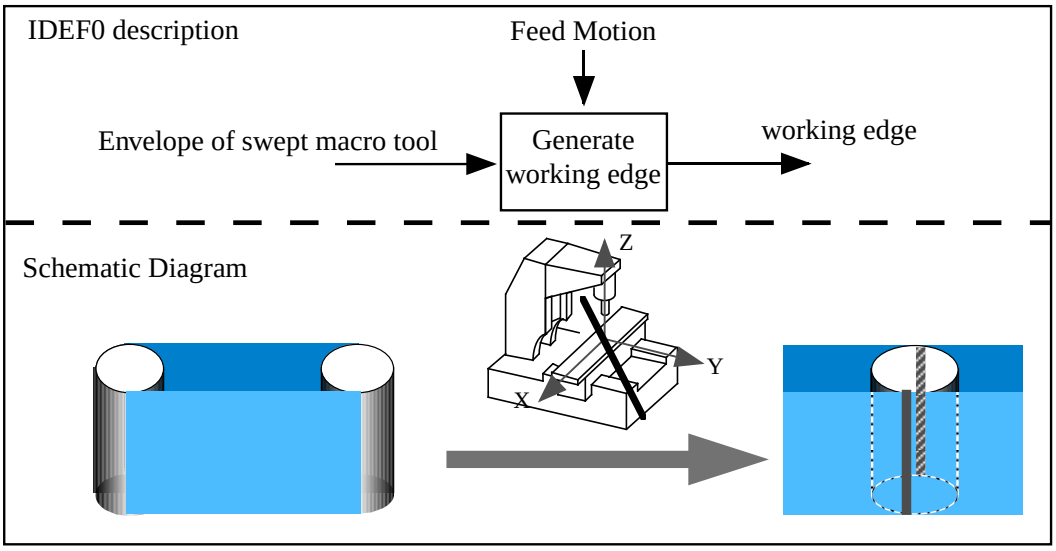


Figure-4.6.

D_T : Translational Motion / D_R : Rotational Motion

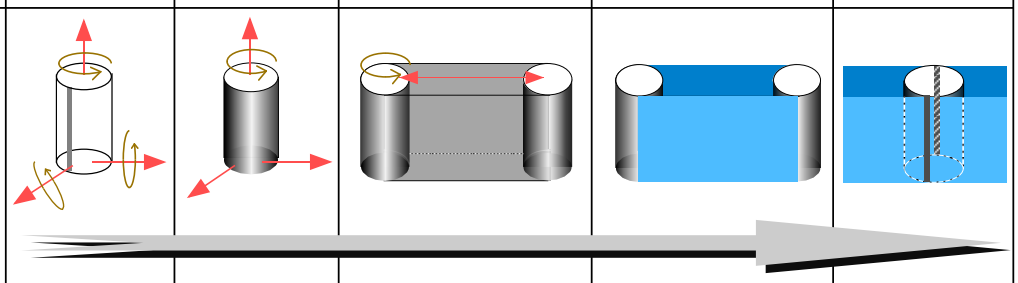
Role of Cutting Edge	Cutting Tool	Macro Tool	Swept Macro Tool	Envelope of Swept Macro Tool	Working Edge
Equation	$D_T D_R \boldsymbol{r}_T(z_T)$	$D_T \boldsymbol{r}_M(\theta, z_T)$	$\boldsymbol{v}_0 = \boldsymbol{r}_{SMT}(x, z, \theta, z_T)$	$\boldsymbol{r}_{ESMT}(x, z, z_T)$	$\boldsymbol{r}_{WE}(z_T)$
Schematic Diagram					
Related Information	Primary Motion	Feed Motion	Envelope Constraint	Feed Motion	
Equation	$A(\theta)$	$A(x,z)$	$\left(\frac{\partial \boldsymbol{v}_0}{\partial x} \times \frac{\partial \boldsymbol{v}_0}{\partial z}\right) \cdot \frac{\partial \boldsymbol{v}_0}{\partial \theta} = 0$	$A(x,z)$	

Figure-4.7.

5. Model of Cutting Tool

$$\boldsymbol{r}_T = A_T \boldsymbol{e}^4 \qquad 5.1)$$

$$\boldsymbol{e}^4 = [0 \quad 0 \quad 0 \quad 1]^T$$

$$A_T = \begin{cases} A_T(const.) : \text{a single - point tool} \\ A_T(u) \quad : \text{a blade tool} \\ A_T(u,v) \quad : \text{a tool working surface} \end{cases}$$

$\boldsymbol{r}_T$ is the shape of cutting edge,
A_T is the cutting edge shaping function.
$\boldsymbol{e}^4$ is the reference point of the cutting tool.
m is the number of the parameter of the cutting edge shape function.

$$m = \begin{cases} 0 : \text{a single - point tool} \\ 1 : \text{a blade tool} \\ 2 : \text{a tool working surface} \end{cases}$$

5.1 Single-Point Cutting Tool

5.1.1 Single-Point Tool

$$\boldsymbol{r}_T = A^1(R)\boldsymbol{e}^4 = [R \quad 0 \quad 0 \quad 1]^T \qquad 5.2)$$

where, R is the radius of the tool.

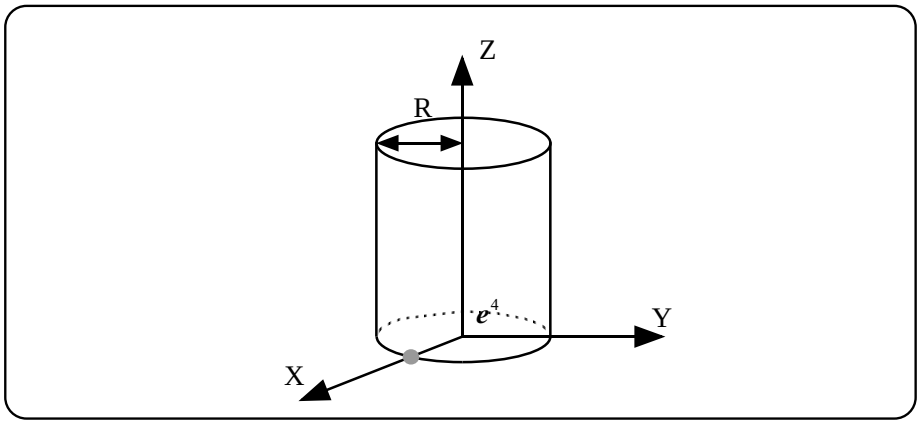


Figure-5.1. A Single-Point Tool

5.1.2 Multi Point Tool

$$\boldsymbol{r}_T = A^6(a_i)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos a_i \\ R\sin a_i \\ 0 \\ 1 \end{bmatrix} \qquad 5.3)$$

where, R is the radius of the tool and a_i is the angle of the cutting edge.

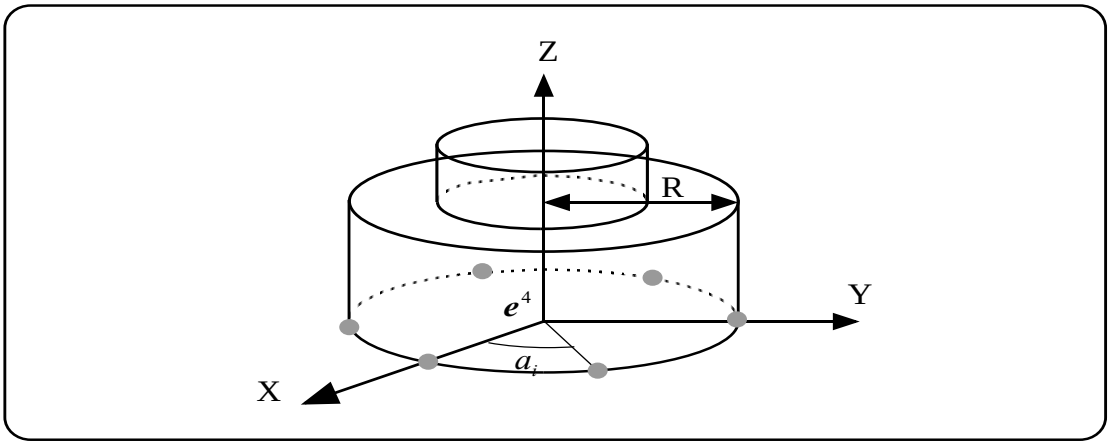


Figure-5.2. A Multi-Point Tool

5.2 Blade Tool

5.2.1 Peripheral cutting edge

5.2.1.1 single blade tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(z_T) = A^3(z_T)A^1(R)\boldsymbol{e}^4 = [R \quad 0 \quad z_T \quad 1]^T \qquad 5.4)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge.

