

Dezembro 04, 2020

Terceira Prévia

WIND WAY

WIND WAY



Primeira Previa



WIND WAY



Objetivo

- Projetar turbina eólica vertical (VAWT)
- Alta Potência 10000W

Benchmarking

- Solar Constructions
- Hivawt

Matriz de Decisão

- Tipo de Turbina
- Faixa de Potência

Motivação

- Metas de Sustentabilidade Onu
- Cenário Brasileiro





Vantagens

- Energia renovável, segura, limpa e inesgotável
- Bom desempenho em ventos turbulentos
- Direção do vento não é fator preponderante
- Baixo nível de ruído
- Não emite gases poluentes
- Versatilidade de ambientes de aplicação
- Acompanha as tendências de mercado



Crédito: JAC/Divulgação



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Sugestão de aplicação

Utilização de energia limpa, renovável, inesgotável e não poluente em postos de abastecimento de automóveis elétricos. Colaborando para a diminuição do efeito estufa.

Segundo pesquisa da Bloomberg New Energy Finance (BNEF), até 2040 serão 56 milhões de carros elétricos em circulação, isso representa 57% da frota mundial.



Impacto Ambiental



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Descarte feito em aterros (criação de resíduo-sólidos)

Perigo de colisão de animais voadores

Possibilidade de erosão do solo

Impacto estético

Interferências eletromagnéticas



Corrosão



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- Exigência de longos intervalos entre manutenções;
- ISO 12944: Paints and varnishes — Corrosion protection of steel structures by protective paint systems;
- Classificação C3 conforme corrosão do ambiente;
- Duração esperada: “medium” (5 a 15 anos);
- Indicado binder de Epóxi e primer de Zinco;
- Exemplo no mercado: Interzinc 52, da Akzo Nobel.

