

AUTORIZOVANÝ SOFTWARE

PARAMETRICKÝ MODEL PRŮTOČNÉ ČÁSTI SPALINOVÉHO VENTILÁTORU

PARAMETRIC MODEL OF THE FLUE FAN FLOW PART

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Poznámka: <http://www.ntc.zcu.cz/vysledky/sw/NTC-ASW-13-006.html>

Název výsledku česky:

Parametrický model průtočné části spalínového ventilátoru

Název výsledku anglicky:

Parametric model of the flue fan flow part

Abstrakt k výsledku česky:

Vytvořený software je řešen v prostředí PYTHON 2.7.3 a pracuje jako parametrický skript kompatibilní a pracující pod programem Salome verze 6.2.0 a vyšší. Pro úpravu vstupních parametrů je nezbytný textový editor či editor PYTHON (gedit/spyder). Software je schopen vytvořit komplexní geometrii segmentu kola radiálního ventilátoru při respektování pravidel návrhu a umožňuje ovlivnit téměř všechny parametry geometrie kola ventilátoru. Software je také schopen parametrizovat objemy a části segmentu, které souvisejí s CFD výpočtem. Výhodou tohoto softwaru je, že minimalizuje nároky na rozsah použitého softwaru a výpočetní techniku. Výpočet parametrů a generace modelu trvá řádově sekundy.

Abstrakt k výsledku anglicky:

Created software is using PYTHON 2.7.3 programming language and works as a parametric script. It's compatible and works under SALOME platform version 6.2.0 and higher. To edit input parameters there is necessary a text or PYTHON editor. Software is able to create complex geometry of the centrifugal fan impeller's segment according to design rules and it's able to affect almost all parameters of the impeller's geometry. Software is also able to parameterize volumes and parts of the segment which are connected with CFD calculation. Advantage of this software is that minimize requirements of the used software and hardware. The calculation and the model generation lasts the order of seconds.

Klíčová slova česky:

Software; parametrický model; ventilátor

Klíčová slova anglicky:

Software; parametric model; fan

Vlastník výsledku: *Západočeská univerzita v Plzni*

IČ vlastníka výsledku: *49777513*

Stát: *Česká republika*

Lokalizace: *Západočeská univerzita v Plzni, Nové technologie
– výzkumné centrum*

Licence: *Ne*

Licenční poplatek:

Ekonomické parametry: *Snížení nákladů související s rychlým a snadným vytvořením výpočetního modelu pro navržené kolo ventilátoru. Další výhodou tohoto softwaru je zkrácení výpočetního času, a proto dochází k výraznému snížení nákladů potřebných na navržení ventilátorového kola.*

Technické parametry: *Software pracuje jako parametrický skript, který je schopen vytvořit komplexní geometrii segmentu kola při respektování pravidel návrhu a umožňuje ovlivnit téměř všechny parametry geometrie kola ventilátoru. Výhodou tohoto softwaru je, že minimalizuje nároky na rozsah použitého softwaru a výpočetní techniku.
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Viz odkaz <http://www.ntc.zcu.cz/vysledky/sw/NTC-ASW-13-006.html>*

Kategorie nákladů: *A - výše nákladů ≤ 5 mil.*

Číselná identifikace výsledku: *NTC-ASW-13-006*

Parametric model of the flue fan flow part

Abstract:

Created software is using PYTHON 2.7.3 programming language and works as a parametric script. It's compatible and works under SALOME platform version 6.2.0 and higher. To edit input parameters there is necessary a text or PYTHON editor. Software is able to create complex geometry of the impeller's segment according to design rules and it's able to affect almost all parameters of the impeller's geometry. Software is also able to parameterize volumes and parts of the segment which are connected with CFD calculation. Advantage of this software is that minimize requirements of the used software and hardware. The calculation and the model generation lasts the order of seconds.

Description of software:

This program is for parametric modeling of the radial fan with annular blades. This is a first version of this program, please note, that some parameters have very large effect to the entire geometry and some combination of parameters are impossible to create. Please respects design process of radial fans and check geometry after using program.

Necessary software

The software is written in PYTHON 2.7.3 programing language and it works as a parametric script compatible and working under program Salome version 6.2.0 or higher. To modify input parameters there is necessary a text or PYTHON editor (gedit/spyder). Highly recommend is to use the program under Linux platforms.

