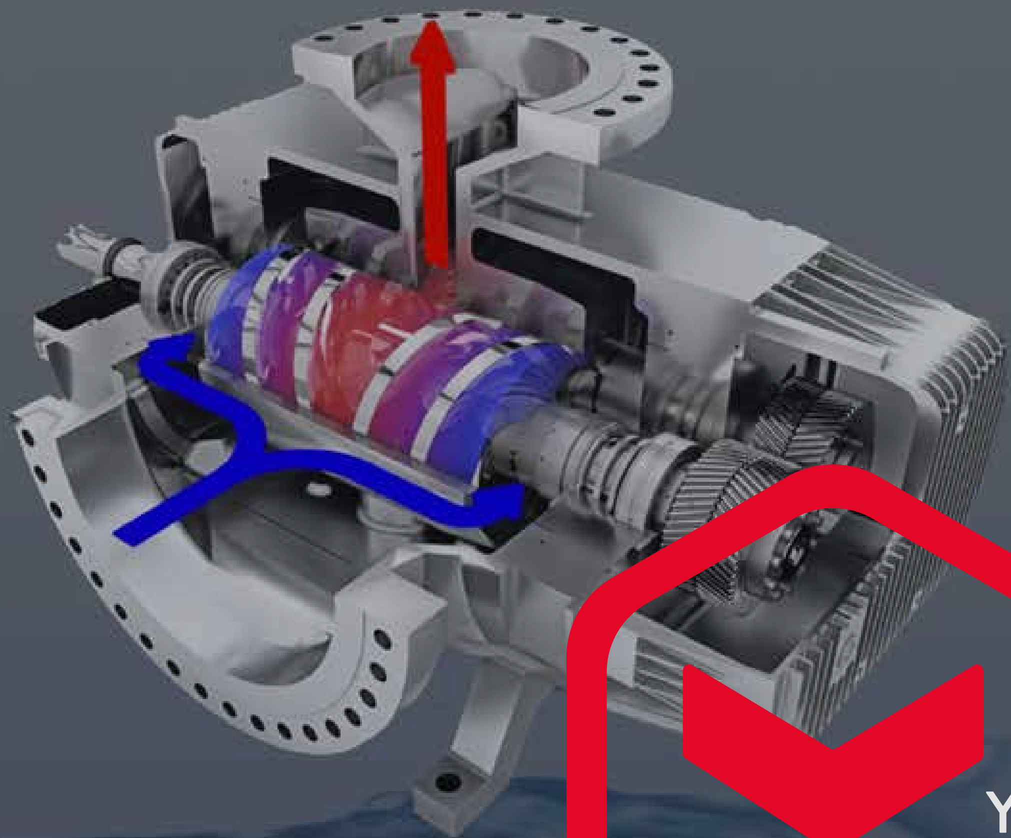

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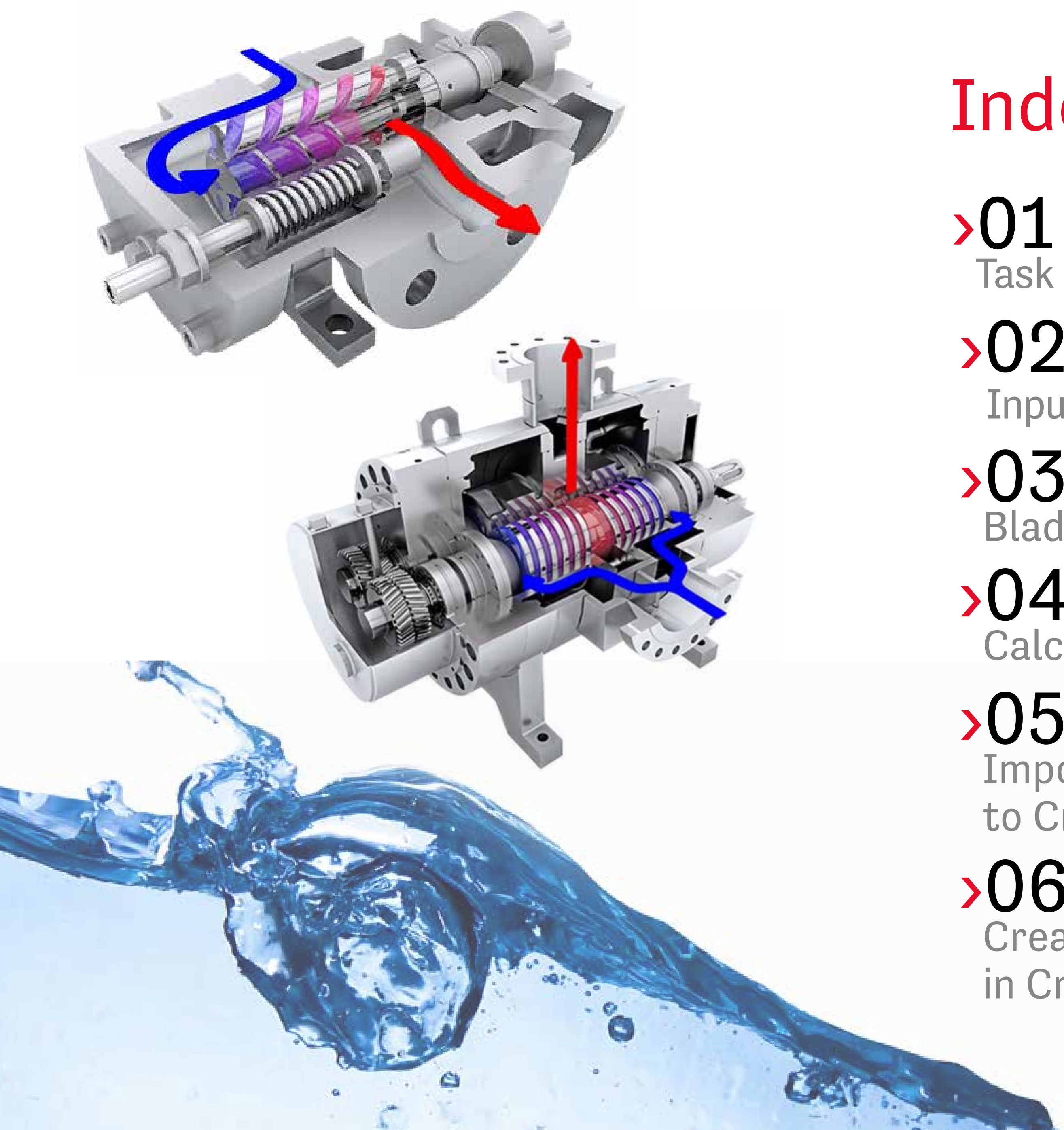
Customer References

Design of a single curving impeller for centrifugal pump

Ing. Massimo Arcolin



Index

›01

Task objectives

›Creo Parametric Essentials
›Creo AAX (Advanced Assembly Extension)
›Creo ISDX (Interactive Surface Design Extention)
›Mathcad
›Creo BMX (Behavioral Modeling Extension)

›Client: DWT Group Pump Manufacturing Spa

›Creating a Mathcad spreadsheet capable of generating the complete geometry of a Centrifugal pump impeller with a single curve blade profile

