Overview of Contents

General basics

Curve types

1. Curves that are described by mathematical equations.

   CURVE2 => CIRCLE
   CURVE2 => ELLIPSE
   CURVE2 => CONIC
   CURVE2 => CONNECT

2. Curves that are defined by support elements.

   Tangential and curvature continuity

   ARC - a full polynomial curve, defined by a formula
   SPLINE - a curve composed of multiple polynomial curves

   Tangential continuity only

   CURVE2 => PTS CST - As for SPLINE, a curve composed of multiple polynomial curves

3. Curves that are generated with CURVE1

   - Curves that are generated on surfaces
     (**=> INTERSEC, => PT-PT, => BOUNDARY** etc.)
   - Curves that are generated with other elements
     (**=> INTERSEC** with planes)

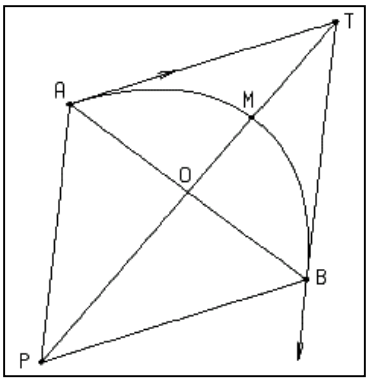
Comments on polynomial curves

- The degree of the polynomial is designated in CATIA with DEG and can have a value from 1 - 15
  ($f(x) = a_0 + a_1x \ ... \ + a_{15}x^{15}$)
- in principle, DEG should be kept as low as possible

DEG = 1 .. 5 - non-problematical
DEG = 6 .. 11 - curves can start to oscillate, i.e. curvature changes can occur
⇨ Curve analysis to avoid oscillations
DEG > 11 - avoid if possible

Function - CURVE2

CURVE2 => CONIC => 3PTS



The curve is defined by:
- Its endpoints,
- Its tangents at its endpoints,
- And a parameter $P = \frac{P_M}{P_T}$

(Ellipse: $0.5 < p < 0.75$
Parabola: $p = 0.75$
Hyperbola: $0.75 < p < 1$),

a midpoint or the curvature (radius) at one of the endpoints.

=> CONIC => 5PTS

The curve is defined by its endpoints
- a point and two tangents or
- two points and one tangent or
- three points.

ANALYSIS => CURVE - Curve analysis

Displays tangent and curvature (continuity)
- Select curve, then click Windows and define window by setting two points.

Es gibt 3 unterschiedliche Analysetypen:
- TXY,TYX,TXZ: Tangentenvektorwinkel auf Fensterebene anzeigen
- CXY,CYZ,CXZ: Krümmung auf Ebene des Analysefensters projiziert anzeigen
- C: 3D-Krümmung anzeigen

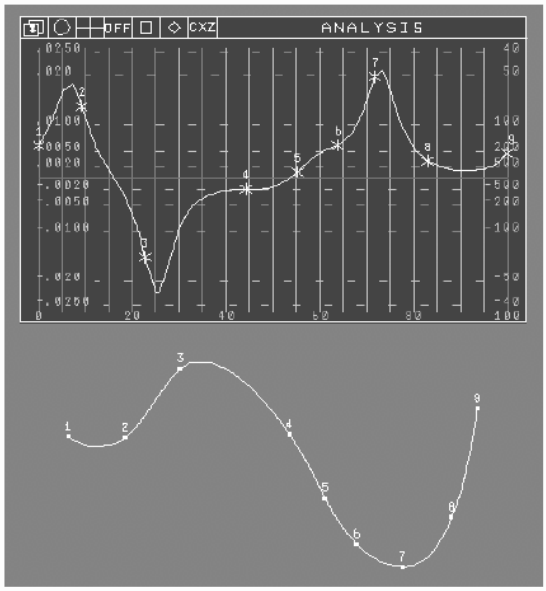
Achsen:

Horizontale Achse:
- Länge der Kurve in Prozent, gestreckte Länge

Vertikale Achse:
- Winkel oder Krümmungsradius

Krümmungsanzeige:
- Rechte vertikale Achse: Radius R
- Linke vertikale Achse: Krümmung 1/R

Horizontale rote Linie:
- Nullwerte entlang vertikaler Achse
- Horizontale Tangentialität, unendlicher Radius



