DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

800 ANNI 1222·2022

www.dii.unipd.it

Università degli Studi di Padova – Dipartimento di Ingegneria Industriale

Corso di Laurea in Ingegneria Meccanica

Relazione per la prova finale

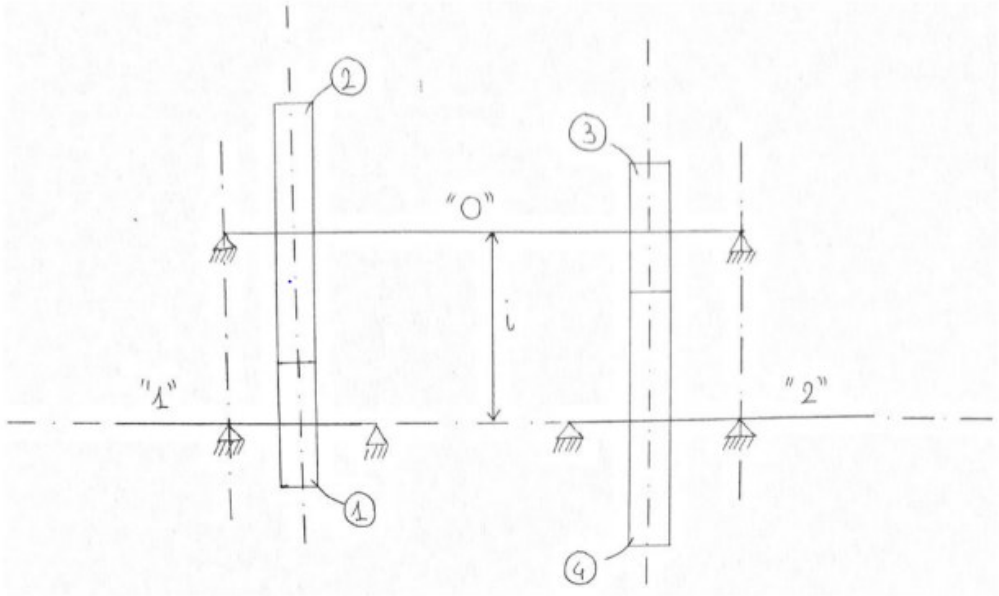
Progettazione strutturale di un riduttore ad ingranaggi con assi paralleli e simulazione tramite analisi agli elementi finiti

Tutor universitario: Prof. Meneghetti G.

Laureando*: Caprari Leonardo 1216805*

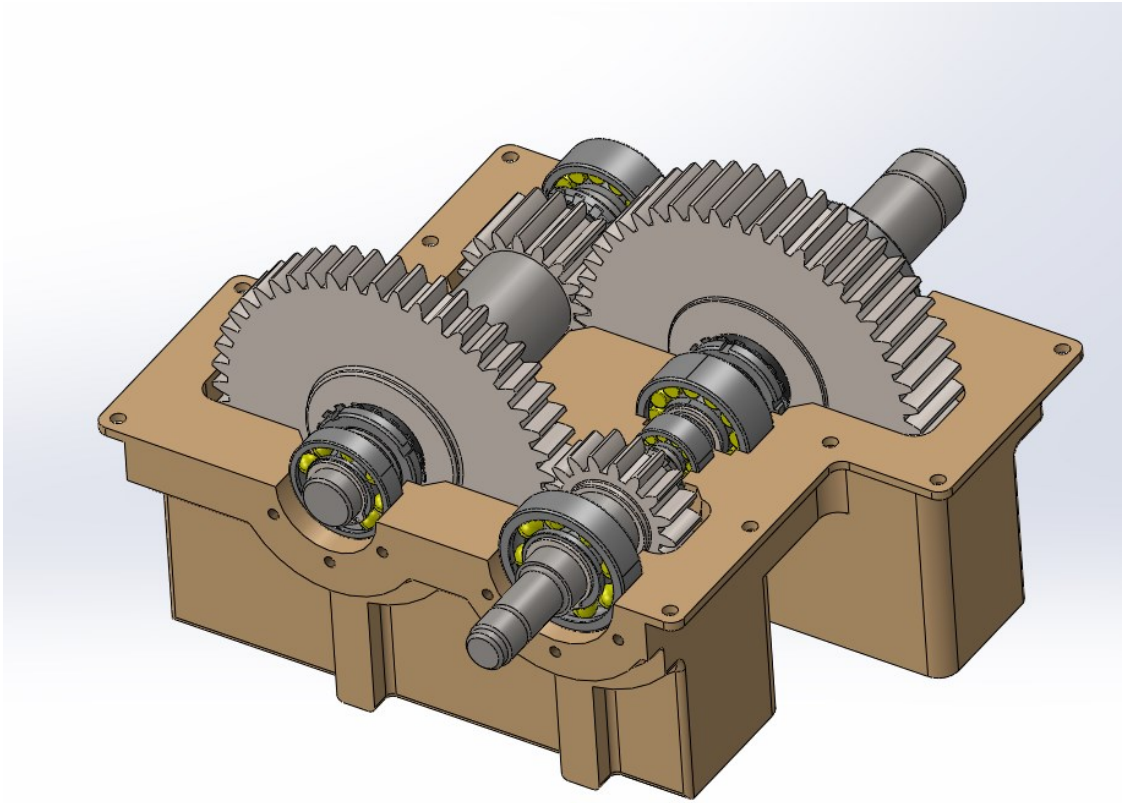
Padova, 2021/2022

INTRODUZIONE



RIDUTTORE: dispositivo meccanico di trasmissione di potenza con un rapporto di riduzione $\tau > 1$.

Viene interposto tra un albero motore ed un albero condotto al fine di ridurre il numero di giri ed aumentare il Momento torcente del secondo rispetto al primo.