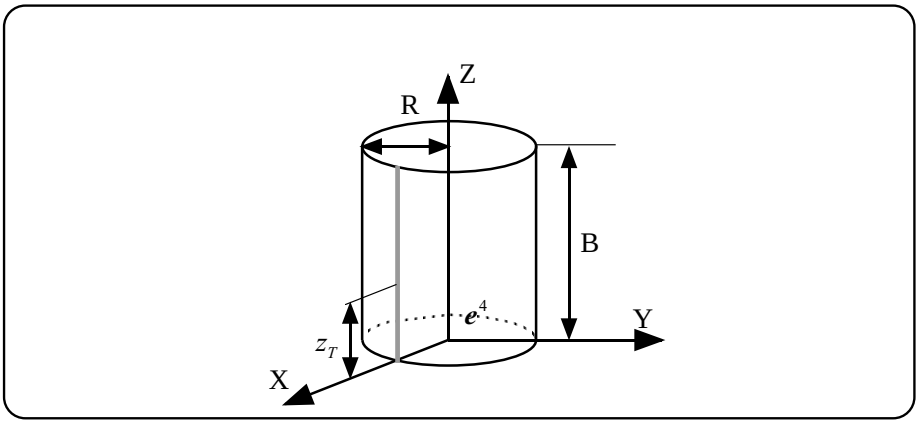


Figure-5.3. A Single blade Tool

5.2.1.2 multi blade tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(z_T) = A^6(a_i)A^3(z_T)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos a_i \\ R\sin a_i \\ z_T \\ 1 \end{bmatrix} \qquad 5.5)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge, and a_i is the angle of the cutting edge.

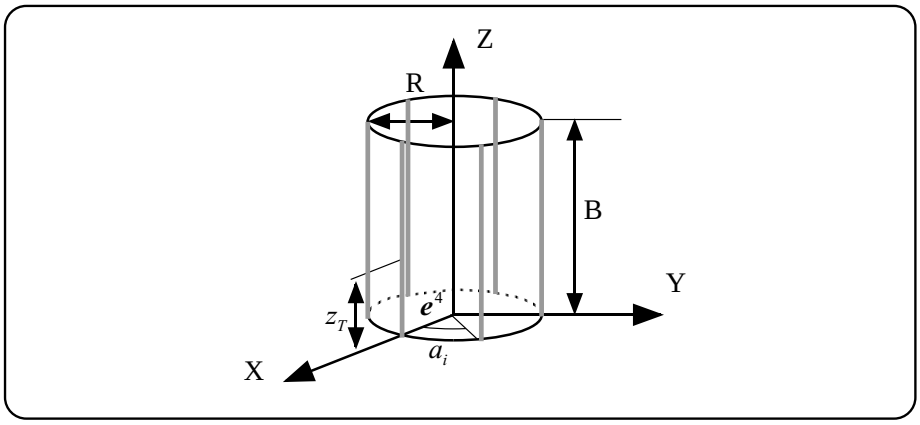


Figure -5.4. Multi-Blade Tool

5.2.1.3 Single helical Blade tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(z_T) = A^6\left(2\pi\frac{z_T}{p}\right)A^3(z_T)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos\left(2\pi\frac{z_T}{p}\right) \\ R\sin\left(2\pi\frac{z_T}{p}\right) \\ z_T \\ 1 \end{bmatrix} \qquad 5.6)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge, and p is pitch of the helical curve.

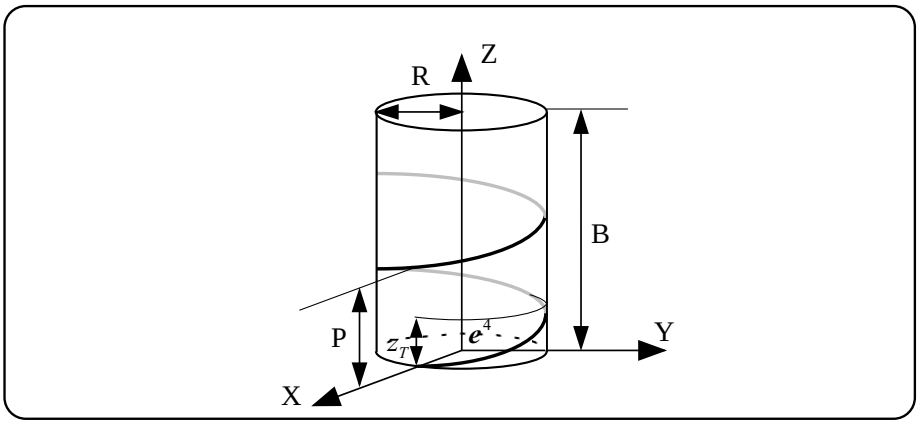


Figure-5.5. Single-helical Tool

5.2.1.4 Multi-helical Blade tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(z_T) = A^6(a_i)A^6\left(2\pi\frac{z_T}{p}\right)A^3(z_T)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos\left(a_i + 2\pi\frac{z_T}{p}\right) \\ R\sin\left(a_i + 2\pi\frac{z_T}{p}\right) \\ z_T \\ 1 \end{bmatrix} \qquad 5.7)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge, p is pitch of the helical curve, and a_i is the angle of the cutting edge.

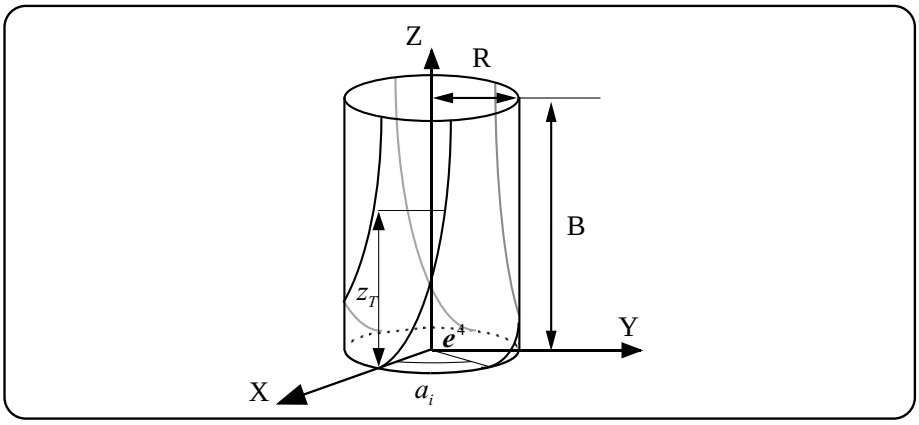


Figure-5.6. Multi-Helical Blade Tool

5.2.1.5 taper blade tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(z_T) = A^1(z_T \tan\beta)A^3(z_T)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R + z_T \tan\beta \\ 0 \\ z_T \\ 1 \end{bmatrix} \qquad 5.8)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge, β is taper angle.

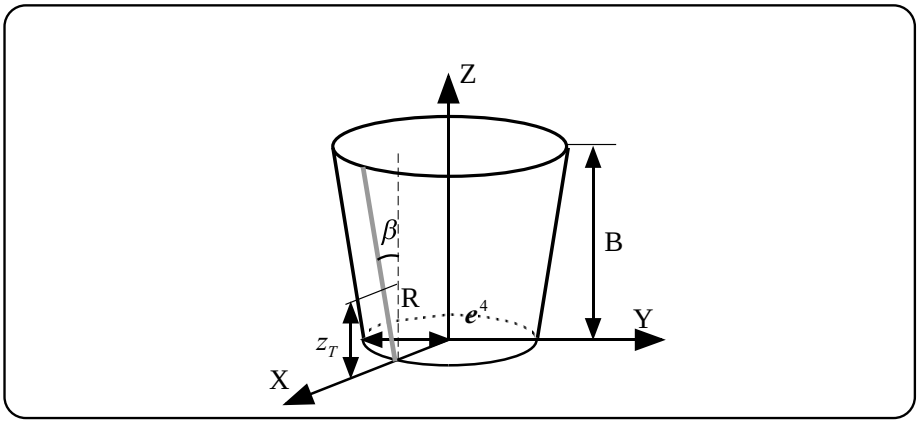


Figure-5.7. Taper Blade Tool

5.2.2 End cutting edge

5.2.2.1 Square end cutting edge

$$\boldsymbol{r}_T = \boldsymbol{r}_T(s) = A^1(s)\boldsymbol{e}^4 = [s \quad 0 \quad 0 \quad 1]^T \qquad 5.9)$$

where $0 \le s \le R$, R is the radius of the tool.