Working in display window:
Button ◊ - Zoom window or YES: Reframe
Button CXY - Select analysis types CEE, TEE
or YES: Delete (deletes window)

CURVE2 => APPROXIM

Generate curve approximation by entering polynomial degree (DEG) of tolerance
- DEG ↑ = fewer curve elements (ARC)
- DEG ↓ = more curve elements (ARC)

CURVE2 => CONNECT

TYPE 1 - Connects two curves in space with tangential and curvature continuity
- No analysis window possible

TYPE 2 - Special case only on planes, smoothest curvature possible
Prerequisite: Curvature circles must lie inside each other
- Connecting curve has DEG = 4

TYPE 3 - Connection through two separate curves with DEG = 4
- Gives a minimum curvature radius

CURVE2 => TGT CONT
- Generate curve with tangential continuity in curve limits

CURVE2 => CVT CONT
- Modify a 2D curve to maintain curvature continuity

CURVE2 => PARALLEL

- Parallel projection of a curve on a SUR on this SUR or vertically to it

CURVE2 => SPINE

- Generate a curve running vertically through all selected PLN (PLN_1 + Start-PT + PLN_2 + ... + PLN_n)

Functions - CURVE1 and POINT

POINT => PROJ INT
- Generate a point on a SUR (set or project)

CURVE1 => PT-PT
- Create a line on a SUR

CURVE1 => PROJECT
- Project curves onto a SUR normal to the SUR

CURVE1 => COMBINE
- Project curves onto a SUR, giving the projection direction

Function - ARC

The polynomial degree of the curve is DEG = 5 as standard. The polynomial degree can change through definition of conditions, min. DEG = no. of conditions - 1. At least two points (up to a max. of 16 points for **ARC=>COMP CPT)** must be defined.

Creating curves

ARC => COMP OPT - Curve with minimum distance quadrants to the defined points (optimised after deviation)

ARC => COMP SMT - Generate curve with minimum curvature change, (optimised after smoothing) => "smooth" curve

ARC => COMP CPT - Generate curve via control points (Bezier points), (linear connection of points gives control polygon)

Assigning curve parameters

ARC => COMP OPT/SMT => PARM I/N

- When calculating the curve, each support point has the same weighting

(Weighting parameter) $P = \frac{\text{I -1 (current point)}}{\text{N-1 (Number of all points)}}$

ARC => COMP OPT/SMT => PARM S

- When calculating the curve, this is split into equally large part sections

ARC => COMP OPT/SMT => PARM ARC

- Take the setting from a reference curve (ARC)

Manually effects on curves

ARC => DEFORM

=> POINT	- Select point through which curve must pass
=> LIM PT	- Redefinition of endpoints by other points
=> LIM TANG	- Modifying tangents at endpoints
=> LIM CRVT	- Select point through which curve must pass
=> CTRL PT	- Modifying a Bezier curve by transforming individual PTs of the ARC

Function - PATCH

A patch surface is defined by a Constrain (CST) similarly to an ARC, whereby for an

ARC a CST consists of multiple points and for a - CST (PT)
PATCH a CST consists of curves, lines and also points - CST (ARC, LN, PT)

PATCH => CREATE

1. PATCH => CREATE => ARC => ADD
2. YES: CREATE
3. Select the elements, a PATCH CST is created immediately, allowed elements are:
   - ARC, LINE, POINT, PARABOLA, PATCH TYPE CST
   - half-circle, half-ellipse
4. PATCH => CREATE => IMPOSE => ARC
   - Select elements through which the PATCH must exactly run

   PATCH => CREATE => IMPOSE => TANGENT
   - Define tangent direction through other elements, allowed are: PT, LN, ARC, SUR und PLN
5. PATCH => CREATE => COMPUTE
   - Create patch

PATCH => DEFORM

=> POINT	- let surface (additionally) run through PT, LN or CCV
=> LIM ARC	- Redefine start and end curve (ARC)
=> LIM TANG	- modifying the tangent direction in the boundary curve Surface 1 to surface 2, only surface 1 (selected first) is modified. - Surface 1 and surface 2 are tangential as result **PROJECT** - Projection of the tangent to surface 2 **ISOPARAM** - The iso-parameters of both surfaces share a joint tangent at the boundary curve **NORMAL** - The tangent of the iso-parameter of surface 1 is aligned normal to the boundary curve
=> MULTIPCH	- Generate tangential transition between 2 or 4 surfaces