OBIETTIVI DEL LAVORO

OBIETIVO: il riduttore verrà utilizzato per collegare coassialmente un motore elettrico asincrono trifase al tamburo di un nastro trasportatore che richiede da progetto una certa coppia nominale M_{R2} ad una certa velocità di rotazione nominale n_2

DATI	VALORI
M_{R2}	1300 Nm
n_2	176 giri/min
τ_{tot}	8

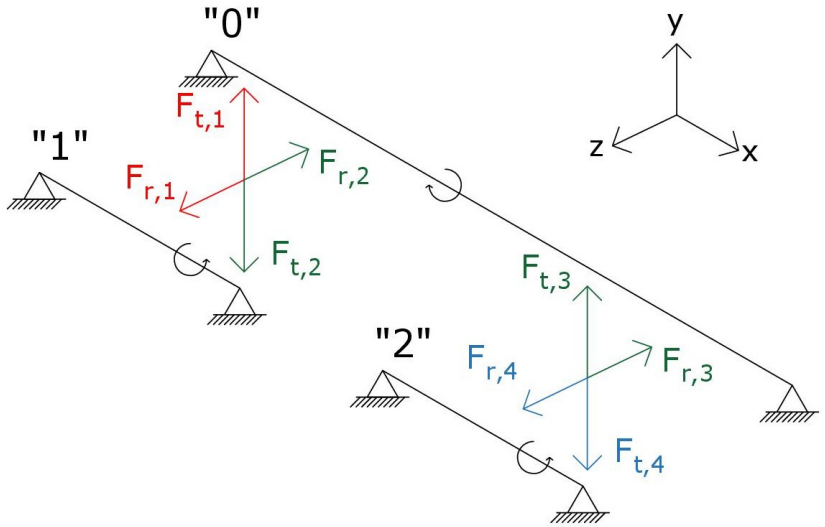
$$\tau = \tau_{12} = \tau_{34} = \sqrt{\tau_{tot}} = \sqrt{8} \cong 2{,}83$$

$$M_2 = M_{R2} \cdot f_S = 1300 \cdot 1{,}5 = 1950\ Nm$$

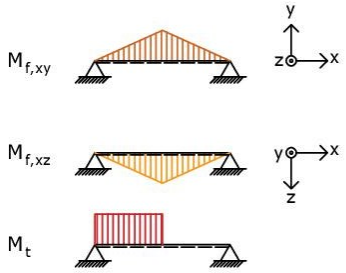
Albero	n [giri/min]	ω [rad/s]	P [kW]	M [Nm]
1	1409,57	147,61	38,99	264,19
0	498,08	52,16	37,44	717,75
2	176	18,43	35,94	1950,00

DIMENSIONAMENTO DELLE RUOTE DENTATE

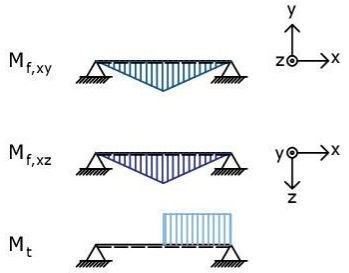
Ruota	Z	m [mm]	Dp [mm]	λ	b [mm]	i [mm]
1	17	5,5	93,5	6	33	178,75
2	48	5,5	264	6	33	
3	17	5,5	93,5	10	55	178,75
4	48	5,5	264	10	55	



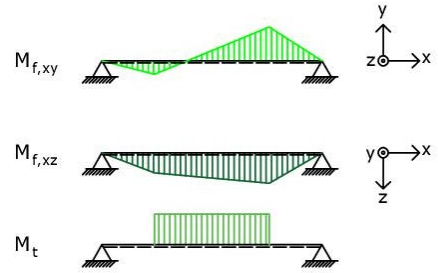
Albero 1



Albero 2

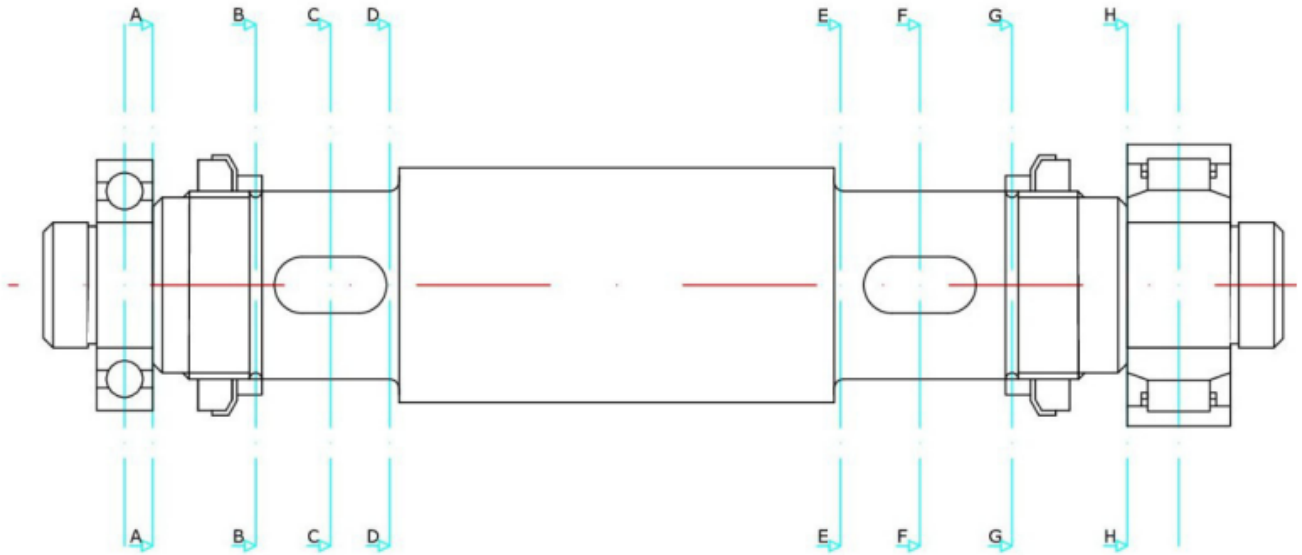


Albero 0



albero	F_r [N]	F_t [N]	M_f [Nmm]	M_t [Nmm]	σ_{id} [MPa]	y_s richiesto	d [mm]	y_s calcolato	L/d
1	2056	5651	198462	264190	78,43	7	34	7,161	3,88
0	5588	15352	948189	948189	53,43	10	60	10,487	5,63
2	5376	14772	652422	1950000	111,09	5	55	5,041	3,02

DIMENSIONAMENTO PRECEDENTE



Sezione	d	M_{fxy}	M_{fxz}	M_f	W_f	W_t	σ_f	τ_{Mt}	σ_{id}	ν_s
[ ]	$[mm]$	$[Nmm]$	$[Nmm]$	$[Nmm]$	$[mm^3]$	$[mm^3]$	$[MPa]$	$[MPa]$	$[MPa]$	$[MPa]$
A-A	40	5454	26631	27184	6283	/	4,3	0	4,3	129
B-B	56	25452	124278	126858	17241	/	7,4	0	7,4	76,1
C-C	60	39996	195294	199348	21206	42411	9,4	16,9	30,8	18,2
D-D	60	66308	216854	226765	21206	42411	10,7	16,9	31,2	17,9
E-E	60	737956	353074	818071	21206	42411	38,6	16,9	48,4	11,6
F-F	60	873243	382464	953327	21206	42411	45,0	16,9	53,7	10,4
G-G	56	562874	246528	614494	17241	/	35,6	0	35,6	15,7
H-H	40	173597	76032	189517	6283	/	30,1	0	30,2	18,6