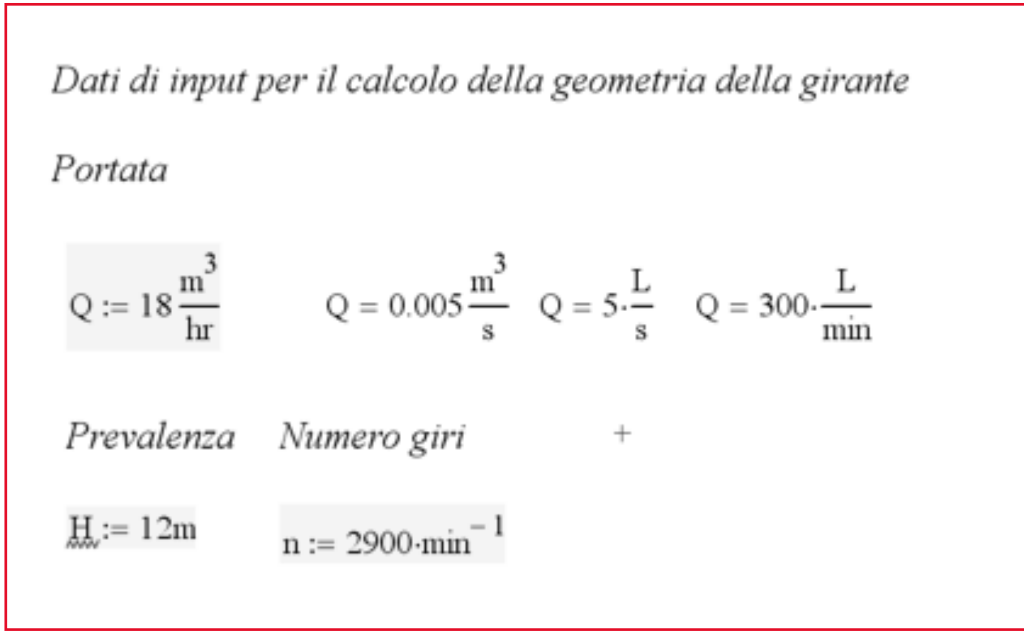
›Importing the geometry in associative mode to Creo Parametric Essentials: dynamic updating of the CAD geometry based on the modifications made to the spreadsheet

›02

Input data

Vincoli legati alle prestazioni della pompa:

- ›Flow rate (Q)
- ›Head (H)
- ›Number of revolutions (n)



Dati di input per il calcolo della geometria della girante

Portata

$Q := 18 \frac{m^3}{hr}$ $Q = 0.005 \frac{m^3}{s}$ $Q = 5 \cdot \frac{L}{s}$ $Q = 300 \cdot \frac{L}{min}$

Prevalenza *Numero giri*

$H := 12m$ $n := 2900 \cdot min^{-1}$

Pressure parameter (Ψ) and flow parameter (Φ) graphs in relation to the typical machine number (this data can be obtained from the literature)

›02

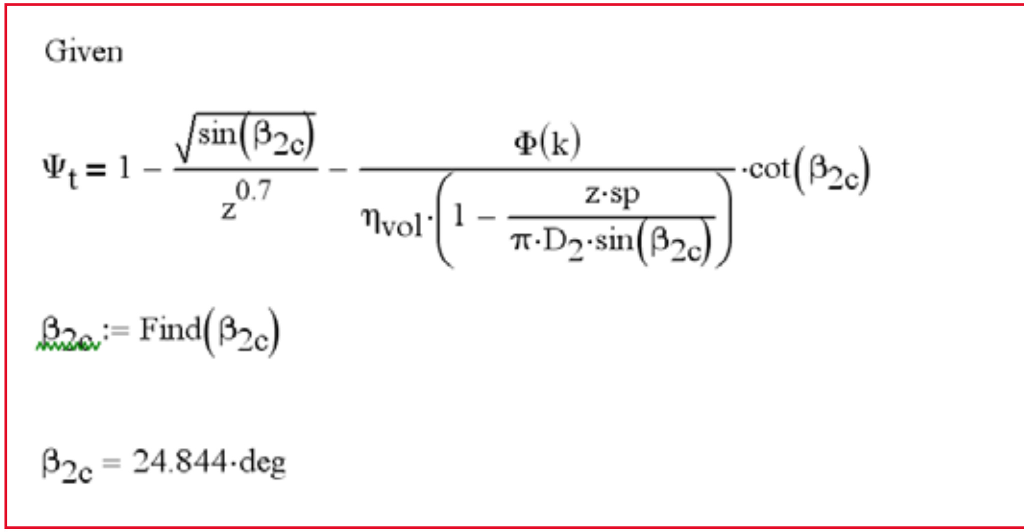
Input data

Calculating several geometrical parameters of the impeller:

- ›Impeller outlet diameter (D2)
- ›Inlet blade angle (β1)
- ›Outlet blade angle (β2)

This calculation is carried out by iteratively solving implicit functions (“Find” function in Mathcad)

The formula to find β2 (Wiesner) is given as an example



Given

$$\Psi_t = 1 - \frac{\sqrt{\sin(\beta_{2c})}}{z^{0.7}} - \frac{\Phi(k)}{\eta_{vol}\cdot\left(1 - \frac{z\cdot sp}{\pi\cdot D_2\cdot\sin(\beta_{2c})}\right)}\cdot\cot(\beta_{2c})$$