Usign of the software/changing parameters

Open the PARAMETRICfan by text or PYTHON editor (gedit/ spyder)

There is possible to change a several parameters see (Fig. 1). For this version of program is not possible to use a "blade curvature" parameter. This parameter is calculated by the program.

```
#####
#####          INPUT PARAMETERS (dimensions in mm and deg°)          #####
#####

n=12                                #number of blades
r2=110.5;                            #inlet radius
beta1dpoz=45;                        #flow inlet angle (deg)
beta2d=35;                            #flow outlet angle (deg)
r3=212.5;                            #outlet radius
r1=0;                                ##### blade curvature - CALCULATED !!!!! #####
bldThick=4.5                          #blade thickness
bldWidth=45;                          #blade width
inRad=13;                              #blade inlet radius
spcAdd=150;                            #height of the space over the chanel (for CFD)
inSpaceWidth=100;                      #distance of the inlet (for CFD)
```

Fig. 1 Input parameters for the program

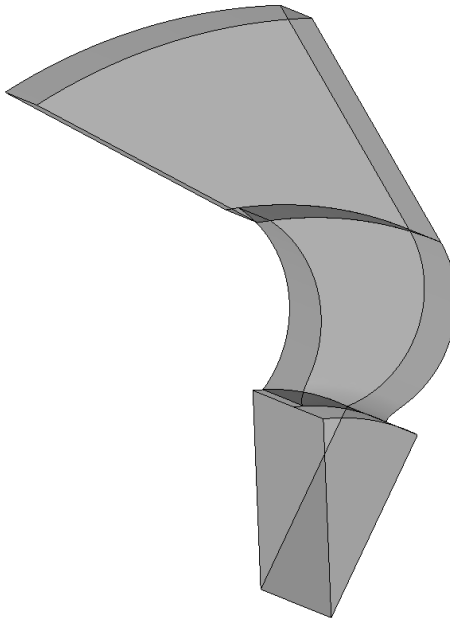


Fig. 2 Segment created by PARAMETRICfan 1.0 – parameters see Fig.1

1 Processing

1.1 Introduction

This program creates segment of the radial fan with forward curved blades, by rotating and copying of the segment, you are able to create entire impeller with appropriate additional volumes for CFD calculation.

To run program is NOT necessary any additional calculation. Script inside the program calculate every parameter, orders the Salome to create geometric objects and add to your study.

Note: It is possible to turn off “add to study” parameter or you can choose which parts of geometry will be added. Go to the “Add to study part” of the script (line 244) and add a “#” to the beginning of the line. If you want to remove more parts at once you can do it with “ , ” “ before and after parts which you want to remove or not add at all. Each line represents one part.

1.2 Pre-processing

Before you run program, you have to set a geometry parameters of the fan (Fig.1). Open the script and in the “INPUT PARAMETERS” section and fill necessary parameters:

- n – Number of blades
- r2 – Inlet radius
- beta1poz – Flow inlet angle (dimension in degrees)
- beta2d – Flow outlet angle (dimension in degrees)

NOTE: Parameters beta1poz and beta2d are very important parameters and this parameters have higher order than others e.g. in some cases may you get unexpected results (the geometry will have smaller outlet radius etc.). After each geometry generation please check the model.

- r3 – Outlet radius
- r1 – Blade curvature

NOTE: Parameter “r1” is calculated. Let this parameter 0.

- bldThick – Blade thickness
- bldWidth – Blade width
- inRad – Blade inlet radius
- spcAdd – height of the space over the channel (for CFD)
- inSpaceWidth – Dimension of the additional space at blade inlet (for CFD)

NOTE: Parameters spcAdd and inSpaceWidth are parameters for CFD calculation and must be defined but these parts are generated separately, so you can remove them in post-processing or remove them in “Add to study part”.

1.3 Geometry generation

To run the program start Salome at first. Create a new study and click File/Load script (or Ctrl+T). After that find your PARAMETRICfan script and open it. The script starts automatically.

After calculation and geometry generation there is a report of parameters in Salome’s python console see Fig.3 (default at the bottom of the Salome window)

```
Python Console
>>> execfile(r"/home/roman/Parametric model/Final/PARAMETRICvent1_0_En.py")
('number of blades', 12)
('blade radius', 65.315999999983262)
('inlet radius', 110.5)
('outlet radius', 212.5)
('inlet angle', 45.00032425101594)
('outlet angle', 35)
('blade thicknes', 4.5)
('blade width', 45)
('blade inlet radius', 13)
>>> |
```

Fig. 3 Report of parameters

To check geometry switch Salome to the geometry module. In this module is also possible further modification of the model.

The effect of each parameters is showed in following pictures:

Note: The blue segment is the new generated model. The grey segment is segment in Fig.2.