Sezione	σ_a	τ_{Mt}	K_d	K_l	K_f	$\sigma^*_{a\infty,-1}$	ν_f
[ ]	$[MPa]$	$[MPa]$	[ ]	[ ]	[ ]	$[MPa]$	[ ]
A-A	4,3	0	1,2	1,07	2,7	112,5	25,2
B-B	7,3	0	1,25	1,2	2,49	104,4	14,3
C-C	9,4	16,9	1,26	1,2	2,1	122,8	13,1
D-D	10,7	16,9	1,26	1,07	1,96	147,6	13,4
E-E	38,5	16,9	1,26	1,07	1,96	147,6	3,7
F-F	44,7	16,9	1,26	1,2	2,1	122,8	2,7
G-G	35,3	0	1,25	1,2	2,49	104,4	2,9
H-H	30,1	0	1,2	1,07	2,7	112,5	3,7

SCELTA DI CUSCINETTI E LINGUETTE ALBERO 1

$$R_{sx,xy}=R_{dx,xy}=\frac{F_{t,1}}{2}=\frac{5651}{2}=2825\,N \qquad R_{dx,xz}=R_{dx,xz}=\frac{F_{r,1}}{2}=\frac{2056}{2}=1028\,N$$

$$R_{sx}=\sqrt{R_{xs,xy}^2+R_{xs,xz}^2}=\sqrt{2825^2+1028^2}=3006\,N$$

$$R_{dx}=\sqrt{R_{dx,xy}^2+R_{dx,xz}^2}=\sqrt{2825^2+1028^2}=3006\,N$$

$$L_{10}=\frac{60\,n_1\,L_{10h}}{10^6}=\frac{60\cdot 1409{,}57\cdot 40000}{10^6}=3383\,milioni\,di\,giri$$

Cuscinetto sinistro SKF 6309

$$C=L_{10}^{P}\cdot R_{dx}=3383^{\frac{1}{3}}\cdot 3006=45124\,N$$

Cuscinetto destro SKF NU 2304 ECP

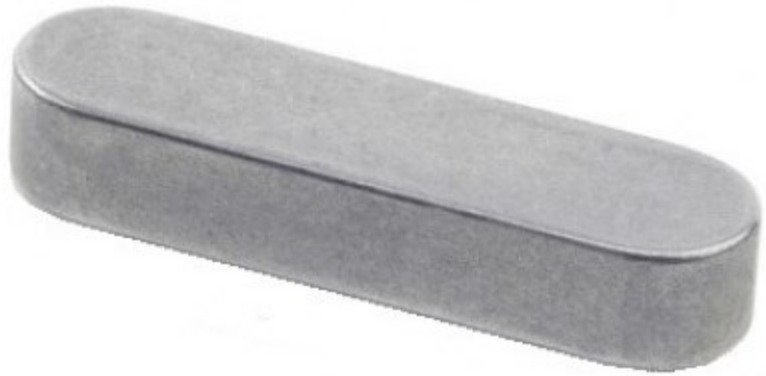
$$C=L_{10}^{P}\cdot R_{dx}=3383^{\frac{3}{10}}\cdot 3006=34417\,N$$

$$\sigma_{adm}=\frac{\sigma_s}{\nu_s}=\frac{420}{1{,}5}=280\,MPa \qquad \tau_{adm}=\frac{\sigma_{adm}}{\sqrt{3}}=\frac{280}{\sqrt{3}}=161\,MPa$$

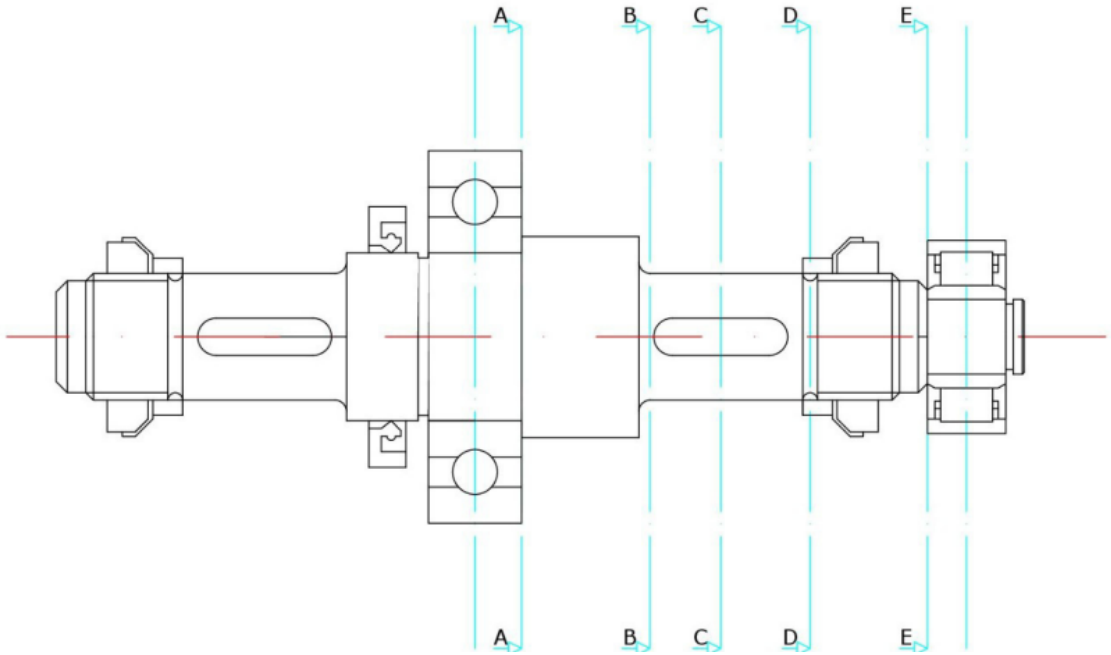
$$l=2\frac{M_{t1}}{d_1\,t_1\,p_c}=2\frac{264190}{34\cdot 5\cdot 90}=34{,}53\,mm\rightarrow scelgo\;\; l=36\,mm$$

$$\tau=2\frac{M_{t1}}{d_1\,b\,l}=2\frac{264190}{34\cdot 10\cdot 36}=43{,}168\,MPa<\tau_{adm}=161\,MPa$$