PATCH - Analysis

- Visual analysis of surface curvature
  1. Obtain Free-Form licence
  2. Menü: Tools -> Analyze -> Curvature,
     - Select surface to be analysed
     - Display curvature (Gaussian) by colouring on shadowed surfaces

- Definition:

$$\text{Curvature} = \frac{1}{\text{Radius}}, \text{ or } \quad C = \frac{1}{R}$$

$$C_{Gauss} = \frac{1}{R_V} \cdot \frac{1}{R_H} = C_V \rightarrow C_H$$

$C_{Gauss} > 0$ - Spherical surface, blue

$C_{Gauss} < 0$ - Concave surface, red

$C_{Gauss} = 0$ - Linear in at least one direction, green

Note: 1) A finer analysis is possible with the limit values

2) To reset the colouring, Menü: Tools -> Analyze -> Remove.

Repeat:

What types of curves are there and what are the basic differences?

What is DEG and what values are possible in CATIA?

How is a PATCH defined?

How can a surface be analysed?

Function - SPLINE

- In contrast to ARC, the curve always passes through all points
- The curve exhibits curvature and tangential continuity
- The curve consists of multiple ARCs with DEG=5,
  DEG = 5, because 6 conditions:
  - Start and endpoint
  - Tangents at endpoints
  - Curvature at endpoints
- Generating a SPLINE:
  1. Define points
  2. Define tangents of endpoints
  3. Generate curve

Function - SURF2

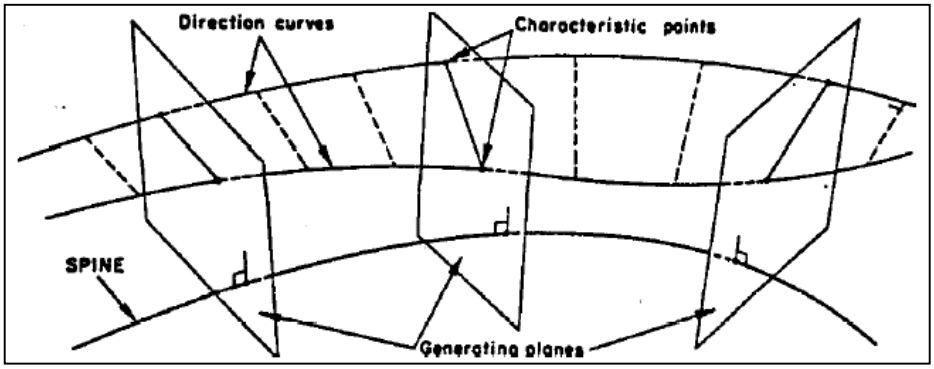
- Necessary conditions for generating a SURF2 surface:

  Generating curve

  - Curve drawn along the spline to span surface between alignment or boundary curves, in the simplest case just a line (see illustration)

  Generating plane

  - Plane on which the generation curve lies



SPINE

- SPINE must be composed of the normals through the generation plane
- The generation plane is drawn vertically along the SPINE and the intersection points with the alignment curve give the boundary points for the surface
- The intersection points must be clear

Direction curves

- Curves that define the boundary curves of spanned surfaces
- The direction curves can be defined by:
  - Limit curves, direct definition of boundary curves
  - Middle curve, two radii determine the boundary curves
  - Centre curve, one radius determines the boundary curves and additional parameters.

SURF2 => CREATE => SEGMENT

- Simplest case, the generating curve is a line
- There are several ways of generating a surface:

e.g.

a) Select the SPINE, the 2 boundary curves (LIM CRV), then command **COMPUTE** and YES:ACCEPT → done with proposed Generating curve

b) Select the SPINE, the 2 middle curve (MID CRV), then enter 2 radii (defines distance between both boundary curves), an angle, then **COMPUTE**, relation plane for the angle and select direction → done