1.4 Effect of number of blades

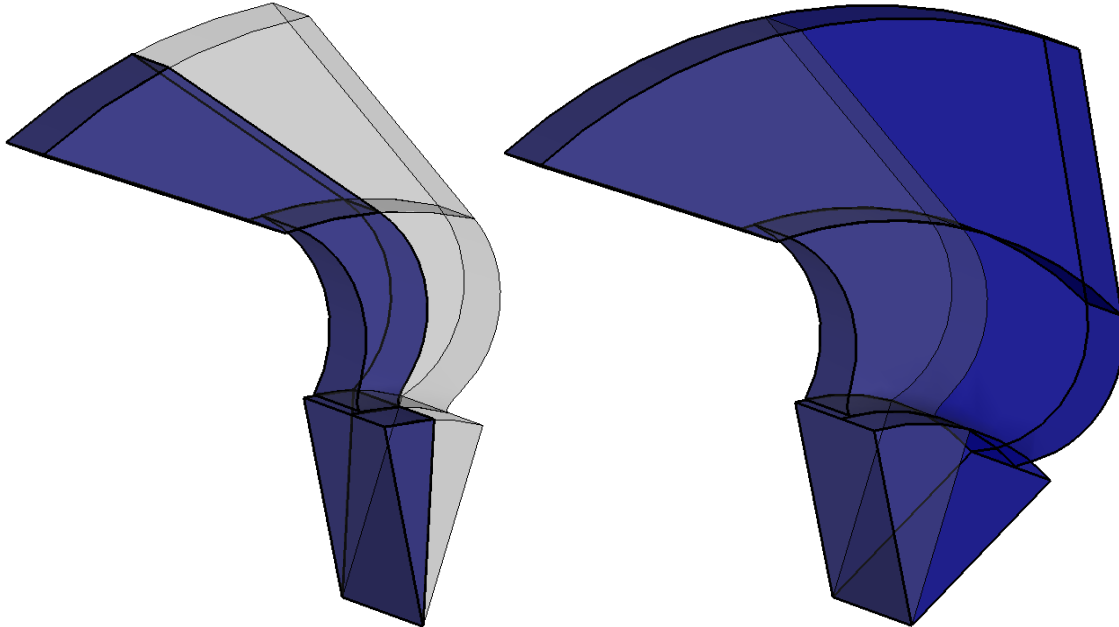


Fig. 4 Effect of the number of blades $n=24$ (left) $n=6$ (right)

1.5 Effect of the inlet radius

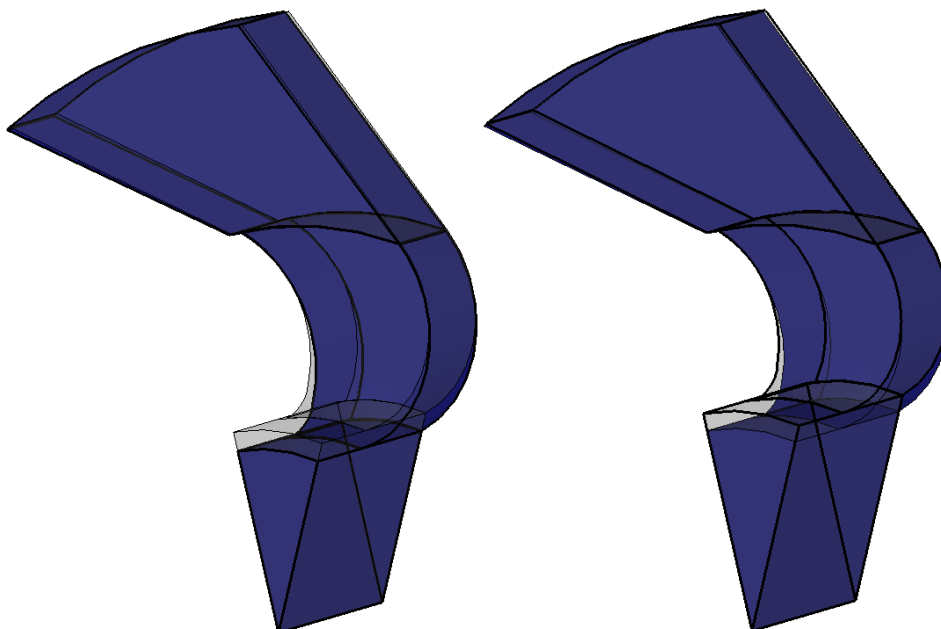


Fig. 5 Effect of the inlet radius $r2 = 100$ mm (left); $r2 = 120$ mm (right)

1.6 Effect of the inlet angle

NOTE: This parameter highly affects the entire solution. Please respects physical rules during design.