$$\beta_{2c} := \mathrm{Find}(\beta_{2c})$$

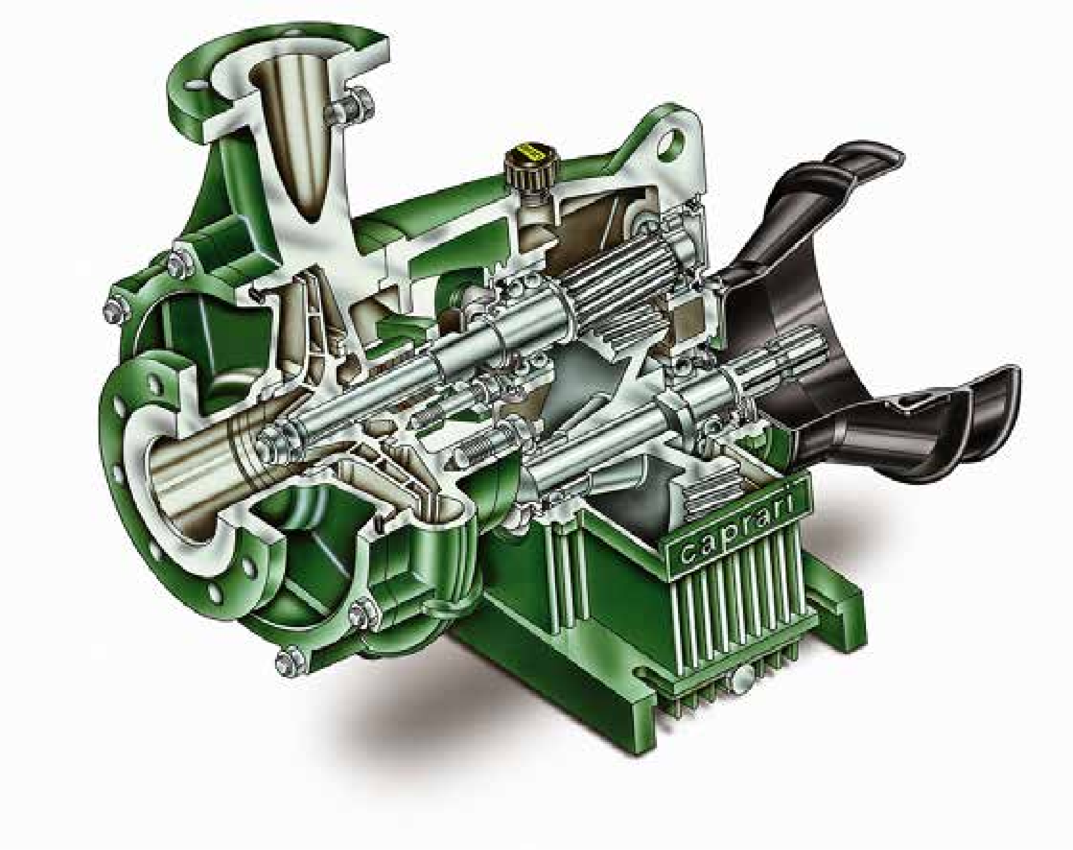
$$\beta_{2c} = 24.844\cdot deg$$

›02

Input data

The user inputs the remaining impeller geometrical parameters:

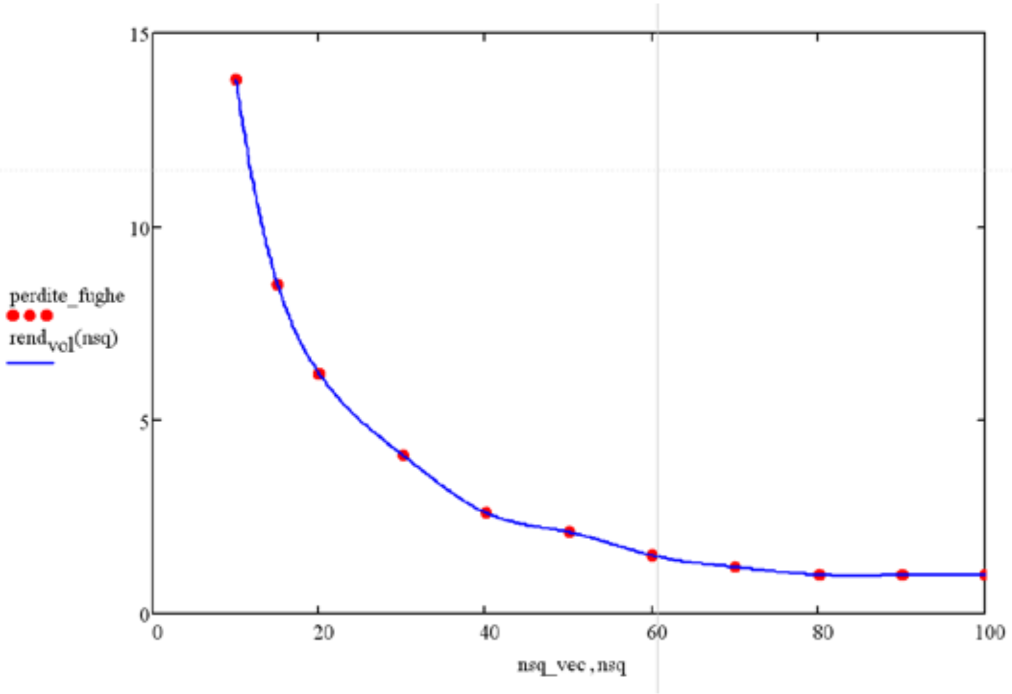
›Impeller inlet diameter
›Hub diameter
›Blade inlet diameter
›Blade thickness (inlet, mid-span, outlet)
›Blade thickness variation law
›Number of blades
›Impeller outlet port



›02

Input data

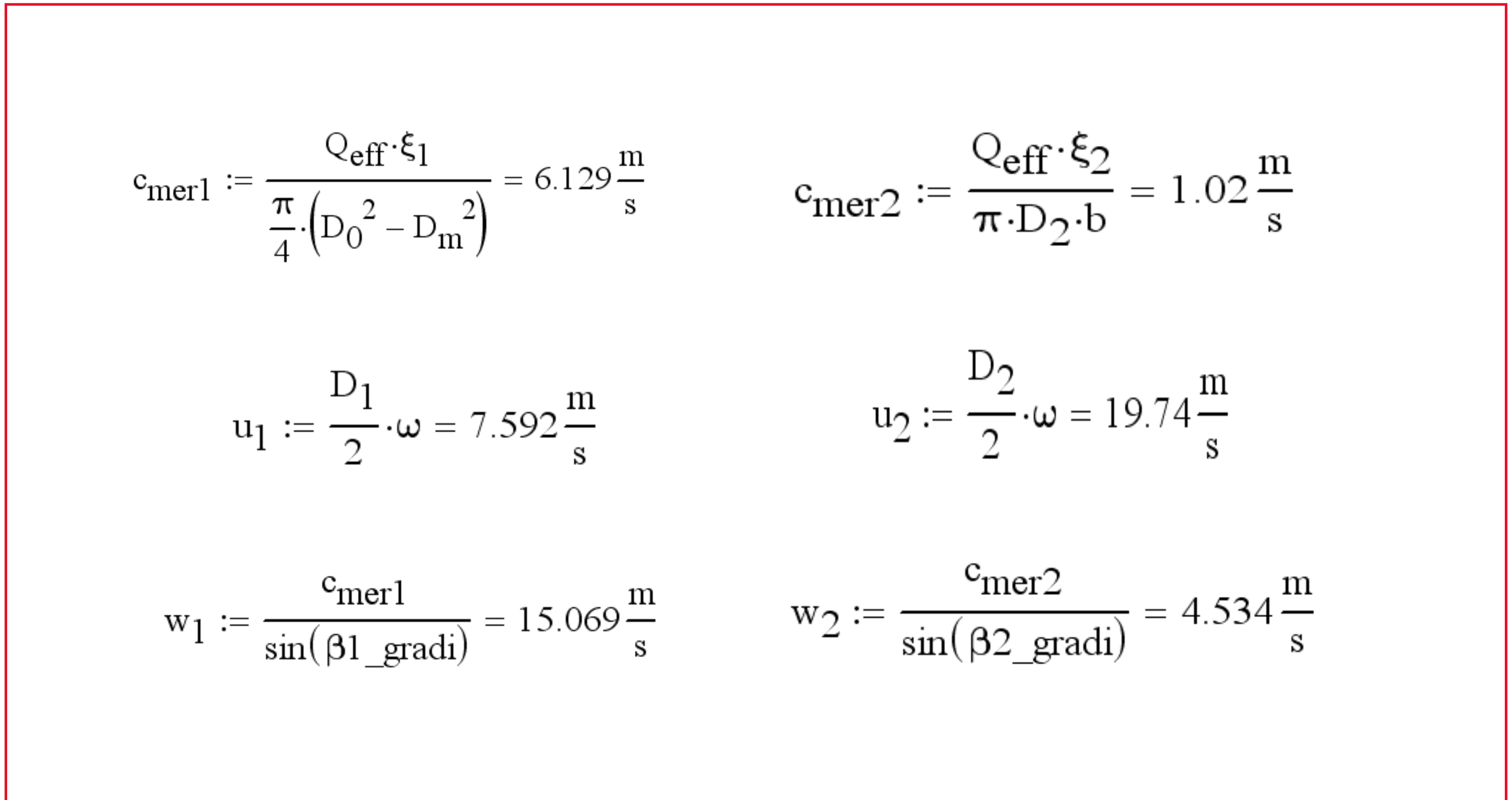
Volumetric output curves in relation to the characteristic kinematic number (data that can be obtained from the literature or from prior company know-how)