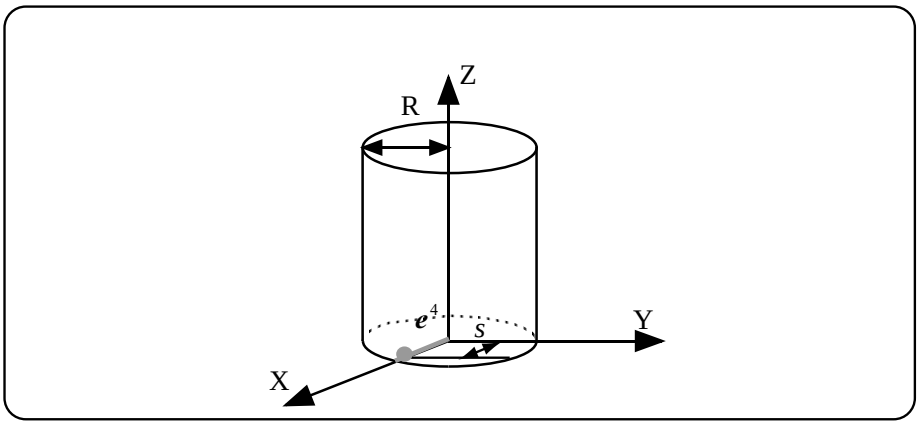


Figure-5.8. Square end cutting edge

5.2.2.2 Drill end cutting edge

$$\boldsymbol{r}_T = \boldsymbol{r}_T(z_T) = A^1(-z_T \tan\beta)A^3(-z_T)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R - z_T \tan\beta \\ 0 \\ -z_T \\ 1 \end{bmatrix} \qquad 5.10)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge, 2β is top angle.

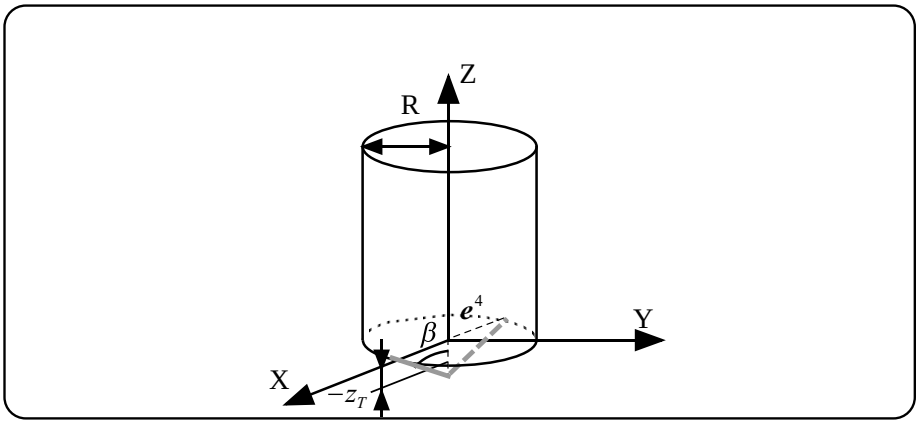


Figure-5.9. Drill end cutting edge

5.2.2.3 Ball end cutting edge

$$\boldsymbol{r}_T = \boldsymbol{r}_T(\phi) = A^6(a_0)A^5(\phi)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos a_0 \cos\phi \\ R\sin a_0 \cos\phi \\ -R\sin\phi \\ 1 \end{bmatrix} \qquad 5.11)$$

where R is the radius of the tool, $0 \le \phi \le \pi$, and a_0 is the angle of the cutting edge.

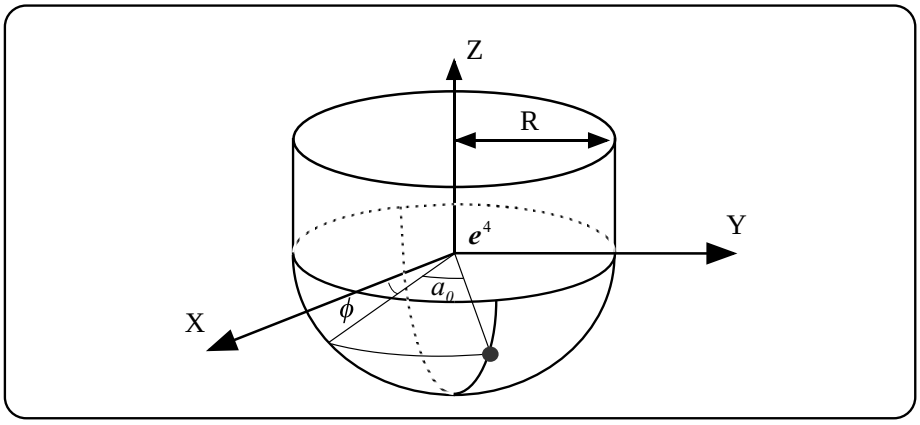


Figure-5.10. Ball end cutting edge

5.2.2.4 Corner radius end cutting edge

$$\boldsymbol{r}_T = \boldsymbol{r}_T(\phi) = A^1(R_L)A^5(\phi)A^1(R_S)\boldsymbol{e}^4 = \begin{bmatrix} R_S\cos\phi + R_L \\ 0 \\ -R_S\sin\phi \\ 1 \end{bmatrix} \qquad 5.12)$$

where, R_L is large radius of the tool , and R_S is small radius of the tool.

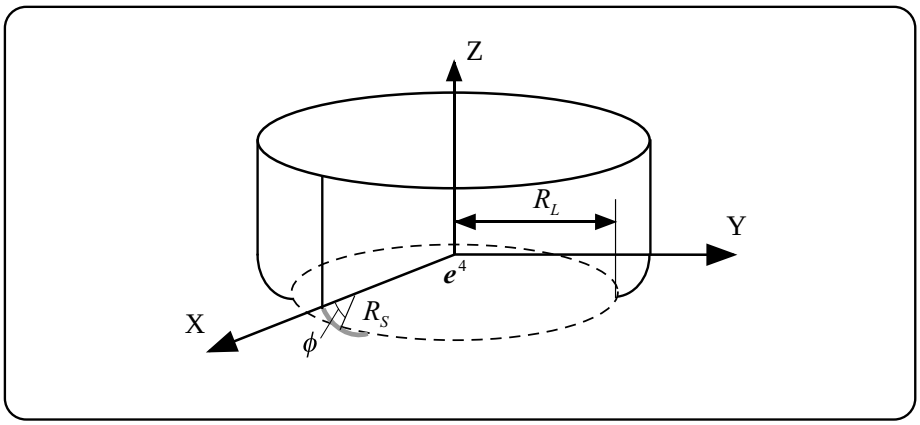


Figure-5.11. Corner radius end cutting edge

5.3 Tool working surface

5.3.1 Cylindrical Tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(\phi, z_T) = A^6(\phi)A^3(z_T)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos\phi \\ R\sin\phi \\ -z_T \\ 1 \end{bmatrix} \qquad 5.13)$$

where R is the radius of the tool, $0 \le z_T \le B$, B is the height of cutting edge.