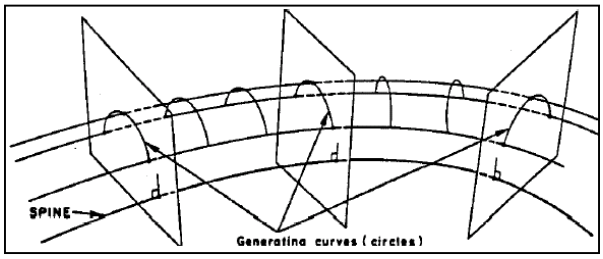
c) Select the SPINE, the 2 centre curve (CTR CRV), then enter the radii (defines the distance of both boundary curves), an angle, then **COMPUTE**, relation plane for the angle and select direction → done

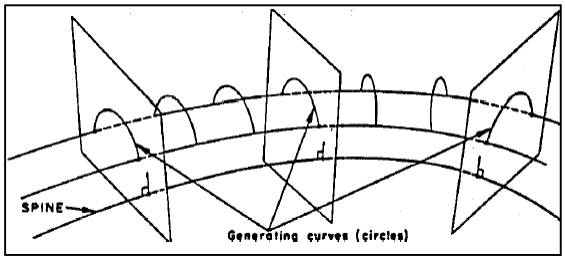
Note:	- When the analysis window is open (Alt + Num+) all possible combinations of the parameters (LIM CRV, MID CRV, Radius, etc.) are displayed, a row shows all entries necessary. - A curve can simultaneously be a SPINE and, for example, a MID CRV

Example: "TRNJGI ASURD SURF2 SEGMENT 001"
"TRNJGI ASURD SURF2 SEGMENT 002"

SURF2 => CREATE => CIRCLE

- The generating curve is a circle
- Through the definition of SPINE and thus the generating plane, this circle is defined by further lines (LIM CRV, MID CRV, CTR CRV) and/or radius and/or angle, see illustration below.





- As for => SEGMENT, all definition possibilities can be seen in the analysis window.

Example: "TRNJGI ASURD SURF2 CIRCLE 001"

SURF2 => CREATE => FILLET

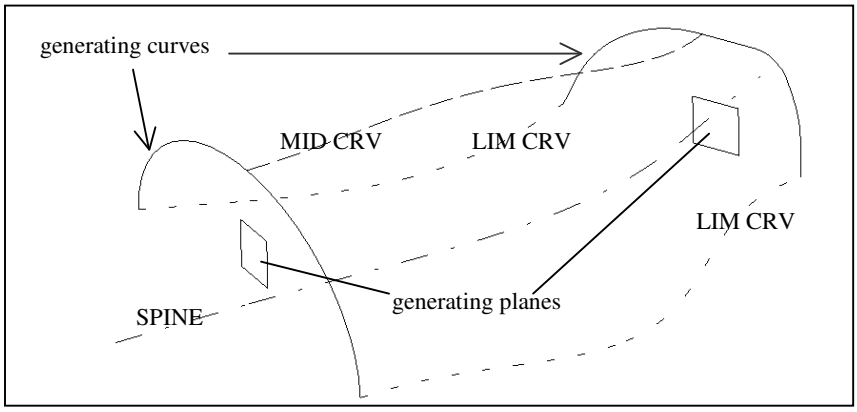
- Generate fillet surfaces between two surfaces
- Crossings are tangential
- The filleting radius is the generation curve and is drawn vertically along a SPINE
- Two possibilities for surfaces generation (no display in analysis window)

1) - Select surface 1 and surface 2 give the direction of rounding (selection direction arrow), then select the SPINE and enter the radius, then YES:COMPUTE → done
2) - select curve on one of the surfaces, then select second surface, select SPINE and then YES:COMPUTE, select a radius → done

Example: "TRNJGI ASURD SURF2 FILLET 001"

SURF2 => CURVE => CRV CRV

- Surface is created over multiple (1 – 50) plane generating curves;
  generating curve can also be a point
- Important: The SPINE must run vertically through all generating planes



Definition:

1. Select SPINE
2. Select direction curves
   LIM CRV (limit curve) - For open generating curves, these must run through their endpoints, for closed generating curves there is only one
   - Form the boundary curve of the surface
   MID CRV (middle curve) - If middle curves are defined, these lie on the generated surface and modify the run of the iso-parametrics,
   - The number of middle curves and/or constrain elements is limited to 26
   Entries must be terminated with YES:END
3. Select all generating curves
4. Enter YES:COMPUTE and tolerance (0.02 - 0.0002)

EXAMPLES: "TRNJGI_ASURD_FOENGEHAEUSE"
- Generating SPLINE 1 and 2
- Handle with SURF1, rest with SURF2 (CURVE and FILLET)
- Remember to generate a corresponding SPINE for FILLET

"TRNJGI_ASURD_SURF2_AF EINGANGSSCHALE START"

- For structure see notes in example

Note:	- SPLINE on SUR, not possible via patch limits (Fct. ANALYSIS), these can be removed with SURF1 => APPROXIM.