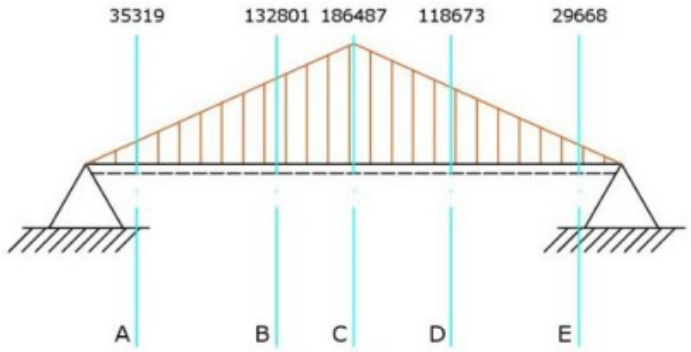
B 10×8×36 UNI 6604



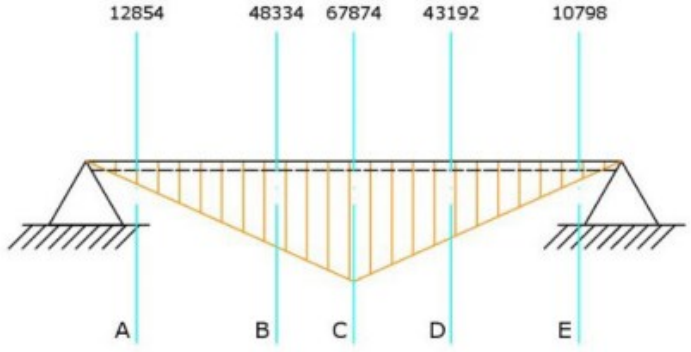
VERIFICA ALBERO 1

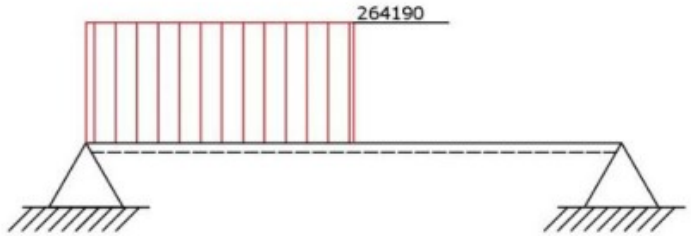


$M_{f,xy}$



$M_{f,xz}$





Sez.	d	σ_a	τ	K_d	K_l	K_f	$\sigma'_{a,\sigma_y=1}$	ν_f
[]	[mm]	[MPa]	[MPa]	[]	[]	[]	[MPa]	[]
AA	45,00	4,20	14,77	1,22	1,07	2,49	119,98	28,57
BB	34,00	36,63	34,23	1,18	1,07	2,1	147,52	4,03
CC	34,00	51,43	34,23	1,18	1,20	2,1	131,54	2,56
DD	32,00	39,26	0,00	1,16	1,20	2,18	128,51	3,27
EE	20,00	40,20	0,00	1,10	1,07	2,21	149,93	3,73

SCELTA DI CUSCINETTI E LINGUETTE ALBERO 2

$$R_{sx,xy}=R_{dx,xy}=\frac{F_{t,4}}{2}=\frac{14772}{2}=7386\,N \qquad R_{dx,xz}=R_{dx,xz}=\frac{F_{r,4}}{2}=\frac{5376}{2}=2688\,N$$

$$R_{sx}=\sqrt{R_{xs,xy}^2+R_{xs,xz}^2}=\sqrt{7386^2+2688^2}=7860\,N$$

$$R_{dx}=\sqrt{R_{dx,xy}^2+R_{dx,xz}^2}=\sqrt{7386^2+2688^2}=7860\,N$$

Cuscinetto destro SKF 6214

$$C=L_{10}^{P}\cdot R_{dx}=422{,}4^{\frac{1}{3}}\cdot 7860=58974\,N$$

Cuscinetto sinistro Nu 2308 ECP

$$C=L_{10}^{P}\cdot R_{dx}=422{,}4^{\frac{3}{10}}\cdot 7860=48210\,N$$

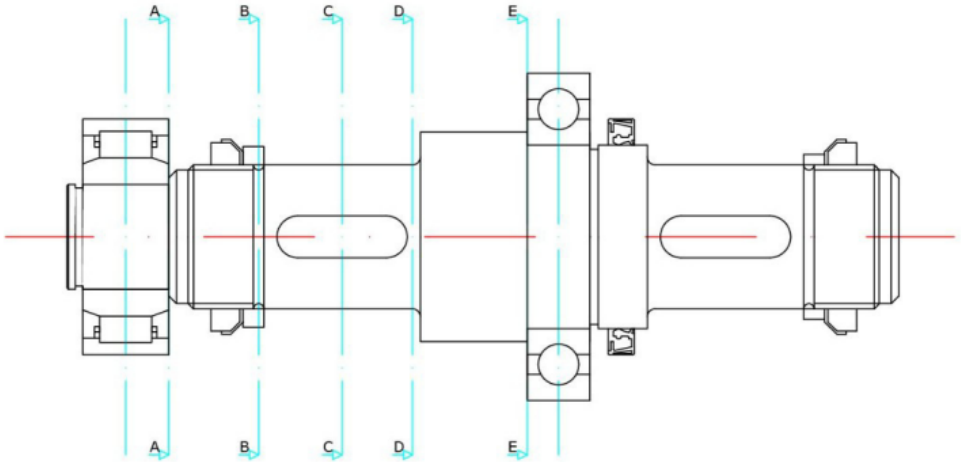
$$\sigma_{adm}=\frac{\sigma_s}{\nu_s}=\frac{420}{1{,}5}=280\,MPa \qquad \tau_{adm}=\frac{\sigma_{adm}}{\sqrt{3}}=\frac{280}{\sqrt{3}}=161\,MPa$$

$$l=2\frac{M_{t2}}{2\cdot d_1 t_1 p_c}=2\frac{1950000}{2\cdot 55\cdot 6\cdot 105}=48{,}23\,mm \rightarrow scelgo\ \ l=50\,mm$$