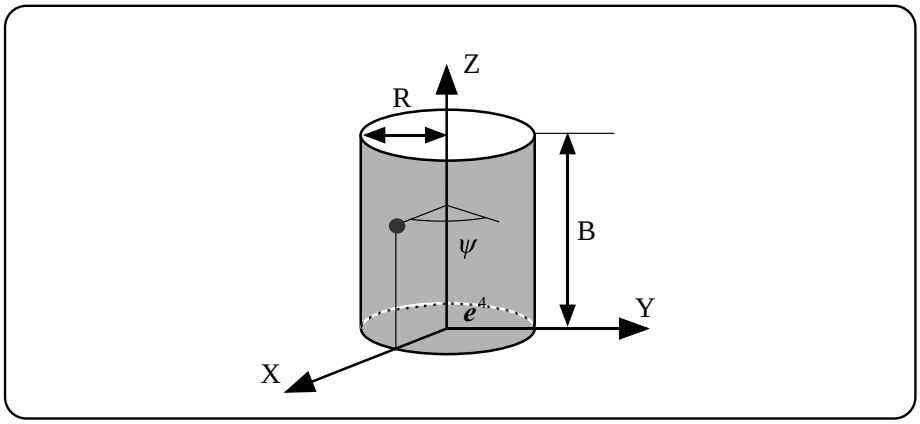


Figure –5.12. Cylindrical Tool

5.3.2 Spherical Tool

$$\boldsymbol{r}_T = \boldsymbol{r}_T(\phi, \psi) = A^6(\psi)A^5(\phi)A^1(R)\boldsymbol{e}^4 = \begin{bmatrix} R\cos\psi\cos\phi \\ R\sin\psi\cos\phi \\ -R\sin\phi \\ 1 \end{bmatrix} \qquad 5.14)$$

where R is the radius of the tool

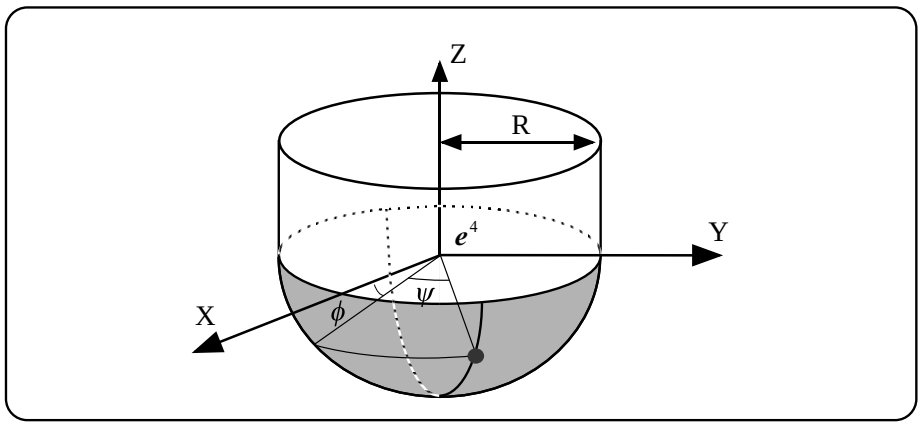


Figure-5.13. Spherical Tool

6. Functional Model of Machine Tools

6.1 Model of 3-axis milling machine

6.1.1 Form-shaping function of 3-axis milling machine

The model of 3-axis milling machine (as shown in figure 1) is equation (6.1).

$$A_{MT}(x, y, z, \theta) = A^1(x)A^2(y)A^3(z)A^6(\theta) \qquad 6.1)$$

Using the equation (6.1), form-shaping function of 3-axis milling machine is equation (6.2).

$$\boldsymbol{r}_0 = A^1(x)A^2(y)A^3(z)A^6(\theta)\boldsymbol{r}_T \qquad 6.2)$$

where, $\boldsymbol{r}_T$ is the cutting edge vector shown later.

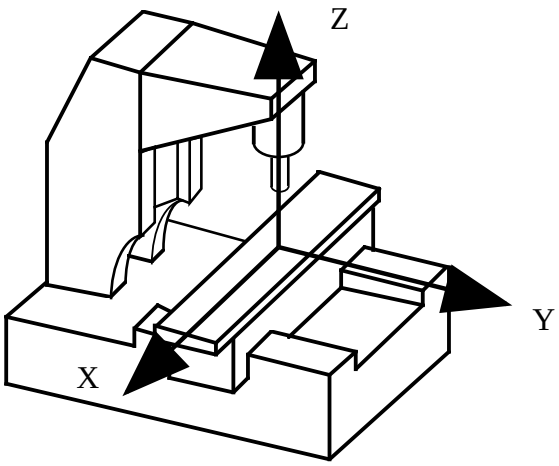


Figure-6.1. 3 -axis machine tool

6.1.2 Primary motion of 3-axis milling machine

$$A_P(\theta) = A^6(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad 6.3)$$

6.1.3 Capable motion of feed driving system in 3-axis milling machine

$$A_{CF}(x,y,z) = A^1(x)A^2(y)A^3(z)$$

$$= \begin{bmatrix} 1 & 0 & 0 & x \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & y \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 & x \\ 0 & 1 & 0 & y \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad 6.4)$$

6.1.4 Feed motion of 3-axis milling machine

$$A_F = \begin{bmatrix} 1 & 0 & 0 & x \\ 0 & 1 & 0 & f(x) \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad 6.5)$$

6.2 Model of 5-axis milling machine

6.2.1 Form-shaping function of 5-axis milling machine

The model of 5-axis milling machine (as shown in figure 2) is equation (6.6).

$$A_{MT}(x,y,z,\alpha,\beta,\theta) = A^4(\alpha)A^5(\beta)A^1(x)A^3(z)A^2(y)A^6(\theta) \qquad 6.6)$$

Using the equation (6), form-shaping function of 5-axis milling machine is equation (6.7).

$$\boldsymbol{r}_0 = A^4(\alpha)A^5(\beta)A^1(x)A^3(z)A^2(y)A^6(\theta)\boldsymbol{r}_T \qquad 6.7)$$

where, $\boldsymbol{r}_T$ is the cutting edge vector shown later.

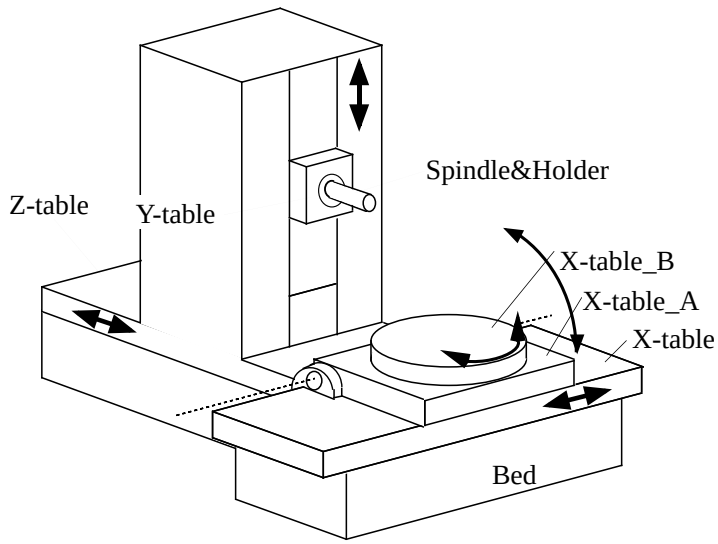


Figure-6.2. 5-axis machine tool

6.2.2 Primary motion of 5-axis milling machine

$$A_P(\theta) = A^6(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad 6.8)$$

6.2.3 Capable motion of feed driving system in 5-axis milling machine

$$A_{CF}(x, y, z, \alpha, \beta) = A^4(\alpha)A^5(\beta)A^1(x)A^3(z)A^2(y)$$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha & 0 \\ 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\beta & 0 & \sin\beta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\beta & 0 & \cos\beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\times \begin{bmatrix} 1 & 0 & 0 & x \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & y \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\beta & 0 & \sin\beta & x\cos\beta + z\sin\beta \\ \sin\alpha\sin\beta & \cos\alpha & -\sin\alpha\cos\beta & x\sin\alpha\sin\beta + y\cos\alpha - z\sin\alpha\cos\beta \\ -\cos\alpha\sin\beta & \sin\alpha & \cos\alpha\cos\beta & -x\cos\alpha\sin\beta + y\sin\alpha + z\cos\alpha\cos\beta \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad 6.9)$$

