Introduction to STEP-NC

The STEP-NC Backbone: Workpiece and Features

STEP Tools, Inc.
14 First Street, Troy, NY 12180
(518) 687-2848 / (518) 687-4420 fax
http://www.steptools.com
Overview

• **Workpiece and Features**
  – Describe the final result of the operation and manufacturing features on that.

• **Questions**
  – How is the workpiece represented?
  – How do we find the shape of the workpiece?
  – What features are available
  – How are features represented?
  – How are features associated with the workpiece shape?
The workpiece is a STEP product

- All of the usual background information
- Product, with a formation, with a definition
- Product definition has associated geometry
STEP Product Description

The Workpiece

- **product name** = “widget”
- **product definition formation** id = “v1.0”
- **product definition** shape

**Shape Representation**
(usually an advanced brep shape rep)

Design owner, approvals
dates and times
Features

Workpiece (product)

Workingsteps (action methods)

Control Flow (action method relationships)

Cutting Tool (action resource)

Operation (action method)

Strategies, Technology, and Toolpaths (action method)

AMR

resource properties

action properties

action properties

action properties

Features (shape aspects)

Workpiece Geometry (shape property)
Features

• Features describe material removal areas on a workpiece.
  – These are manufacturing features, well-defined set.
  – Not design features, which can be anything!

• Features describe the desired result of a machining process.
  – Features describe “what”, the controller will decide “how”
  – Tool paths describe “how”, no one really knows “what”
STEP-NC Machining Features

- **2.5D milling features**
  - Hole, pocket, slot, step, etc
- **Transition features**
  - Edge round and chamfer
- **Replicate feature**
  - Patterns of repeated features

- **Region features**
  - Surfaces for freeform milling

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slot with radius ends

pocket with flat bottom condition
counterbore hole

pocket with through bottom condition

round hole

compound feature

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STEP-NC Features

- manufacturing feature
  - transition
  - 2.5D manufacturing
  - region

- machining feature
  - replicate feature

- compound feature
  - toolpath feature
    - planar face
    - hole
    - pocket
    - slot
    - profile
    - step

Explicit geometry, points out a surface for freeform milling (5 axis and such)

Implicitly described using profile and path parameters, not explicit geometry
Feature Description

• Features are described parametrically using a combination of Profiles and Paths
  – A Profile is swept over the entire length of a Path
  – Profiles described by key parameters, like length, radius.

• For example, a round_hole is defined by a Complete_circular_profile and a Linear_path
Open Profiles

Rounded “U”

Partial Circular

“Vee” Profile

Square “U”

“Tee” Profile
Closed Profiles

**Rectangular**

- `profile_width`
- `profile_length`

**Circular**

- `diameter`

**N-Gon**

- `number_of_sides = 6`
- `circumscribed_or_across_flats = False`

- `number_of_sides = 5`
- `circumscribed_or_across_flats = True`

**General**

- `closed_profile_shape`
• A planar face sweeps a linear profile along a linear path
Round Holes

- A Round Hole sweeps a circular profile down a linear path
  - Also can have taper and bottom conditions
  - Special counterbore and countersunk hole types

Hole Taper and Bottom Conditions
Pockets

- A pocket sweeps a boundary profile down to a depth
  - Also can have bottom condition and bosses
  - Bosses have a profile for their top
Pocket Bottom Conditions

Flat

Radiused

Through
• A Slot sweeps an open profile along a path
  – Also has an end type for each end
Slot End Types

Radius

Flat

Open

Woodruff

Loop
• A Step sweeps a Vee profile along a linear path
  – Often a right angle, but could be other angles
Two kinds of profile features

- A general outside profile sweeps a line along a profile (which could be either implicit or explicit geometry)
- A shape profile sweeps a line along a profile leaving a floor condition.
Other Types of Features

- **Region Feature**
  - Region can calls out specific geometry types (swept surface, geometrically bounded bag of surfaces, and open shell)
  - Used for freeform milling

- **Toolpath Feature**
  - Just a “marker” to associate a location on the part with a pre-computed tool path — no other information.

- **Compound Feature**
- **Replicate Feature**
- **Transition Feature**
Compound Feature

- Union of one of more features to create a more complex feature definition.
  - For example, a counterbore hole in the bottom of a countersunk hole.
Replicate Features

• Three different ways to replicate features
  – Circular_pattern
  – Rectangular_pattern
  – General_pattern
• Chamfer and edge round relate two surfaces
  – AP-224 also had a fillet, but in STEP-NC this is just the consequence of a particular tool choice.
• These are the ARM information requirements
  – How are they represented in the AIM?