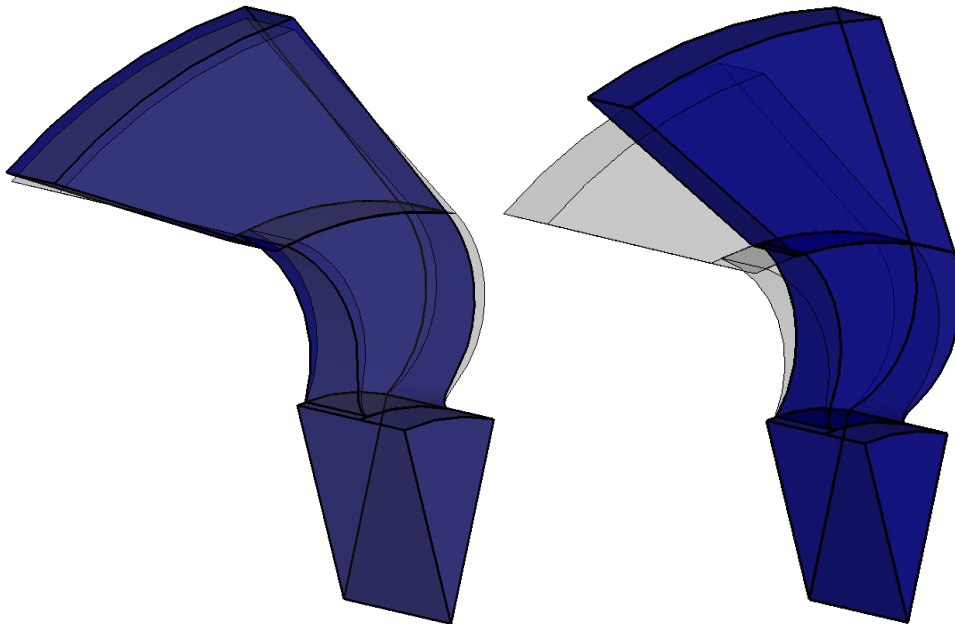


Fig. 6 Effect of the inlet angle - $\beta_{1dpoz} = 35^\circ$, $\beta_{2d} = 50^\circ$ (left), $\beta_{1dpoz} = 55^\circ$, $\beta_{2d} = 40^\circ$ (right)

1.7 Effect of the outlet angle

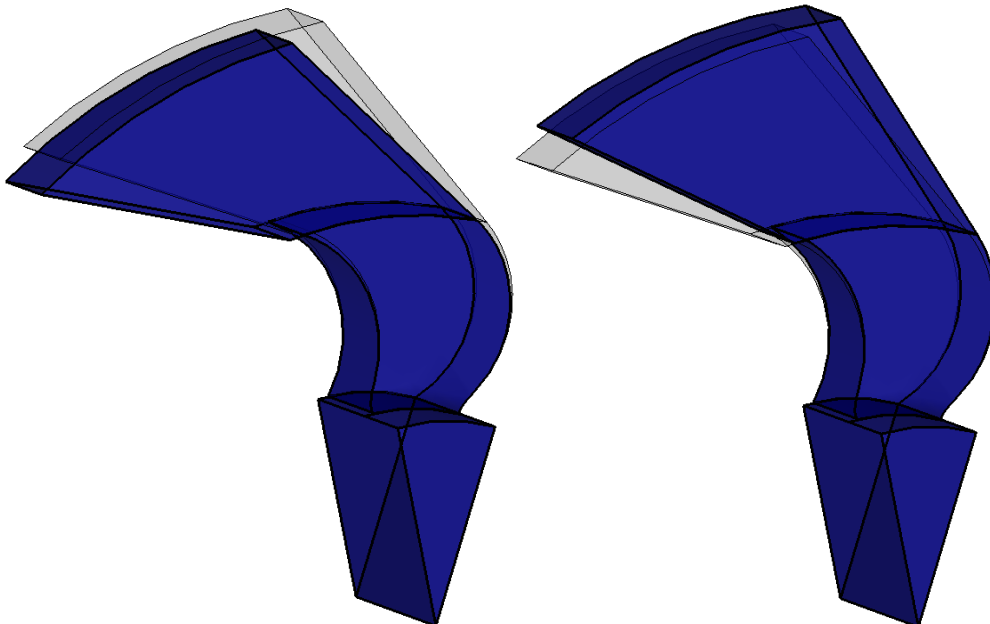


Fig. 7 Effect of the outlet angle – $\beta_{2d} = 30^\circ$ (left) $\beta_{2d} = 40^\circ$ (right)

1.8 Effect of the outlet radius

NOTE: This parameter highly affects the entire solution. Please respects physical rules during design.