6.2.4 Feed motion of 3-axis milling machine

$$A_F = \begin{bmatrix} \cos\beta(u,v) & 0 & \sin\beta(u,v) & \begin{matrix} x(u,v)\cos\beta(u,v) \\ +z(u,v)\sin\beta(u,v) \end{matrix} \\ \sin\alpha(u,v)\sin\beta(u,v) & \cos\alpha(u,v) & -\sin\alpha(u,v)\cos\beta(u,v) & \begin{matrix} x(u,v)\sin\alpha(u,v)\sin\beta(u,v)+ \\ y(u,v)\cos\alpha(u,v) \\ -z(u,v)\sin\alpha(u,v)\cos\beta(u,v) \end{matrix} \\ -\cos\alpha(u,v)\sin\beta(u,v) & \sin\alpha(u,v) & \cos\alpha(u,v)\cos\beta(u,v) & \begin{matrix} -x(u,v)\cos\alpha(u,v)\sin\beta(u,v) \\ +y(u,v)\sin\alpha(u,v) \\ +z\cos\alpha(u,v)\cos\beta(u,v) \end{matrix} \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad 6.10)$$

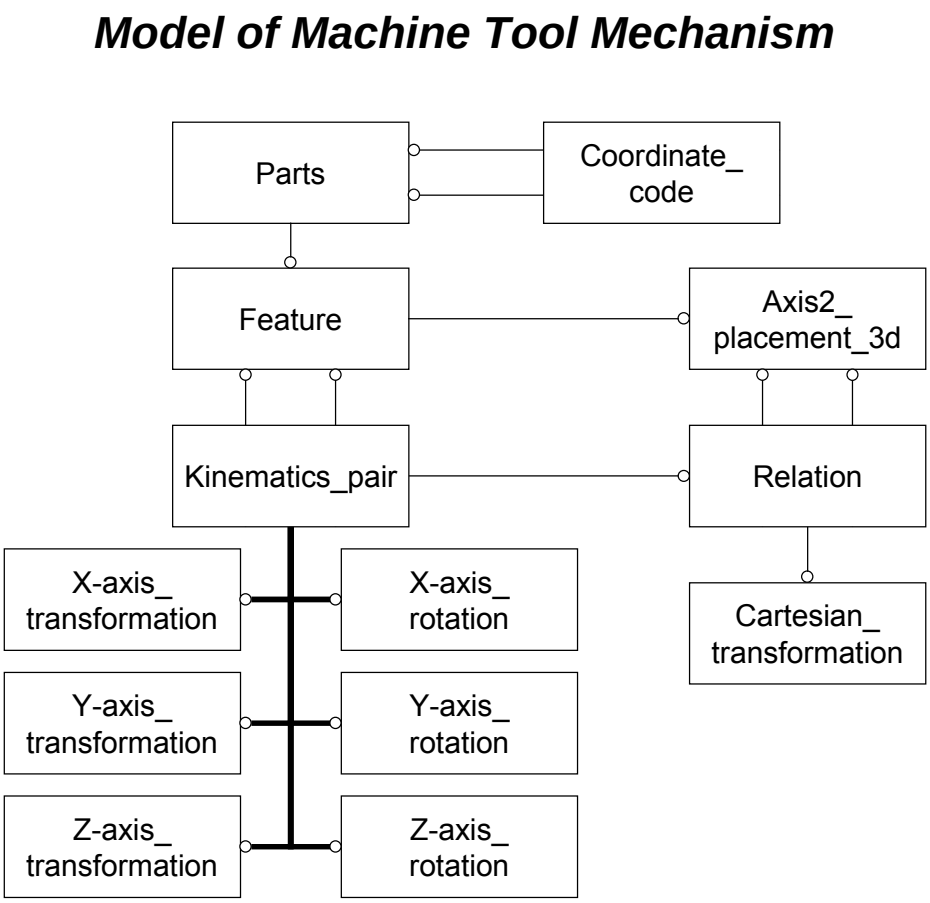


Figure-6.3. Model of Machine Tool Mechanism

6.3 Basic Notation

6.3.1 Coordinate transformation matrix

X-axis translation: $A^1(x) = \begin{bmatrix} 1 & 0 & 0 & x \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 6.11)

Y-axis translation: $A^2(y) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & y \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 6.12)

Z-axis translation: $A^3(z) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 6.13)

X-axis rotation: $A^4(\varphi) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\varphi & -\sin\varphi & 0 \\ 0 & \sin\varphi & \cos\varphi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 6.14)

Y-axis rotation: $A^5(\phi) = \begin{bmatrix} \cos\phi & 0 & \sin\phi & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\phi & 0 & \cos\phi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 6.15)

Z-axis rotation: $A^6(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 6.16)