Repeat:

What direction curves are there and what are their functions?

How are surfaces generated with SURF2 => SEGMENT, CIRCLE, FILLET?

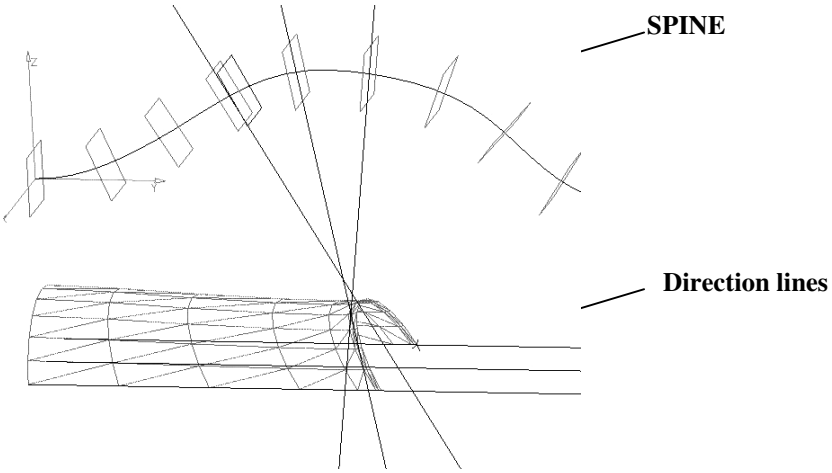
How is a surface generated with SURF2 => CURVE => CRV CRV?

Where can the definition combinations be seen?

Note:	History	ON	- Later modification of surfaces possible
		OFF	- No later modifications possible

Error message: SPN CRVT and DIR CRV incompatible

Cause: The SPINE is very curved and too far away from the direction curves, the normals on the SPINE intersect above the surface to be generated.



→ Position the SPINE closer to the new surfaces

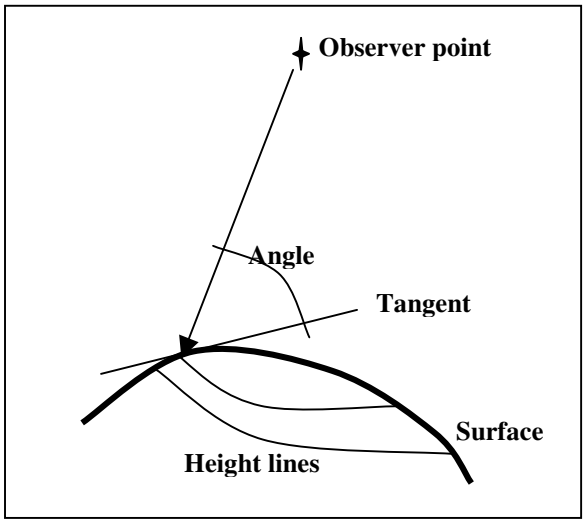
Tangent definition for CRV CRV

- Generating SURF2 surfaces tangential to neighbouring surfaces
- Tangents over the limit curves and the generating curves if possible
- First the definition on the limit curves:
  1) Select SPINE and both LIM CRV
  2) Enter ANGLE, = 0 for tangential alignment (A1 for LIM1, A2 for LIM2)
  3) Select TANG INT => T1 for LIM1, surfaces bordering on LIM1
     => Select T2 for LIM2, for surfaces bordering on LIM2
  4) YES: END
- Now follows the definition on the limit curves:
  1) Select the first generating curve, then select the neighbouring surface
     Select the second generating curve, then select the neighbouring surface
- then YES: **COMPUTE** and done.

Analysing surfaces crossings

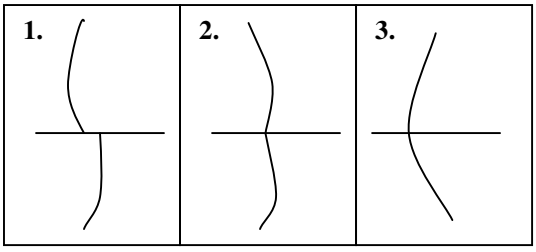
CURVE1 => REFLECT => ISO NORM => CONICAL

- From an observer point to be defined, after giving an angle (90° > x > 0°), a type of height lines are drawn over the selected surfaces.