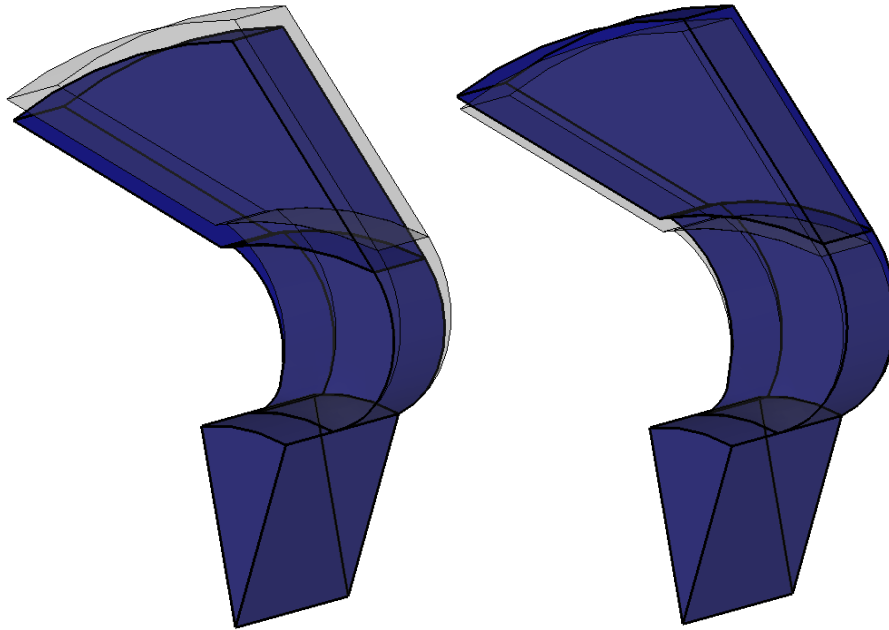


Fig. 8 Effect of the outlet radius – $r_3 = 200$ mm (left); $r_3 = 220$ mm (right)

1.9 Effect of the blade thickness

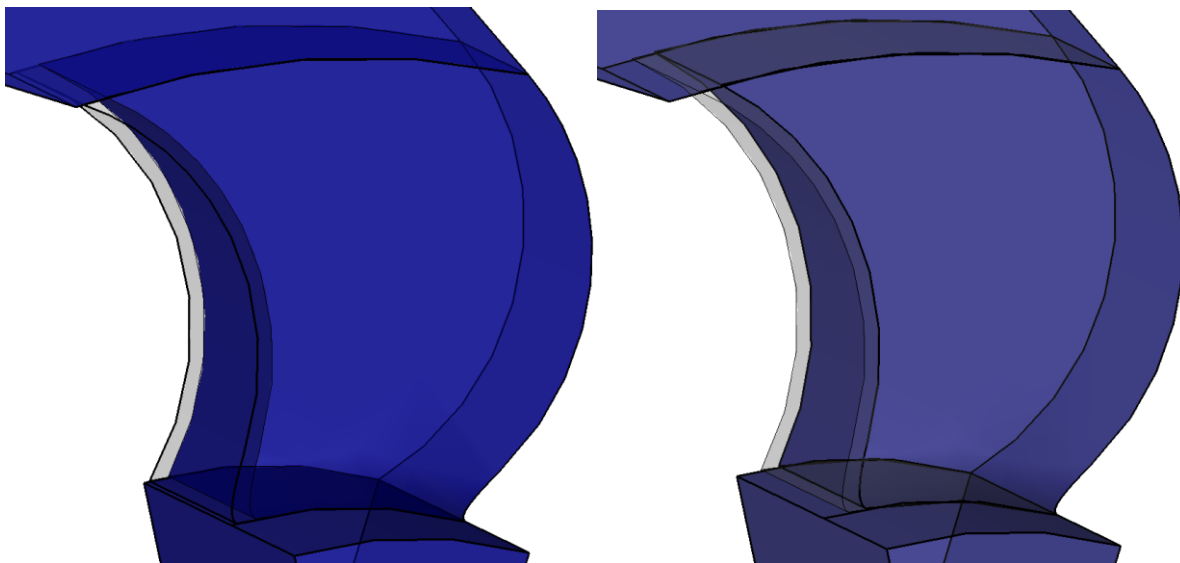


Fig. 9 Effect of the blade thickness - $\text{bldThick} = 1$ mm (left); $\text{bldThick} = 8$ mm (right)