7. Machining Feature Model

7.1 Basic concept of machining feature based on form-shaping function

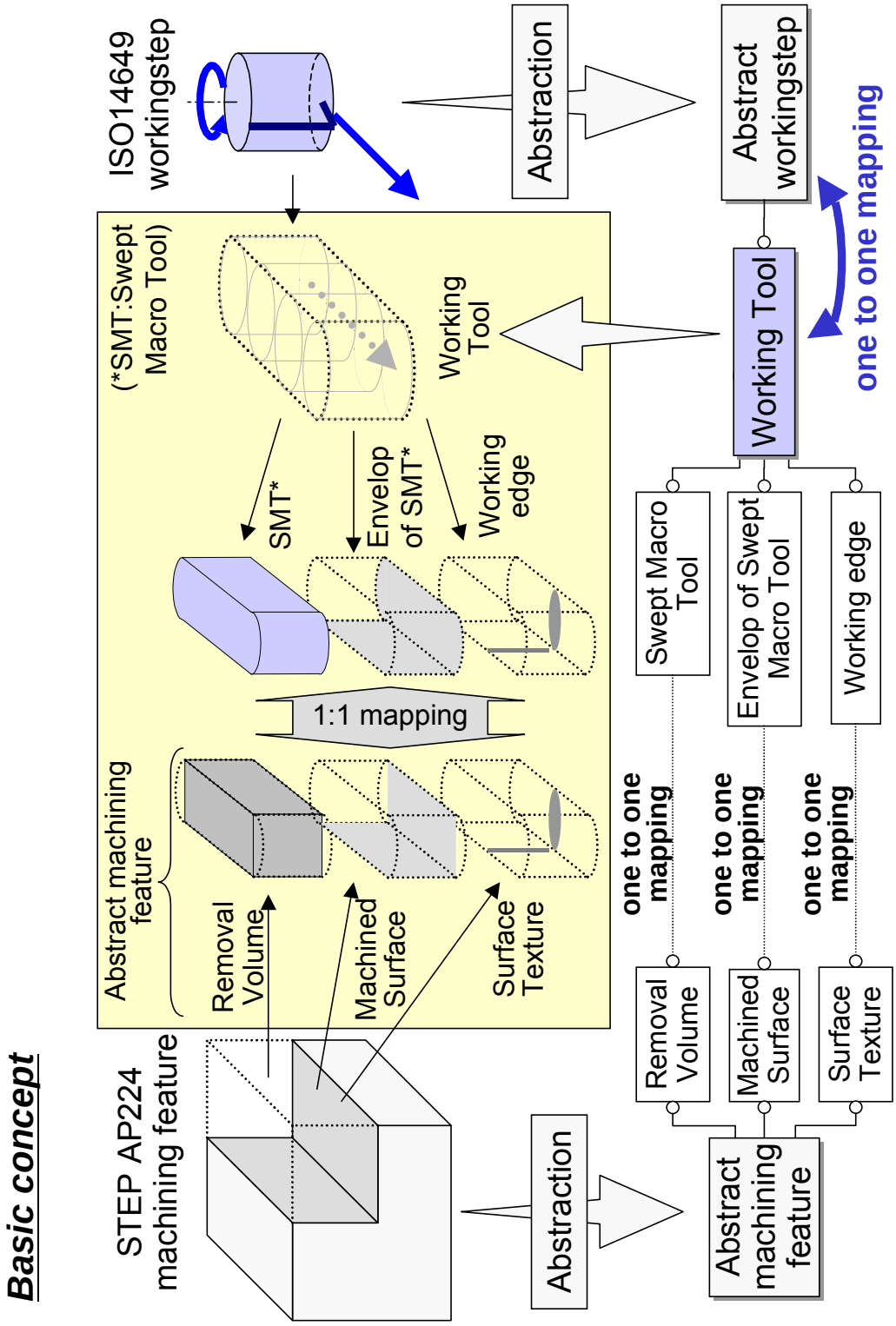


Figure- 7.1

7.2 A single cutting edge machining feature

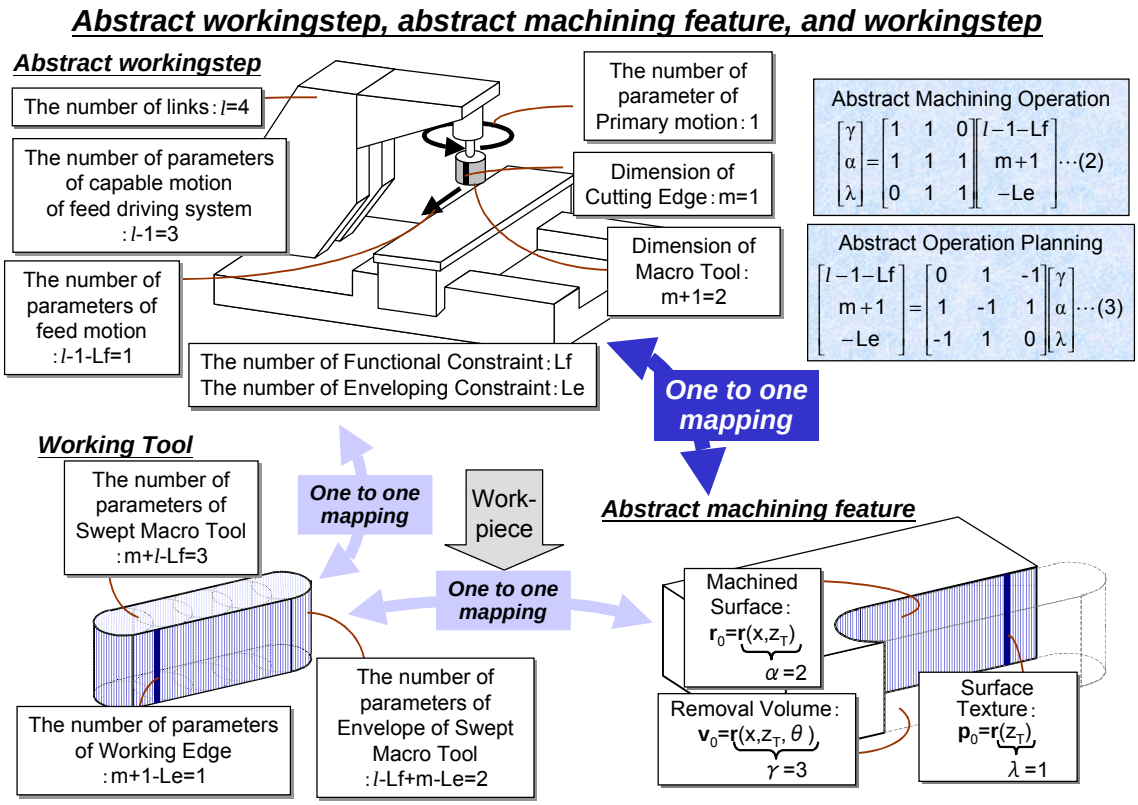
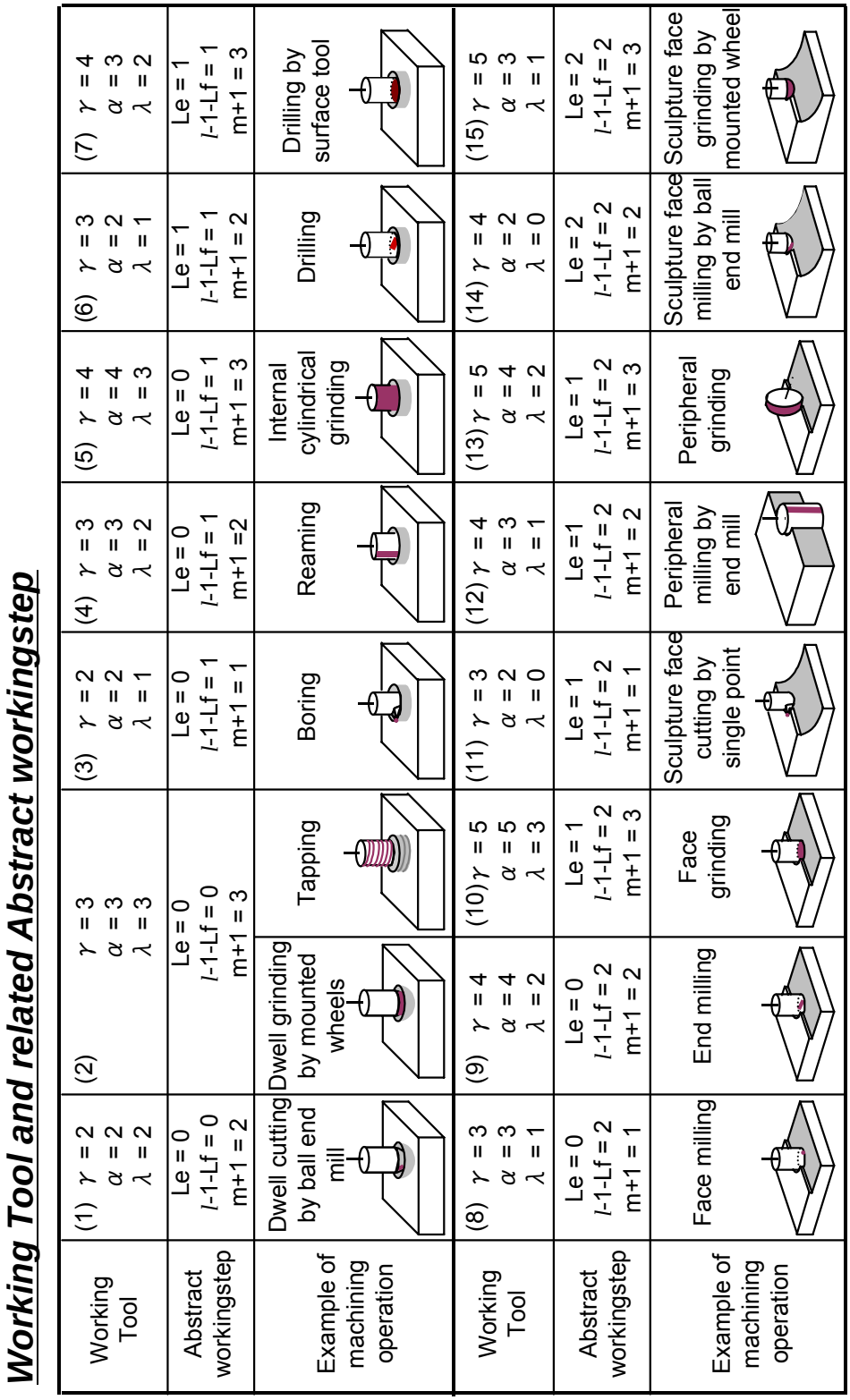


Figure- 7.2

7.2.1 Type of a single cutting edge machining feature



Abstract machining feature: The number of the parameter of Removal volume, Machined surface,and Unit shaping element is γ, α, and λ, respectively.

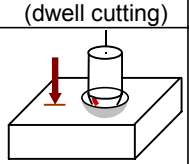
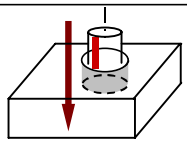
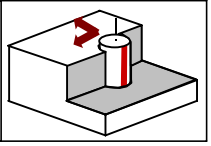
Abstract workingstep: The number of the parameter of Enveloping Constraint, Feed motion, and Macro Tool is Le, *l*-1-Lf, and m+1, respectively.

