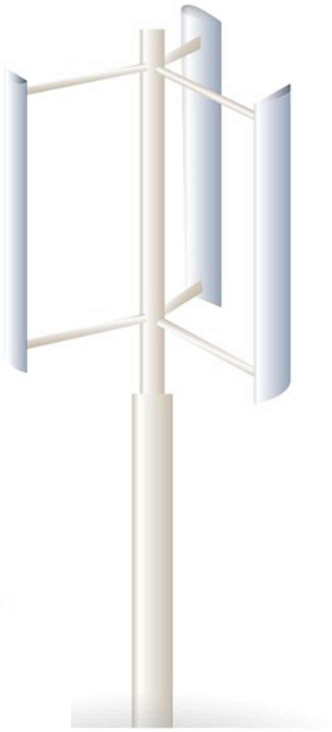
DISEGNO

FLUID MECHANICS
1 PRESSURE IN A FLUID
$P = \frac{F}{A} = \frac{Force}{Area}$
2 VARIATION IN PRESSURE WITH DEPTH
$P_h = P_o + \rho gh$
P_o
h
P_h
3 BAROMETER
Measures atmospheric pressure
$P_o = \rho gh$
Sealed Tube
h
Atmospheric Pressure
Atmospheric Pressure P
Container of Mercury
4 MANOMETER
Measures the Pressure of gas inside a container
$P - P_o = \rho gh$
P
P_o
h
5 PASCAL'S LAW
The pressure applied at one point in an enclosed fluid is transmitted uniformly to every part of the fluid and to the walls of the container.
$\frac{F_1}{S_1} = \frac{F_2}{S_2}$
F_1
S_1
S_2
F_2
6 HYDRAULIC LIFT
$P_2 = P_1$
$F_2 = P_1 S_2$
S_2
F_2
F_1
S_1
7 BERNOULLI'S PRINCIPLE
A simultaneous increase in the speed of fluid occurs with a decrease in pressure or a decrease in the fluid's potential energy.
$v_2 \Delta t = S_2$
$v_1 \Delta t = S_1$
P_1
P_2
v_1
v_2
A_1
h_1
h_2
$P + \rho gh + \frac{1}{2}\rho v^2 = constant$
8 EQUATION OF CONTINUITY
In steady flow, the mass of fluid entering per second at one end is equal to the mass of fluid leaving per second at the other end
$A_1 v_1 = A_2 v_2 = Constant$
Meaning that in steady flow the product of cross-section and the speed of fluid remains constant everywhere .
v_2
A_2
A_1
v_1
9 ARCHIMEDE'S PRINICIPLE
A body totally or partially submerged in a fluid is subjected to an upward force equal in magnitude to the weight of fluid it displaces.
$F_2 = V_i \rho_L g$
V_i : submerged volume of solid
Archimedes
water displaced by Archimedes
Archimedes

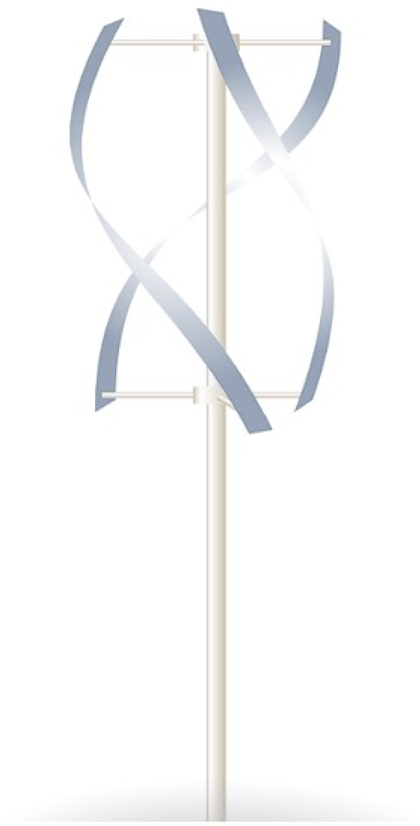
TURBINA EOLICA DARRIUS VERTICALE (VAWT)

La turbine Darrius (con le sue varianti) è fra le turbine ad asse verticale più diffuse per la produzione di energia elettrica. Questa tiplogia di turbine adotta profile alari della pale come nel caso di turbine ad asse orizzontale.

ad D

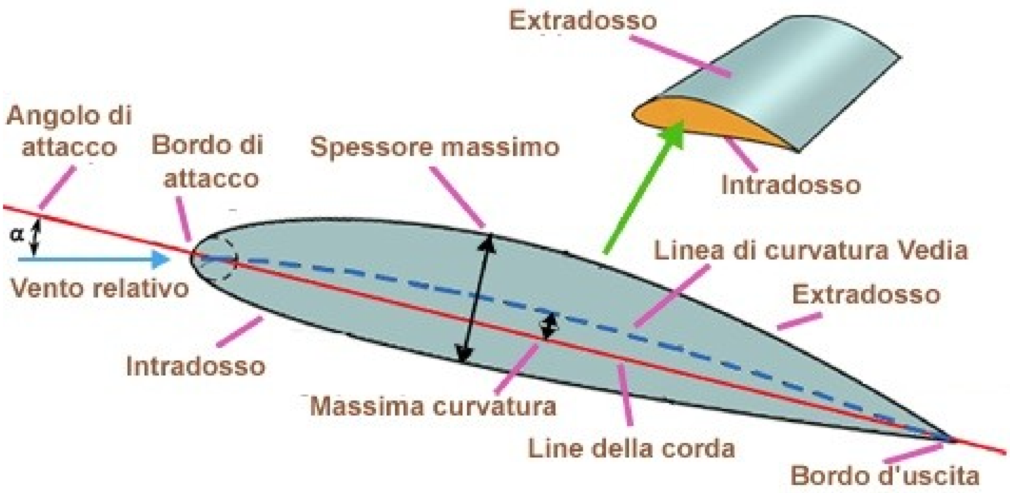


ad H

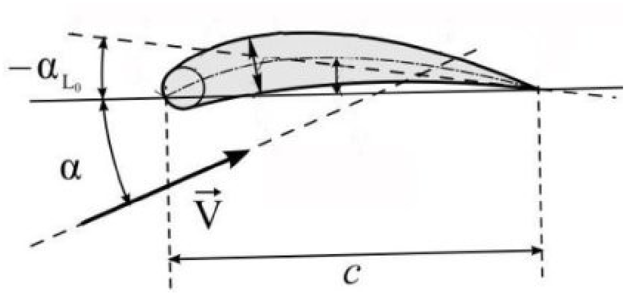


ad ELICA

DEFINIZIONI PROFILO ALARE



- Bordo d’attacco: il punto geometricamente più avanzato del profilo;
- Bordo d’uscita: il punto geometricamente più arretrato del profilo;
- Corda: la linea retta che unisce il bordo d’attacco con il bordo d’uscita;
- Extradosso (Dorso): la linea che delimita superiormente il profilo;
- Intradosso (Ventre): la linea che delimita inferiormente il profilo;
- Linea curvatura media: la linea che unisce i punti equidistanti tra dorso e ventre;
- Spessore: la distanza tra dorso e ventre misurata perpendicolarmente alla corda o alla linea di inarcamento medio;
- Freccia (Massima curvatura): distanza tra linea media e corda misurata perpendicolarmente alla corda;
- Angolo d’attacco geometrico (Incidenza geometrica): angolo formato dalla corda con la direzione della corrente indisturbata;
- Linea di portanza nulla: linea lungo la quale è investito il profilo senza generare portanza;
- Angolo di portanza nulla: angolo formato tra la corda e la direzione di portanza nulla;



- Incidenza aerodinamica: angolo formato dalla linea di portanza nulla con la direzione della corrente indisturbata;
- Centro di pressione: punto in cui possiamo immaginare applicata la risultante delle forze aerodinamiche; al variare dell’angolo d’attacco, varia la posizione del centro di pressione.

The performance of a VAWT relies principally on its airfoil, which obtain lift or drag forces necessary to produce high efficient torque at its edge. Airfoil design and selection is an important task that depends on three main parts: wind flow conditions, airfoil shape and modelling.

Currently, Darrieus (*) VAWT (based on lift aerodynamic force) uses the commercial NACA0018 (**) airfoil. In a previous research [Claessens (2006)], a new airfoil for these turbines is developed. He presents the DU06W200 airfoil, which improves the performance of the NACA0018. The research made experiments and modelling of the airfoil based on Blade Element Momentum (BEM) theory. After that, [Castelli et al. (2012)] compared the airfoils DU06W200 and NACA0021. He evaluated their energy performance and aerodynamic forces that interact between the three wind turbine blades. The analysis was done with the commercial CFD software "Fluent 6.3.26" (***) at wind speed of 9 [m/s] (much higher than the found at the "Cañón del Chicamocha") under three different turbulence models: k-ω SST, k-ε Realizable and Spalart-Allmaras. [Chandrala et al. (2013)] analyzed the NACA0018 airfoil for horizontal wind turbines at wind speed of 32 [m/s]. He used the commercial software "ANSYS CFX" with the standard "k-E" turbulence model. Finally, [Boutilier (2011)] developed an experimental investigation of transition over the NACA0018 airfoil at a Reynolds number of $1x10^5$. He focused the work specifically at the shear layer.

This research determines experimentally the feasibility installation of VAWT at "Cañón del Chicamocha". Furthermore, the research is centered in the analysis of the airfoils DU06W200 and NACA0018 under the wind flow conditions at "Cañón del Chicamocha". The study uses CFD through the free software "OpenFOAM" (****) and the one equation turbulence RANS model developed by Spalart-Allmaras [NASA]. The difference between the airfoils can be seen at figure 1.

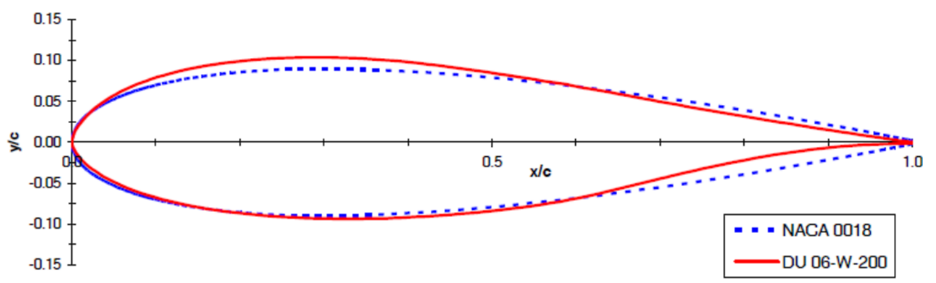


Figure 1. Comparison between airfoils NACA0018 and DU06W200 [Claessens (2006)]

ESPORTAZIONE FILE CON PROFILE ALARE

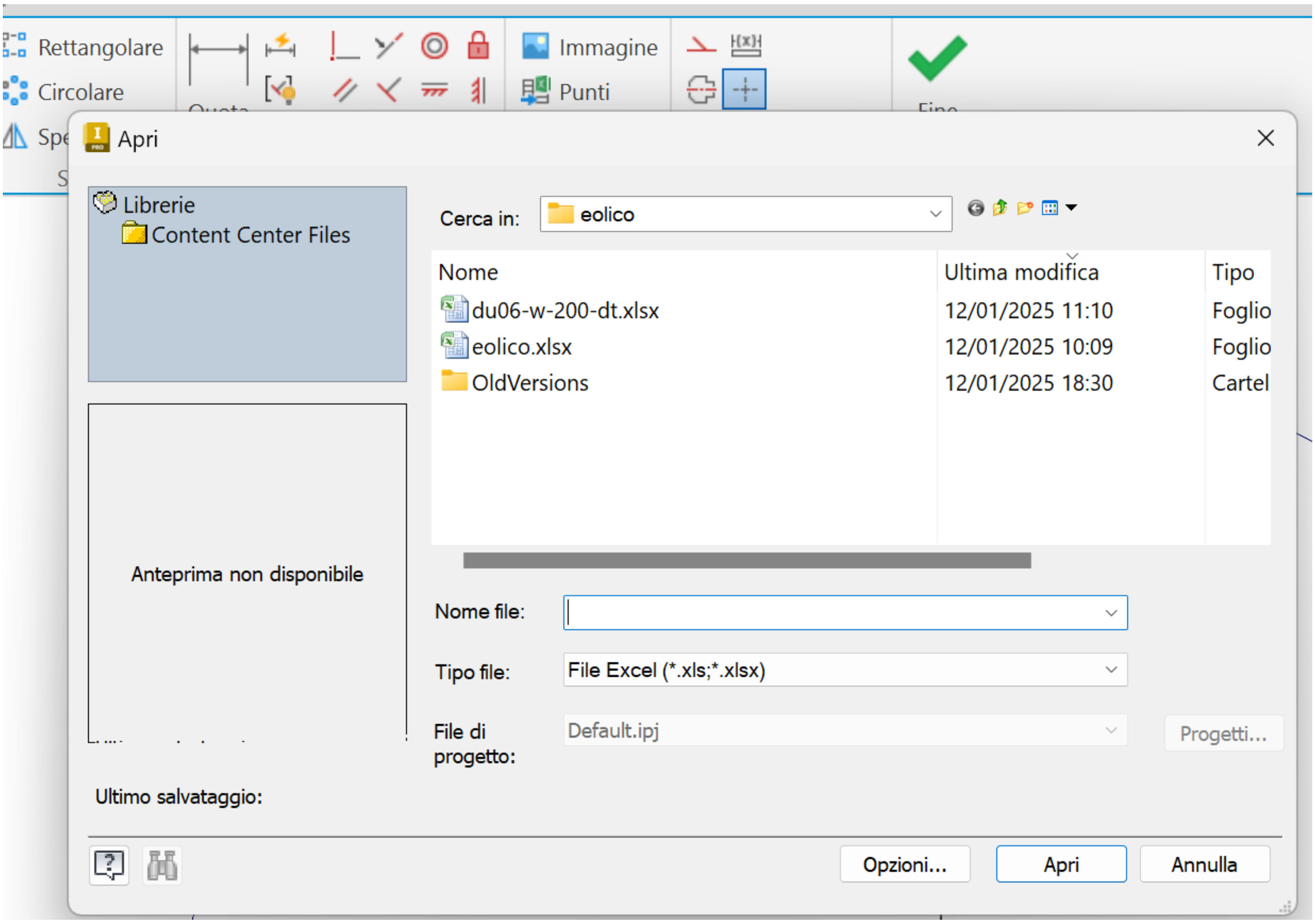
http://airfoiltools.com/plotter/index?airfoil=du06-w-200-dt

Il file di testo va modificato per essere importato in excel in modo da essere compatibile con l'importazione di Inventor.

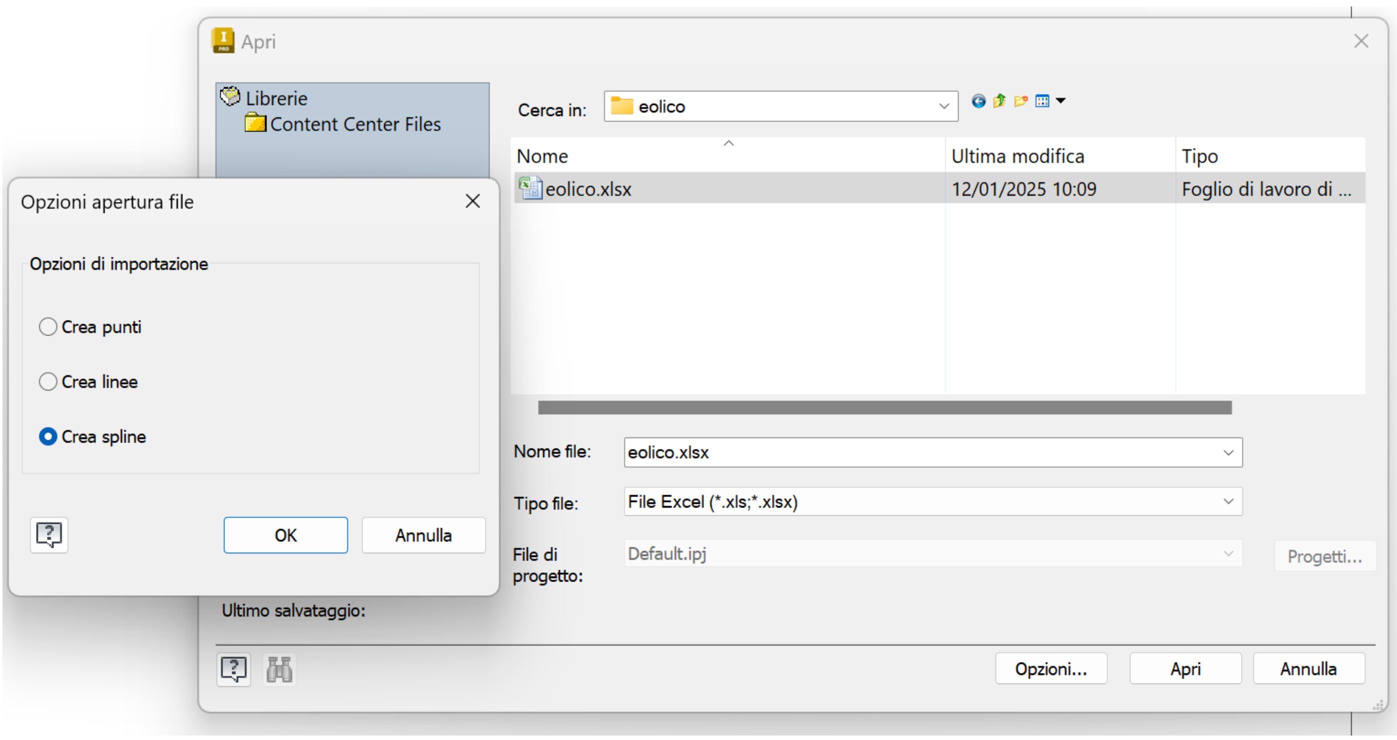
Il foglio dati deve avere due colonne con le coordinate x,y dei vari punti.

TURBINA DARRIUS CON PALE AD H (DRITTE)

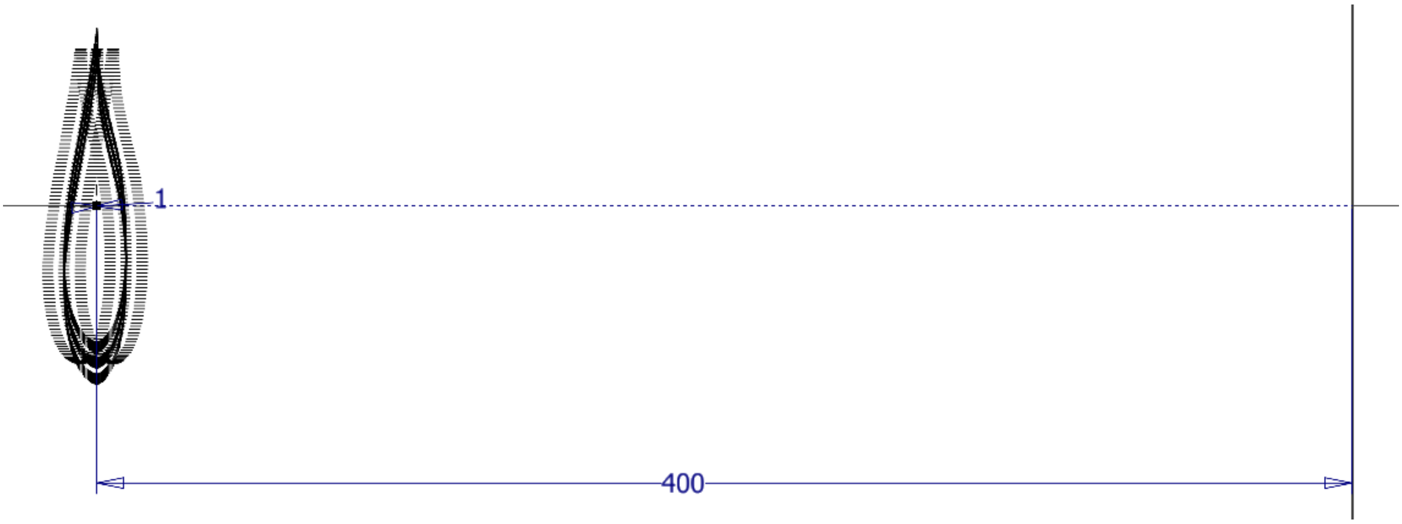
Creare uno schizzo 2D e cliccare su "Punti".



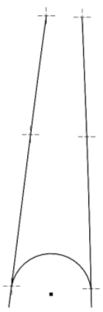
Abilitare nelle opzioni "Crea spline" per ottenere un profilo facilmente modioficabile.