1.10 Effect of the blades' width

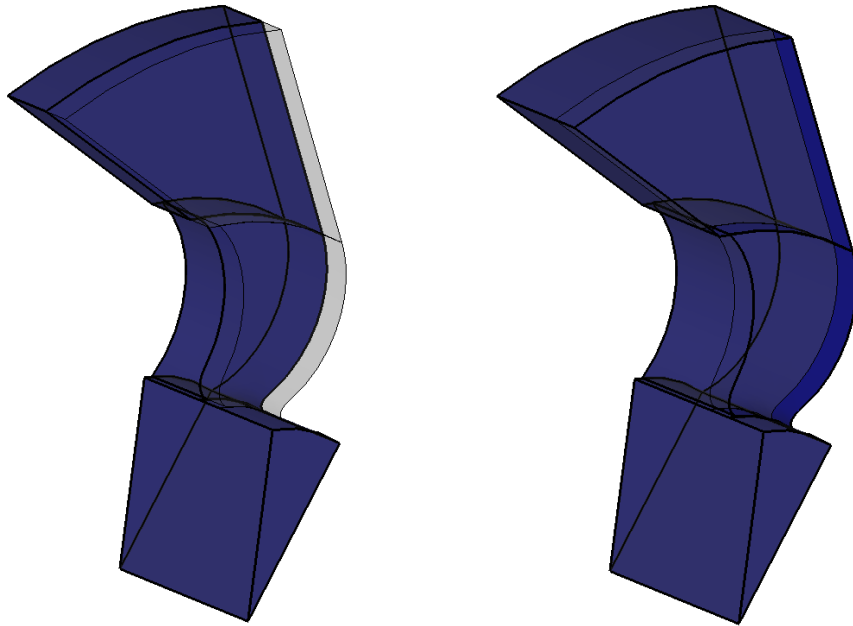


Fig. 10 Effect of the blades' width – bldWidth = 30 mm (left); bldWidth = 60 mm (right)

1.11 Effect of the blades' inlet radius

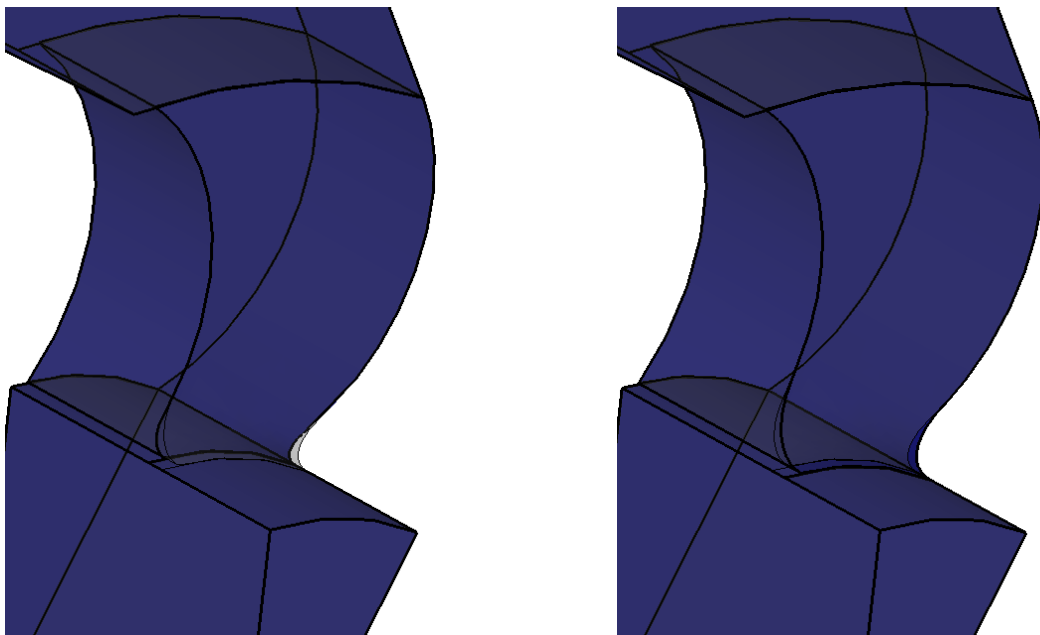


Fig. 11 Effect of the blades' inlet radius – inRad = 8 mm (left); inRad = 18 mm (right)