Figure- 7.3

7.2.2 Meaning of the parameter of Abstract workingstep

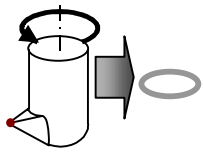
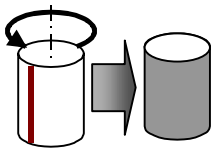
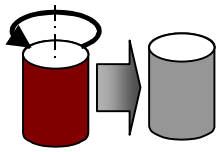
Number of feed directions : $l-1-Lf$ ⇒ Type of feed direction

domain : $0 \leqq l-1-Lf \leqq 2$

$l-1-Lf$	0	1	2
Feed direction	0-direction (dwell cutting)	1-direction	2-direction
Example of machining operation			

Number of Macro Tool : m+1 ⇒ Type of Macro Tool

domain : $1 \leqq m+1 \leqq 3$

m+1	1	2	3
Cutting edge type	Single point	Blade	Surface
Example of machining operation			

Number of Enveloping Constraint : Le ⇒ Type of machining process

domain : $0 \leqq Le \leqq 2$

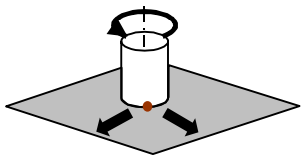
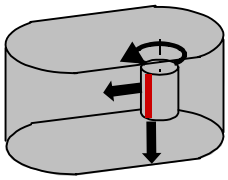
Le	0	1 or 2
Machining Type	Surface milling	Volumetric milling
Example of machining operation		

Figure – 7.4.

7.2.3 Meaning of the parameter of Abstract workingtool

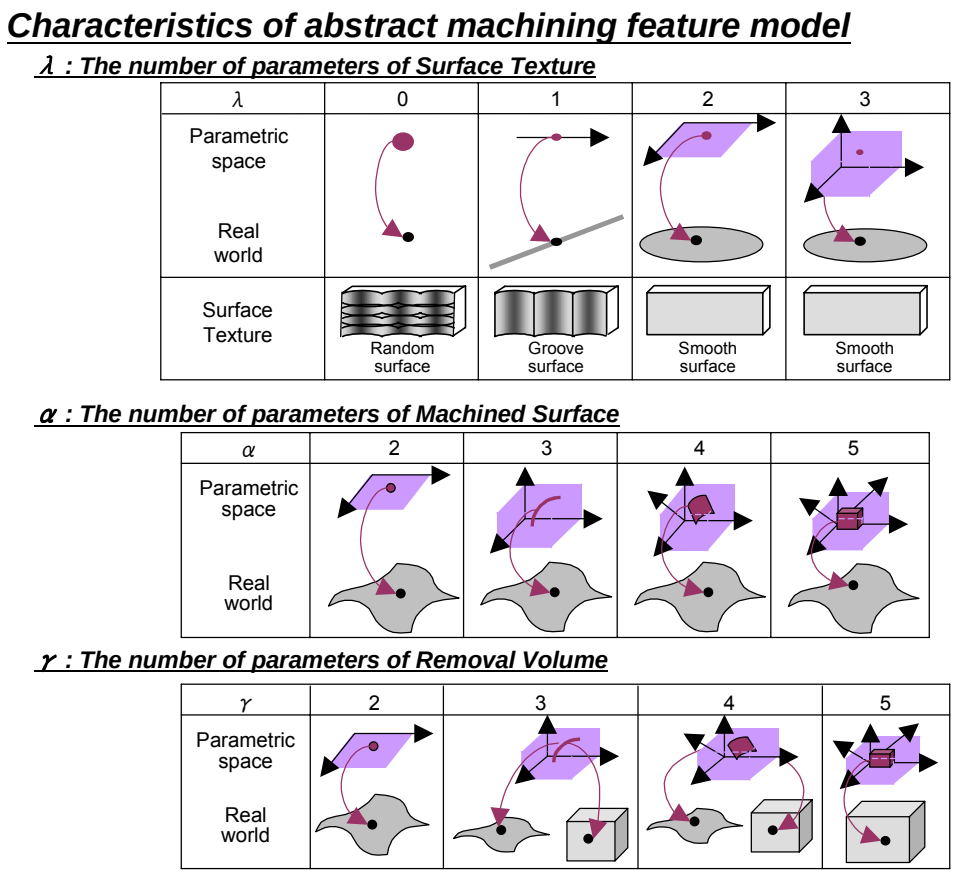


Figure – 7.5.

7.3 Compound cutting edge machining feature

7.3.1 Compound cutting edge machining feature model

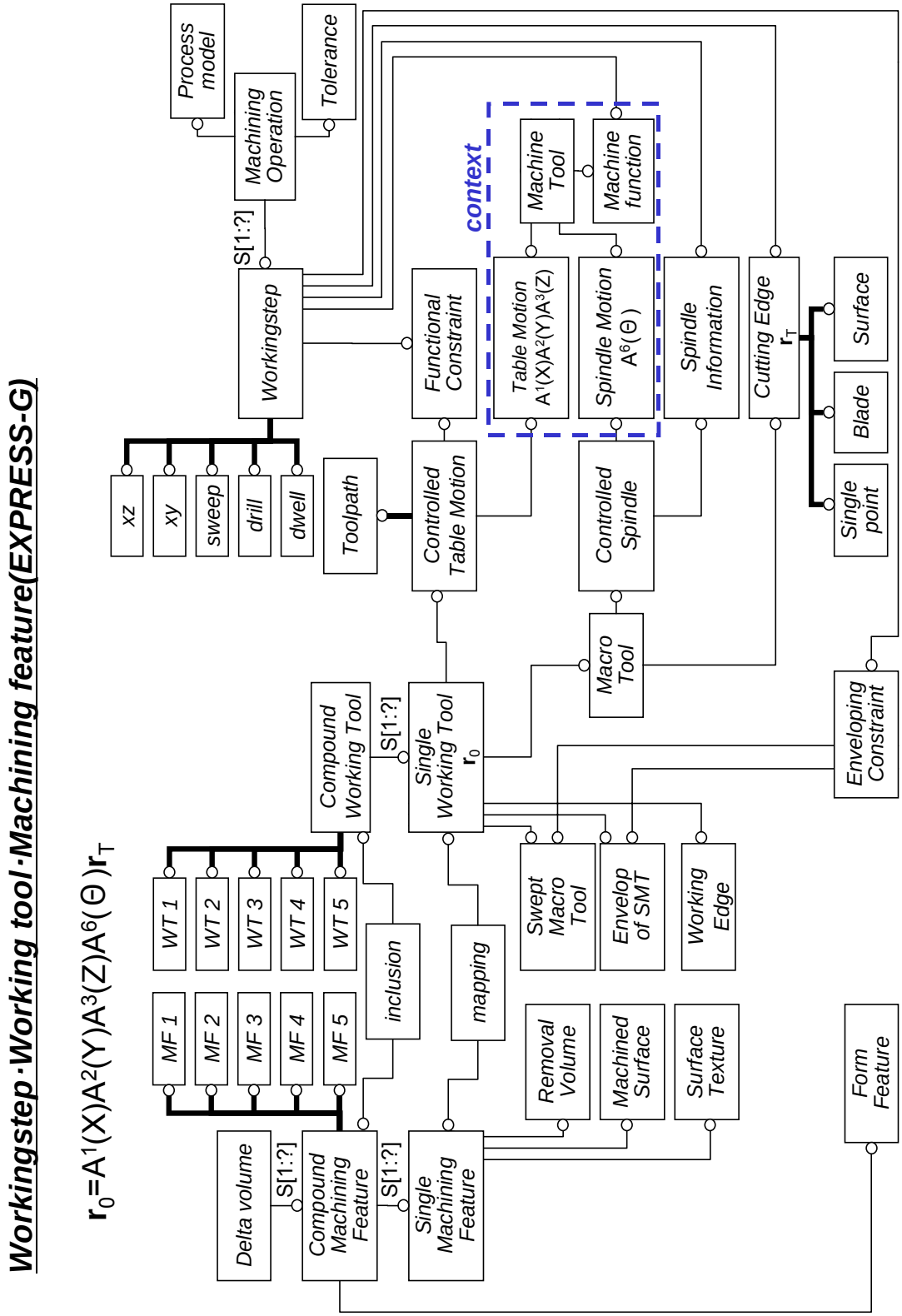


Figure – 7.6.