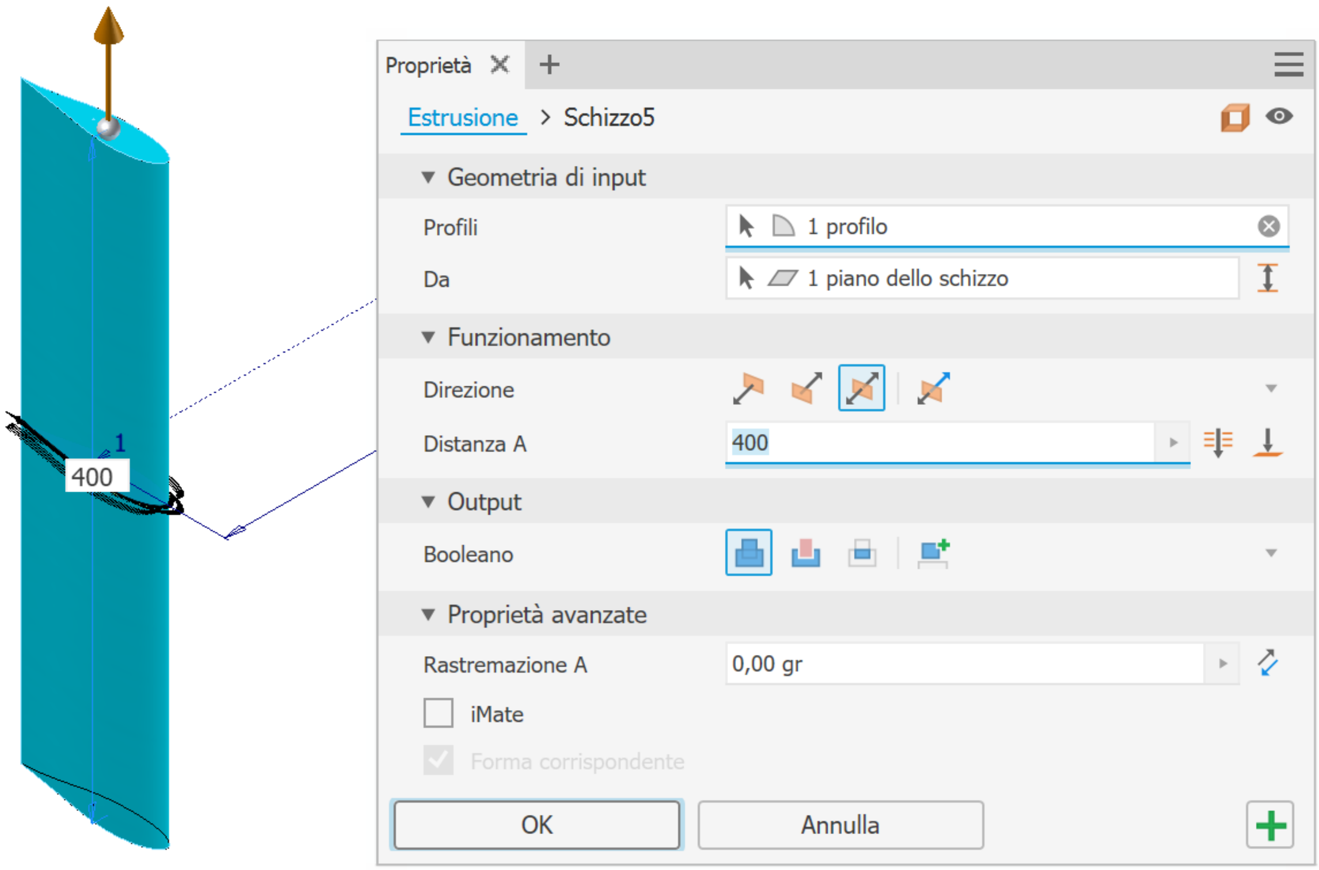


Spostare lo schizzo 2D come in figura:

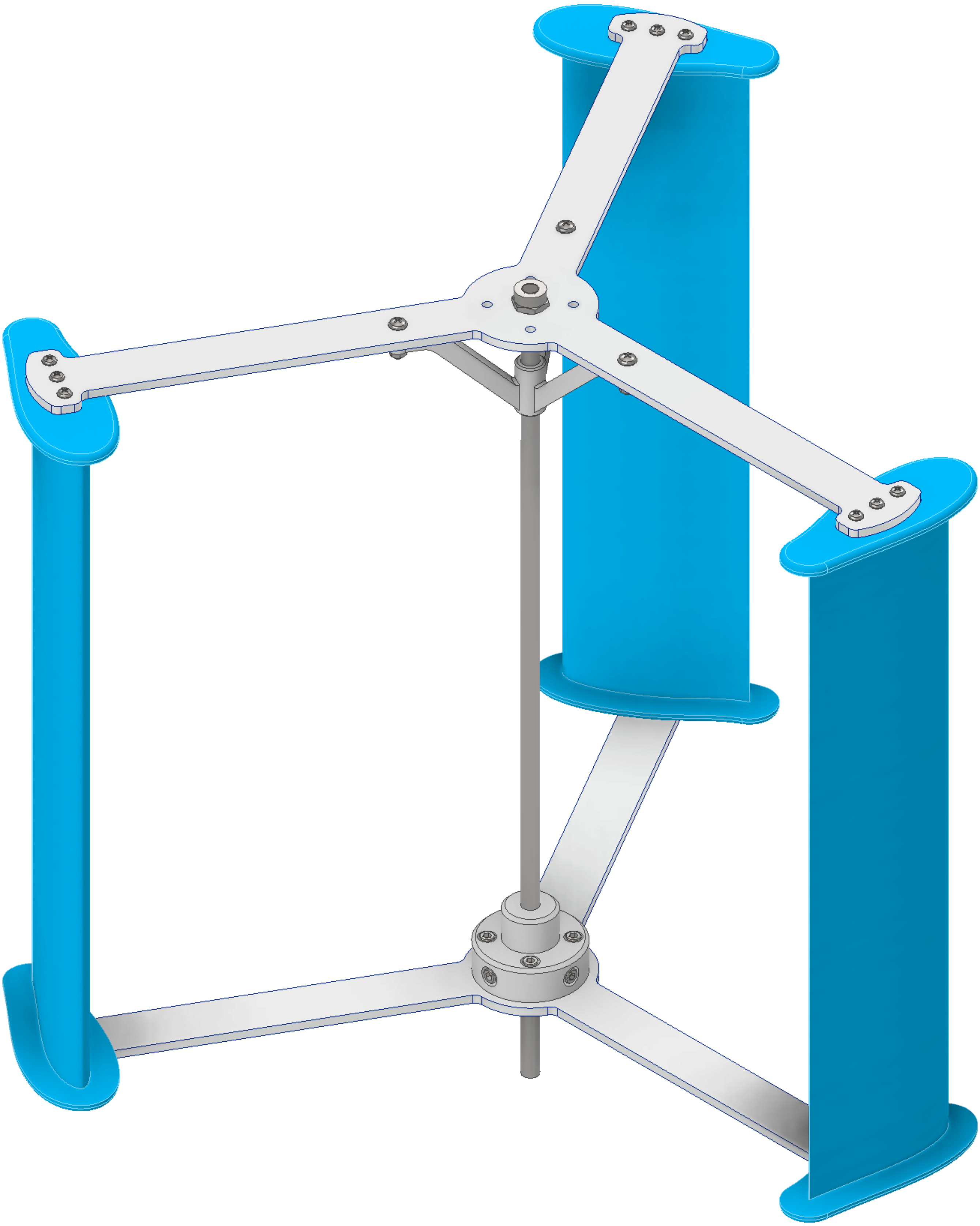


Chiudere la coda della schizzo con un piccolo arco in modo che si possa estrudere.

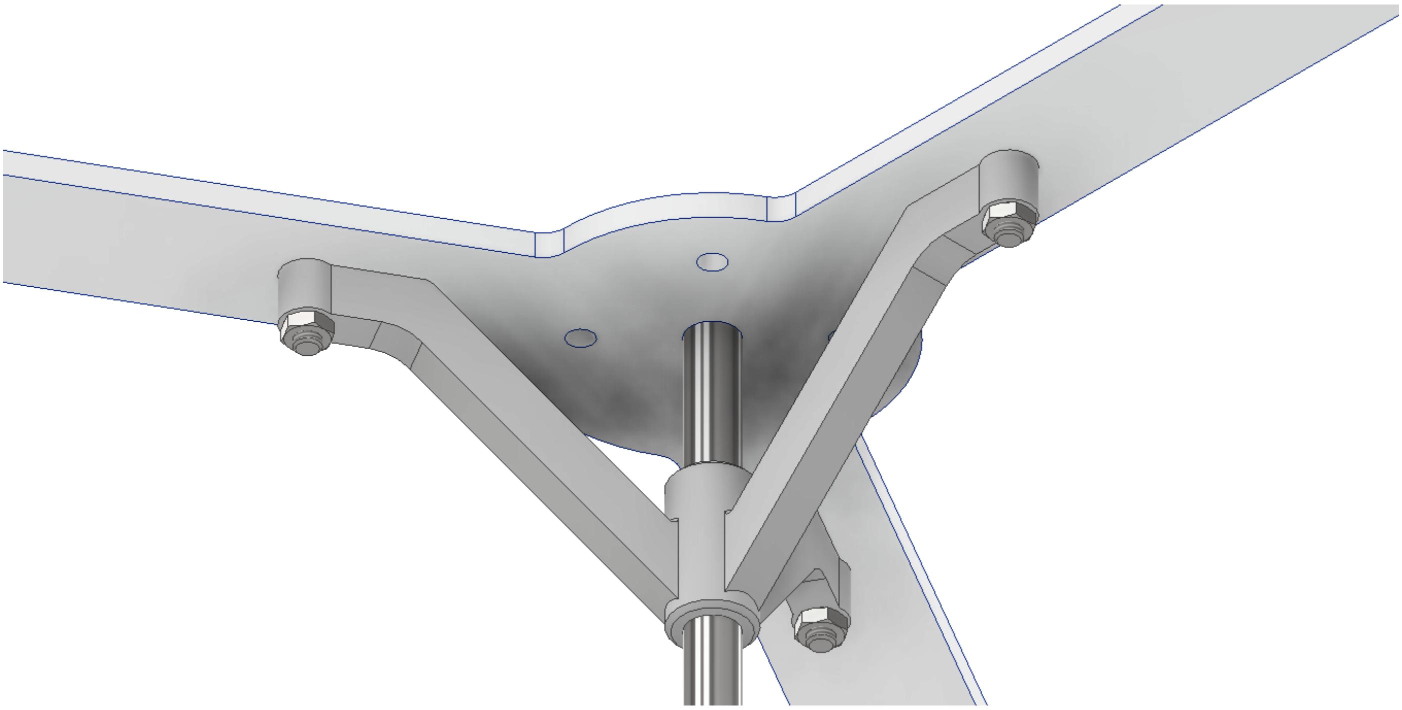




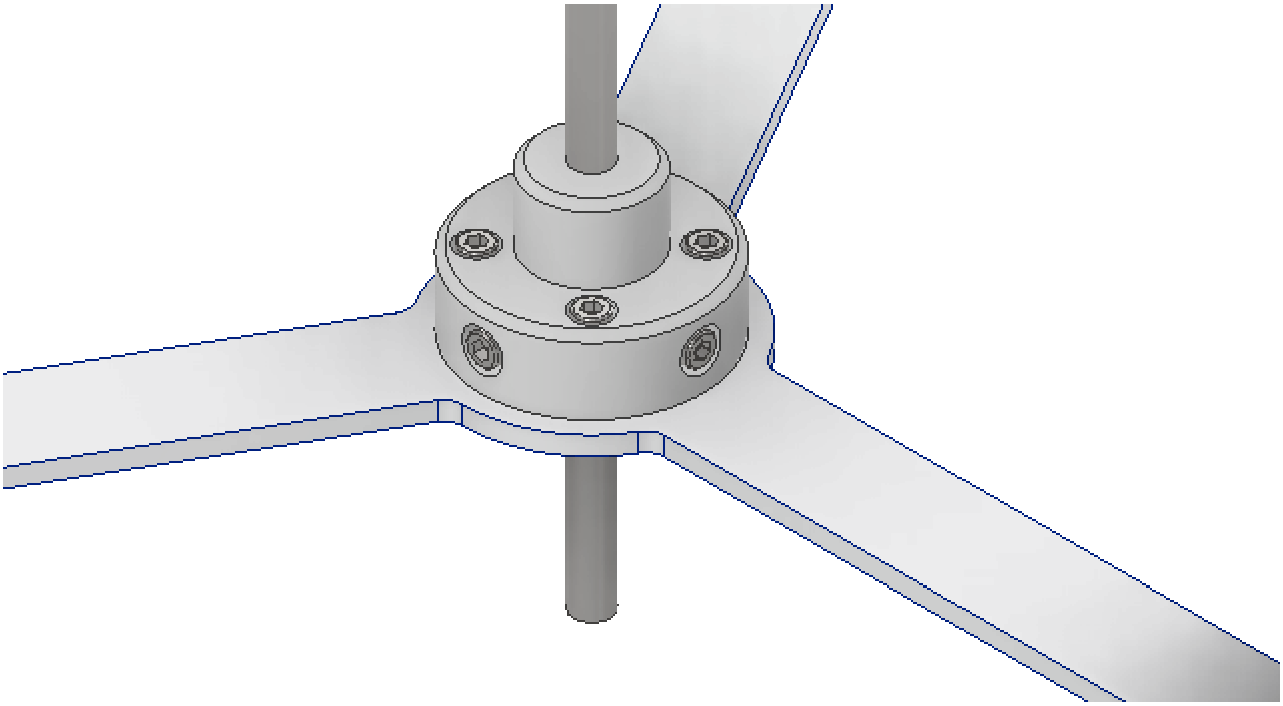
MODELLO FINALE DA REALIZZARE



Blocco superiore

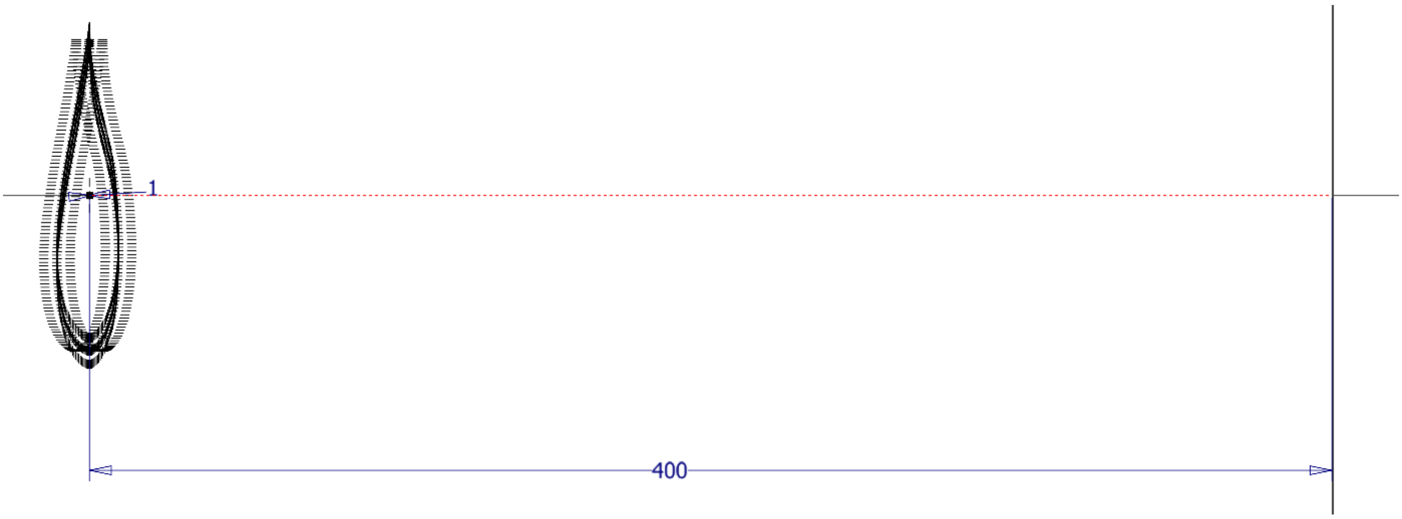


Blocco inferiore

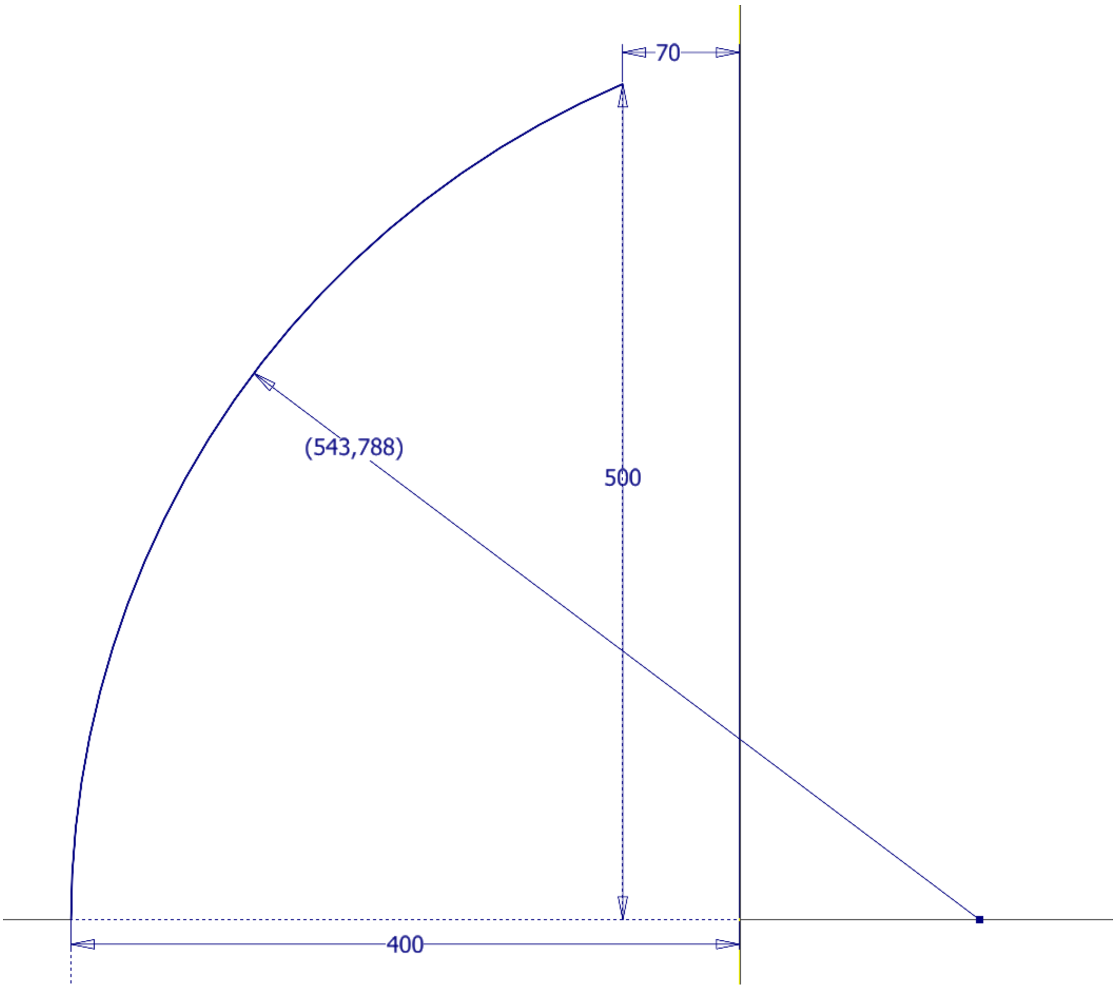


TURBINA DARRIUS CON PALE A D (CURVE)

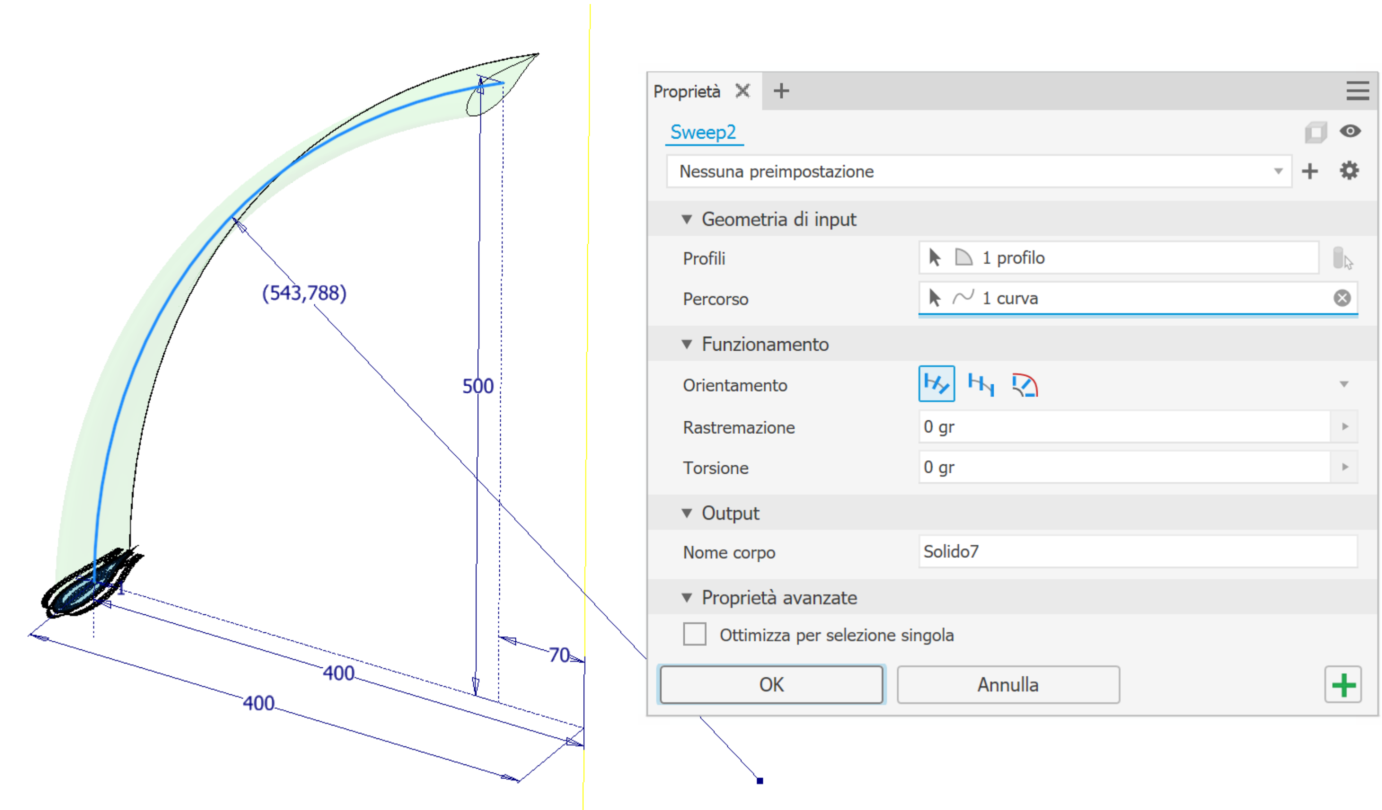
Importare il profilo alare in uno schizzo 2D e posizionarlo come in figura rispetto all'origine



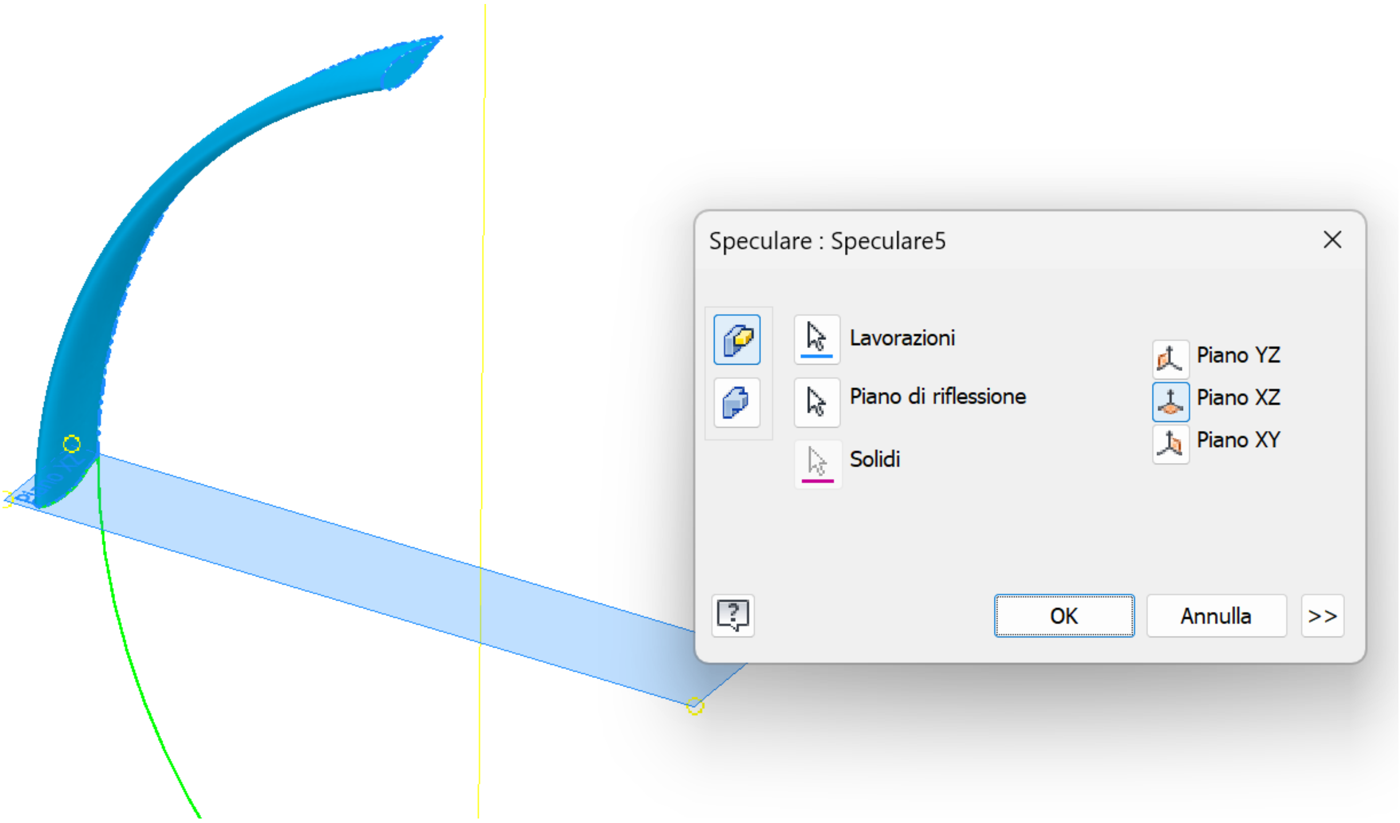
Creare un nuovo schizzo con l'asse mediano curvo della pala