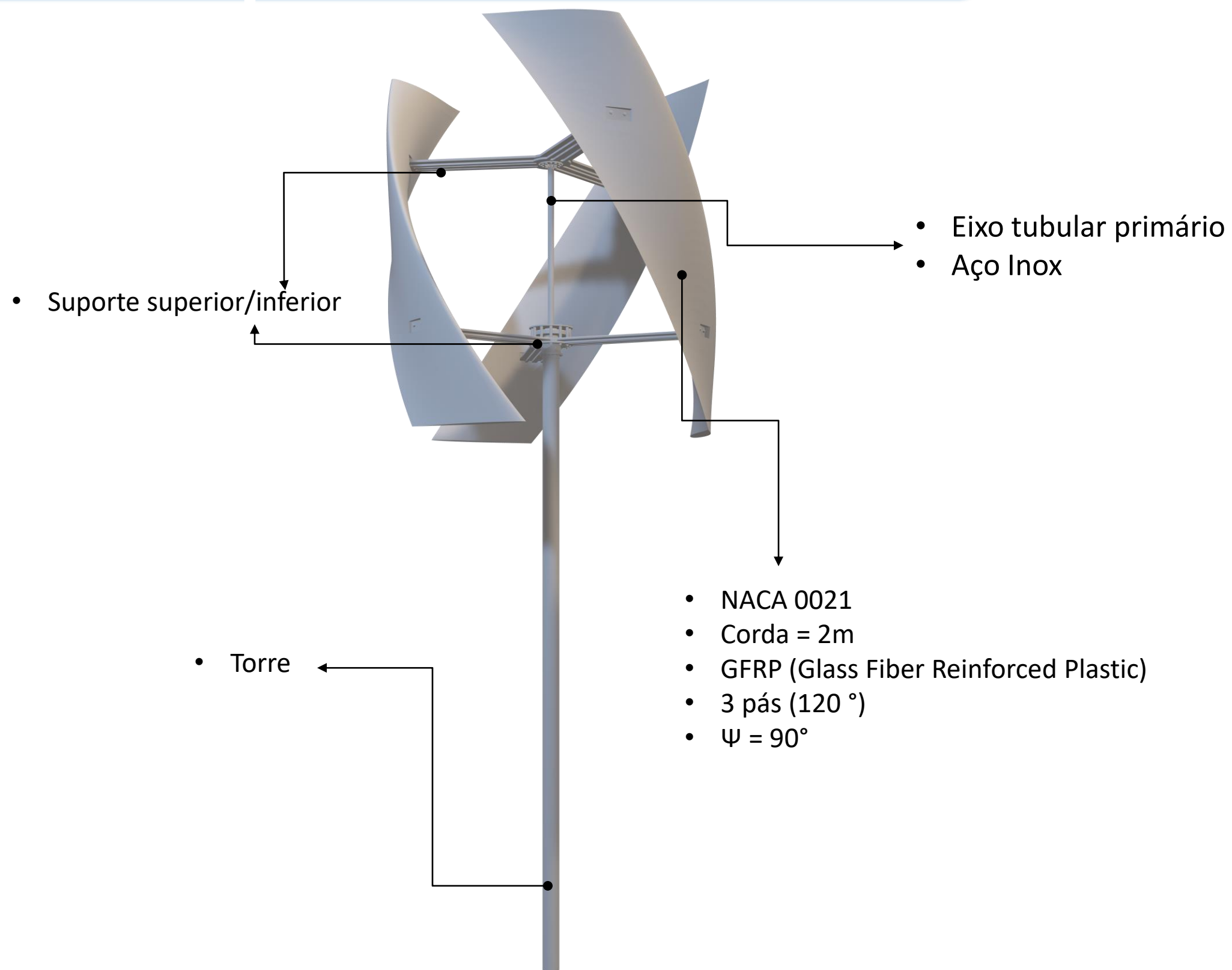




Segunda Previa



WIND WAY



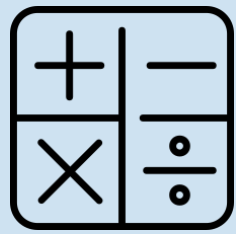
Fonte: Autor

Normas e Patentes

- Patente Gorlov
- Patente Stampa
- NBR 8800
- ISO 12944
- AISI 316/L
- DIN 13
- NACA

Gerador

- Síncrono de ímãs permanentes
- Ímãs de Neodímio
- 10KW
- Sem necessidade de caixa de transmissão



Cálculos

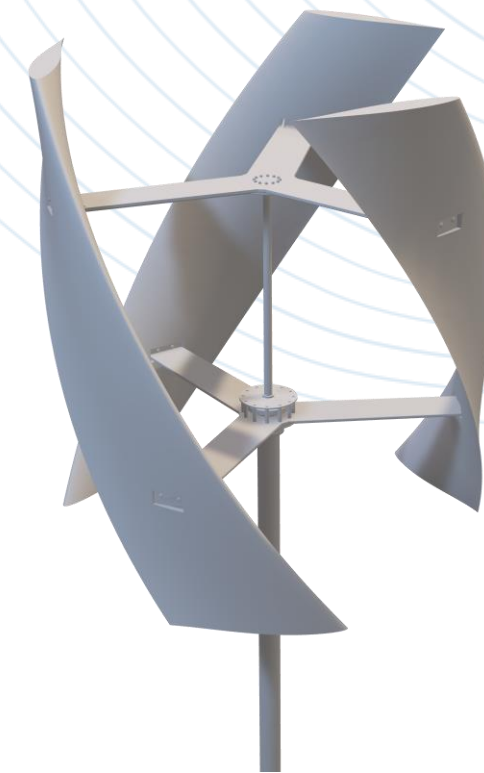
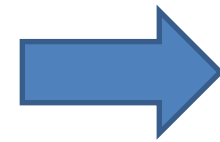
Área estimada



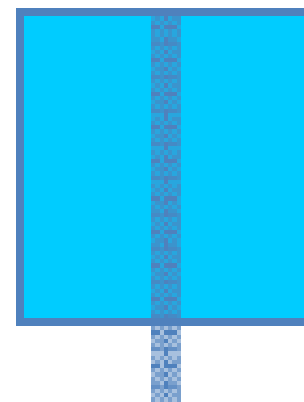
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$$\left\{ \begin{array}{l} P_{in} = \frac{1}{2} \rho A v_{\infty}^3 \\ P_{out} = \eta_b \cdot \eta_m \cdot \eta_e \cdot P_{in} \\ C_p = \eta_b \cdot \eta_m \cdot \eta_e \end{array} \right.$$