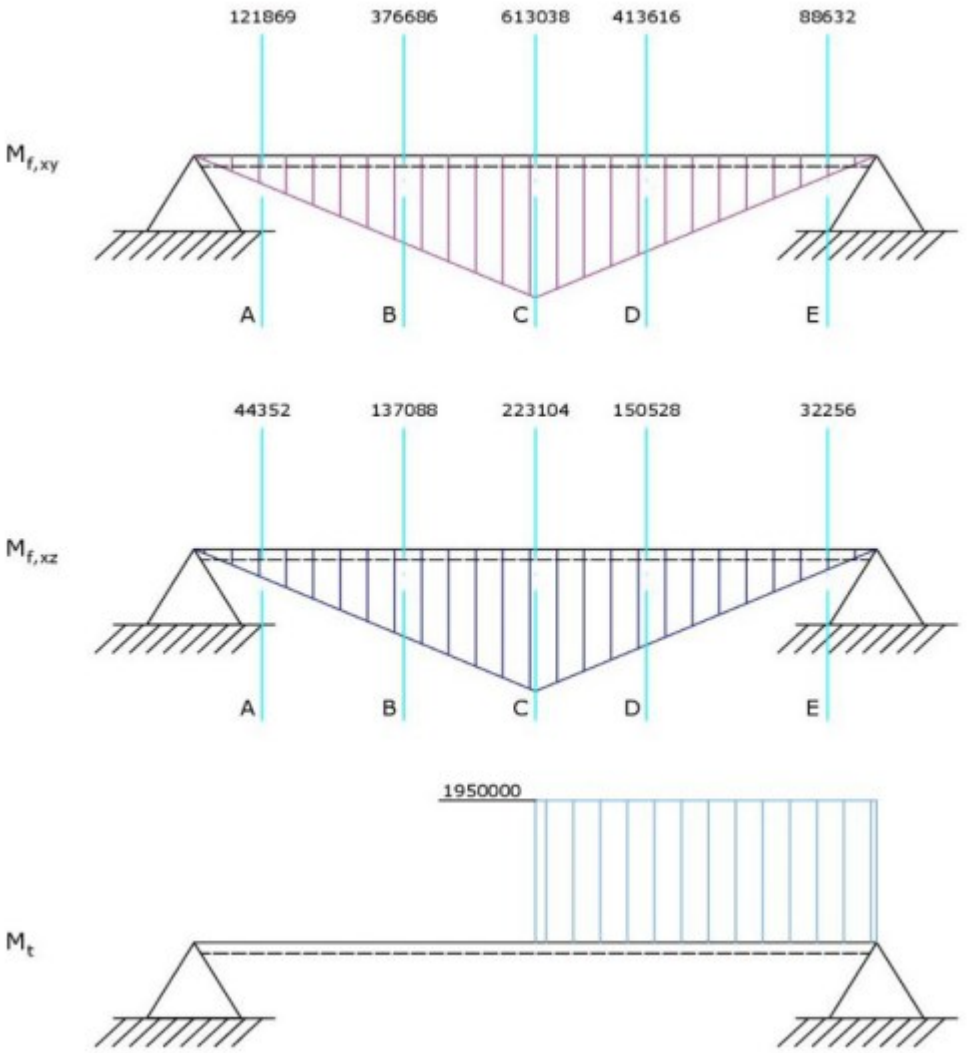
$$\tau=2\frac{M_{t1}}{d_1 b l}=2\frac{1950000}{2\cdot 55\cdot 16\cdot 50}=44{,}318\,MPa < \tau_{adm}=161\,MPa$$

