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TRUMPF

Bend Part Template Catalogue

Trumpf produces human-handled programmable machines for sheet metal bending, along with related software. A bending program is needed to produce a bending part. We aim at reducing the effort of bending program design by creating templates for groups of parts of similar shapes, so that a template could easily be adjusted to fit one's needs and avoid a costly design process. We have developed the part template concept, defined its representation and the procedures for the creation and usage of templates. Workable prototypes of tools to perform these procedures have been implemented.

Sheet metal

Embedded system

Press brake

C#.NET

Bending

Motivation

Product portfolios of Trumpf customers contain a number of similar parts. Up to now each customer has had to create bending programs for these parts separately. The bending program is designed in two steps:

- The part geometry is defined using special CAD system
- A bending sequence is calculated and the bending program settings are specified using corresponding software

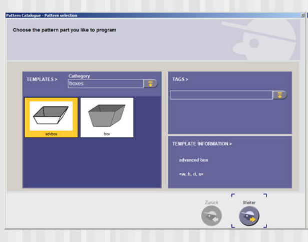
These steps require both special skills from the operator and certain amount of computational power from the machine.

The Template Approach

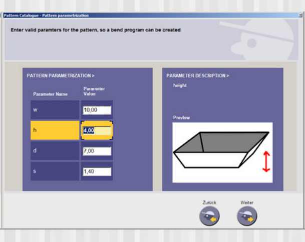
On the other hand, the template approach, enables workers to create instances of corresponding parts by simply specifying several values for the parameters exposed by a particular template. No heavy calculation done, no special skills required. Here are the three easy steps

- Analyze the specifications and find a template that fits. This sounds complicated, but with a bit of experience workers will simply know which template they need in most cases. We also provide filtering mechanisms (by category and tags) to facilitate the choice of a template
- Specify the parameter values. Each parameter is assigned a textual description and an explanatory picture for better understanding of its semantics
- Check that the concrete part generated fits the original specification and the bending program is valid

While usage of templates is simple, their design is much more consuming than that of concrete parts. Nevertheless, it is more efficient than designing all the instances of a template independently, if the number of instances is high.


Pattern Catalogue - Pattern selection

Choose the pattern part you like to program

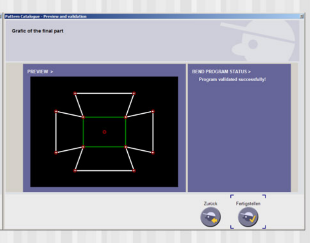

Pattern Catalogue - Pattern parametrization

Enter valid paramters for the pattern, so a bend program can be created

PATTERN PARAMETRIZATION >

Parameter Name	Parameter Value
w	10,00
h	4,00
d	7,00
s	1,40

PARAMETER DESCRIPTION >
height


Pattern Catalogue - Preview and validation

Grafic of the final part

BEND PROGRAM STATUS >
Program validated successfully!

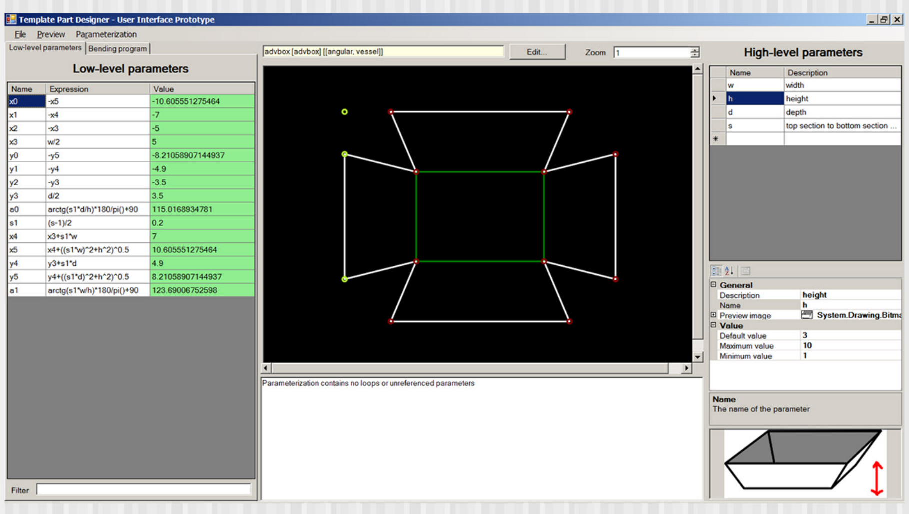
In order to reduce the complexity of template design, we have decided to derive templates from concrete parts. This reduces significantly the complexity of tools we have to develop, thus cutting both the implementation costs and the amount of learning for the user.

Flexibility

We allow varying the vertex coordinates, bending angles and some bending program components and preserve the contour edges and bending lines, as well as the bending sequence. One main reason is that we disallow bending sequence recalculation on template instantiation at the moment. This could be a future improvement to allow adding or removing the bending lines.
The template designer is to define the parameters exposed to the user and the way a template is instantiated, given values for these parameters, which is not an easy task. The Designer tool we provide is considered a special purpose IDE (Integrated Development Environment) – it enables the user to input the program in a convenient way (mostly visually), test and verify it. It also provides the user with some interface features like word completion or dependency highlighting.

The Catalogue

The tool used by the workers is called The Catalogue tool. It is designed using Trumpf touch screen controls and provides an intuitive way to select a template, instantiate it and verify the result. The Catalogue tool will soon be integrated with the press brake interface software.


Template Part Designer - User Interface Prototype

Low-level parameters

Name	Expression	Value
x0	-x5	-10.605551275464
x1	-x4	-7
x2	-x3	-5
x3	w/2	5
y0	-y5	-8.21058907144937
y1	-y4	-4.9
y2	-y3	-3.5
y3	d/2	3.5
a0	arctg(s1*d/h)*180/pi()+90	115.0168934781
s1	(s-1)/2	0.2
x4	x3+s1*w	7
x5	x4+((s1*w)^2+h^2)^0.5	10.605551275464
y4	y3+s1*d	4.9
y5	y4+((s1*d)^2+h^2)^0.5	8.21058907144937
a1	arctg(s1*w/h)*180/pi()+90	123.69006752598

Parameterization contains no loops or unreferenced parameters

High-level parameters

Name	Description
w	width
h	height
d	depth
s	top section to bottom section ...

General	
Description	height
Name	h
Preview image	System.Drawing.Bitma
Value	
Default value	3
Maximum value	10
Minimum value	1

Name
The name of the parameter