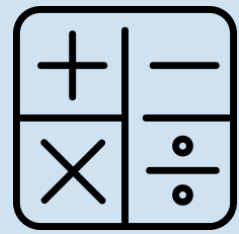
$$A = HD$$



$$\left\{ \begin{array}{l} A = 25.85 \text{ m}^2 \\ D = 4.88 \text{ m} \\ H = 5.3 \text{ m} \end{array} \right.$$

$$\left\{ \begin{array}{l} \rho = 1.225 \text{ kg/m}^3 \\ v_{\infty} = 12 \text{ m/s} \\ P_{out_projeto} = 10 \text{ kW} \\ \eta_b = 0.397 \text{ (aerodinâmica)} \\ \eta_m = 0.96 \text{ (mecânica)} \\ \eta_e = 0.94 \text{ (elétrica)} \end{array} \right.$$

Fonte: Workshop PUCRS 2012



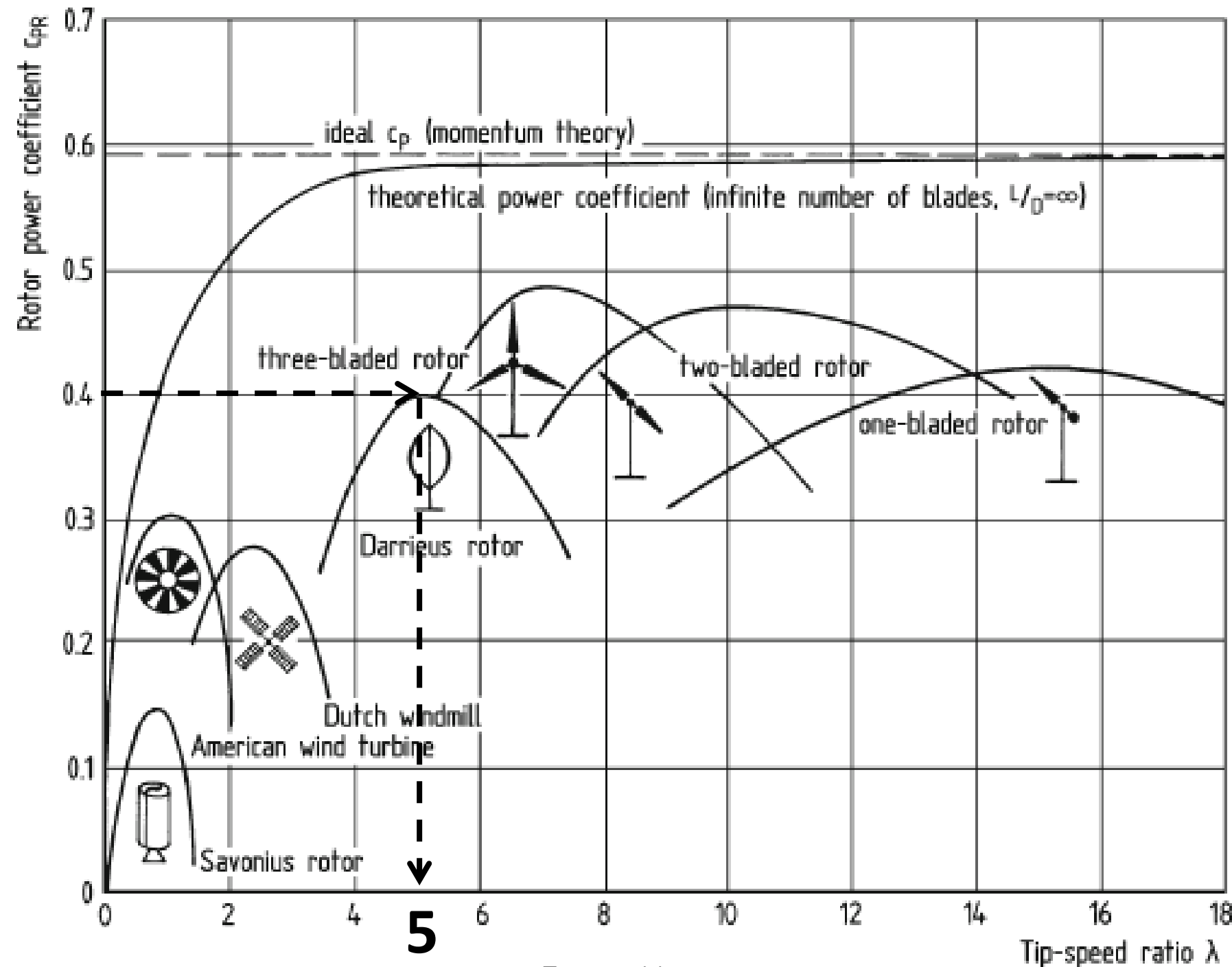
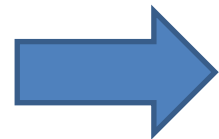
Cálculos TSR