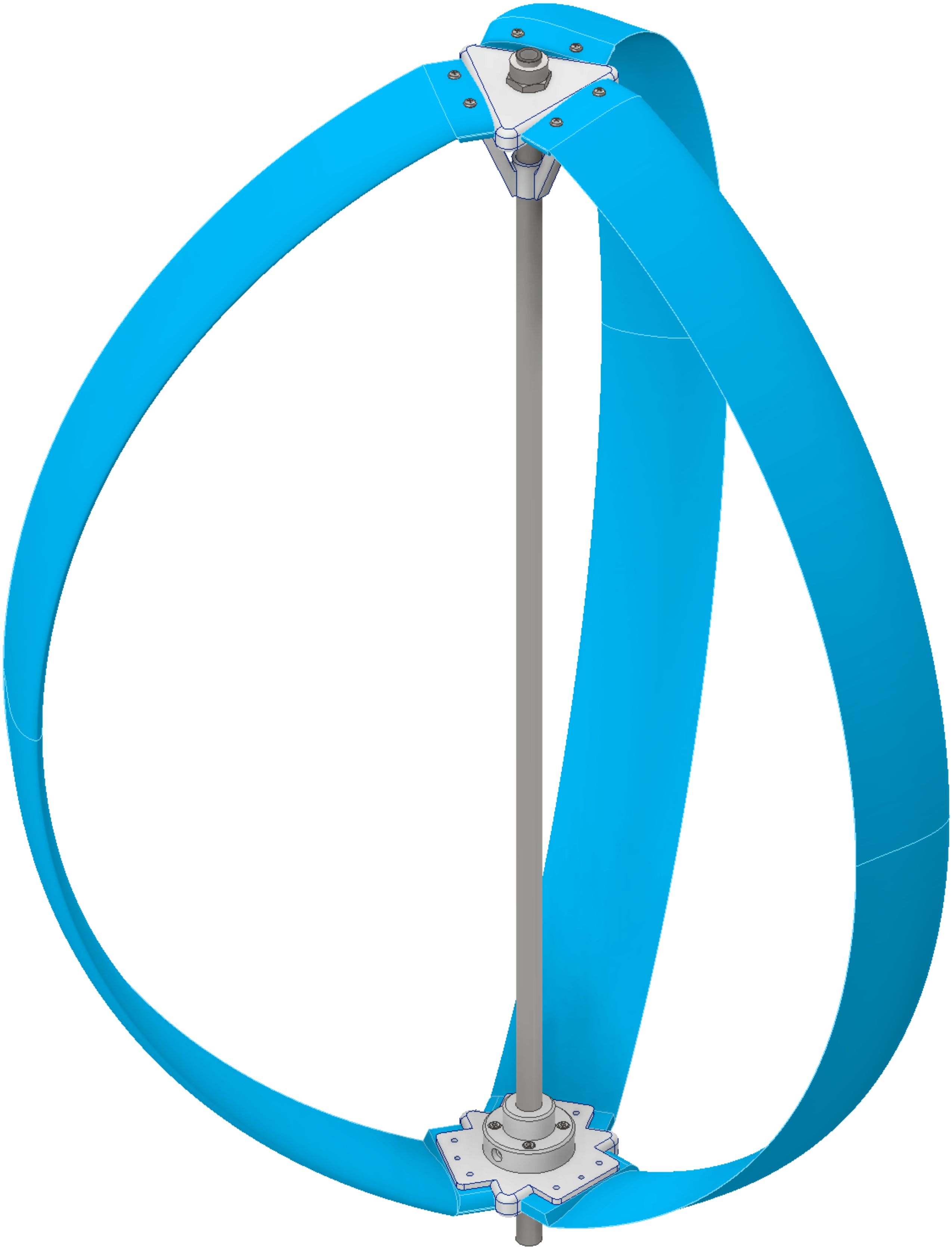
Usare il comando 3D “Sweep” per ottenere metà dell pala curva con i due schizzi precedenti.



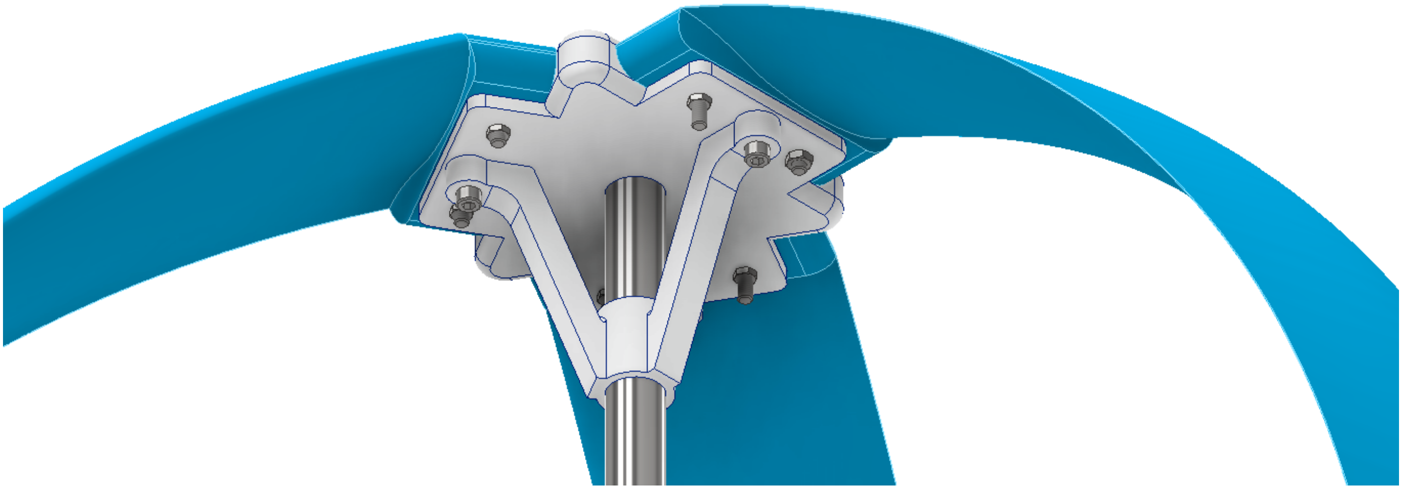
Usare il comando 3D “Speculare” per completare la pala.



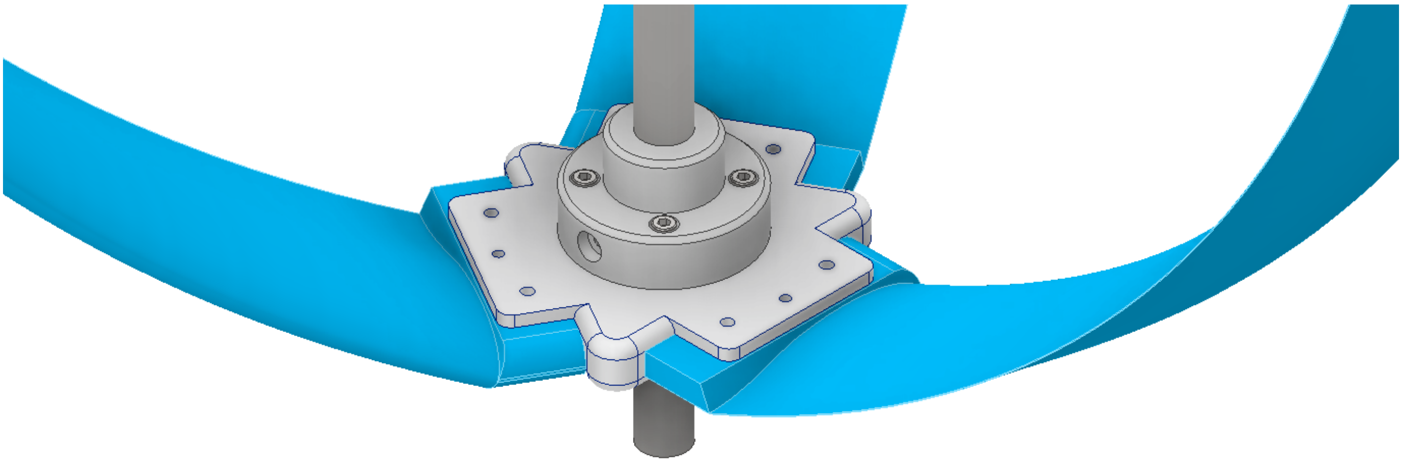
MODELLO FINALE



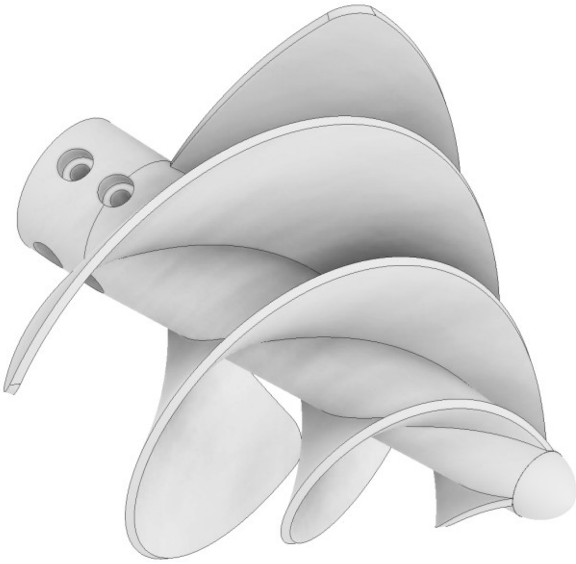
Blocco superiore



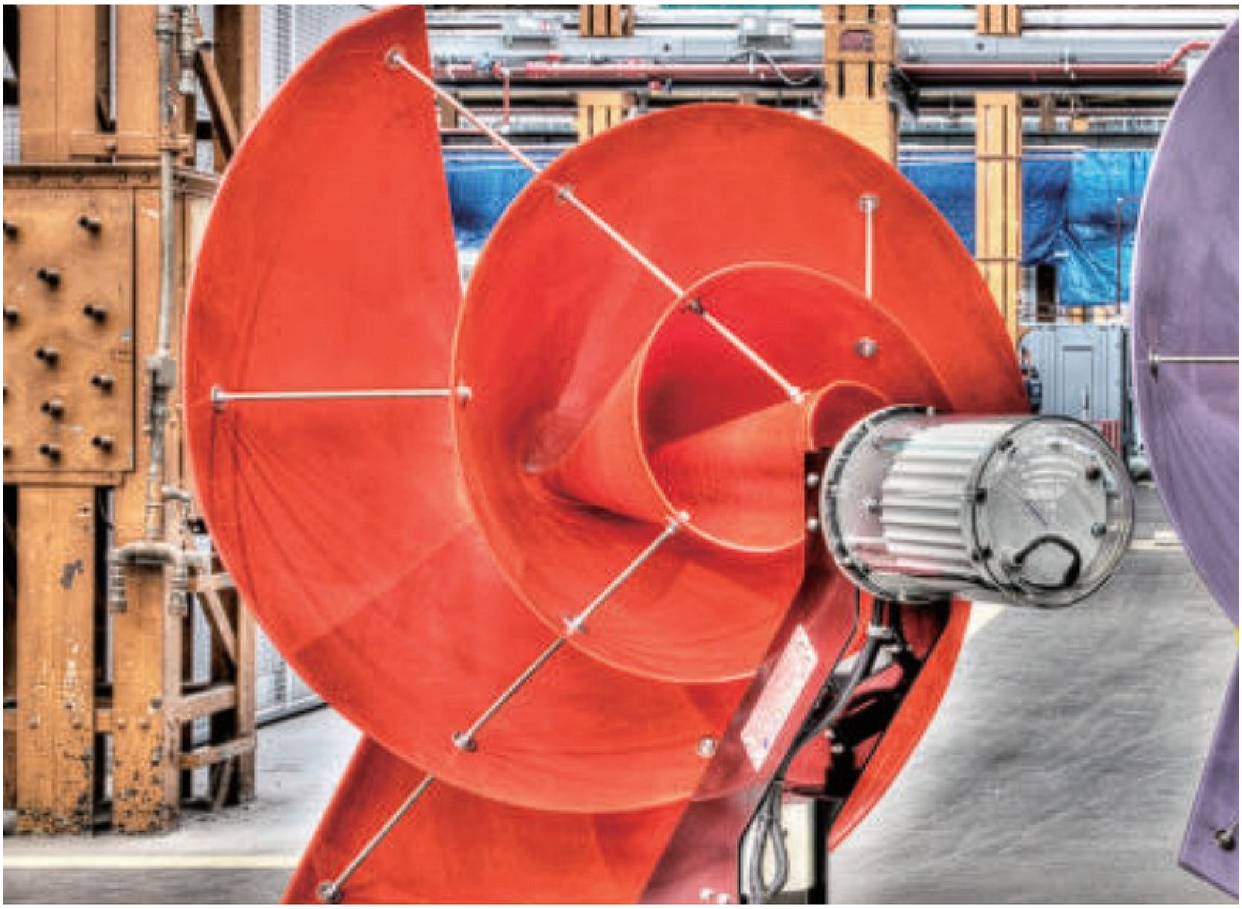
Blocco inferiore



TURBINA EOLICA ARCHIMEDE AD ASSE ORIZZONTALE



Video https://www.youtube.com/watch?v=BF7yX-7Wy30&t=40s

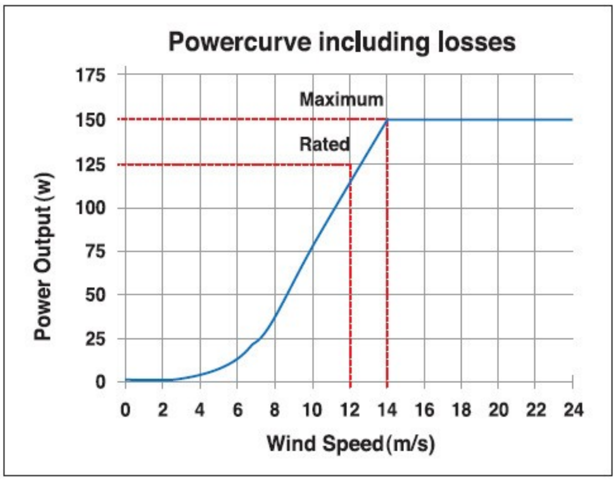


https://thearchimedes.com/

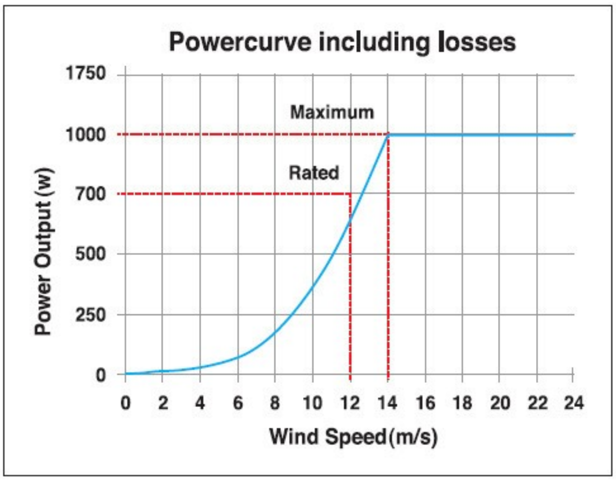
L'AWM si dimostra altamente efficiente (circa il 35% di tutta l'energia cinetica presente nell'aria), molto silenzioso (inferiore a 45 dBa), rispettoso degli uccelli e dei pipistrelli e con un design accattivante, adatto sia alle aree urbane che a quelle rurali.
L'AWM è disponibile in due dimensioni:
- Diametro di 1,5 metri con una potenza nominale di 550 w/h e un massimo di 700 w/h.
- Diametro di 0,75 metri con una potenza nominale di 100 w/h e un massimo di 150 w/h.

AWM wind turbines

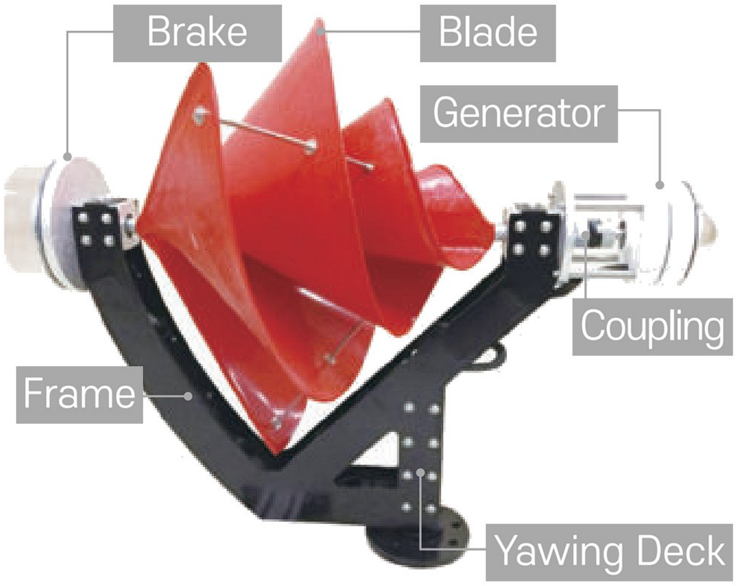
MODEL NAME		AWM - 750D - 150W	AWM - 1500D -1000W
POWER	RATED	125W	700W
	MAXIMUM	150W	1000W
WIND SPEED	OPERATING	0.9m/s (Cut in : 3m/s)	
	RATED	12m/s	
	CUT OUT	14m/s	
	SURVIVAL	50m/s	
BLADE RPM	RATED	600	330
	CUT OUT	600	400
SIZE		0.75m(W) x 1.1m(L) x 0.91m(H)	1.5m(W) x 1.9m(L) x 1.75m(H)
WEIGHT		32Kg	120Kg
CONTROL SYSTEM		MTTP control, Auto & Manual Braking System	