›03

Blade profile calculation

Calculate the velocity triangles at the impeller inlet and outlet



$$c_{mer1} := \frac{Q_{eff}\cdot\xi_1}{\frac{\pi}{4}\cdot\left(D_0^{\,2} - D_m^{\,2}\right)} = 6.129\,\frac{m}{s}$$

$$c_{mer2} := \frac{Q_{eff}\cdot\xi_2}{\pi\cdot D_2\cdot b} = 1.02\,\frac{m}{s}$$

$$u_1 := \frac{D_1}{2}\cdot\omega = 7.592\,\frac{m}{s}$$

$$u_2 := \frac{D_2}{2}\cdot\omega = 19.74\,\frac{m}{s}$$

$$w_1 := \frac{c_{mer1}}{\sin(\beta 1\_gradi)} = 15.069\,\frac{m}{s}$$

$$w_2 := \frac{c_{mer2}}{\sin(\beta 2\_gradi)} = 4.534\,\frac{m}{s}$$

›03

Blade profile calculation

Calculate the time for the fluid streamline to cross through the impeller (hypothesis: the mean acceleration of the fluid streamline within the impeller is constant)

$$c_{media} := \frac{cm1 + cm2}{2}$$

›

$$t2 := \frac{r2 - r1}{c_{media}} = 0.013161 \qquad t1 := 0$$

›03
Blade profile calculation

Calculate the angular coordinate of the fluid streamline:

$$\boxed{\varphi(t) := \int_0^t \frac{cm(t)}{r(t)\cdot\tan(\beta(t))}\,dt}$$

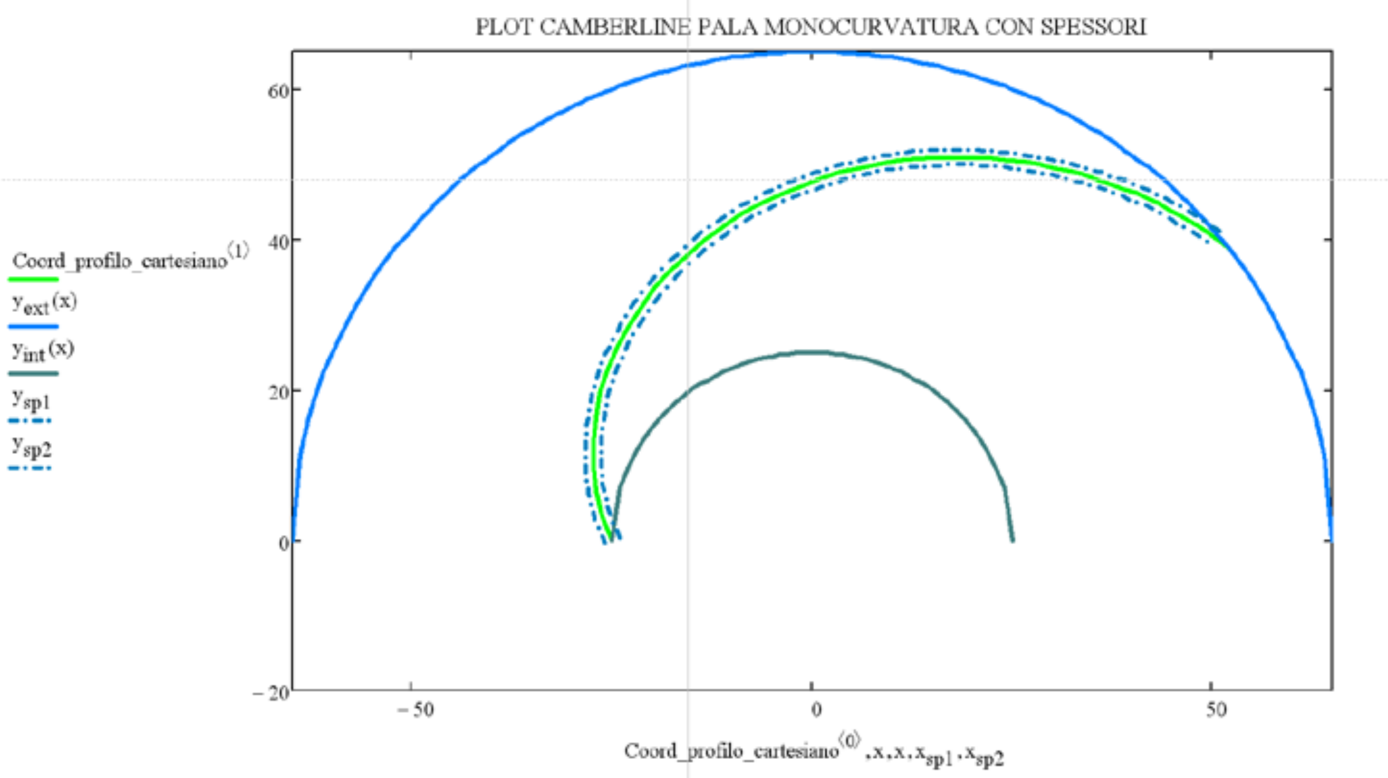
Calculate the radial coordinate of the fluid streamline: it is obtained by integrating the mean component of the absolute velocity

$$\boxed{r(t) := \frac{m_{cm}\cdot t^2}{2} + q_{cm}\cdot t + r1}$$

›03

Blade profile calculation

Blade profile and “camber line” thickening plot driven by the thickness form functions