2 linguette
B 16×10×50 UNI 6604

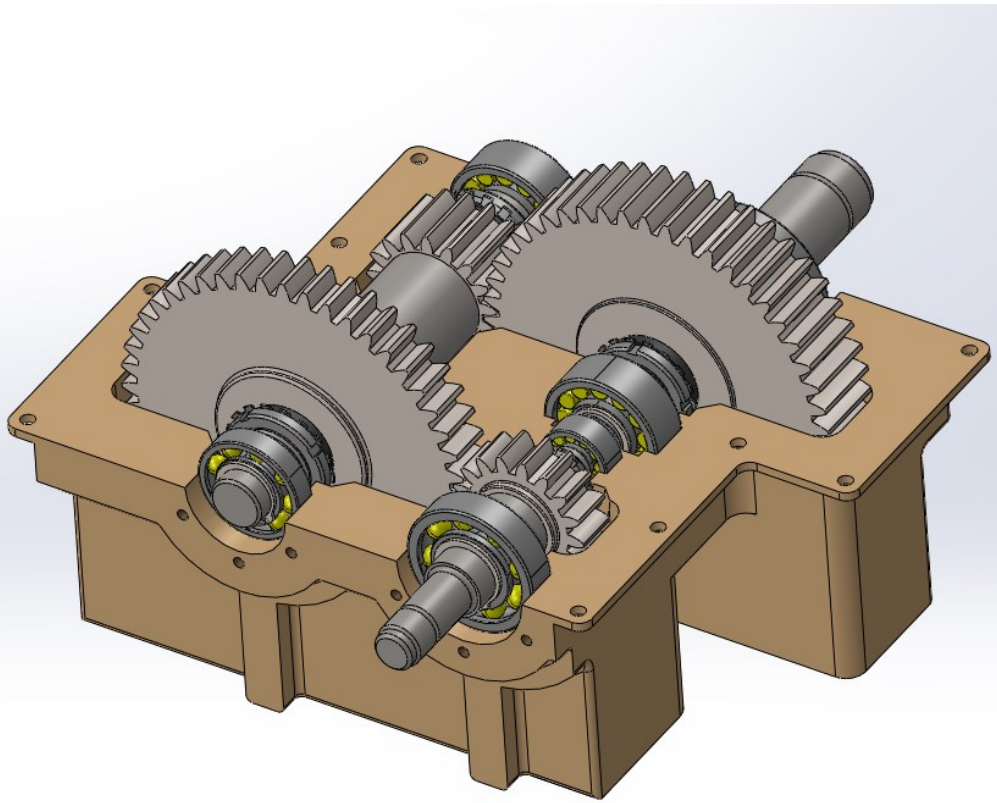
VERIFICA ALBERO 2

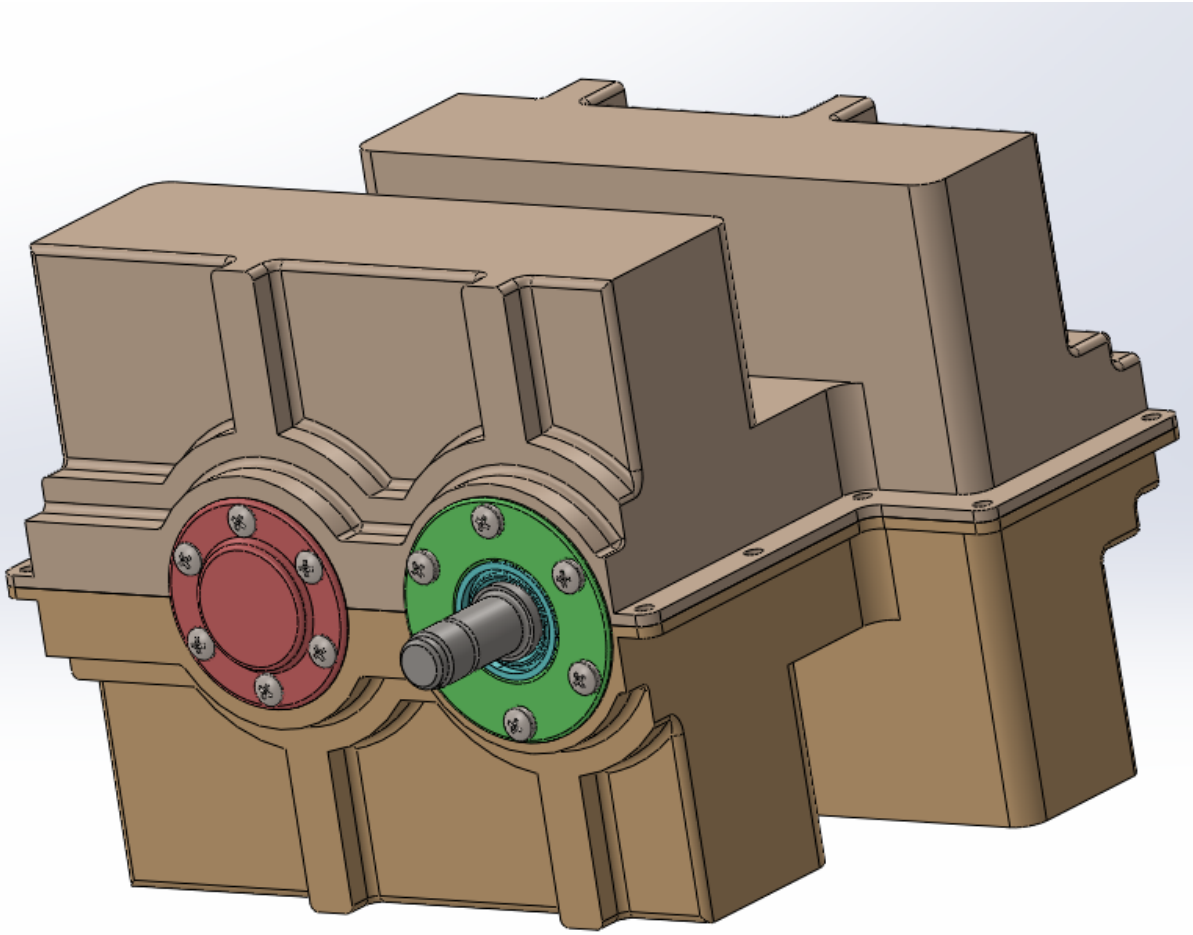


Sez.	d	σ_a	τ	K_d	K_l	K_f	$\sigma'_{a,\infty,-1}$	ν_f
[]	[mm]	[MPa]	[MPa]	[]	[]	[]	[MPa]	[]
AA	40,00	20,64	0,00	1,20	1,07	2,47	122,97	5,96
BB	51,00	30,78	0,00	1,24	1,20	2,16	121,83	3,96
CC	55,00	39,94	59,69	1,25	1,20	2,1	124,21	3,11
DD	55,00	26,95	59,69	1,25	1,07	2,08	140,64	5,22
EE	70,00	2,80	28,95	1,28	1,07	2,28	124,82	44,56