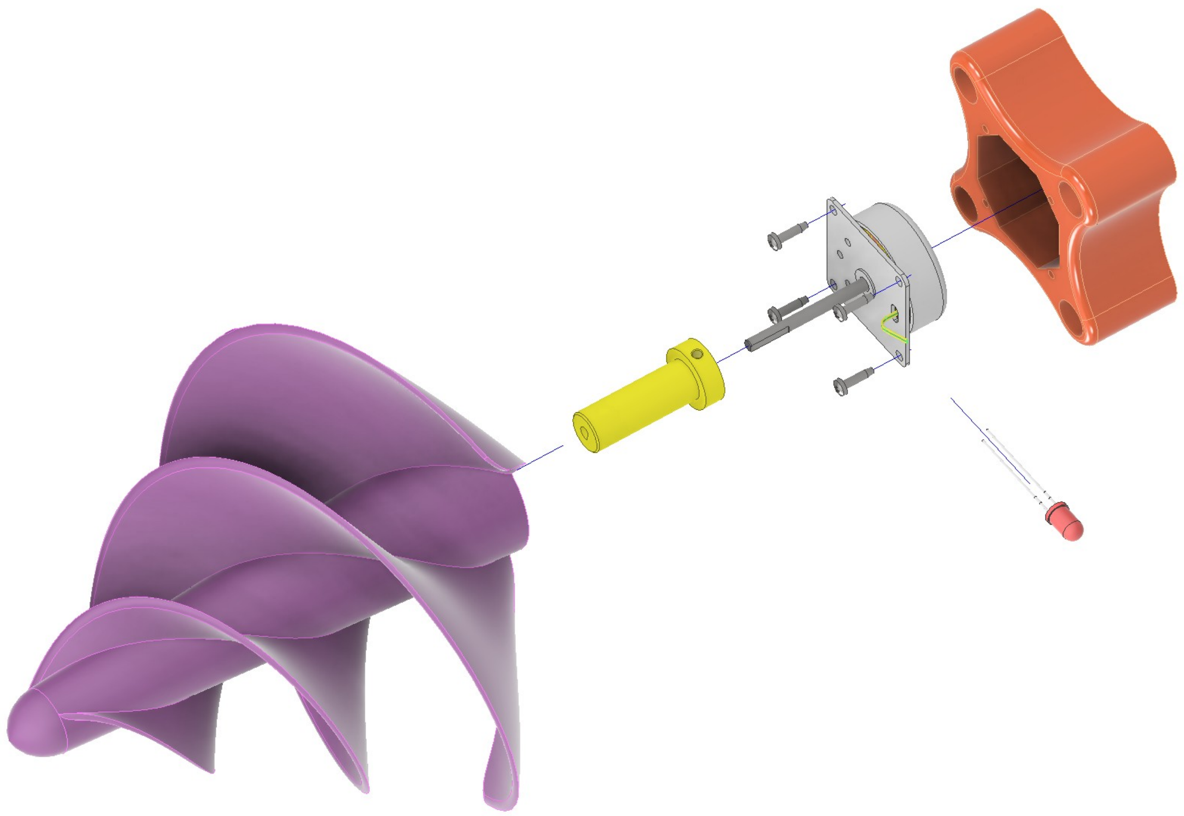
AWM - 750D - 150W

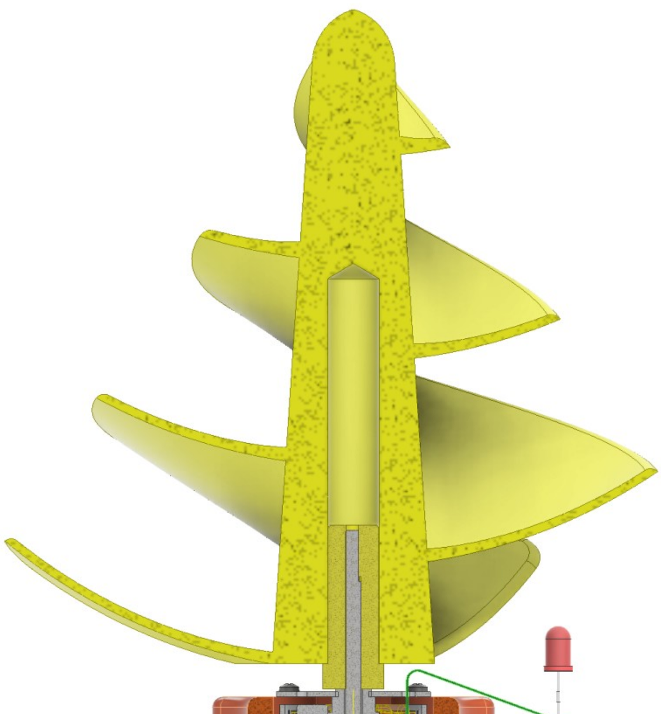


AWM - 1500D - 1000W



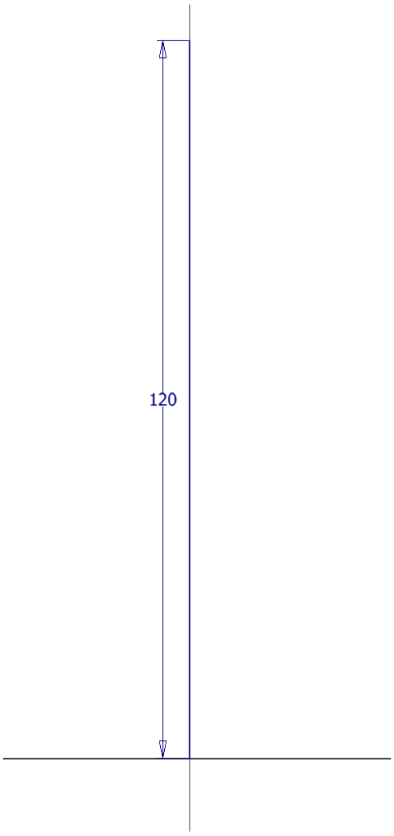
ASSIEME MODELLO

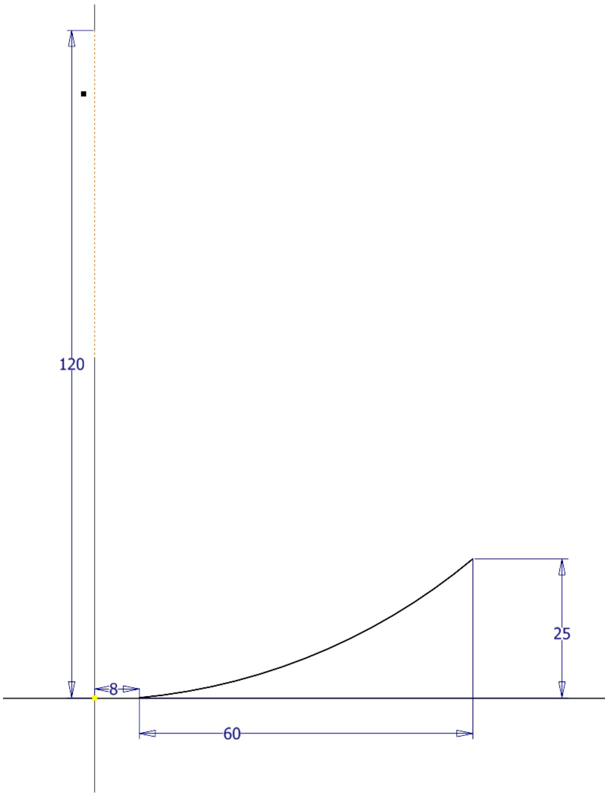




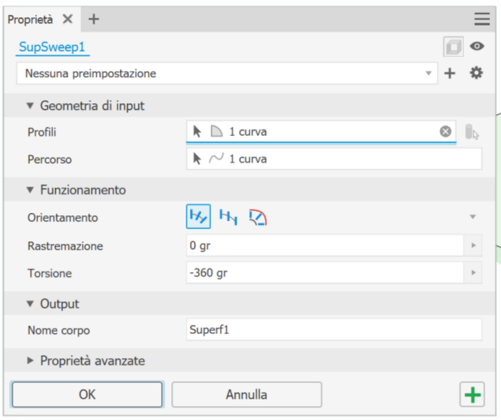
DISEGNO IN INVENTOR DEL ROTORE

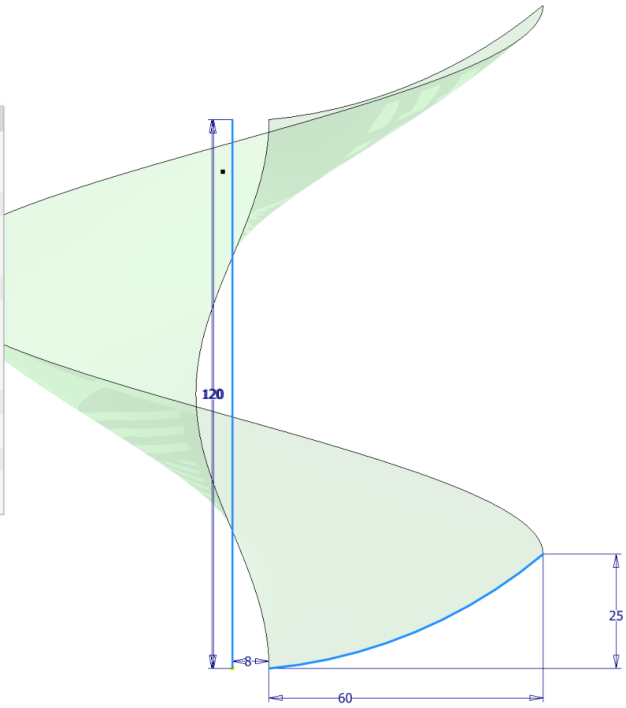
Creare due schizzi distinti come nelle figure sottostanti.



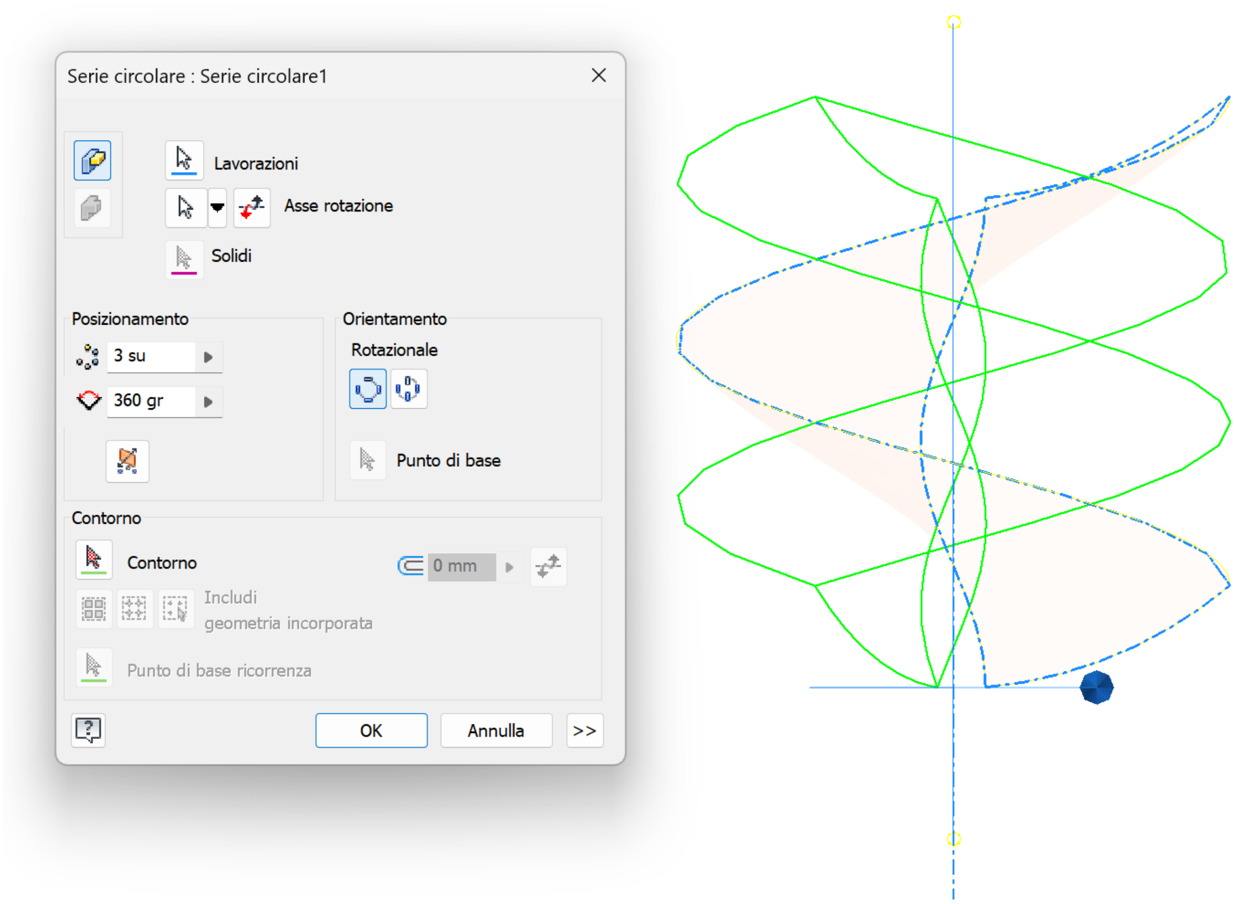


Creare la superficie a spirale col comando SWEEP

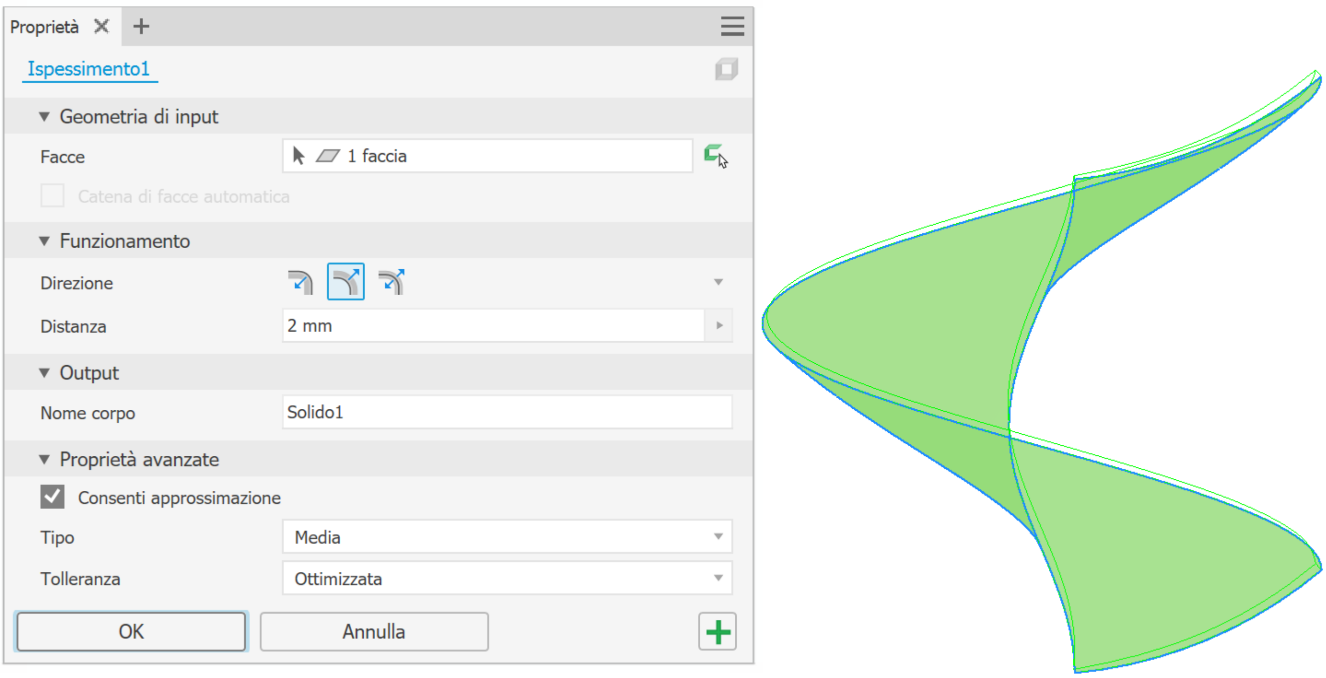




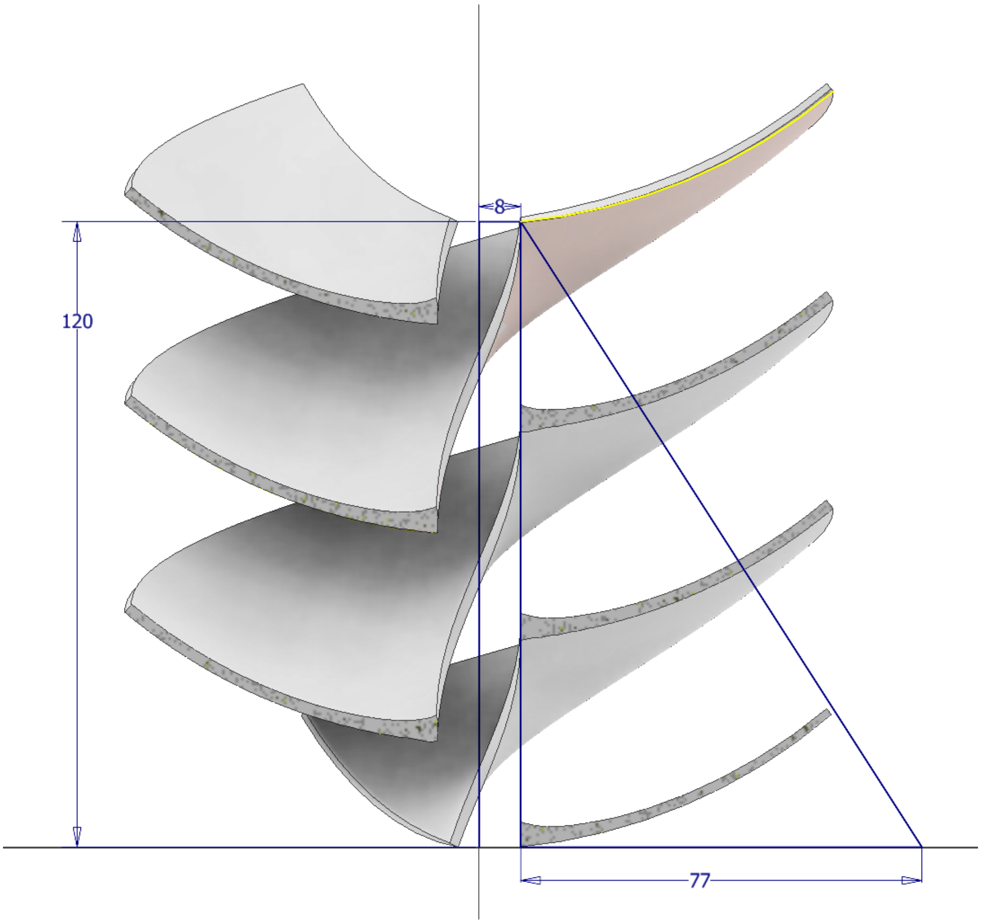
Utilizzare il comando SERIE CIRCOLARE per creare 3 pale



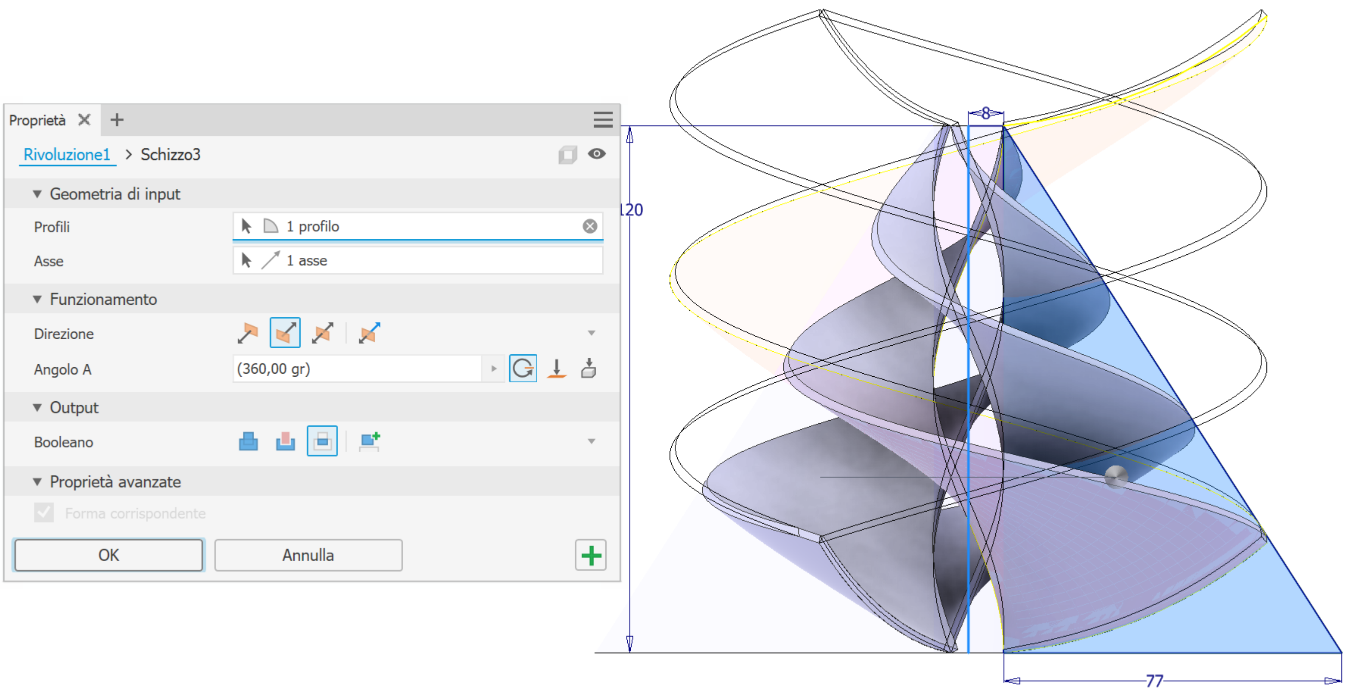
Utilizzare il comando “INSPESSISCI” per dare spessore ad ogni pala (UNA alla volta)



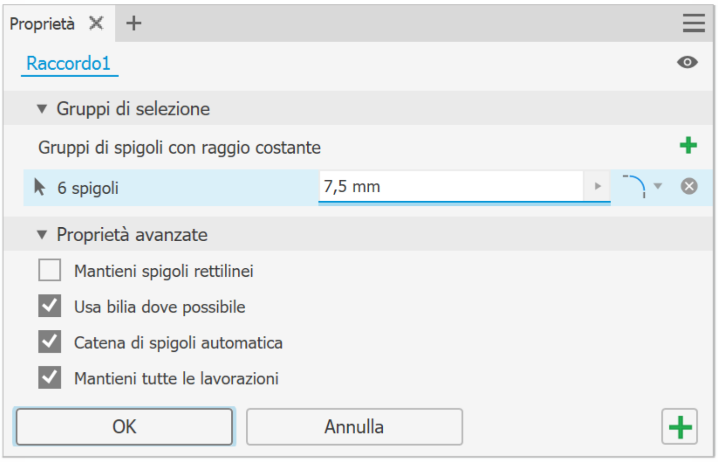
Creare lo schizzo in figura

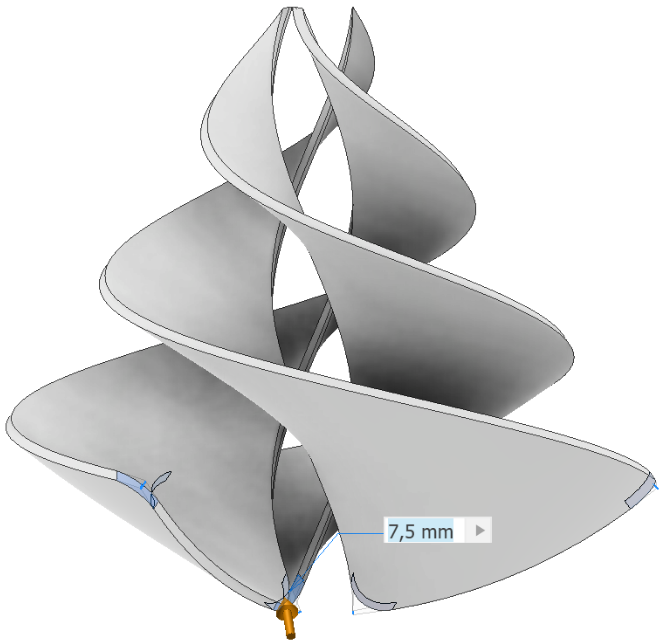


Utilizzare il comando RIVOLUZIONE in modalità INTERSEZIONE per profilare le pale.

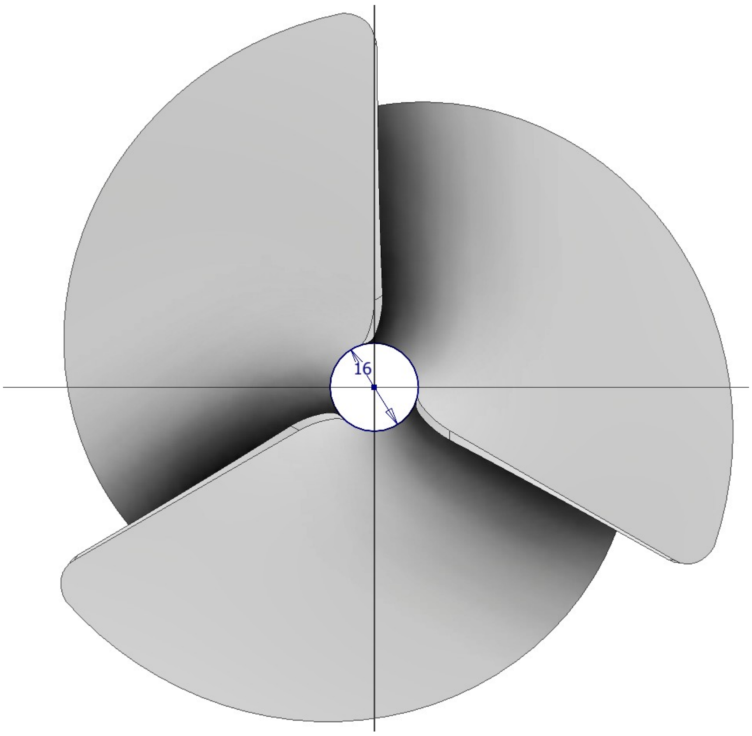


Raccordare le estremità.