- If the run of the height line curves is observed at the limit edges between the surfaces, the following can be noted:

1. Jump in line => crease between the surfaces
2. Crease in line => crossing is tangentially continuous
3. Tangentially continuous line => crossing is tangentially continuous and curvature continuous

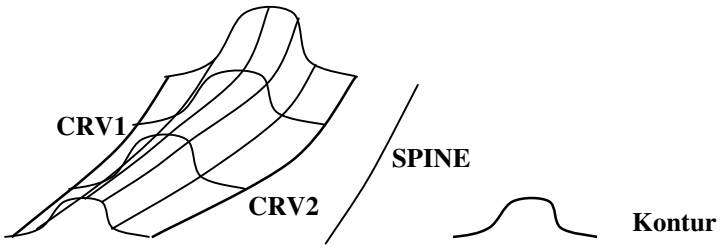


Note:	- Very small holes in skins are difficult to find. To make these visible, select the skin with the NOSHOW function, which shows all the boundary curves and therefore the holes on the skin.

SURF2 => CURVE => PT PT

Surface is defined by the following elements:

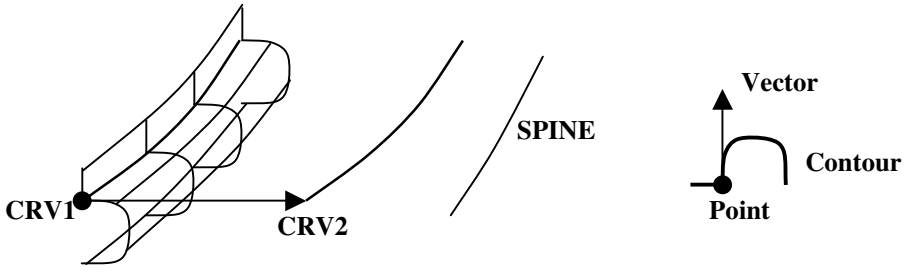
- A flat generating curve (contour)
- 2 reference points (endpoints by default) on this contour,
- 2 direction curves, along which the contour is drawn by means of the reference points.
- A SPINE, vertical to plane at every point, on which the generating curve is drawn along the direction curves



SURF2 => CURVE => PT DIR

Surface is defined by the following elements:

- A flat generating curve (contour)
- 1 reference point and one reference vector on this contour,
- 2 direction curves, along which the contour is drawn by means of the reference point (on CRV1) and the vector (direction CRV1 to CRV2)
- A SPINE (as for PT PT)
- No scaling of the contour takes place

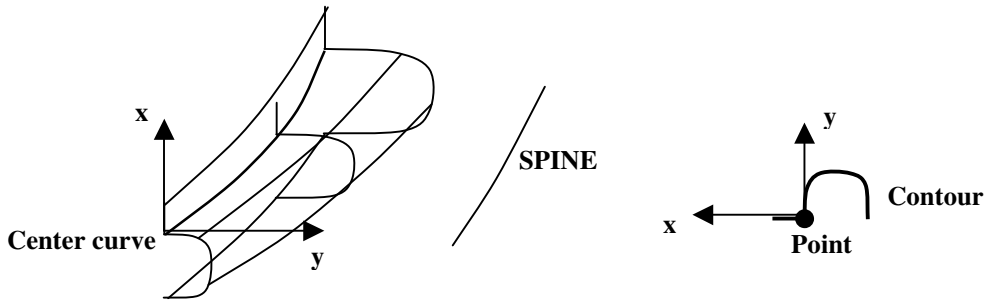


SURF2 => CURVE => UNSPEC

(Similar to SOLIDS - SWEEP, but with more ways of influencing)

Surface is generated by drawing a flat contour along a centre curve, the contour can be rotated and scaled.
The following elements are needed for definition:

- A flat generating curve (contour), on which a 2D axis system is aligned along the x and y axes with reference to coordinates origin and direction.
- A SPINE, to which the generation plane is aligned
- A centre curve, on which a 2D axis system is aligned. If no centre curve is defined, then SPINE = centre curve
- Scaling in the x and the y direction or both simultaneously by a parameter or a parameter rule