1.12 Effect of the additional space on inlet

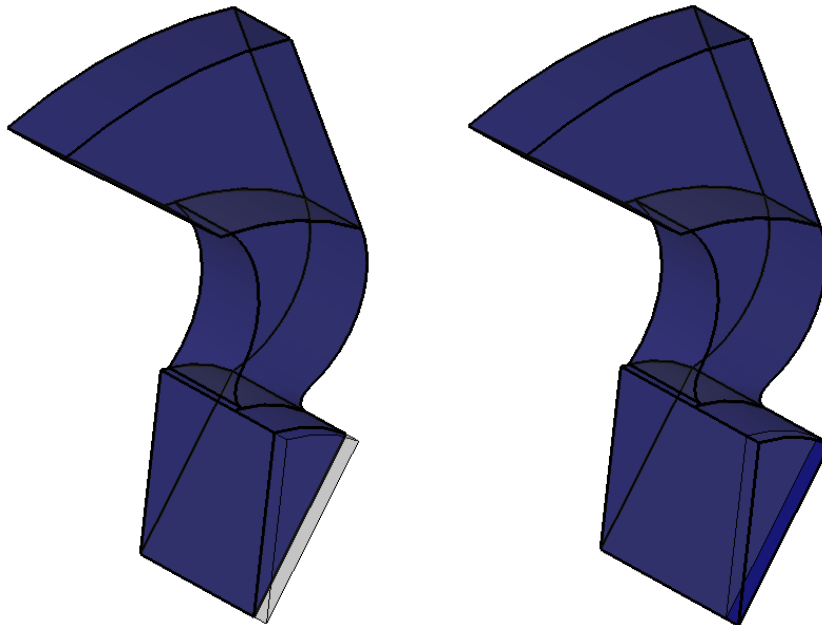


Fig. 12 Effect of additional space on inlet - inSpaceWidht = 90 mm (left); inSpaceWidht = 110 mm (right)

1.13 Effect of the additional space on outlet

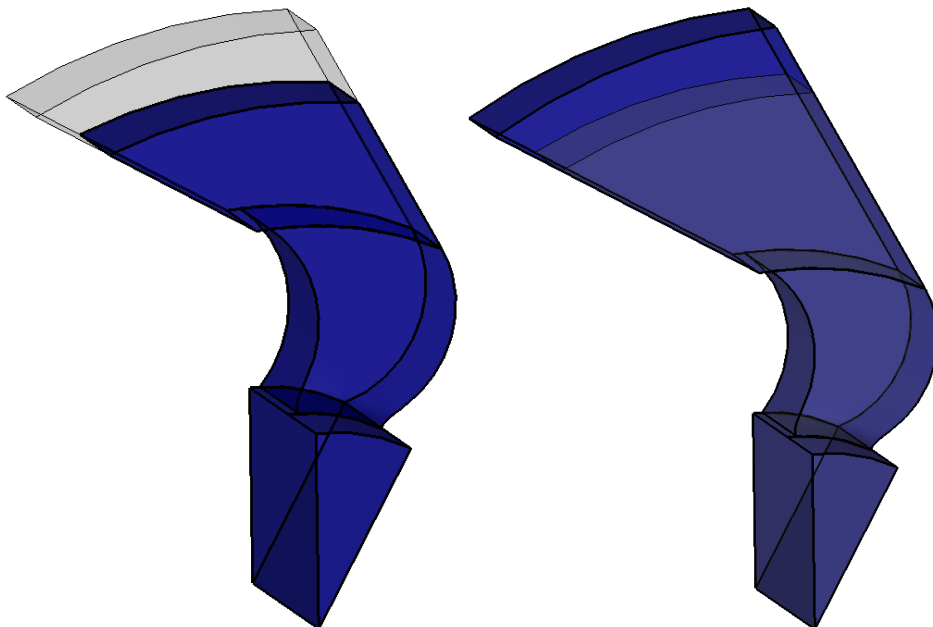


Fig. 13 Effect of the additional space in outlet – bldSpace = 100 mm (left); bldSpace = 200 mm (right)

2 Governing Equations

Governing equations are presented at current example:

Calculate length of the A-B curve

Given parameters $r_1 = 65,3[mm]$; $r_2 = 110,5 [m]$; $r_3 = 212,5 [mm]$; $\beta_2 = 35[^\circ]$