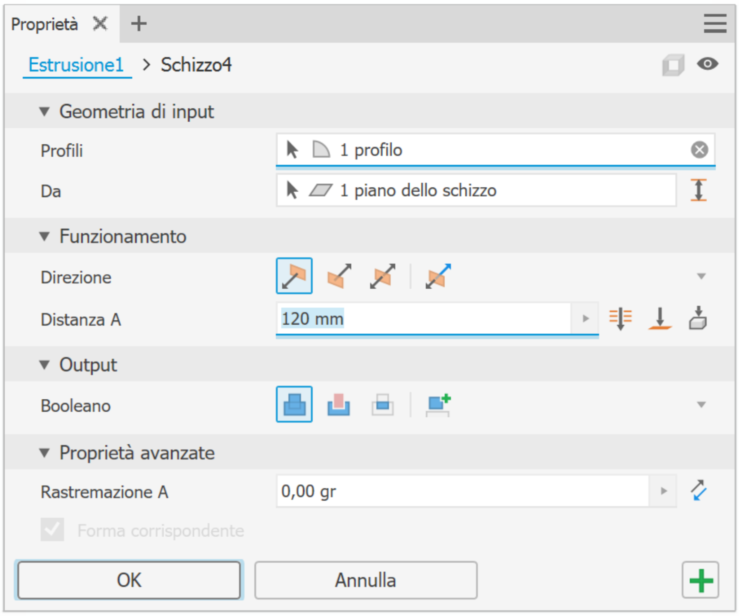


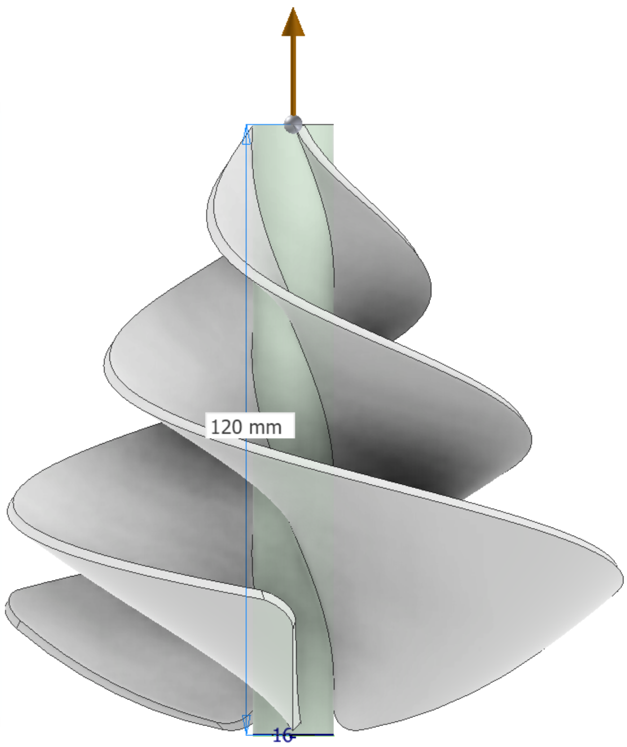


Creare lo schizzo in figura

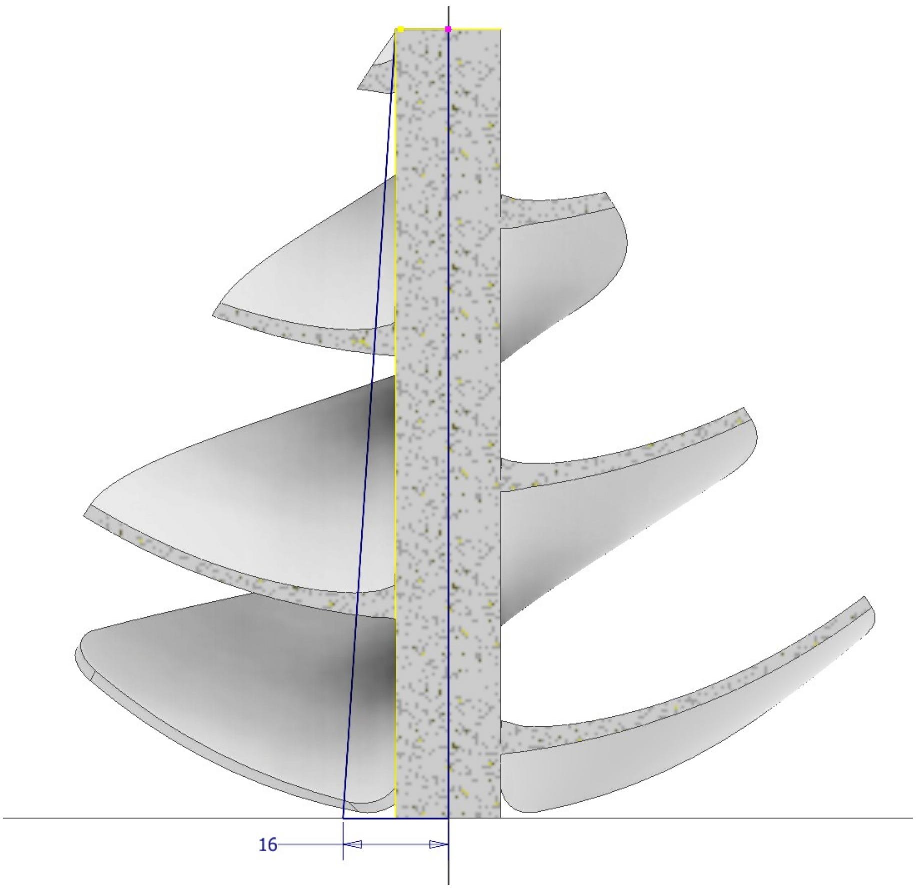


Estrudere lo schizzo

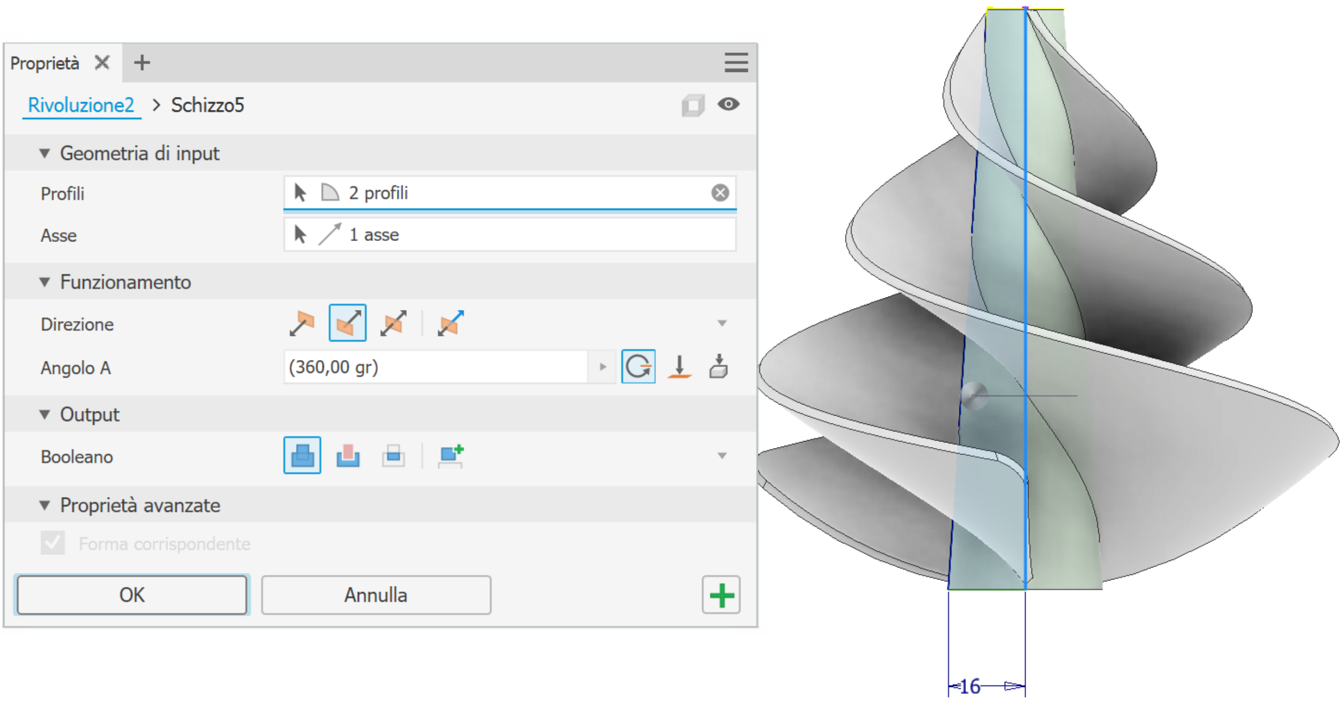




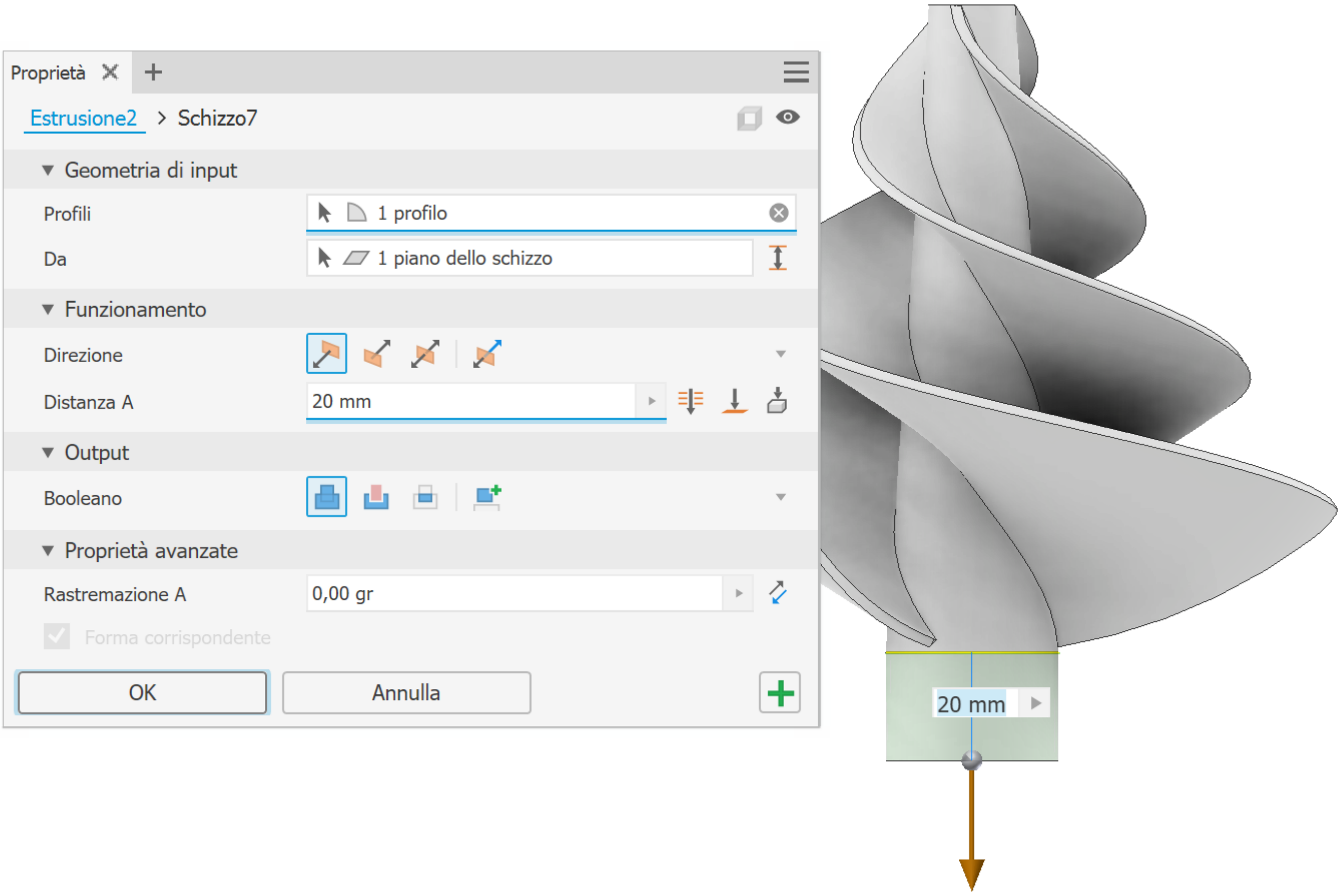
Creare lo schizzo di figura



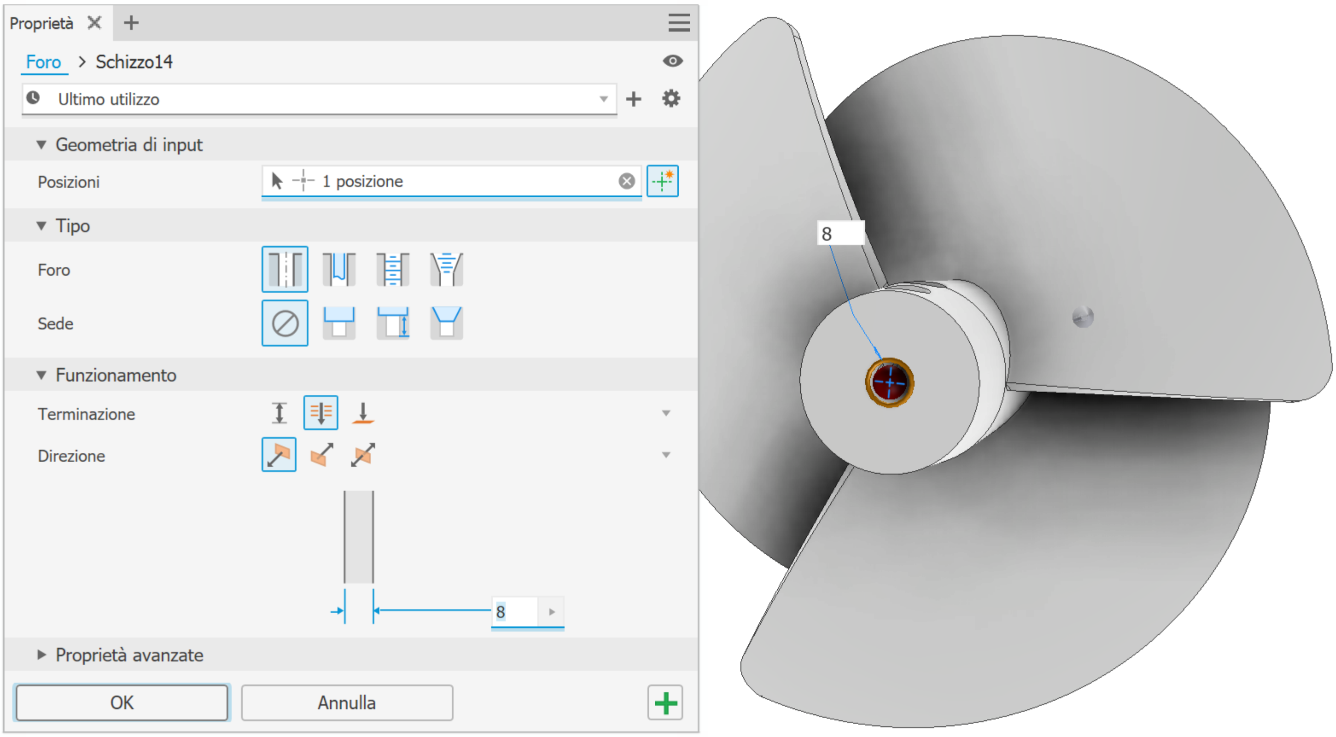
Effettuare RIVOLUZIONE



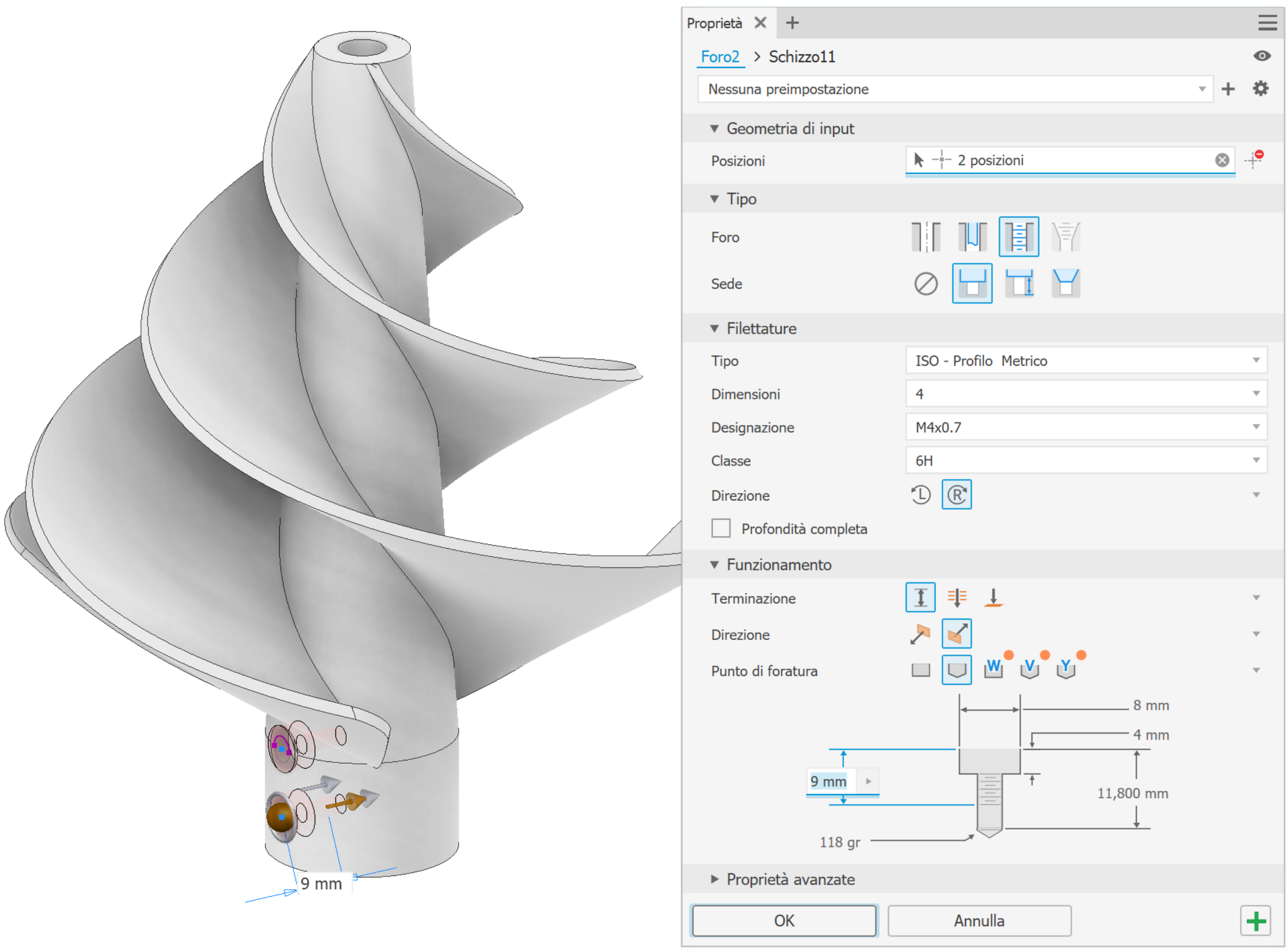
Creare la parte terminale dell’albero



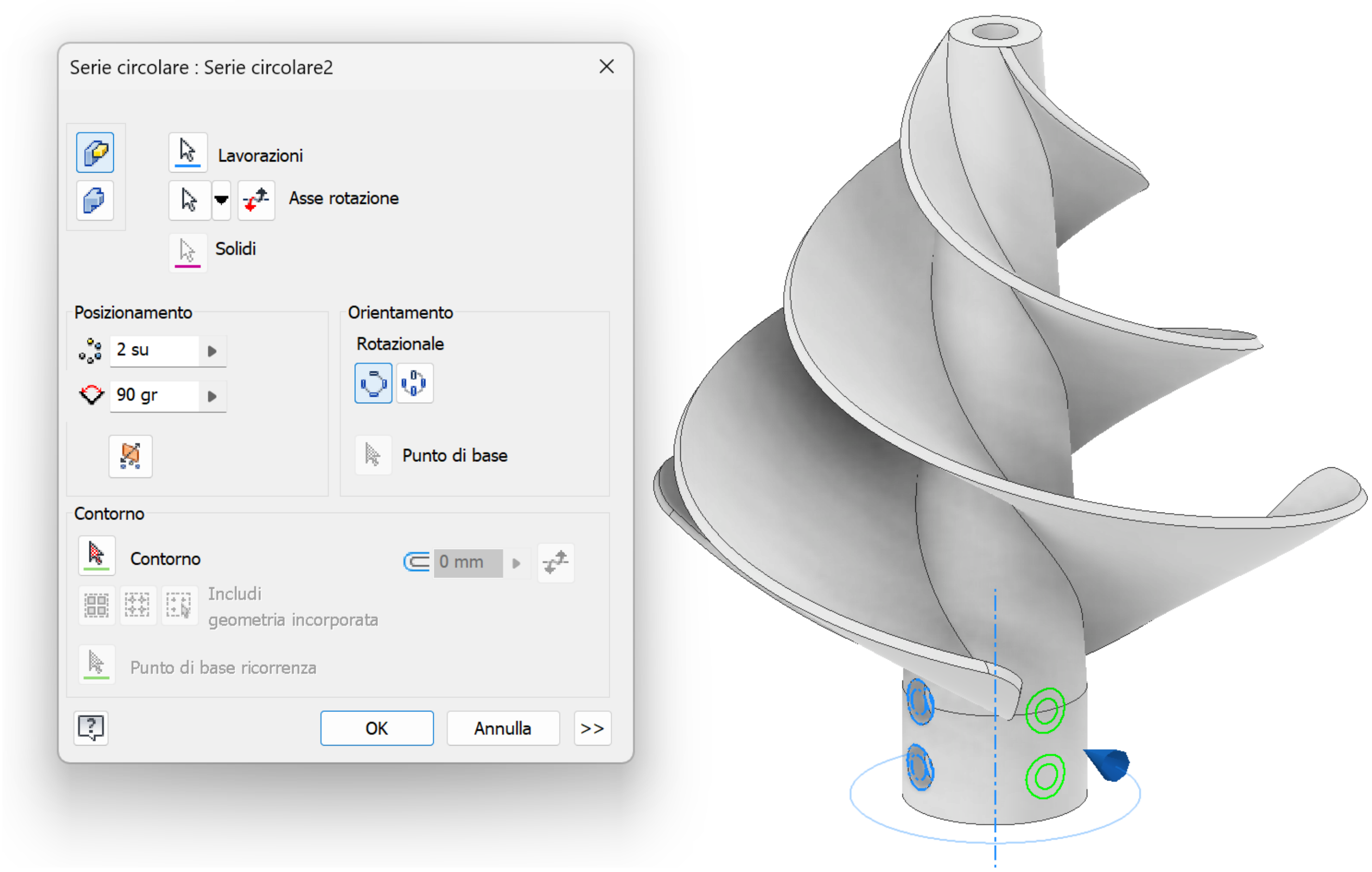
Realizzare foro semplice da 8mm



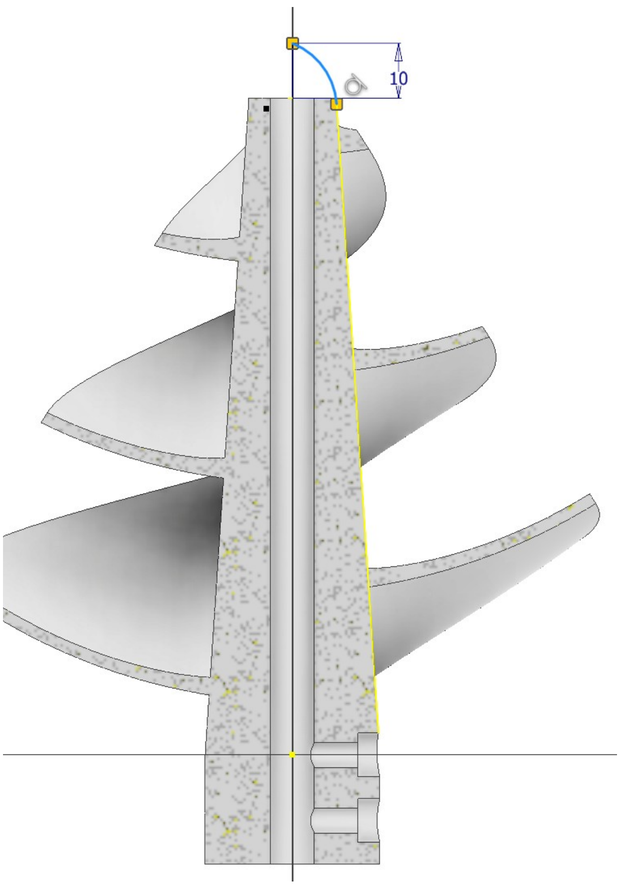
Creare una coppia di fori sull'albero

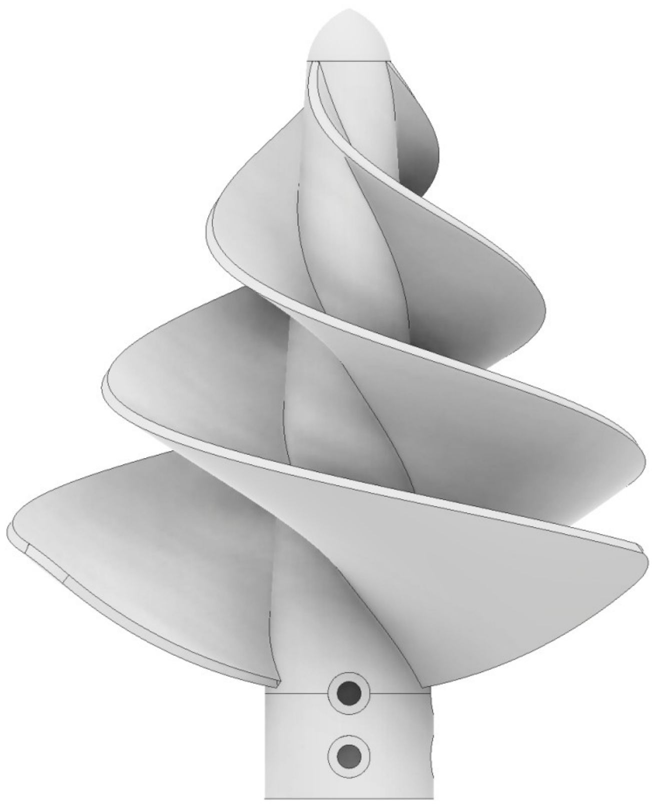


Creare un’altra coppia di fori col comando SERIE

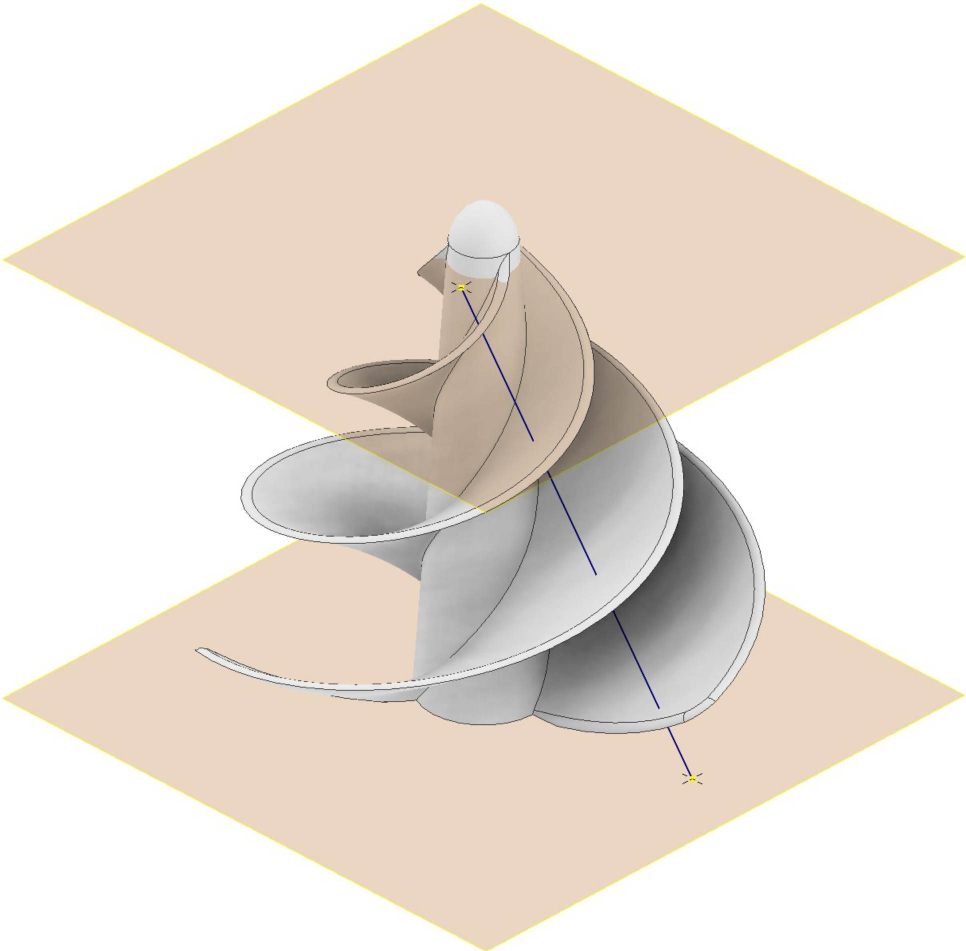


Creare lo schizzo di figura e utilizzare il comando RIVOLUZIONE per terminare

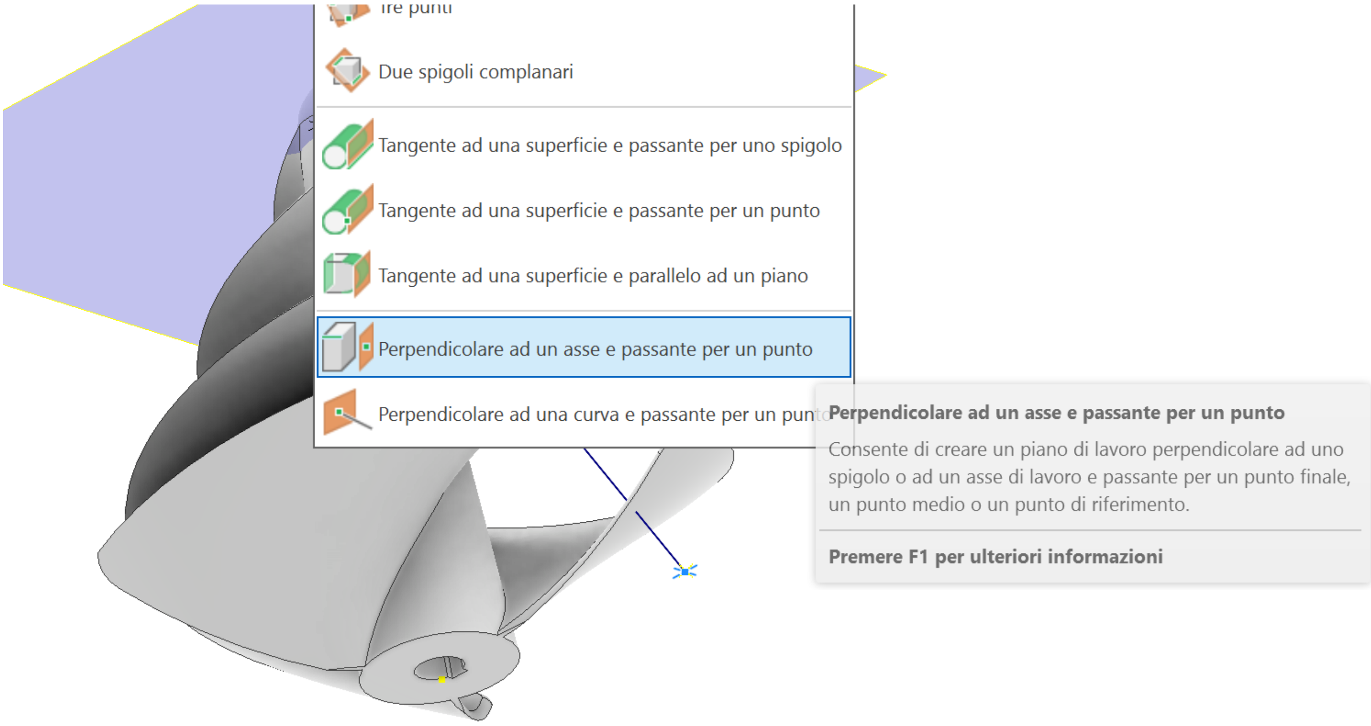