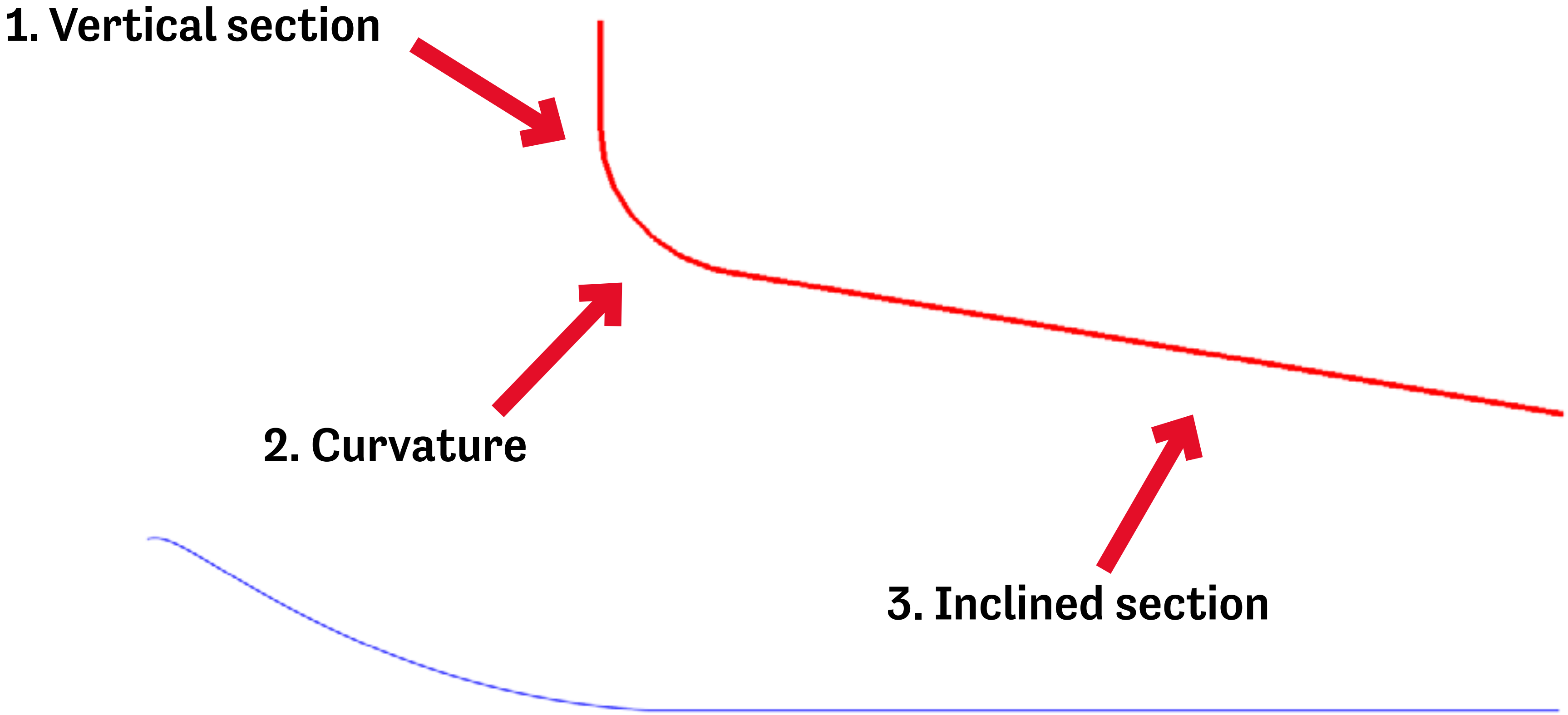


›03
Blade profile calculation

Exporting the blade profile to Creo Parametric Essentials

›04
Hub profile calculation

The hub profile comprises three geometrical entities:



1. Vertical section

2. Curvature

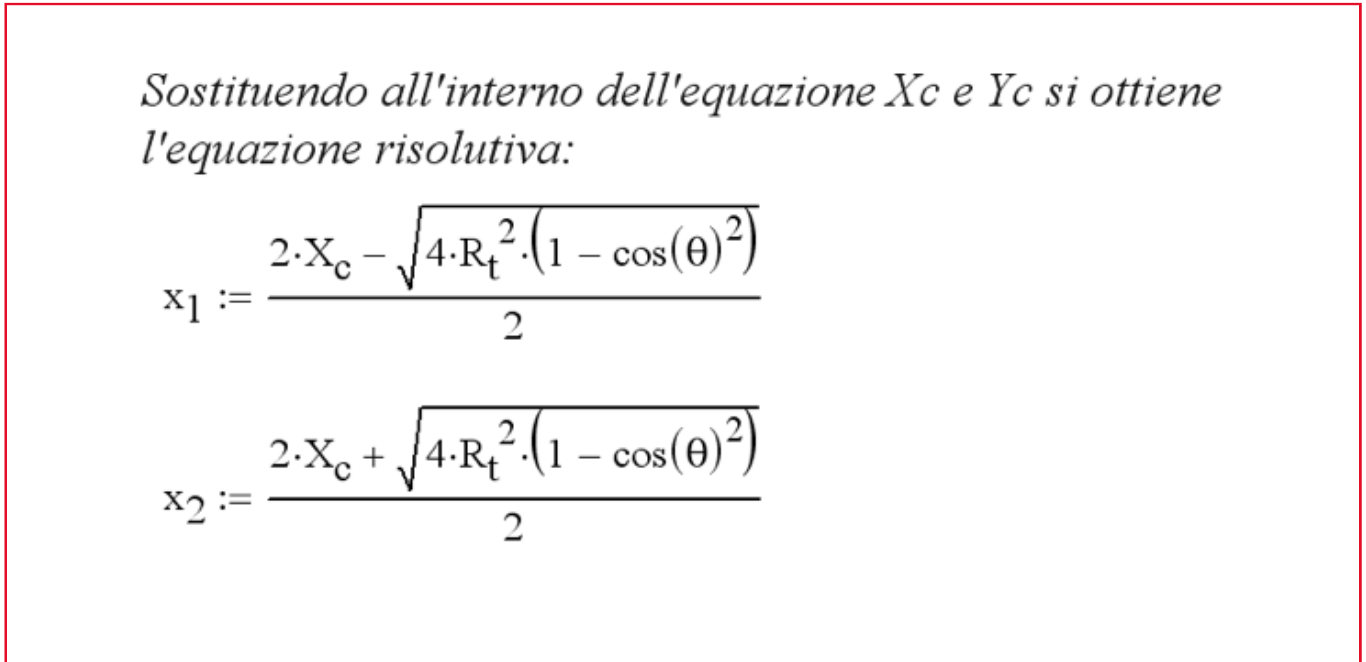
3. Inclined section

›04

Hub profile calculation

The inputs are:
- ›Angle of inclination of the inclined section
- ›Radius of curvature

The design coordinates of the hub are calculated and exported to Creo Parametric Essentials



Sostituendo all'interno dell'equazione Xc e Yc si ottiene l'equazione risolutiva:

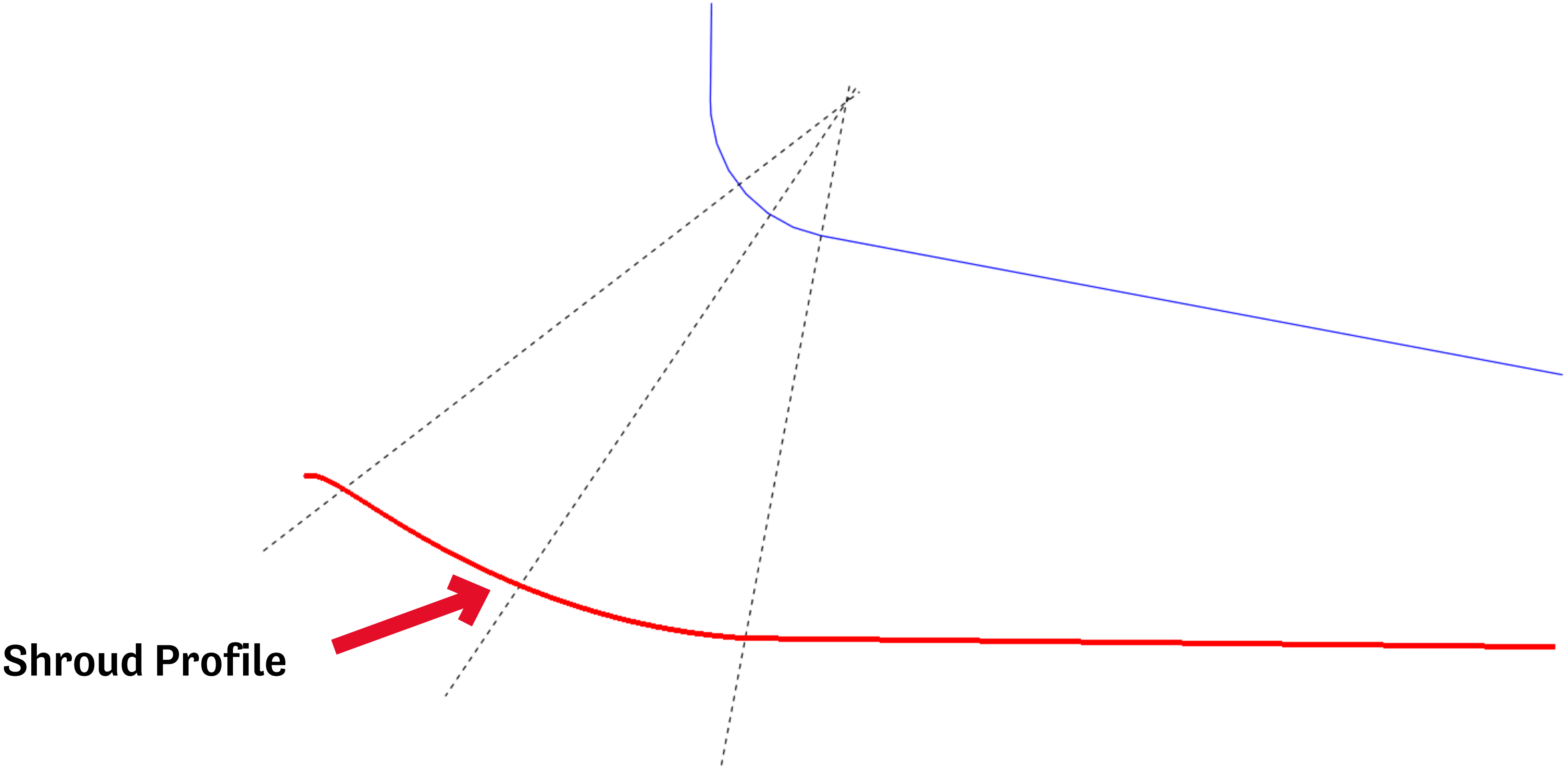
$$x_1 := \frac{2 \cdot X_c - \sqrt{4 \cdot R_t^{2} \cdot \left(1 - \cos(\theta)^{2}\right)}}{2}$$

$$x_2 := \frac{2 \cdot X_c + \sqrt{4 \cdot R_t^{2} \cdot \left(1 - \cos(\theta)^{2}\right)}}{2}$$

›04

Shroud profile calculation

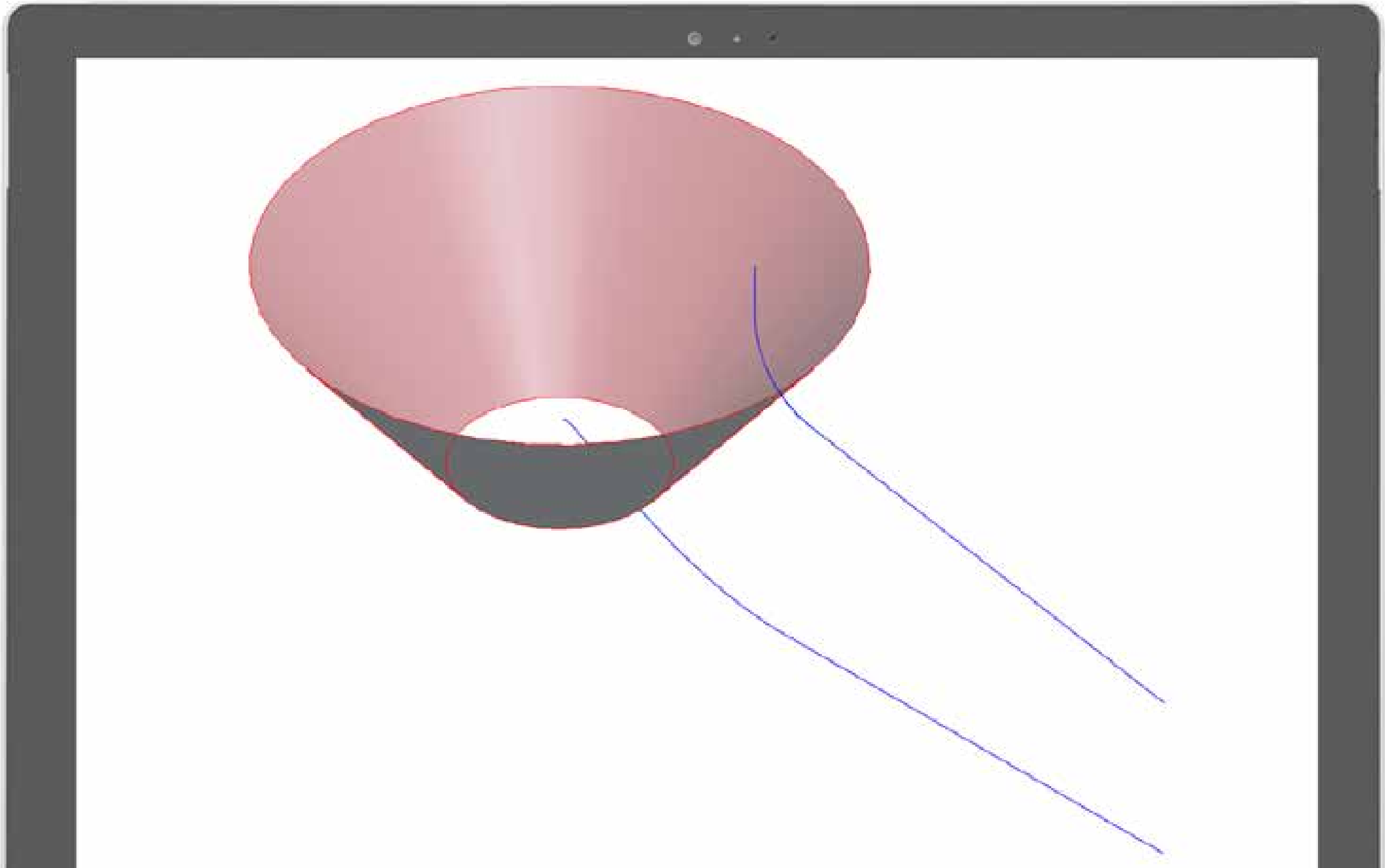
The shroud profile is made up of a single geometrical entity : it is built up by imposing a linear variation on the transit area