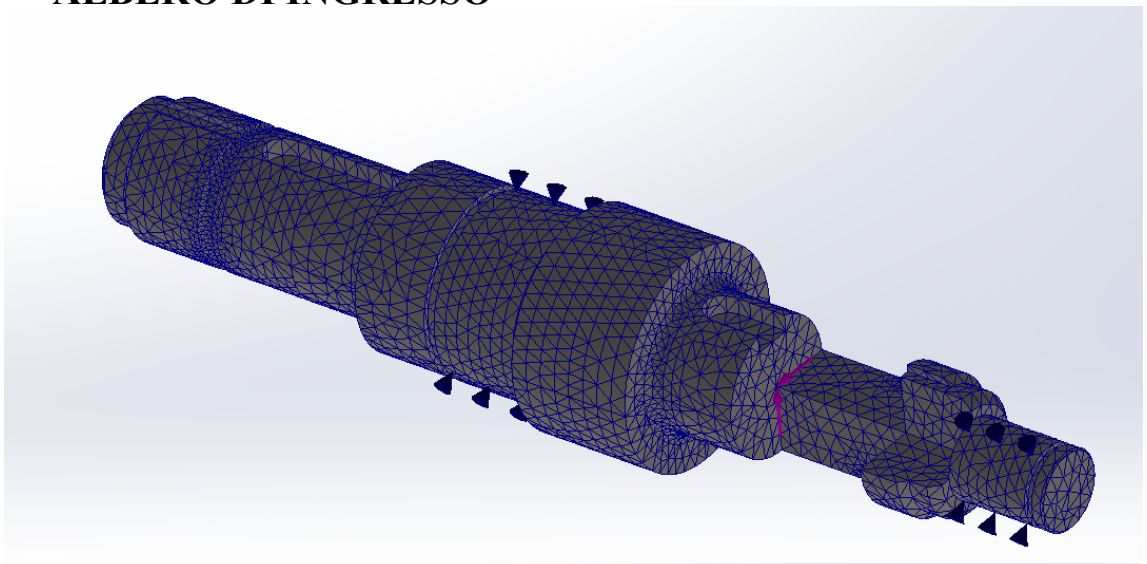


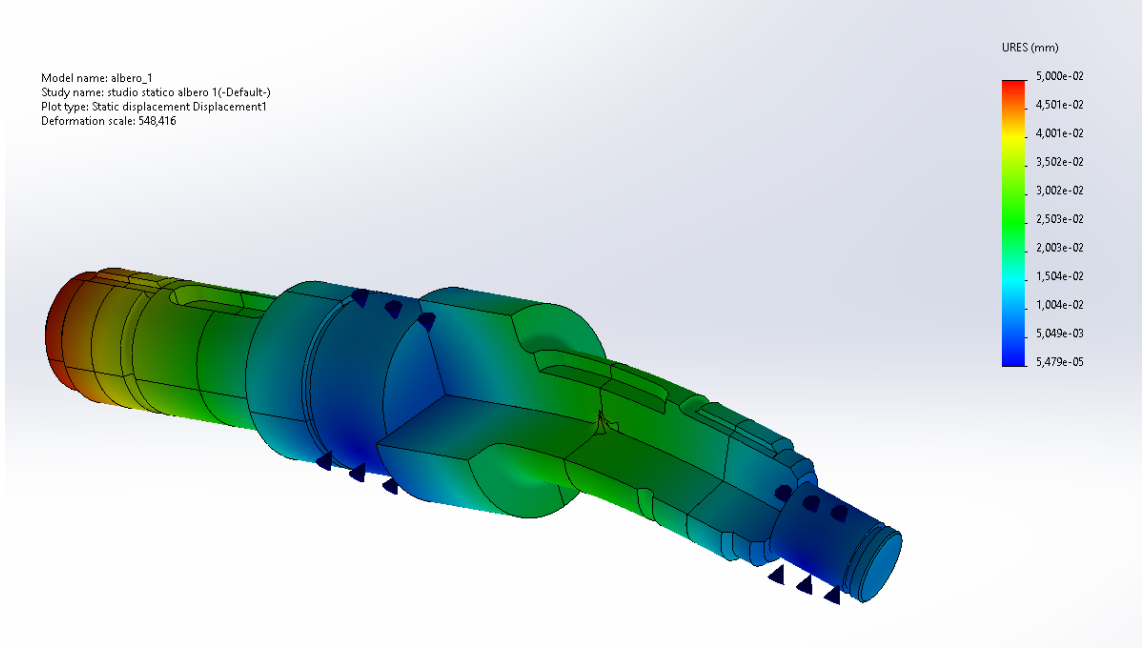
REALIZZAZIONE DEL MODELLO SOLIDWORKS

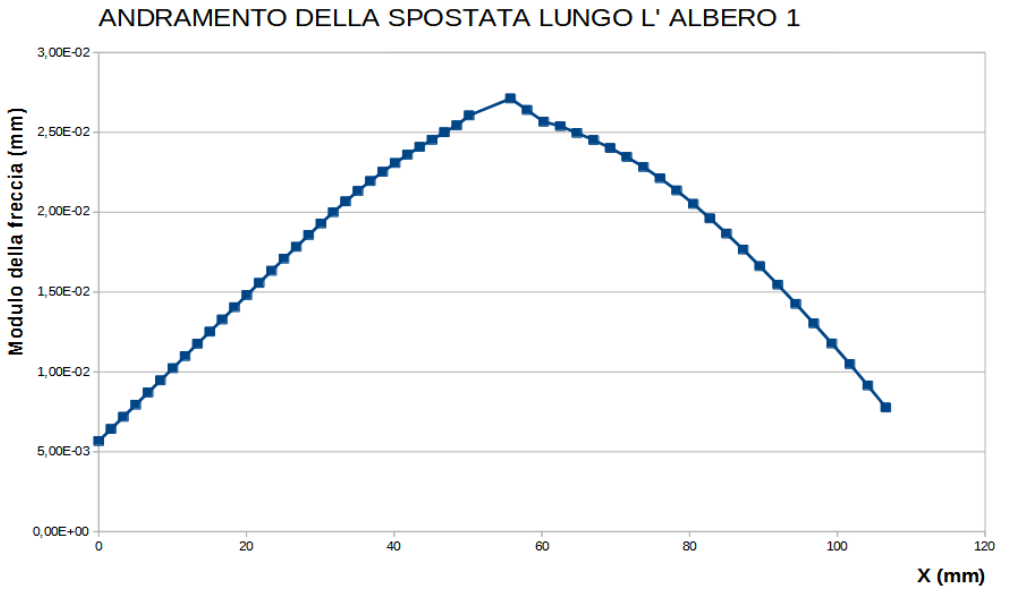


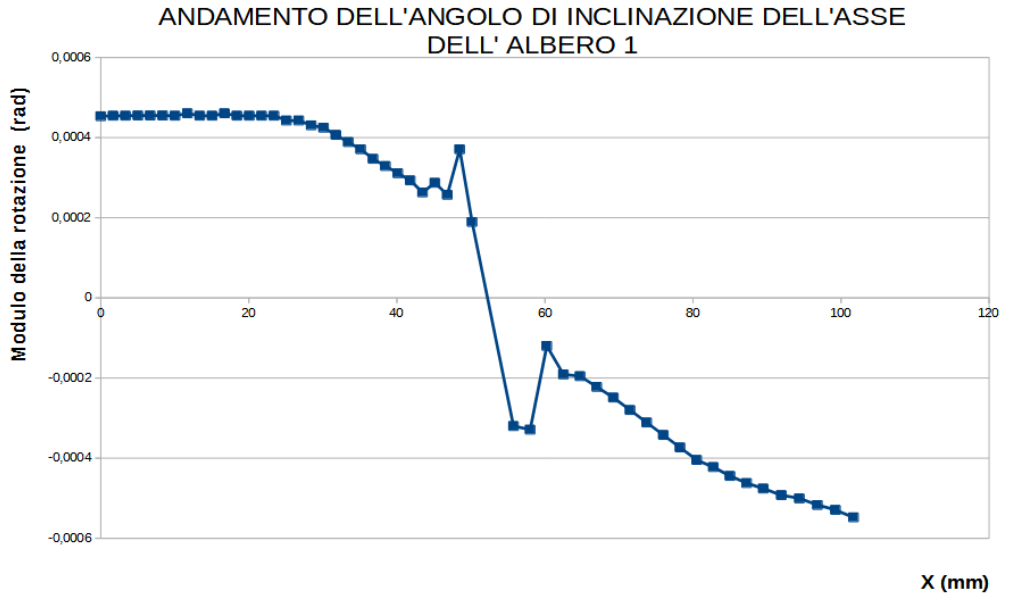


ALBERO DI INGRESSO

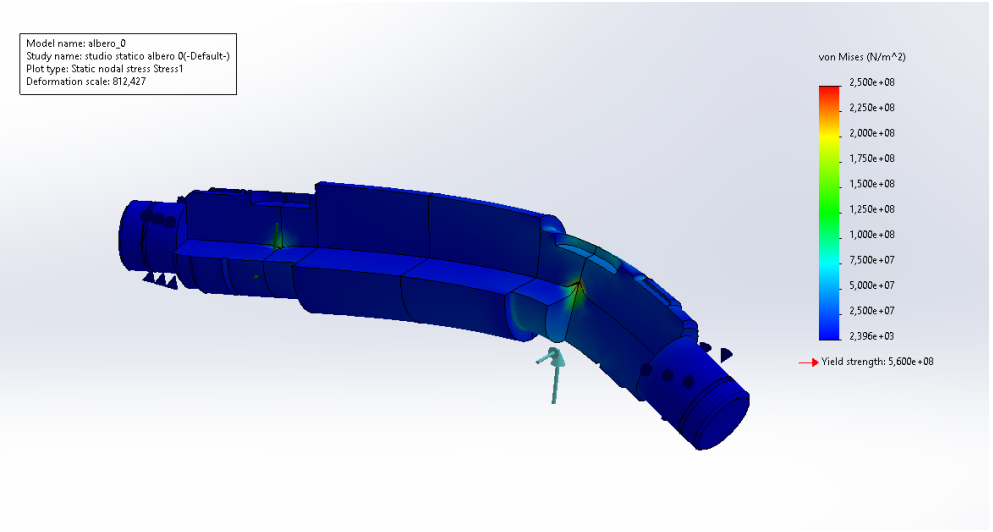


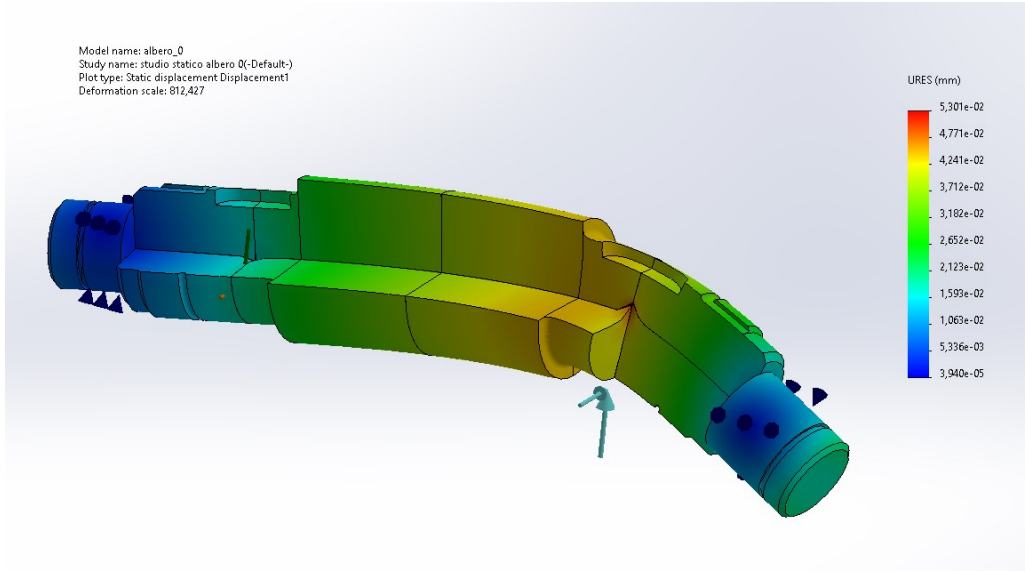




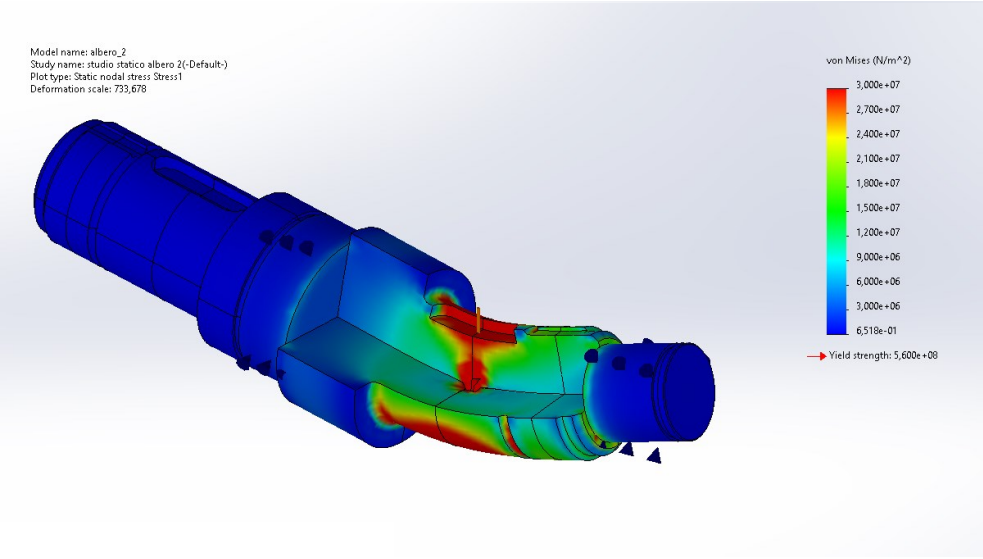