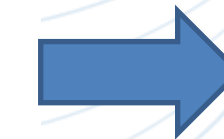
WIND WAY



$$TSR = \lambda = \frac{\omega R}{v_{\infty}}$$



Fonte: Hau.



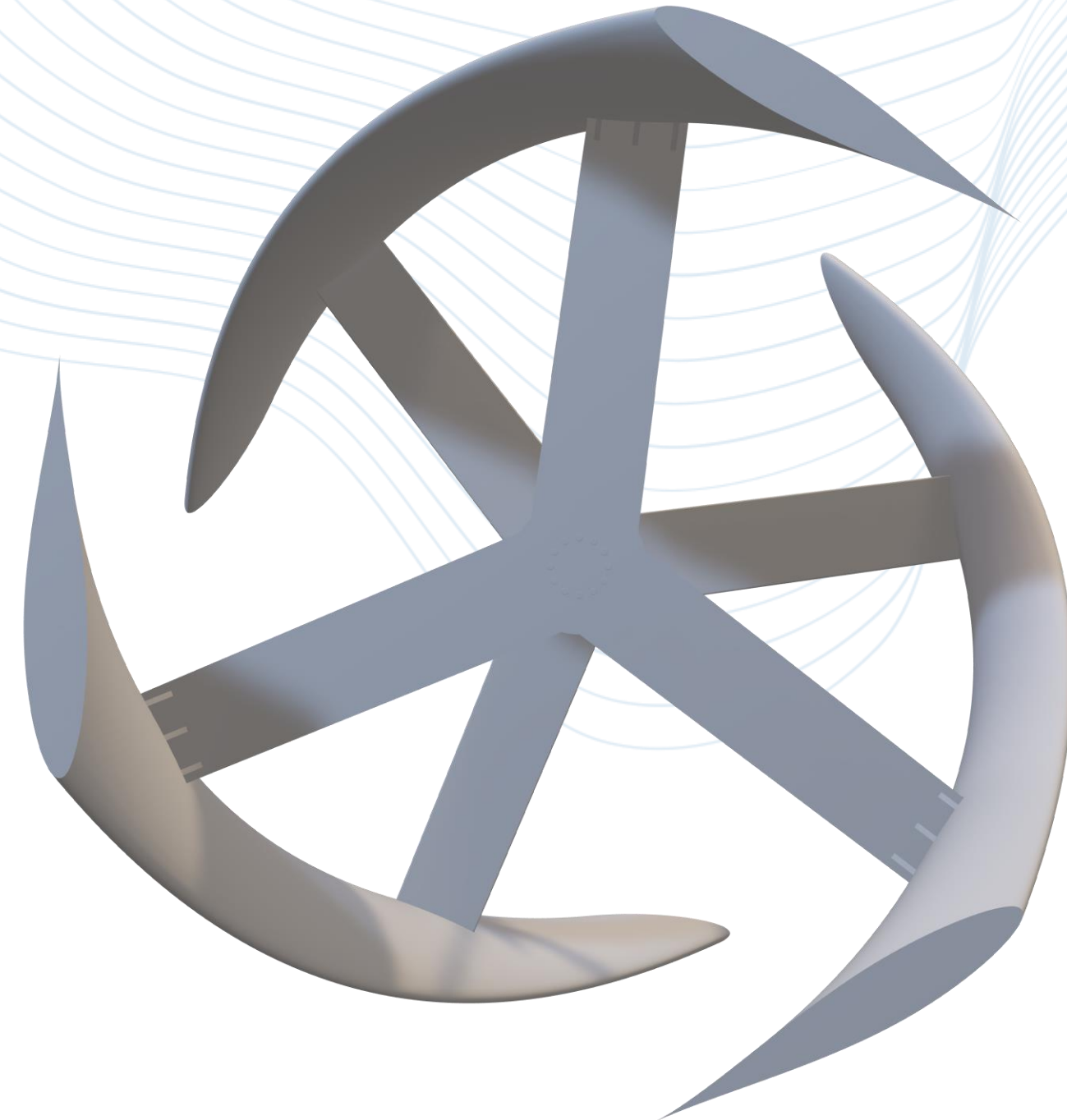