›04

Shroud profile calculation

In the curvature zone the transit area consists of a cone segment



›04

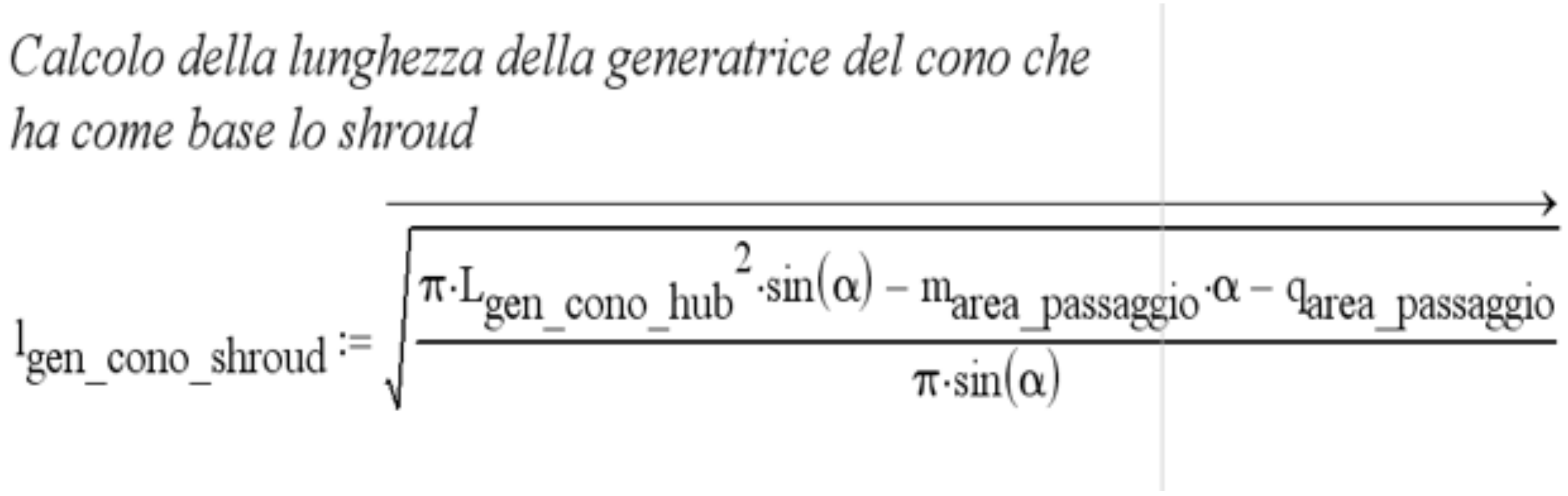
Shroud profile calculation

›The area is parametrized according to the angle of curvature

›Imposing a linear type variation of the area, it is possible to calculate the shroud profile using Mathcad

›04
Shroud profile calculation

›Solution equation



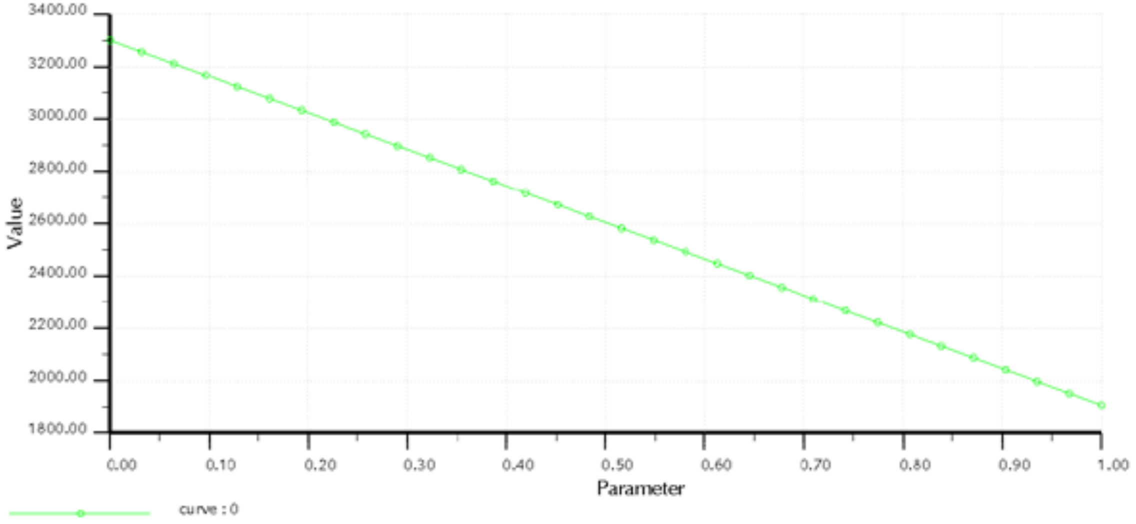
Calcolo della lunghezza della generatrice del cono che ha come base lo shroud

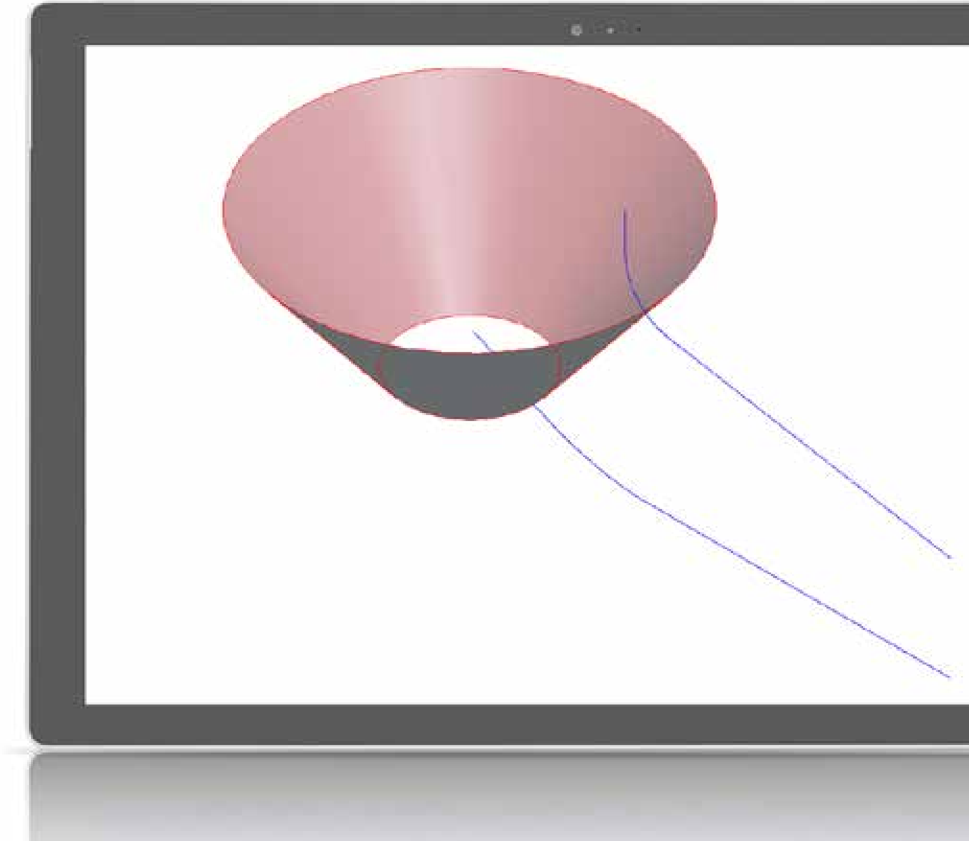
$$l_{gen\_cono\_shroud} := \overrightarrow{\sqrt{\frac{\pi \cdot L_{gen\_cono\_hub}^{2} \cdot \sin(\alpha) - m_{area\_passaggio} \cdot \alpha - q_{area\_passaggio}}{\pi \cdot \sin(\alpha)}}}$$