7.3.2 Type of Compound cutting edge machining feature model

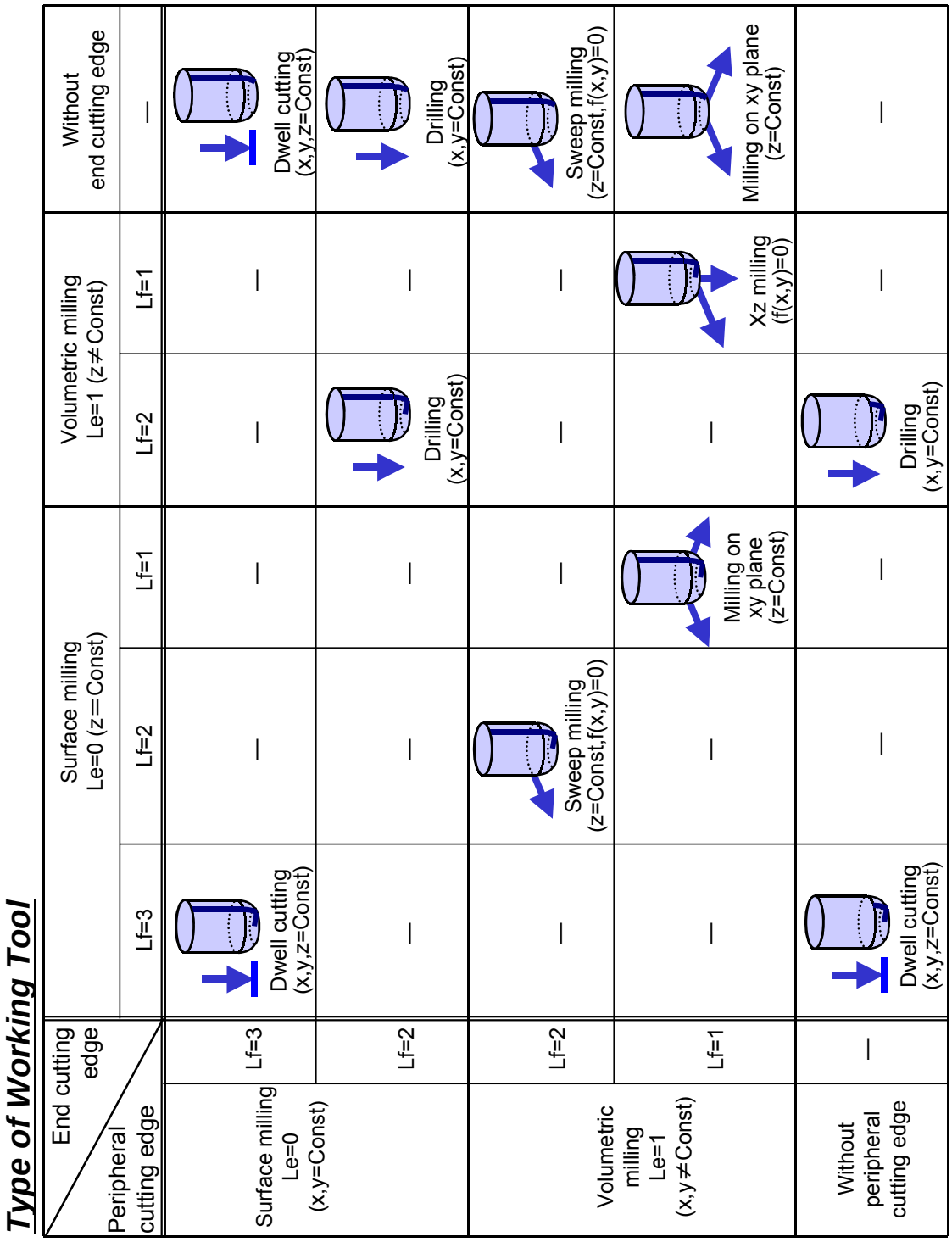


Figure – 7.7.

7.4 Example of Machining feature

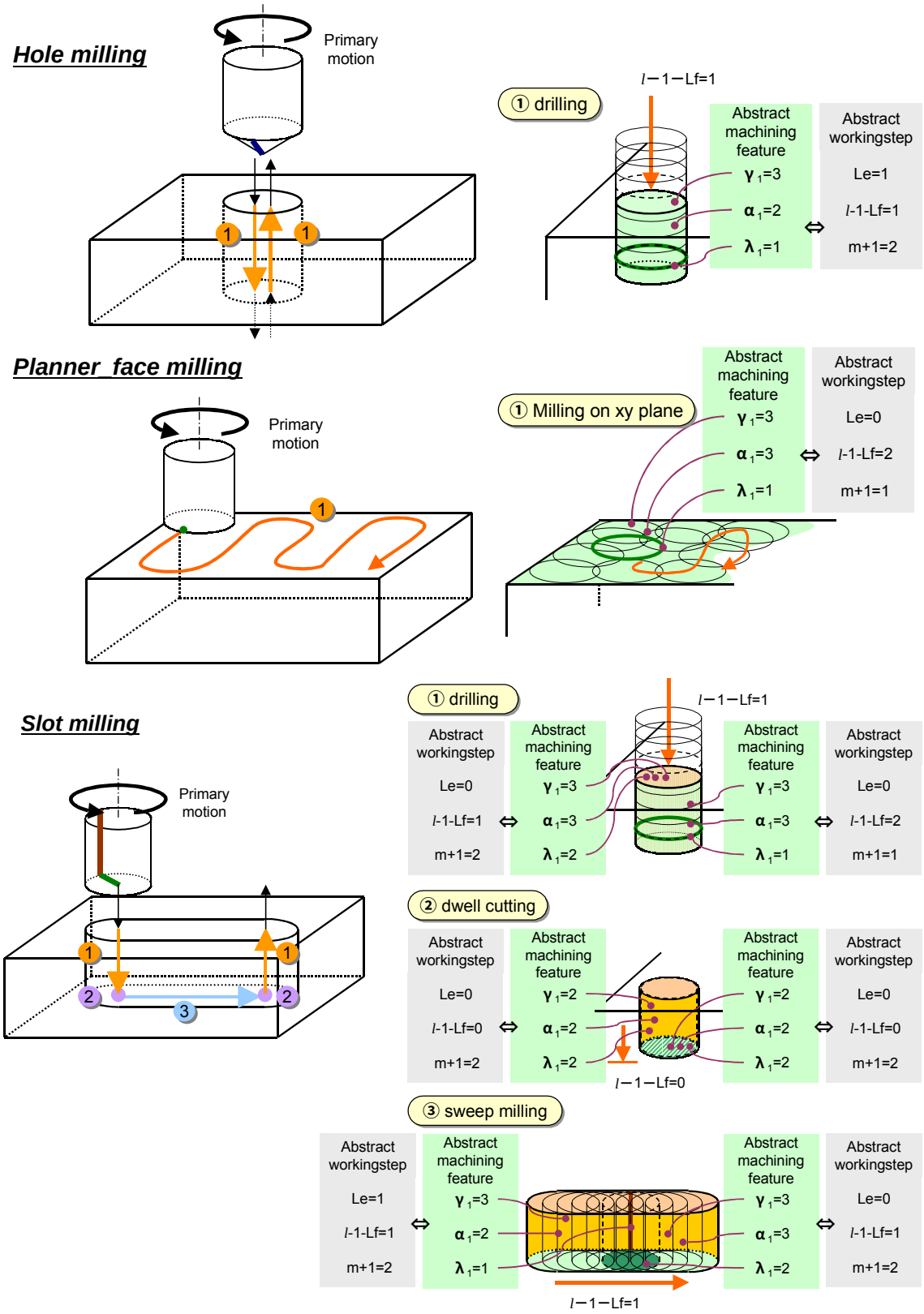


Figure- 7.8

8. Summary

In this paper we limit it to the Process planning/Operation planning activities which are necessary for the information conversion to Machining Operation Information from the Design Information of the machine product, and we pointed out the need to examine about the part of Machining feature, especially the part of Machining feature of AP224, AP214, ISO14649 which becomes the core of the input and output information about those activities.

And, in this report, we pointed out that Machining feature should be defined based on the Machined Surface formed when a tool is driven, and we expressed the form of cutting edge, Functional Model of machine tools, generated Machining feature and those relations based on the mathematical model of Machining Process. We think that it is possible to use these Shape of cutting edge expressions, Functional Model of machine tools, generated Machining feature as Data Model in Operation planning.