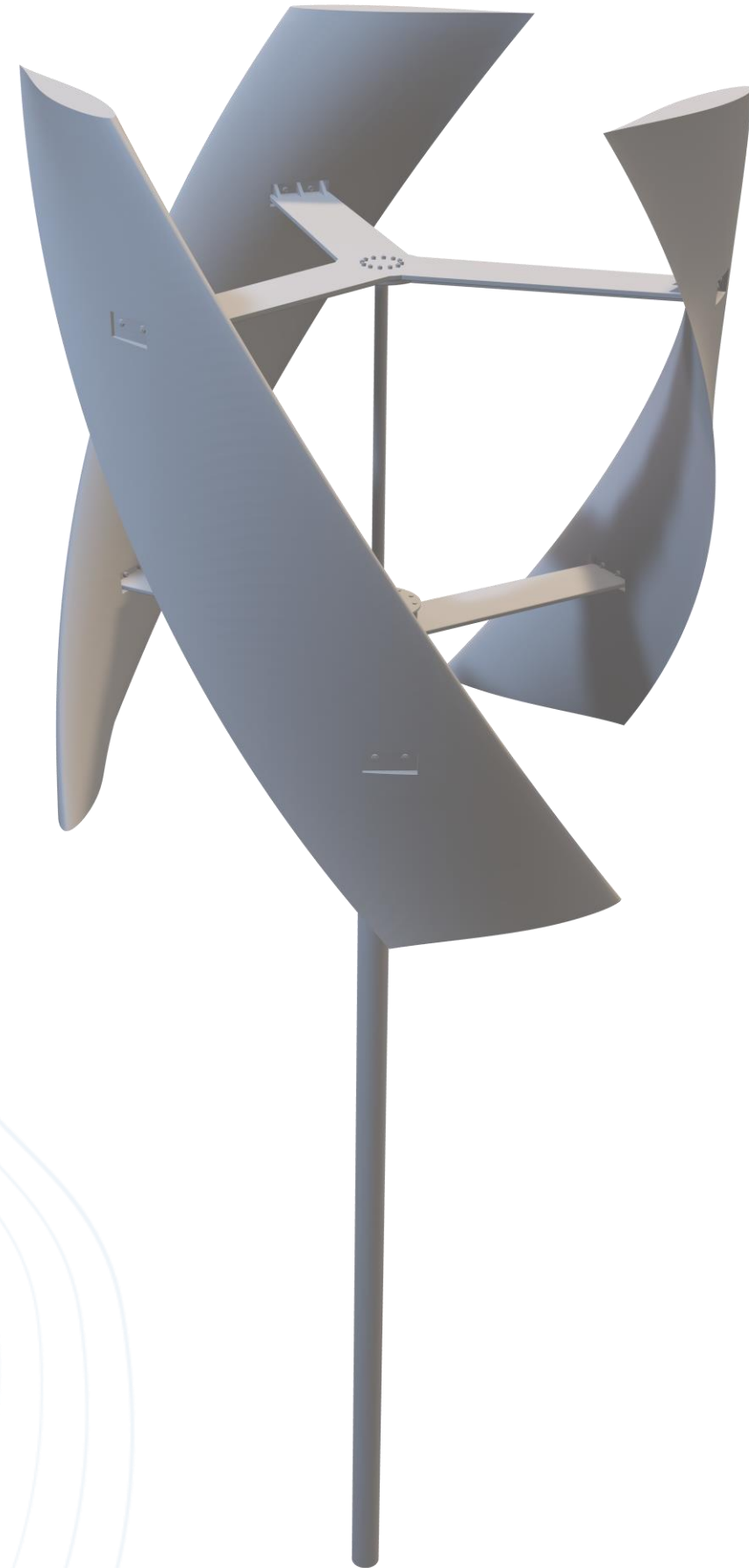
$$\begin{aligned} v_{pás} &= 60 \text{ m/s} \\ \omega &= 234.98 \text{ RPM} \\ T &= 0.255 \text{ s} \end{aligned}$$