›04

Shroud profile calculation

›Checking for correct transit area trend using the BMX feature of Creo Parametric Essentials





›05

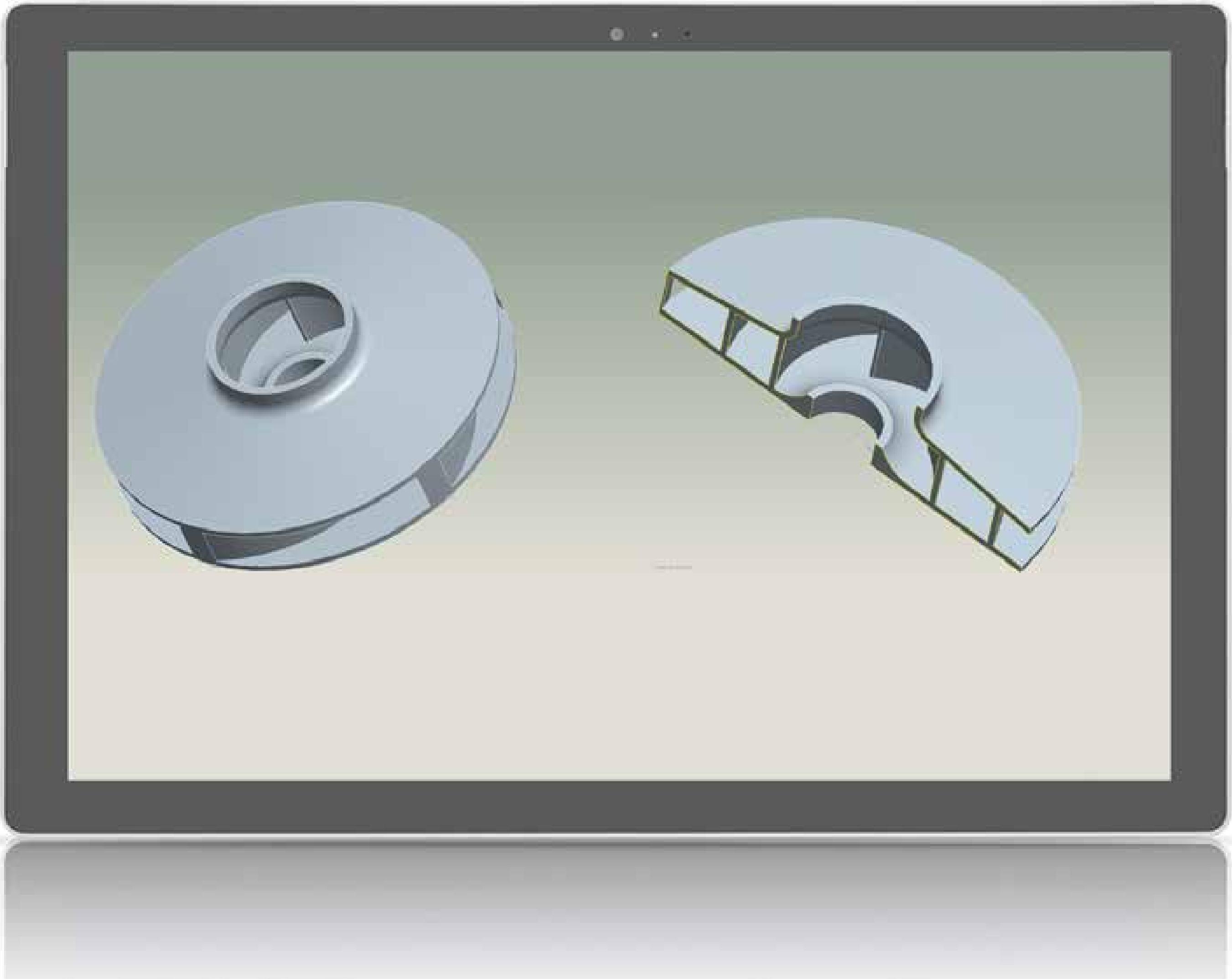
Importing the geometry into Creo Parametric Essential

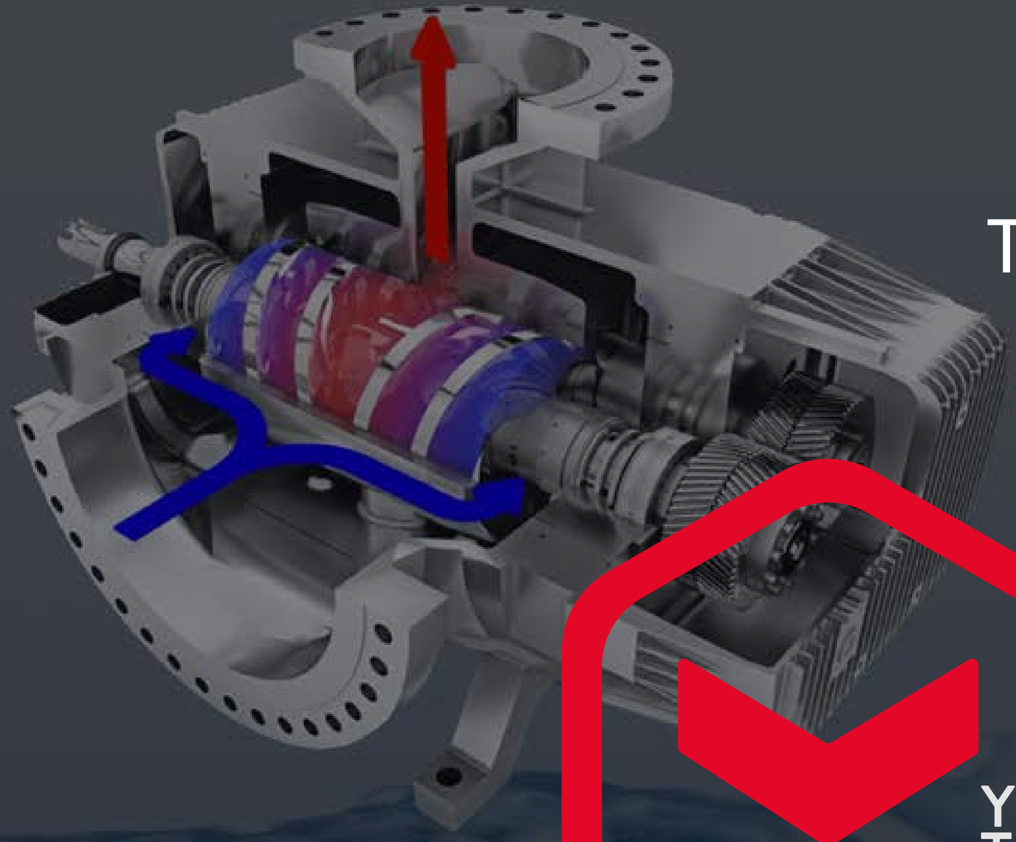
›The geometry and parameters calculated using Mathcad are exported
to Creo Parametric Essentials

›The spreadsheet is dynamically connected to the 3D model: each modification
of the design parameters gives rise to the geometry being automatically reconstructed

›06

Importing the geometry to Creo Parametric Essential





Thank you!

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