Function - BLENSURF

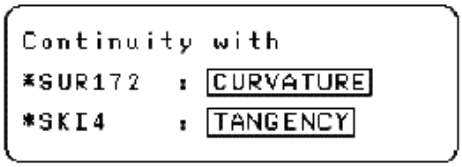
- Generating of crossing surfaces between two surfaces. The boundary curves cannot be influenced. There are two ways of generating such crossing surfaces:

BLENSURF => MAN LIM

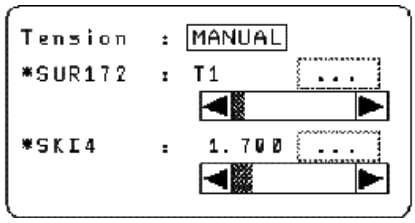
Definition:

1. Select CRV on the first SUR
2. Select CRV on the second SUR
3. Define the crossing characteristics of SUR1 and SUR2:

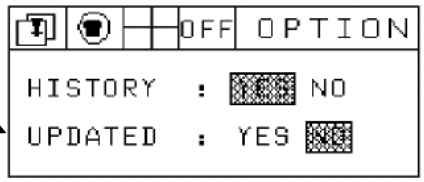
a) CURVAT - curvature continuity
b) TANGENT - tangent continuity
c) POINT - with a crease



4. Define TENSION, i.e. carry out a weighting of the tangent runs to both SUR
   e.g. CRV1=1.0, CRV2=3.0 => tangent run from CRV2 (SUR2)
   is followed longer.



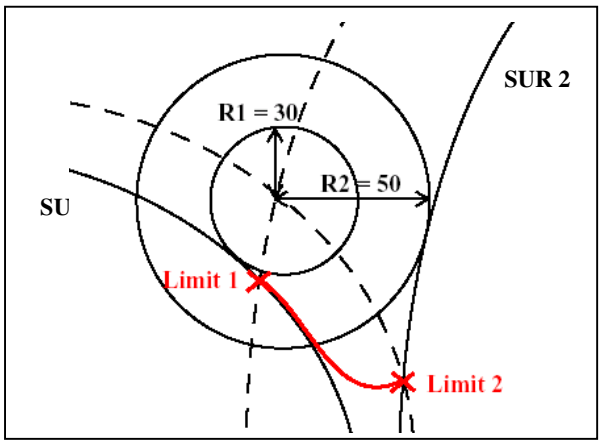
5. UPDATED : YES-Select field,
   then the surface is generated.



BLENSURF => BTGT LIM

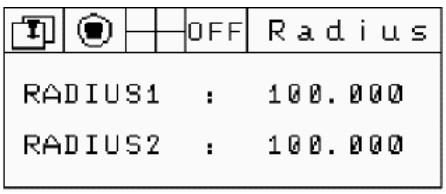
Generate transition surface by giving two intersecting radii.

- The intersecting edges are the boundary curves of the intersecting surface.



Definition:

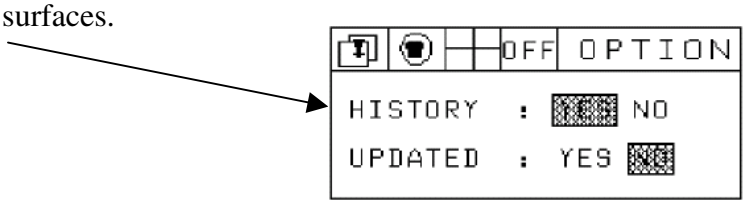
1. Select SUR1, then SUR2
2. Enter Radius1(SUR1) and Radius2(SUR2)



3. and 4. Intersection characteristic and TENSION same as for **MAN LIM**
5. Generate the surface as for **MAN LIM**

BLENSURF => MODIFY

Modify is only possible when the HISTORY switch is set to YES when generating the surfaces.