CAD



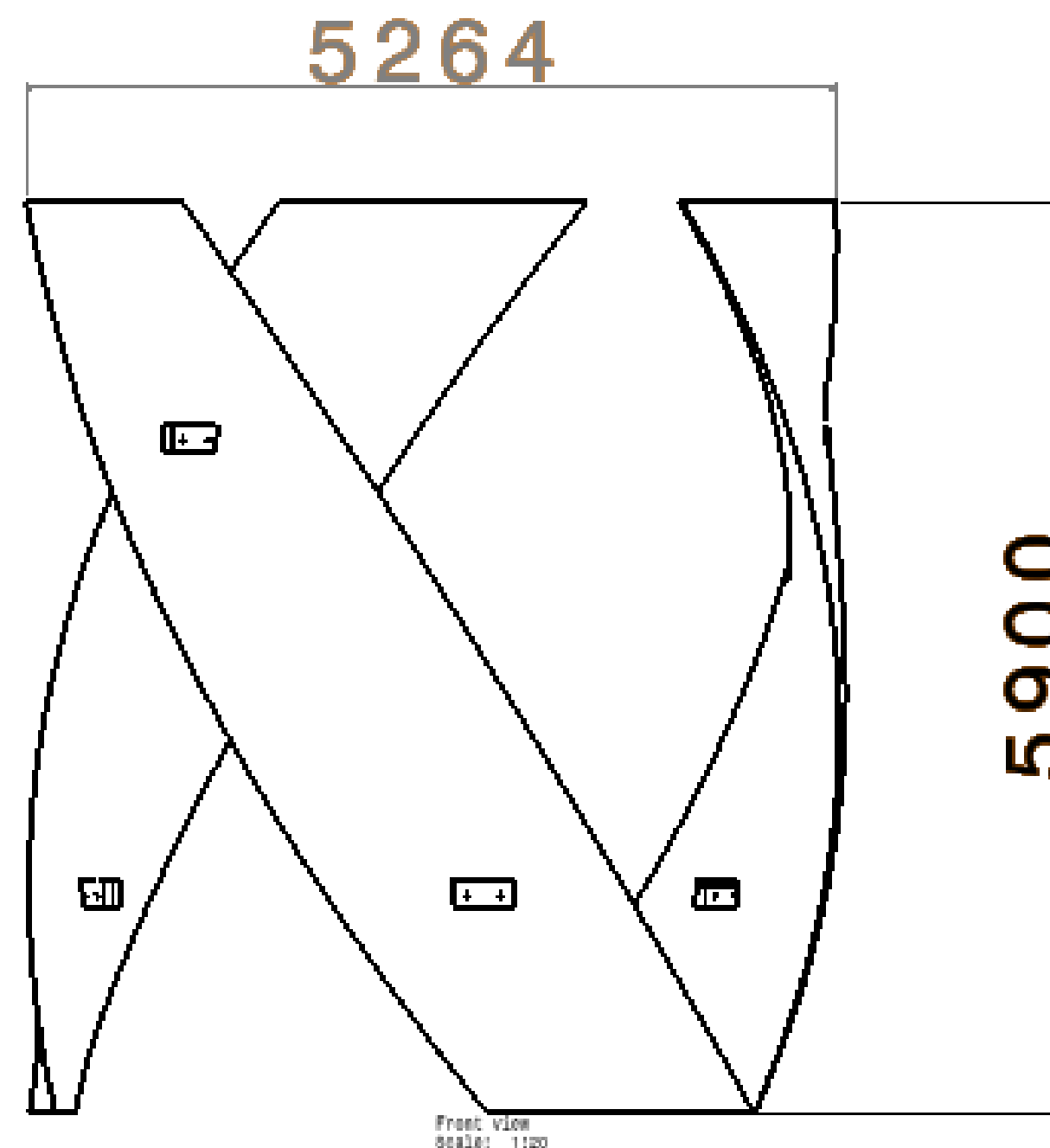
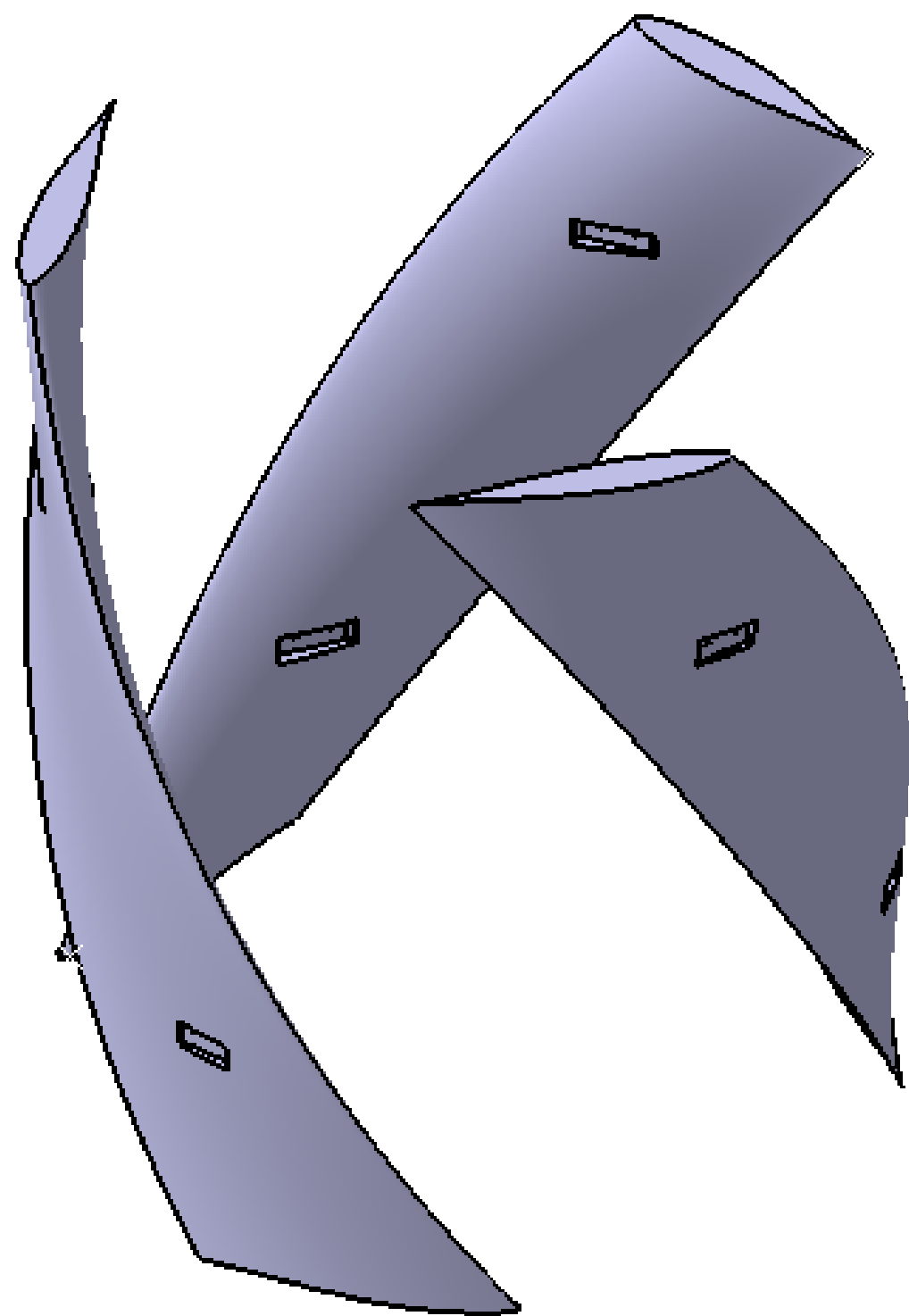
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CAD - Pás