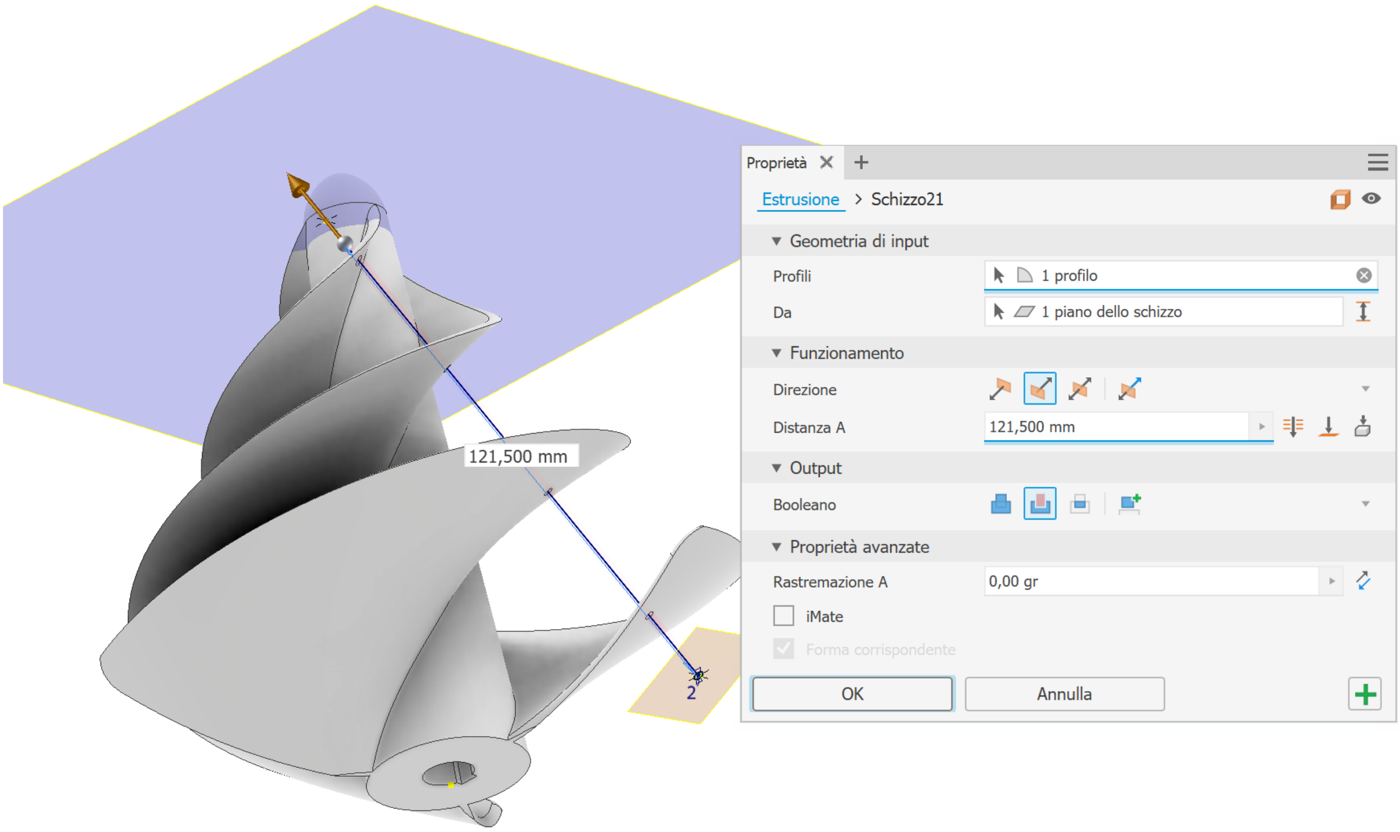
Creare un piano parallello a quello origine in modo da inserire due punti (su due schizzi 2D) che verranno uniti tamite una liena 3D (schizzo 3D) come in figura.

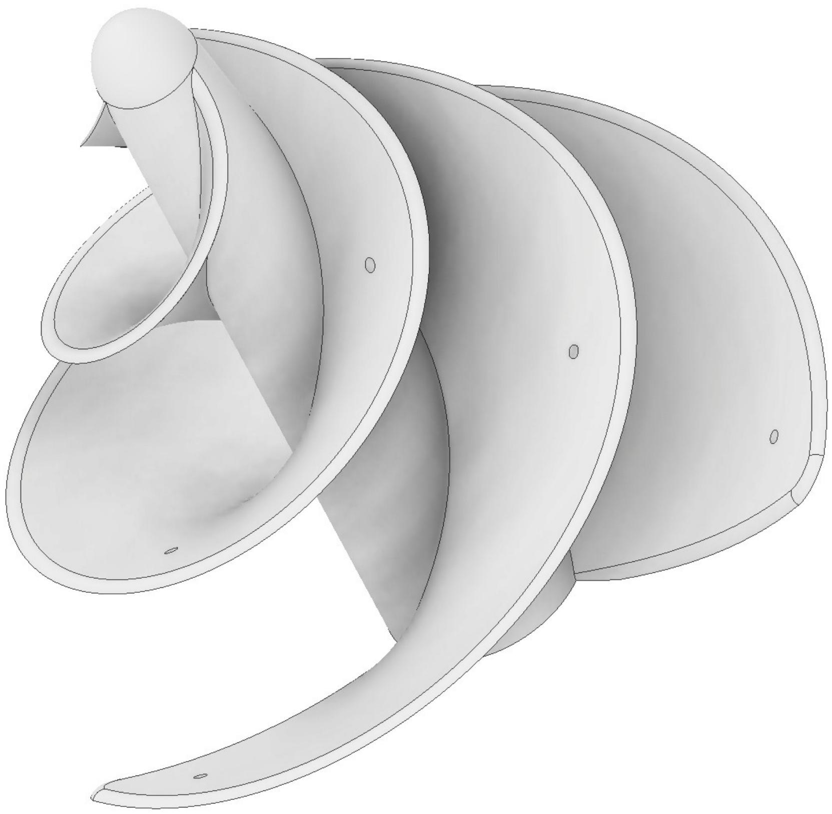


Creare un piano perpendicolare al'asse come in figura.



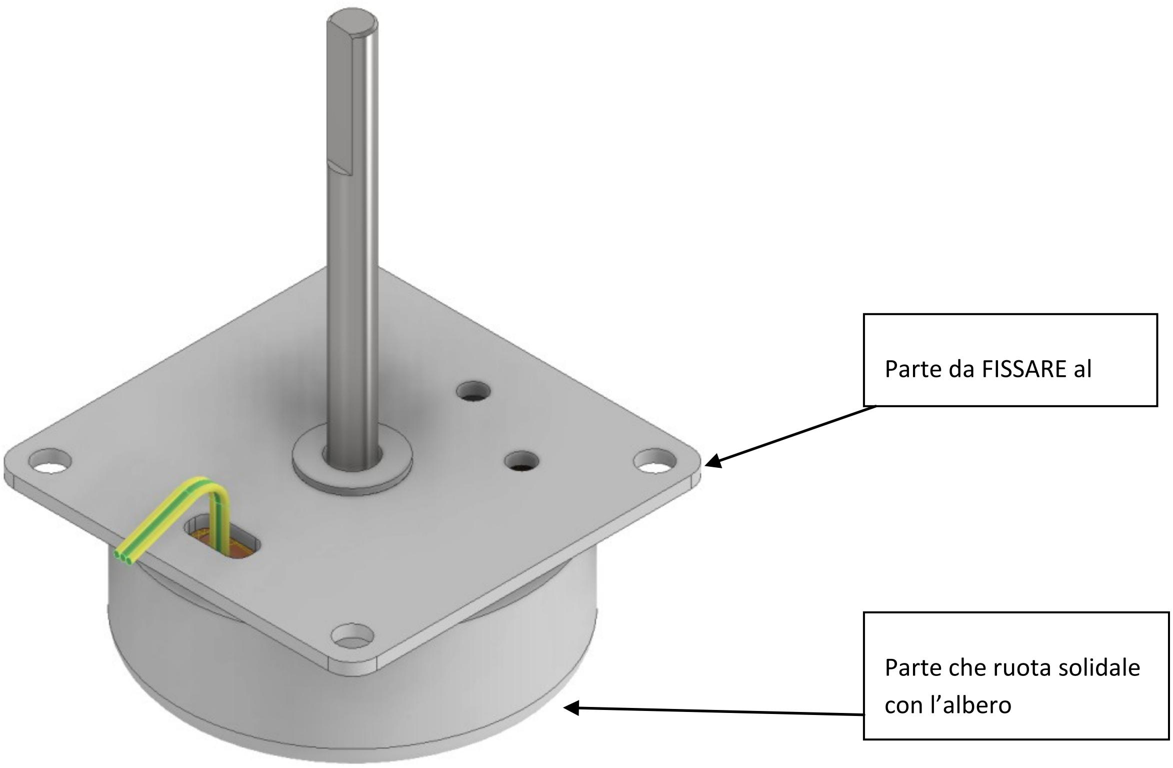
Creare uno schizzo con un cerchio da 2mm ed estrudere in taglio fino a bucare tutte le pale.



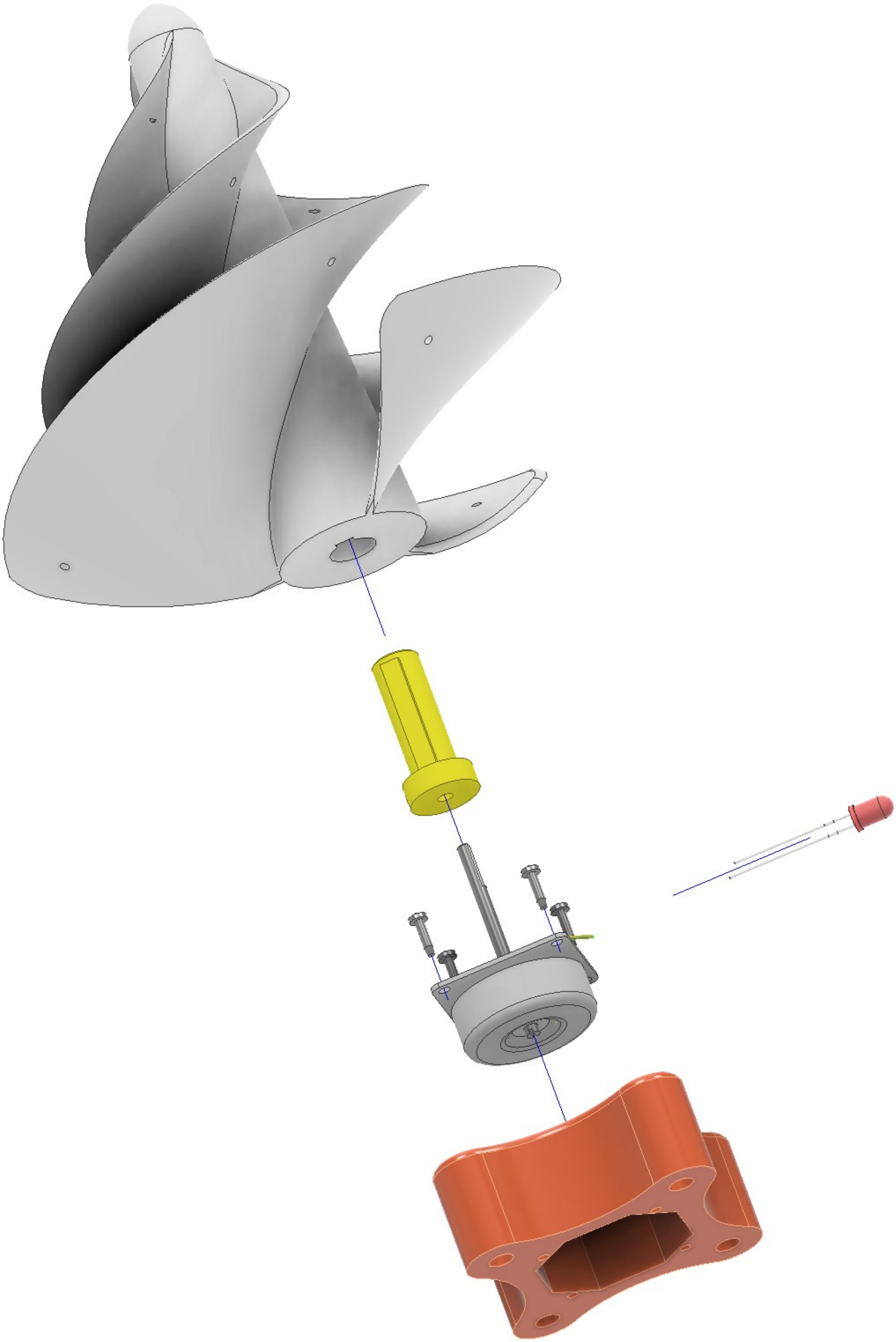


Terminare un una serie circolare della lavorazione per bucare le altre due pale.
Raccordare Infine I bordi delle pale.

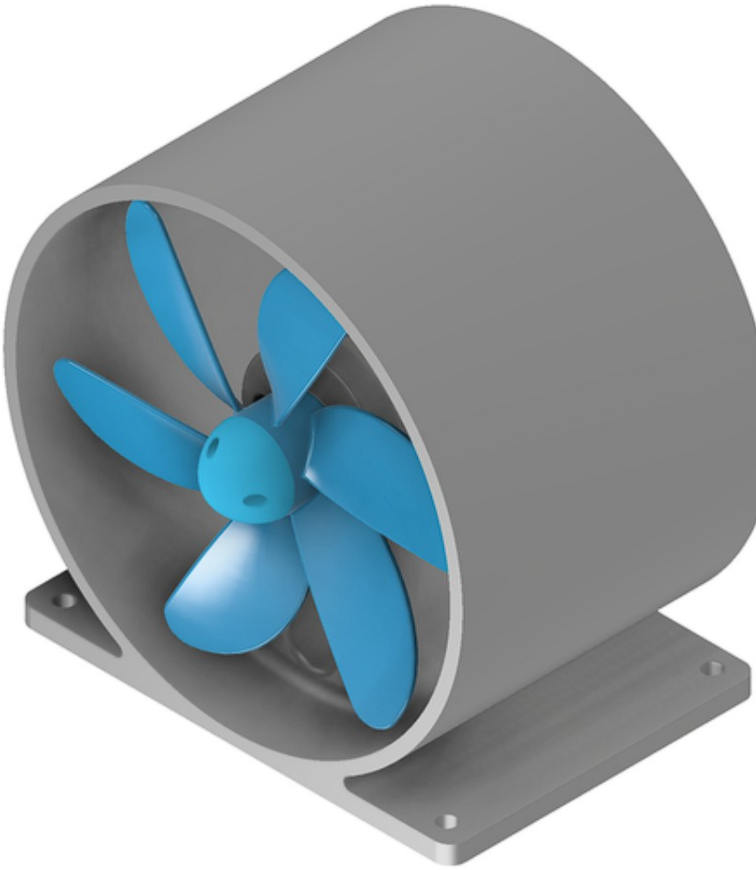

30mm
28.5mm
30mm
30mm

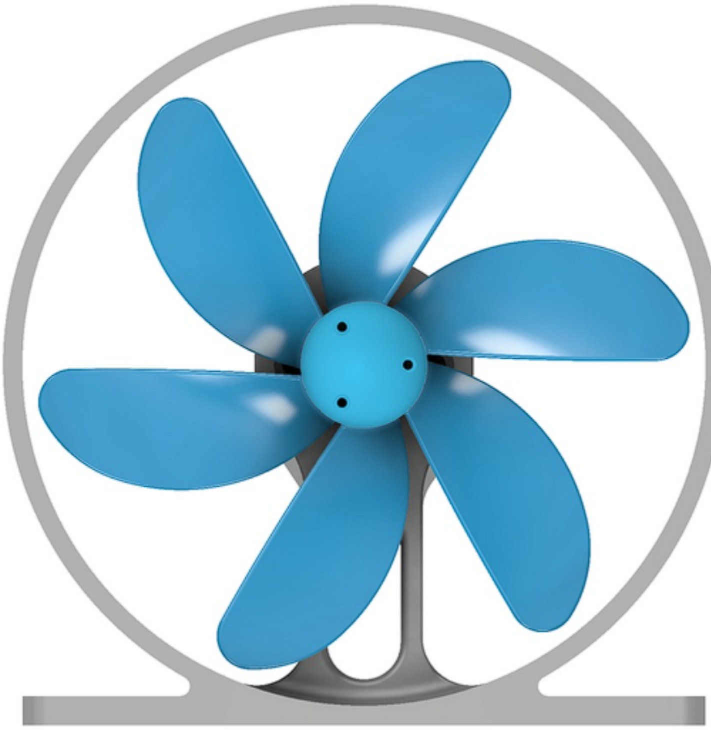

Parte da FISSARE al
Parte che ruota solidale con l'albero

COMPLETARE L'ASSIEME CON LE PARTI MANCANTI.