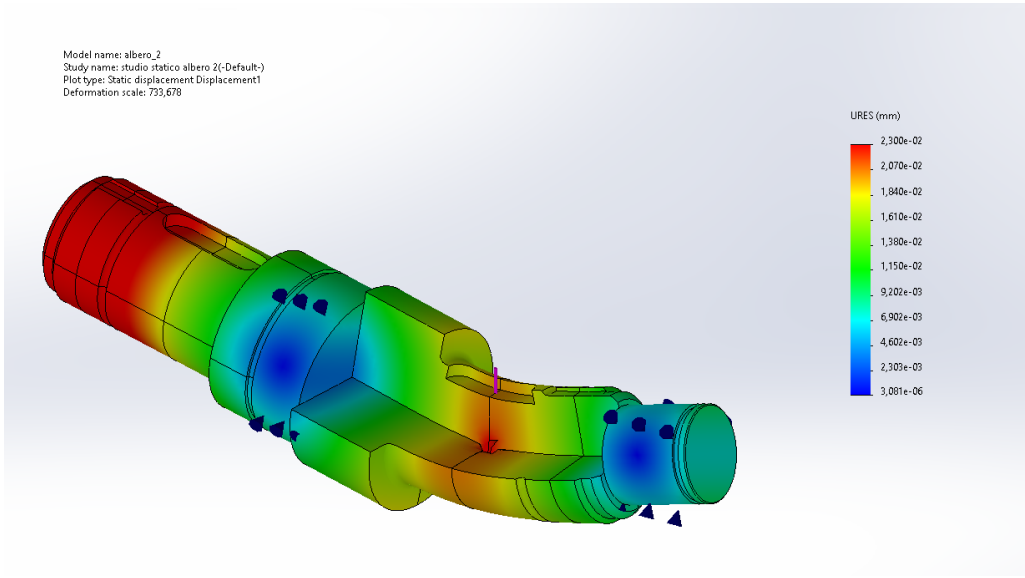
ALBERO INTERMEDIO





ALBERO DI USCITA





CONCLUSIONI

- Verifica statica ✓
- Verifica a fatica ✓
- Verifica a deformazione

FORMULE ✓

FEM ✓

IMPRECISIONI

- Occorre affinare il modello mesh
- Studio più accurato della cassa del riduttore
- Mancanza di informazioni sul budget di progetto