• Features are shape aspects on the product shape
  – Features can have both implicit and explicit descriptions of the shape
    – Implicit uses shape_representation_with_parameters
      » captures how feature is formed with a constellation of associated shape aspects.
      » representation items are measures for length, width, etc.
    – Explicit uses shape_representation
      » uses surfaces also referenced by the workpiece shape
      » representation items are Part 42 geometry
How Features are Attached

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1. **Workpiece**
   - product / product definition formation / product definition

2. **The Feature**
   - complex instance of instanced_feature and feature_definition subtype

   - through shape_aspect of_shape

   - other shape aspects describing aspects of the feature

   - product definition shape

3. **product definition shape**

   - shape definition representation

   - shape representation (usually an advanced brep shape rep)

   - shape representation (usually an advanced brep shape rep)

   - shape definition representation

   - shape representation with parameters

   - shape representation

   - implicit description

   - explicit description

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Feature AIM Hierarchy

characterized_object

feature_definition

instanced_feature

replicate_feature

transition_feature

shape_aspect

profiles, and bottom conditions

boss

flat_face

pocket

slot

step

compound_feature

outside_profile

removal_volume

round_hole

circular_pattern

rectangular_pattern

feature_pattern

chamfer

edge_round

profiles,

and bottom

conditions
Feature AIM Hierarchy

characterized_object

feature_definition

instanced_feature

replicate_feature

transition_feature

shape_aspect

profiles, and bottom conditions

Complex Instance

boss
flat_face
pocket
slot
step

compound_feature
outside_profile
removal_volume
round_hole

circular_pattern
rectangular_pattern
feature_pattern

chamfer
edge_round

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• Define a round hole feature
  – Implicitly described by sweeping a circular profile along a path.

• Instance Diagram
  – Will be represented by instanced feature and round_hole
  – Will other shape aspects will describe the circular profile and the swept path.
Round Hole Parametric Description

The Feature
complex instance
of instanced_feature
and feature_definition
subtype

shape representation
(usually an advanced
brep shape rep)

shape representation
with parameters

explicit
description

other shape aspects describing
aspects of the feature

shape definition representation

shape representation

through
shape_aspect
of_shape

Workpiece
product /
product definition
formation /
product definition

product definition
shape

shape definition
representation

shape definition
representation

product definition
shape

shape definition
representation

product definition
shape

shape definition
representation

shape representation

Round Hole Diameter

The Feature
complex instance of instanced_feature and round_hole

shape defining relationship

shape aspect

The Diameter
circular_closed_profile

property definition

shape definition representation

shape representation with parameters

axis_placement_3D
name = “orientation”

length_measure_with_unit
“diameter”
value = 25 mm

feature component definition

product definition shape

shape aspect

This “stub” says that it is an aspect of a feature, rather than a whole product

Lets profile be shared by many features

product definition shape

shape defining relationship

shape aspect

The Diameter
circular_closed_profile

property definition

shape definition representation

shape representation with parameters

axis_placement_3D
name = “orientation”

length_measure_with_unit
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feature component definition

product definition shape

shape aspect

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Lets profile be shared by many features

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Round Hole Depth (Sweep Path)

The Feature
complex instance of instanced_feature and round_hole

product definition shape

shape definition representation

shape representation with parameters

axis_placement_3D name = "orientation"

shape defining relationship

The Depth
path_feature_component description = "linear"

property definition

property definition representation

direction shape representation

shape representation with parameters

length_measure_with_unit name = "distance" value = 100 mm

feature component definition

product definition shape

axis_placement_3D
Round Hole Bottom Condition

The Feature
complex instance of instanced_feature and round_hole

product definition
shape

shape definition
representation

shape representation
with parameters

axis_placement_3D
name = “orientation”

feature component
relationship

shape aspect

The Bottom
hole_bottom “flat with radius”

property definition

shape definition
representation

shape representation
with parameters

length_measure_with_unit
name = “radius”
value = 5 mm

feature component
definition

product definition
shape
• The relationship between the feature and it’s parts tells you how the part is used.

• shape_defining_relationship
  – paths and profiles that sweep out the feature shape.

• feature_component_relationship
  – bottom conditions, tapers, and other aspects.

• Both are subtypes of shape_aspect_relationship
Profiles, Paths, and Bottom Conditions

- shape_aspect
  - boss_top
  - hole_bottom
  - pocket_bottom
  - profile_floor
  - slot_end
  - chamfer_offset
  - taper

- open_path_profile
  - partial_circular_profile
  - linear_profile
  - rounded_u_profile
  - tee_profile
  - vee_profile

- closed_path_profile
  - rectangular_closed_profile
  - circular_closed_profile
  - ngon_closed_profile
  - path_feature_component
  - modified_pattern
  - applied_area
• Planar Face
  – Sweeps a linear profile along a path

• Slot
  – Sweeps an open profile along a course of travel
  – Has slot end conditions on each side

• Pocket
  – Sweeps an open or closed profile down a depth
  – Has a pocket bottom condition
Summary

• **Workpiece describes the final output of a manufacturing process**

• **Workpiece is represented as a product**
  – The shape of the workpiece is a property of the product

• **Features describe material removal areas**

• **Features are represented as shape aspects on the workpiece shape**
  – Implicitly defined features are described by a profile moving along a path.
  – Explicitly defined features are described by surfaces from the workpiece shape.
  – Profiles, paths and other conditions are defined as shape aspects associated with the feature.
Region Feature

The Feature
complex instance of instanced_feature and round_hole

product definition
shape

shape definition
representation

shape representation
with parameters

axis_placement_3D
name = “orientation”

shape aspect
“shape volume occurrence”

shape defining
relationship
“volume shape usage”

shape_aspect
“volume shape”

property definition

shape definition
representation

shape representation

The Product

product definition
shape

faces and whatnot