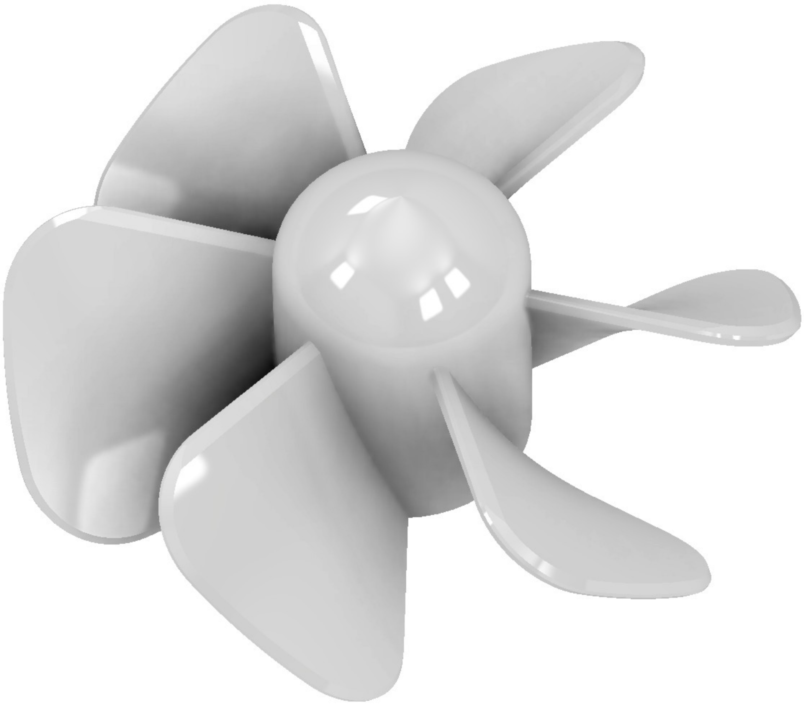
VENTILATORE ASSIALE



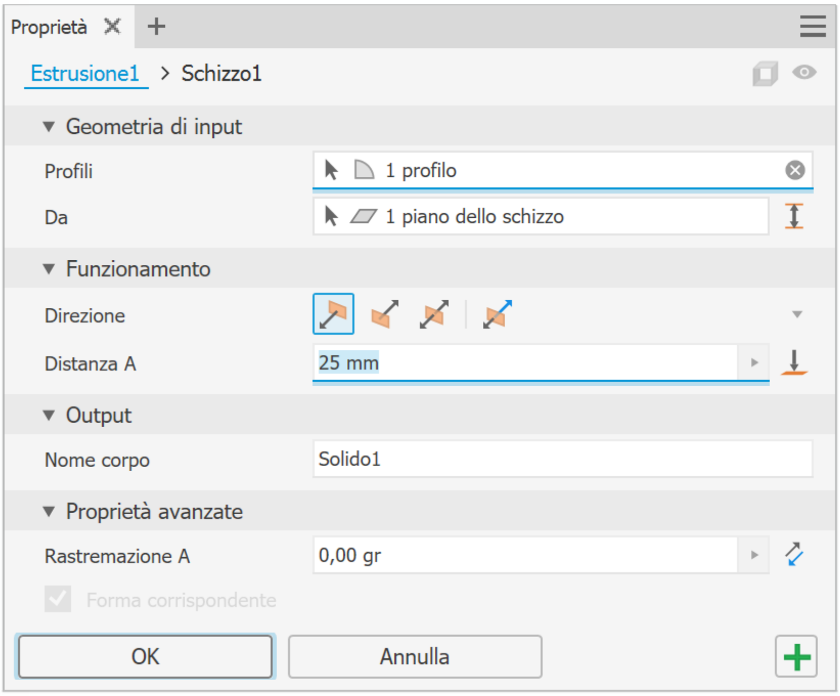


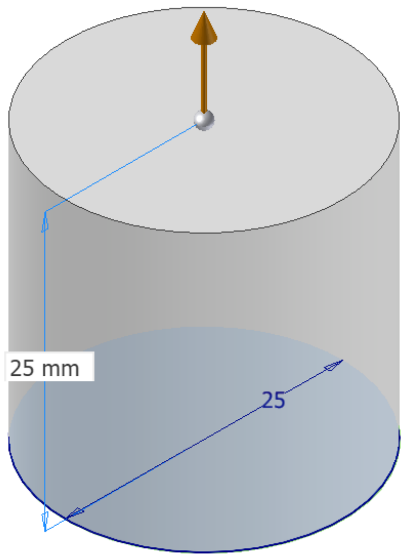
GIRANTE VENTILATORE ASSIALE

Per ottenere le migliori prestazioni le pale devono avere un andamento a spirale.

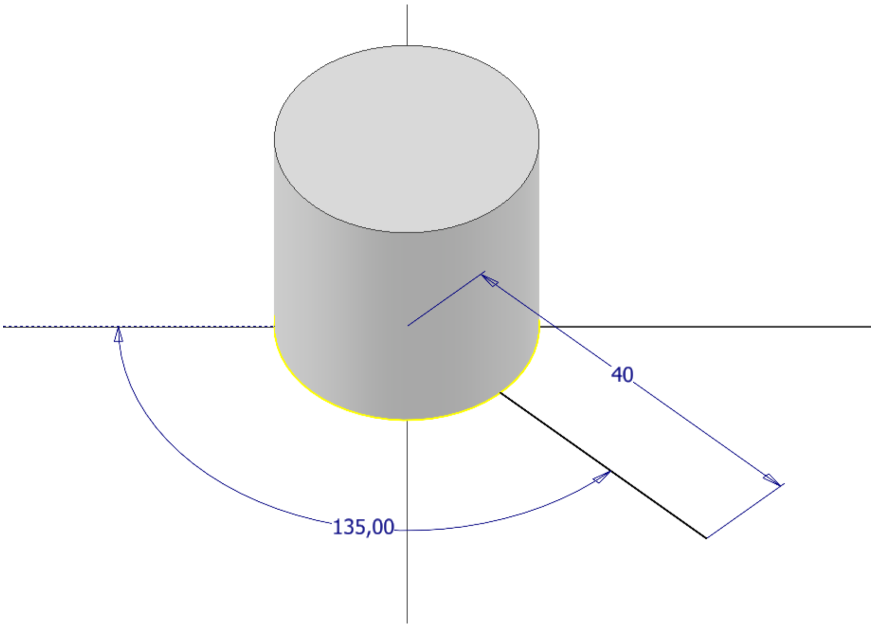


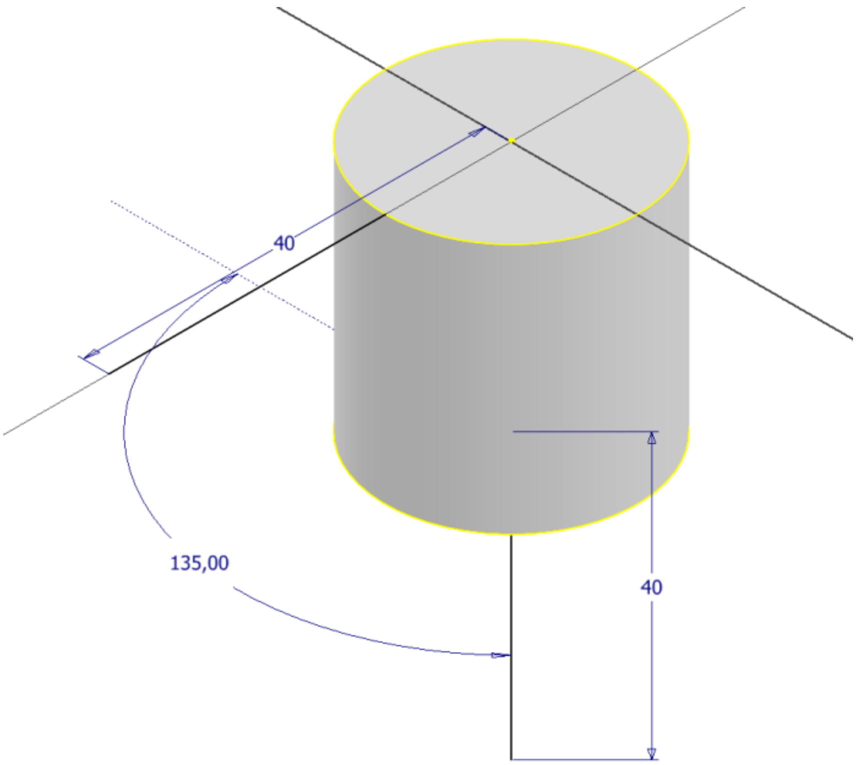
Schizzo + estrusione sul piano orizzontale



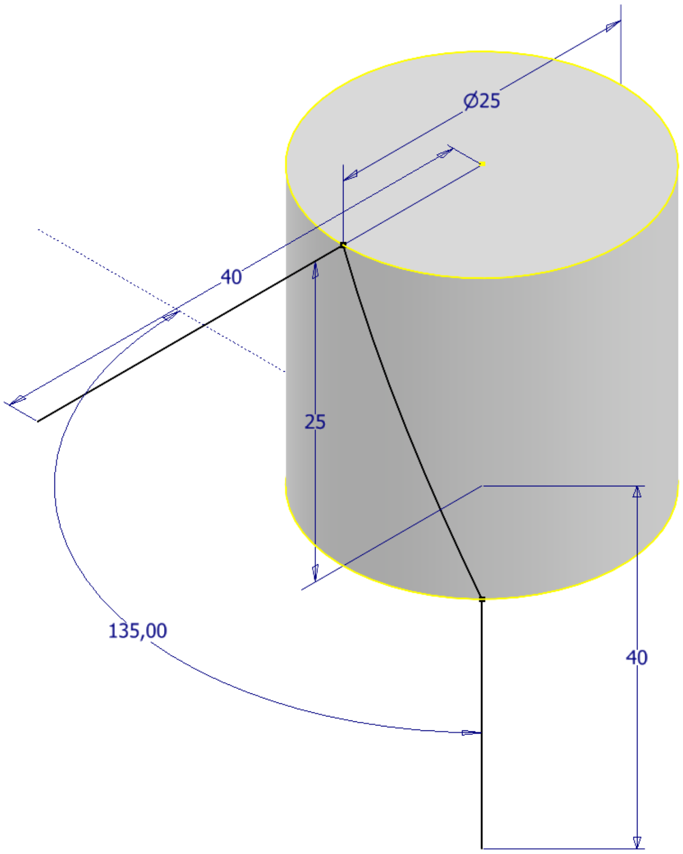


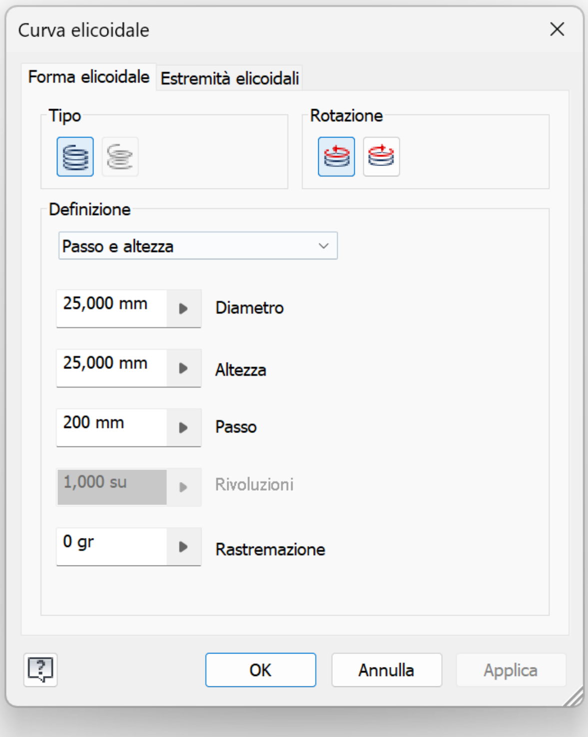
Creare 2 segmenti su schizzi distinti come nelle figure.



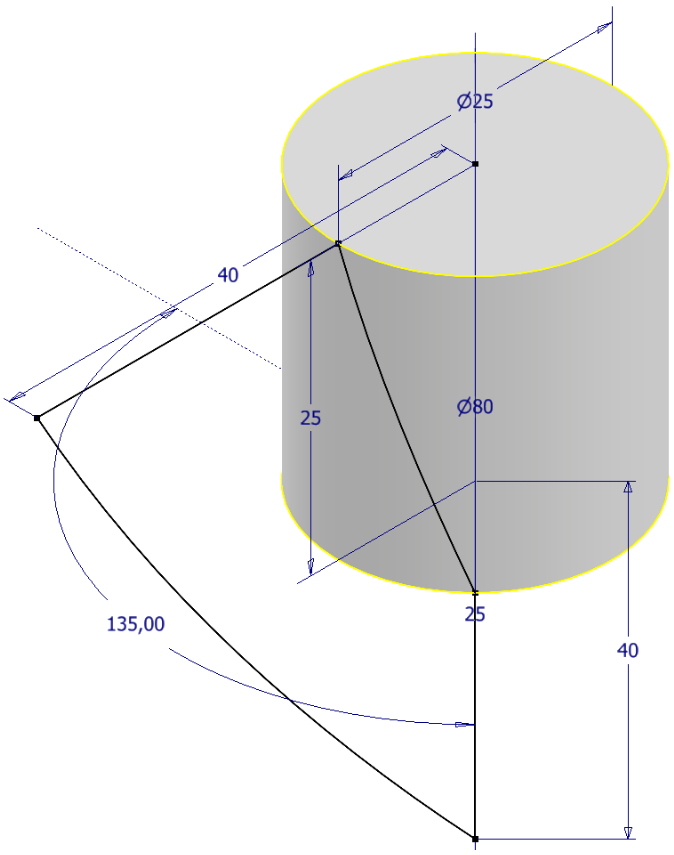


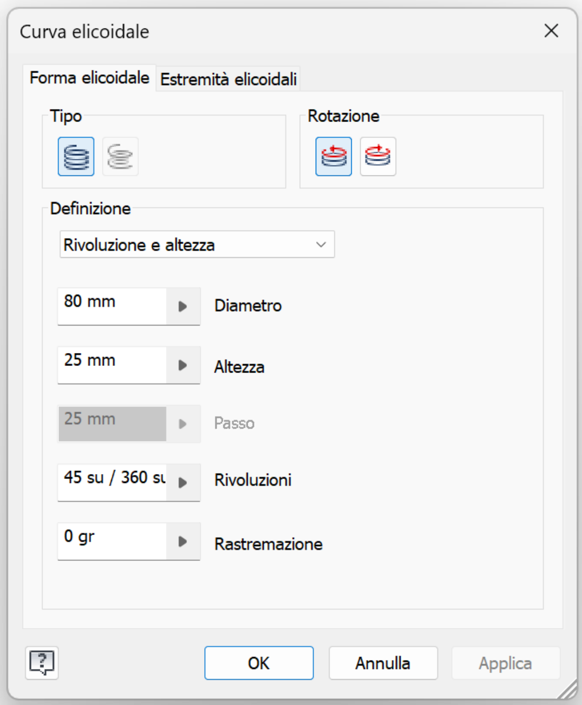
Schizzo 3D con prima curva elicoide come in figura.



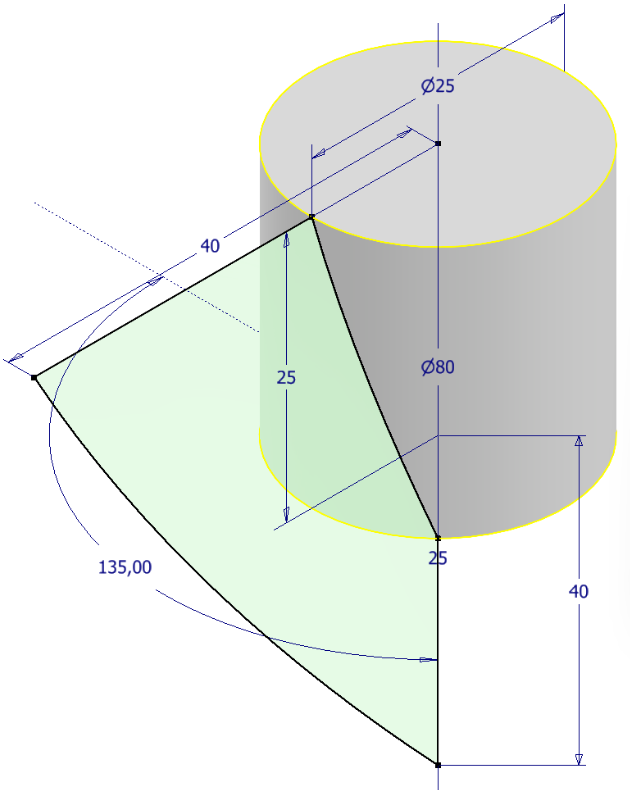


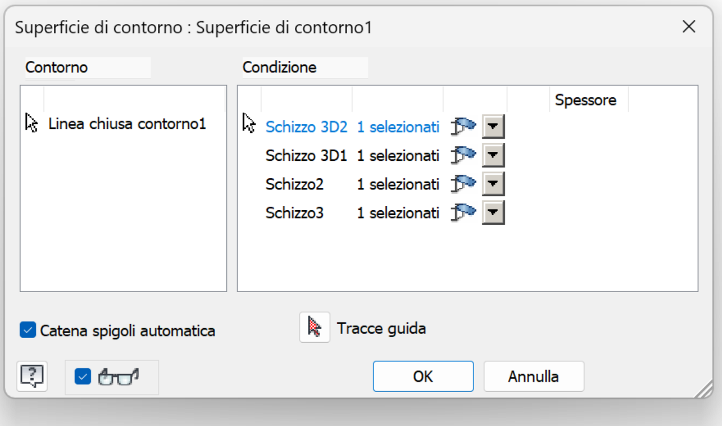
Schizzo 3D con seconda curva elicoide come in figura.



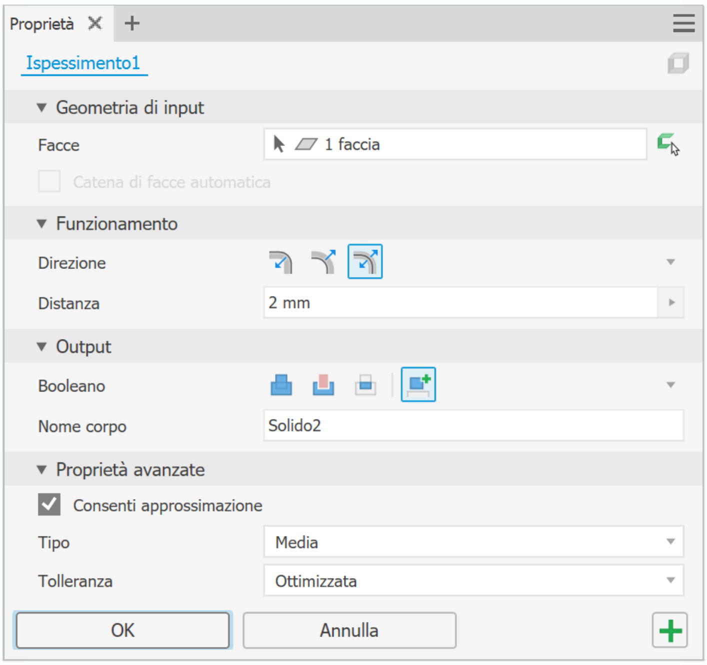


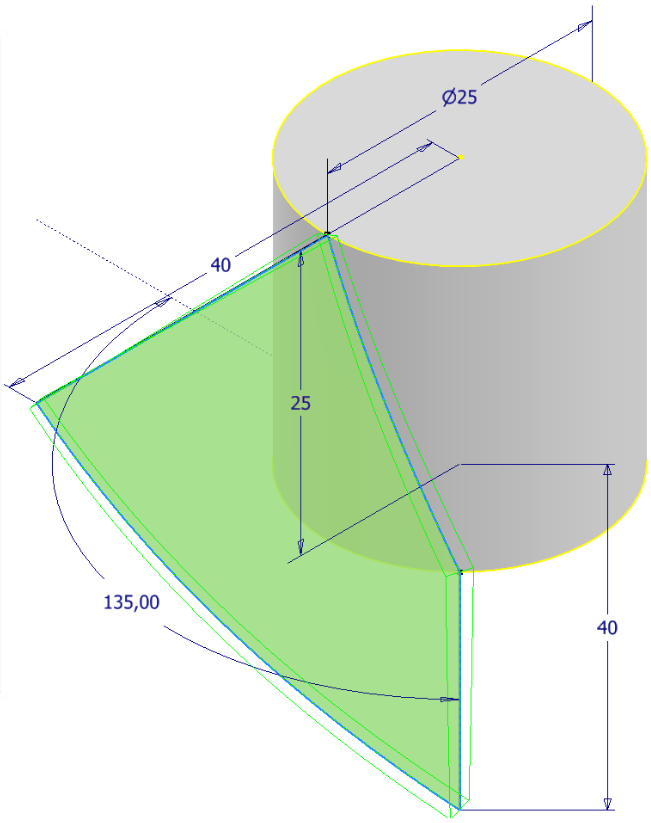
Creazione “superficie di contorno” utilizzando I 4 schizzi precedent.



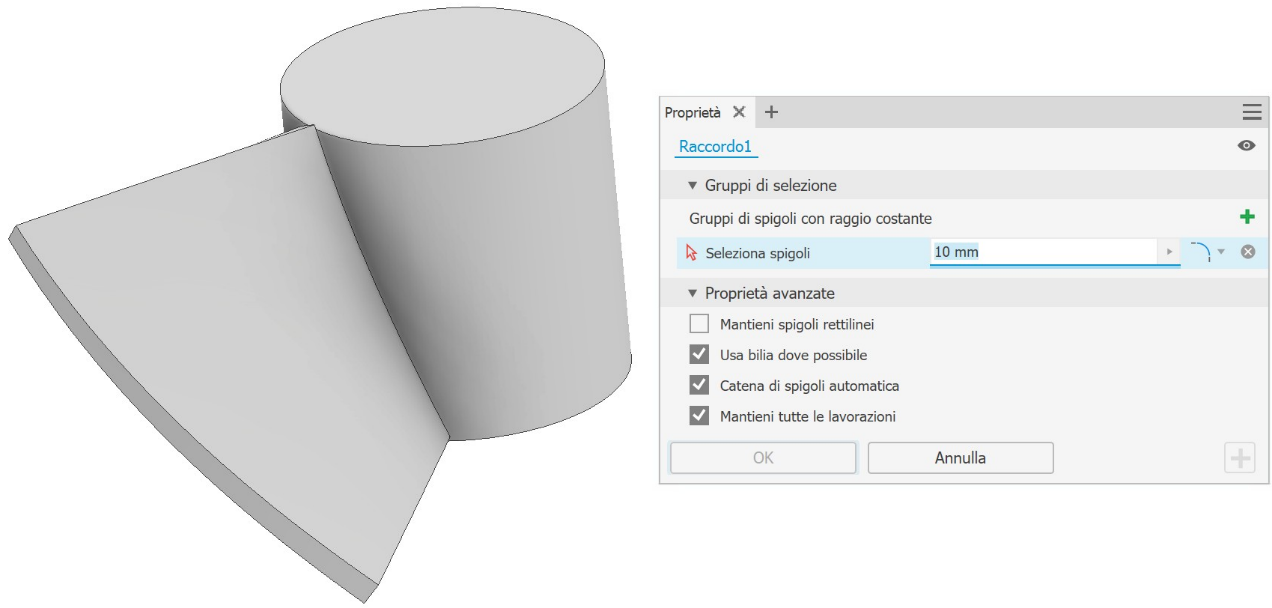


Inspessimento della supericie.