1. Select the SUR to be modified.
2. Change the parameters Radius, Tension and/or Continuity.
3. **UPDATED : YES** select, done.
   (**MODE** switch: **REP** = Replace surface
   DUP = Duplicate, new surface)

Function - MOLDPART

MOLDPART => DRAFTSUR

Generating of form release diagonals on surfaces.
The surface parameters are defined as follows:

1. Give the form release direction (default direction is the Z axis), the arrow direction can be reversed by selecting
2. Select the surfaces to be released (SUR or FAC). SKI can be selected by selecting a FAC contained therein
3. Or give – slope, slope = tan (angle)
4. MOLD JOIN - Select limiting plane (PLN or SUR) fo0r the form release diagonal
5. YES: Create

=> Function generates a form release tangential on the selected surface up to the limiting surface (tangent to form release direction = release angle)

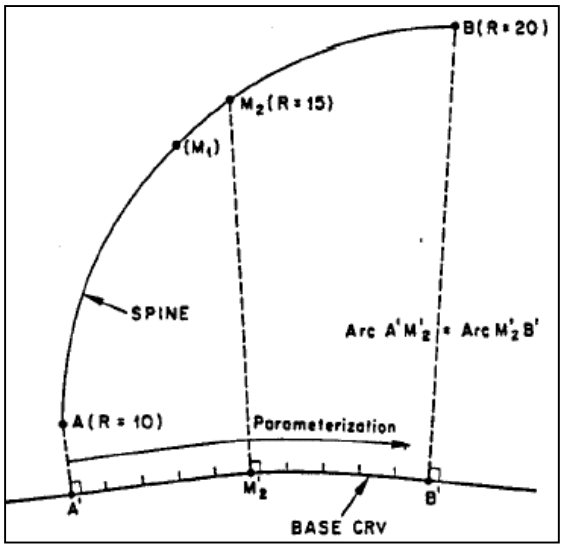
Function - LAW

Rules (LAW) can be used for SURF2 definitions instead of fixed values. A LAW always relates to a curve used as a SPINE. The value defined by a LAW can change linearly, according to a rule or on certain curve points.

LAW values: Radius, Angle, Parameter, Area

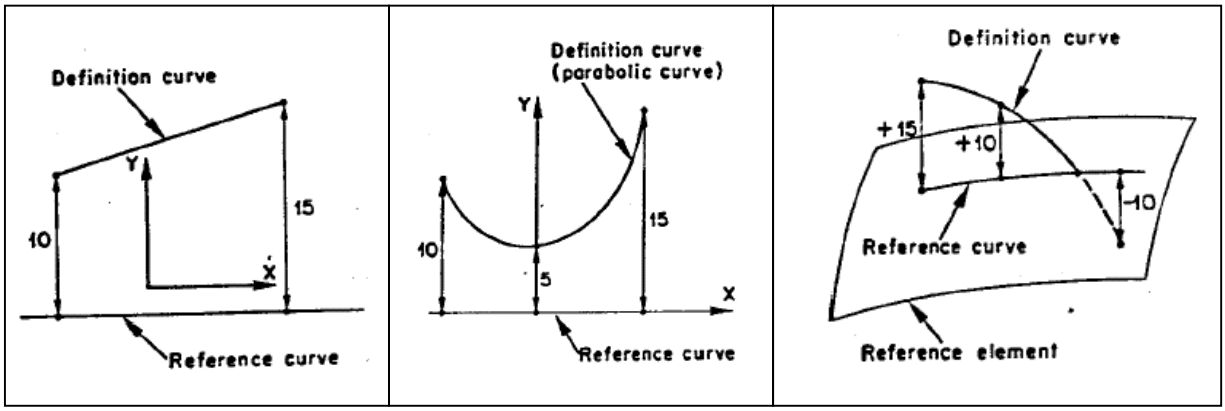
1. Base Curve Concept

A base curve is defined along which the value changes linearly. This curve is placed in a geometric relationship to a SPINE.
(Base Curve = SPINE possible)



2. Definition Curve and Reference Curve Concept

Generates curves that define the changing value (e.g. a radius) through their distance to one another. A curve is the reference curve (LN, CCV, PLN or SUR), this serves as a reference and is sometimes simultaneously used as the base curve. The other curve, the definition curve, defines the change rules for the value.



LAW definition in second case:

1. Select definition curve
2. Select reference curve
3. Select SPINE
4. Base curve (= reference curve or = SPINE possible)
5. YES: CREATE
6. Enter name for the rule (LAW), name appears on the SPINE → **fertig**

- Now just select the LAW for the SURF2 definition instead of entering a value (radius, etc.)