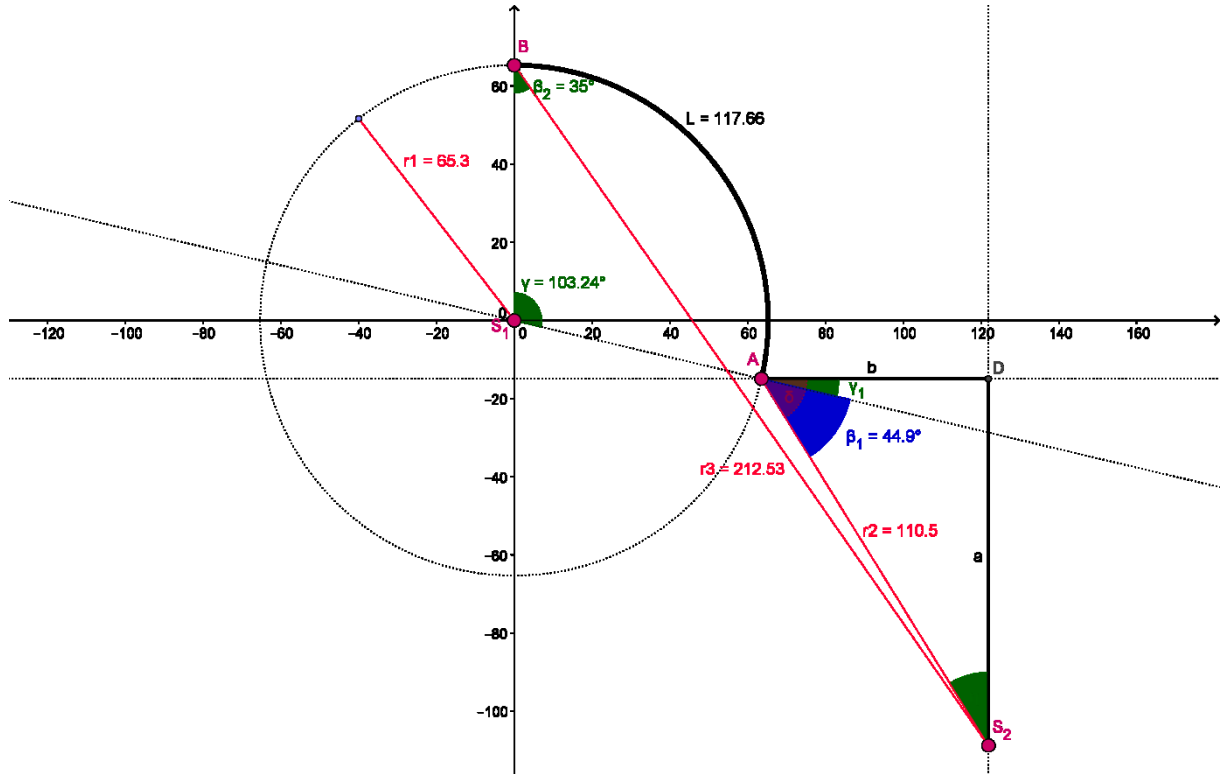


Fig. 14 Geometry characteristics of the annular blades

Coordinates: $S_2(x_{S2}, y_{S2})$

$$x_{S2} = r_3 \cdot \sin \beta_2$$

$$y_{S2} = r_1 - r_3 \cdot \cos \beta_2$$

Circles:

$$x_{S2}^2 + y_{S2}^2 = r_1^2 + r_3^2 - 2 \cdot r_1 \cdot r_3 \cdot \cos \beta_2$$

Intersection of circles at point A (x_A, y_A):

Circle 1: $k_1(S_1, r_1)$

Circle 2: $k_2(S_2, r_2)$

$$x_{A,2} = \frac{1}{2} \left(x_{S2} \left(1 + \frac{r_1^2 - r_2^2}{x_{S2}^2 + y_{S2}^2} \right) \pm y_{S2} \sqrt{\frac{2(r_1^2 + r_2^2)}{x_{S2}^2 + y_{S2}^2} - \left(\frac{r_1^2 - r_2^2}{x_{S2}^2 + y_{S2}^2} \right)^2 - 1} \right)$$

There is two intersection at A – take higher value of x_A than y_A :

$$y_A = \pm \sqrt{r_1^2 - x_A^2}$$

Sign + in case if: $r_2 > \sqrt{2 \cdot r_1^2 + r_3^2 - 2 \cdot r_1 \cdot r_3 \cdot (\sin \beta_2 + \cos \beta_2)}$

Angle of the arc of the circle (curve A-B):

$$\gamma = \frac{\pi}{2} - \arctg \frac{y_A}{x_A}$$

Curve length:

$$L = 2 \cdot \pi \cdot r_1 \cdot \frac{\gamma}{360}$$