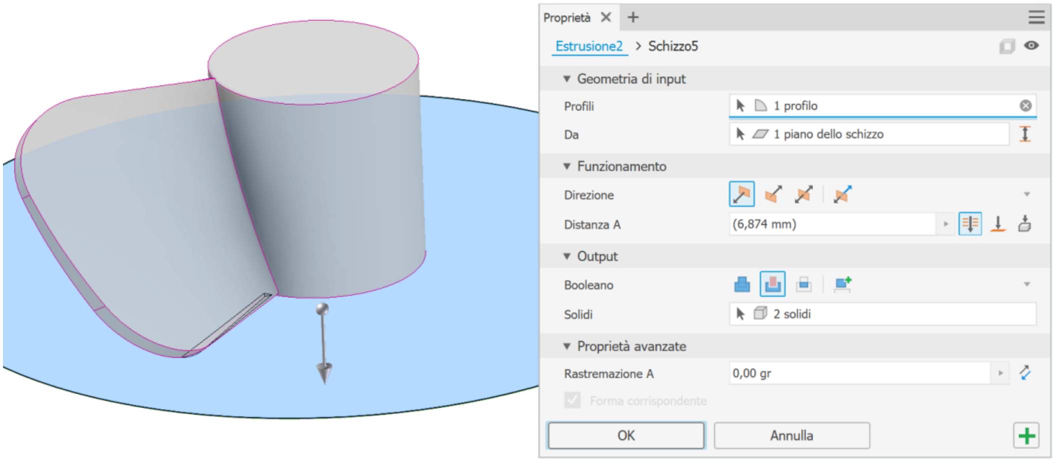


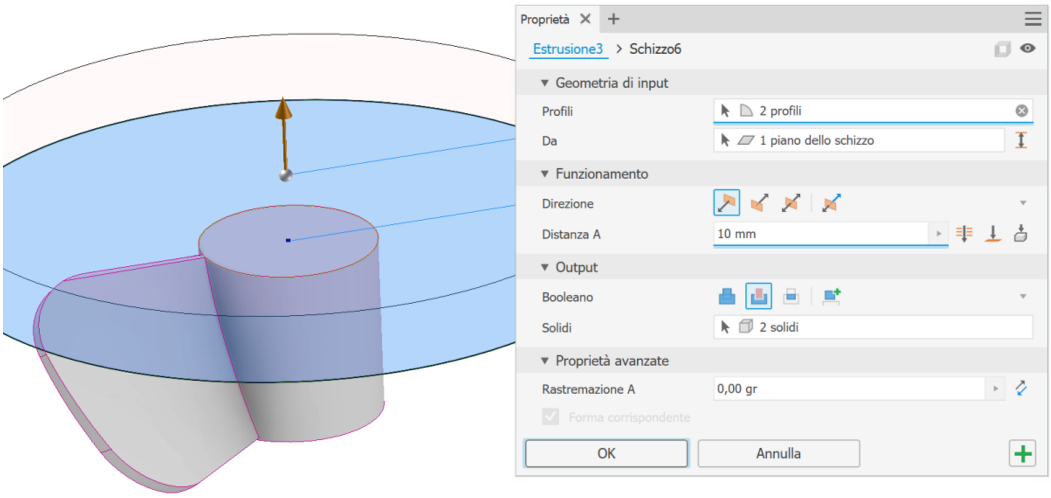


Raccordo bordi pala

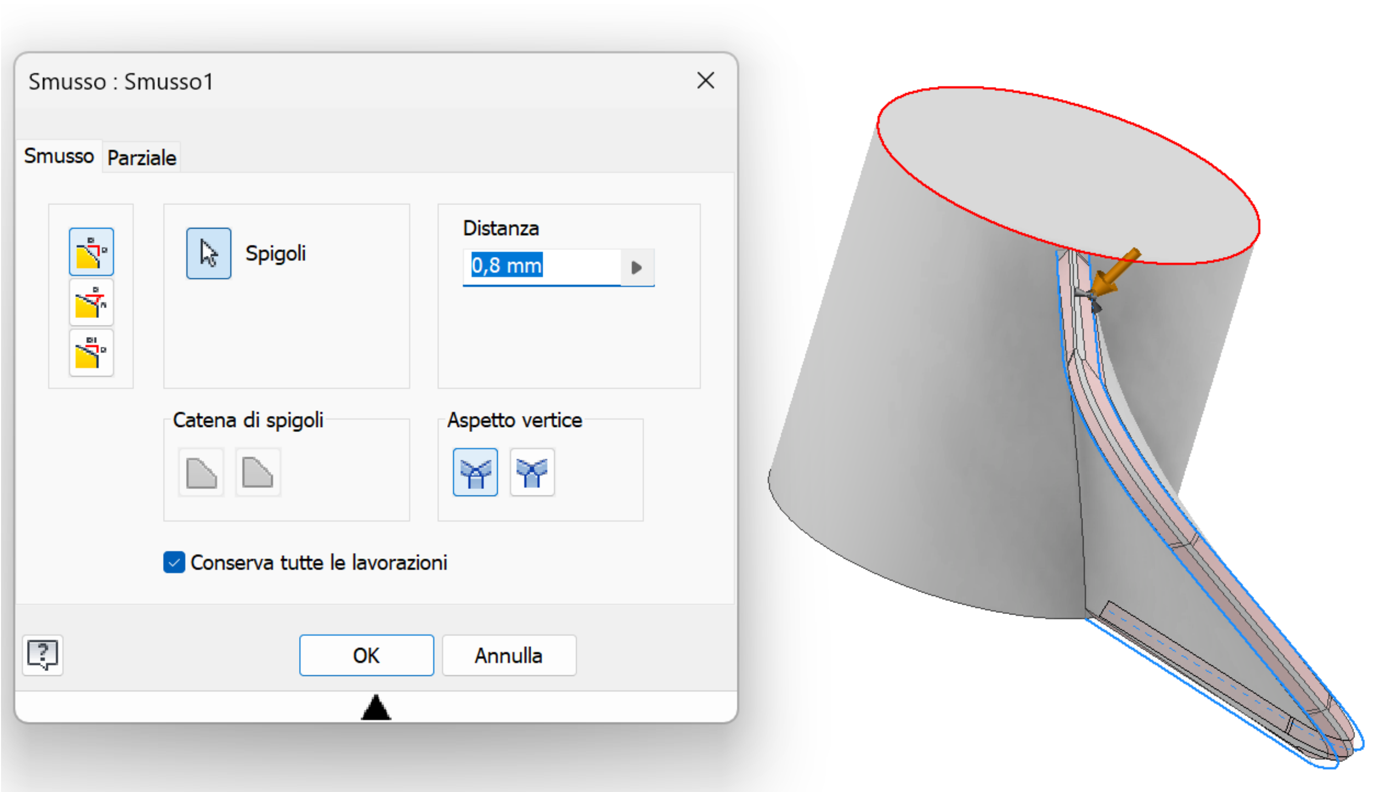


Eliminazione delle parti di pala che eccedono le faccie orizzontali del cilindo.

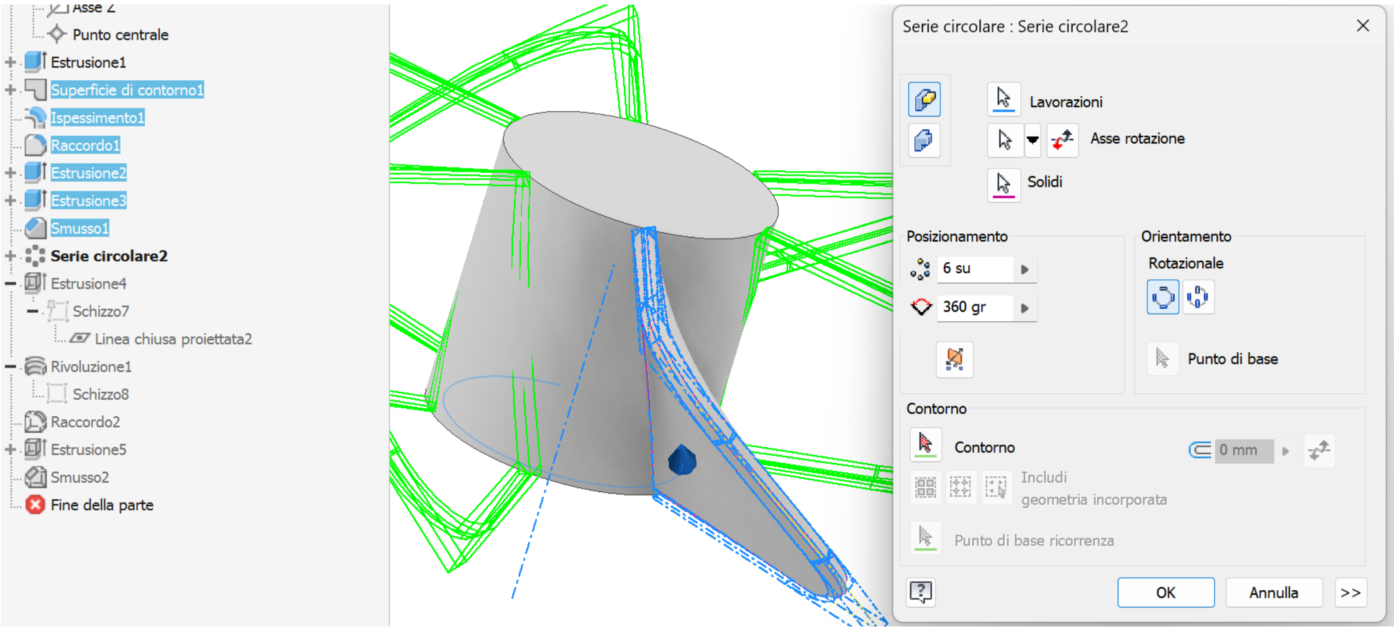




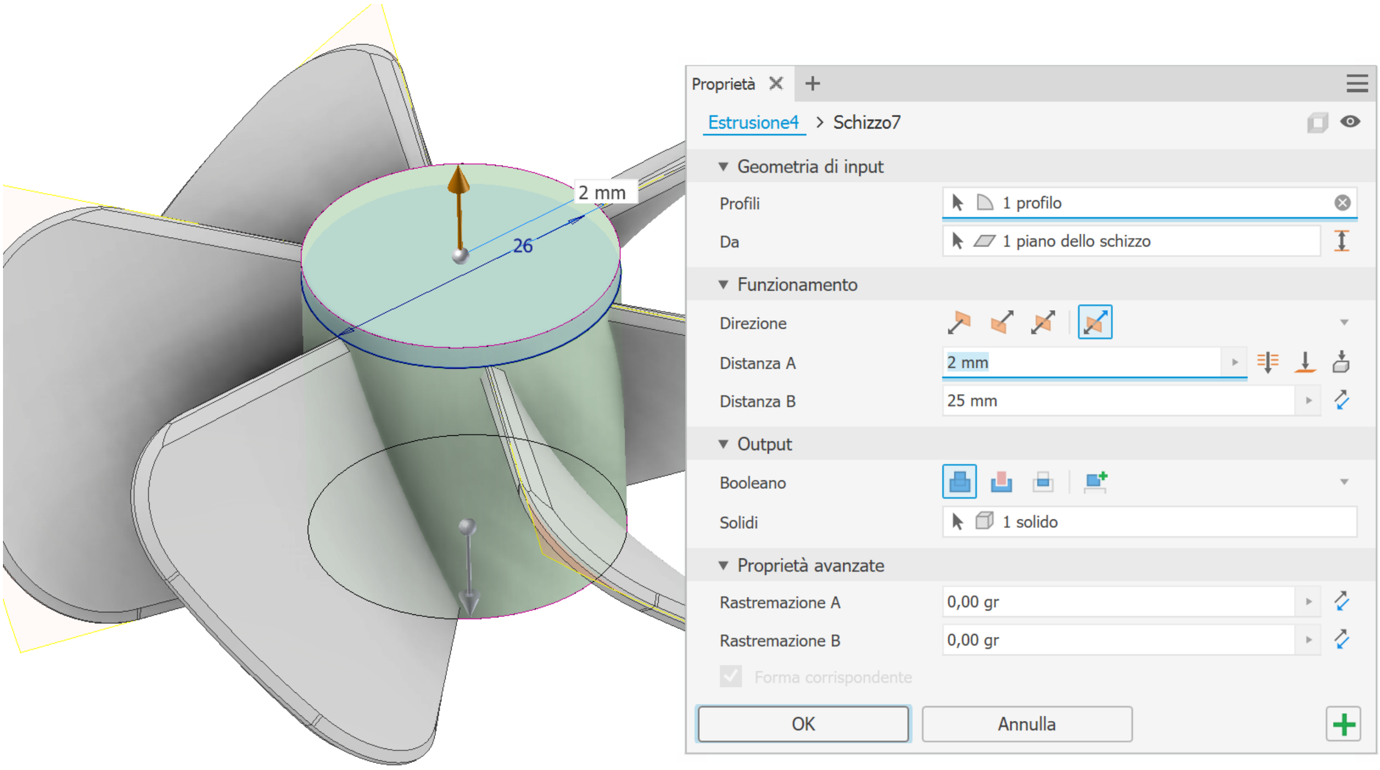
Smusso profile pala



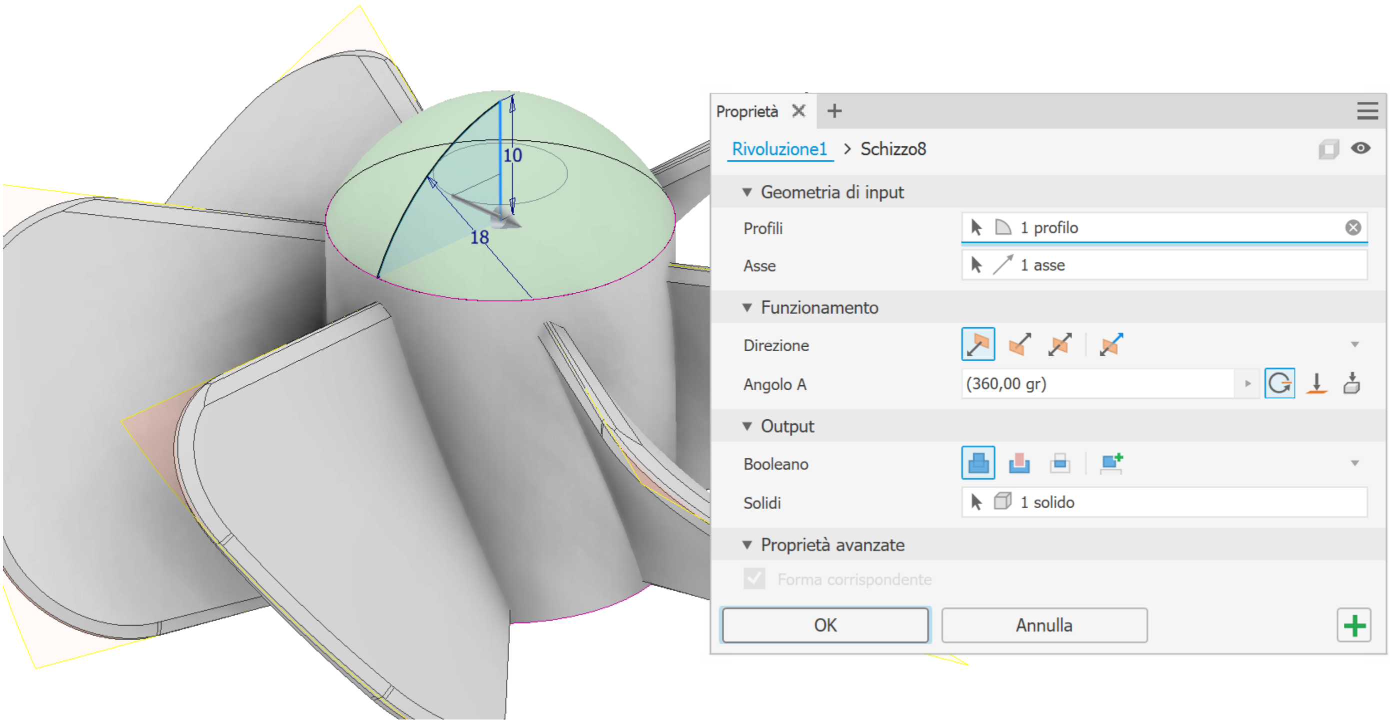
Serie circolare (attenzione a selezionare anche la superficie di contorno).



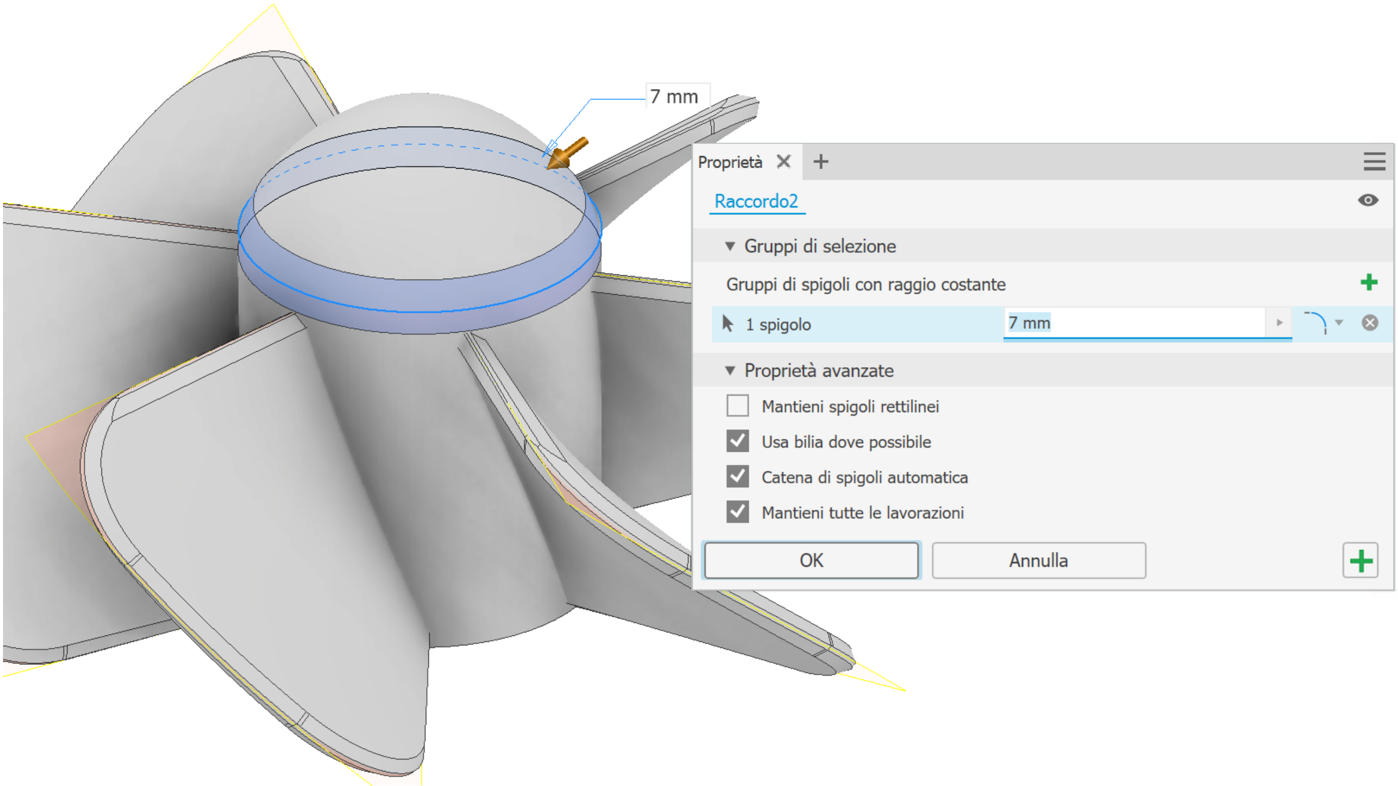
Estruzione asimmetrica come in figura (attensione al diametro da 26mm).



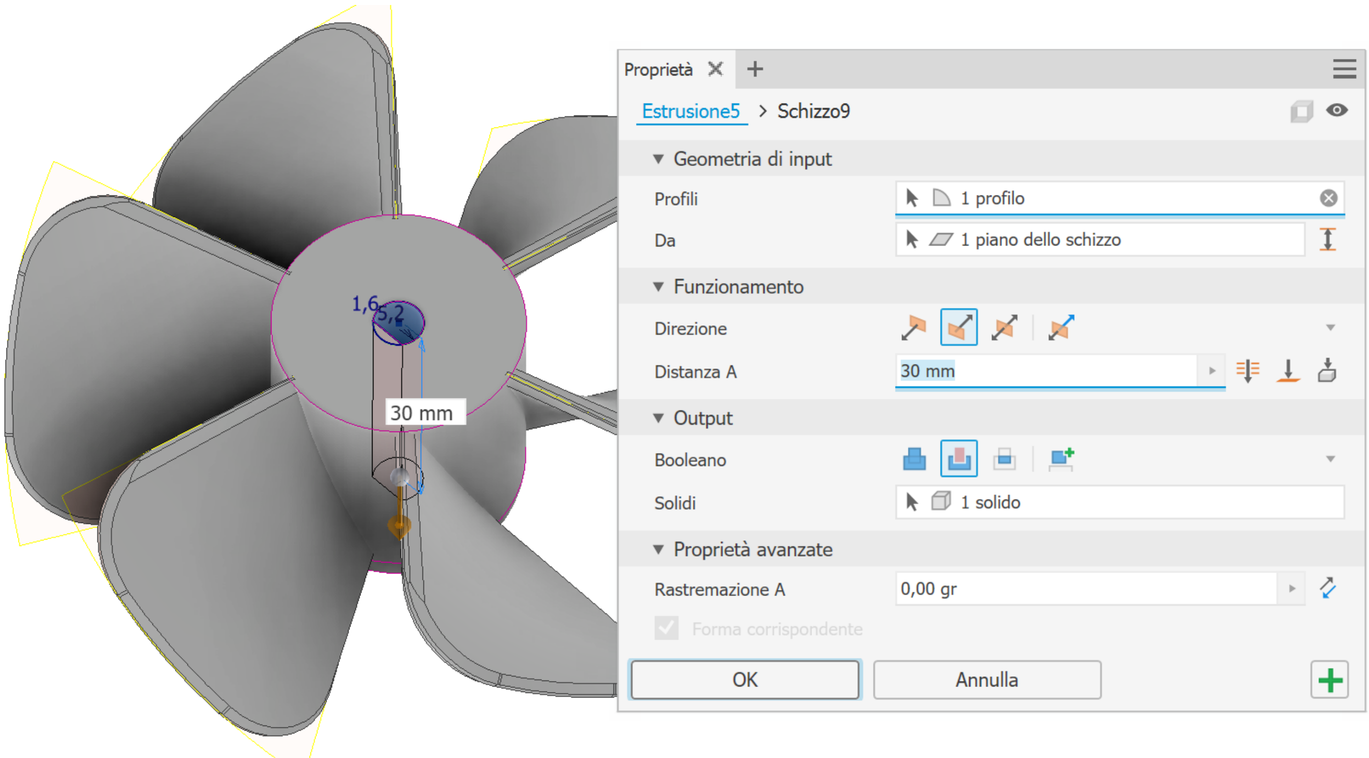
Creazione superficie corva in testa.



Raccordo.



Foro centrale per albero motore smussato da 5mm (es. DC 775) .



Smusso posteriore.