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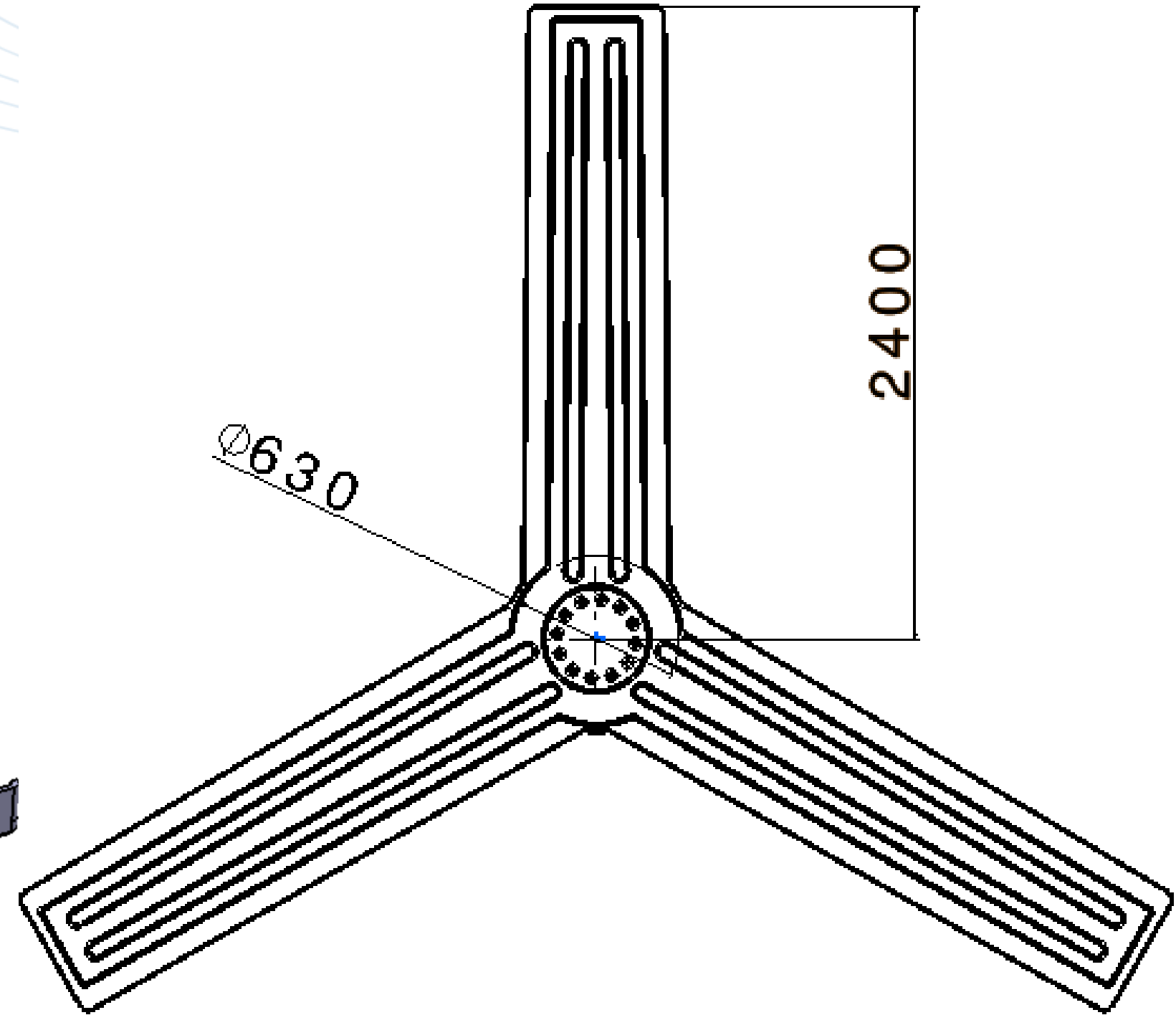
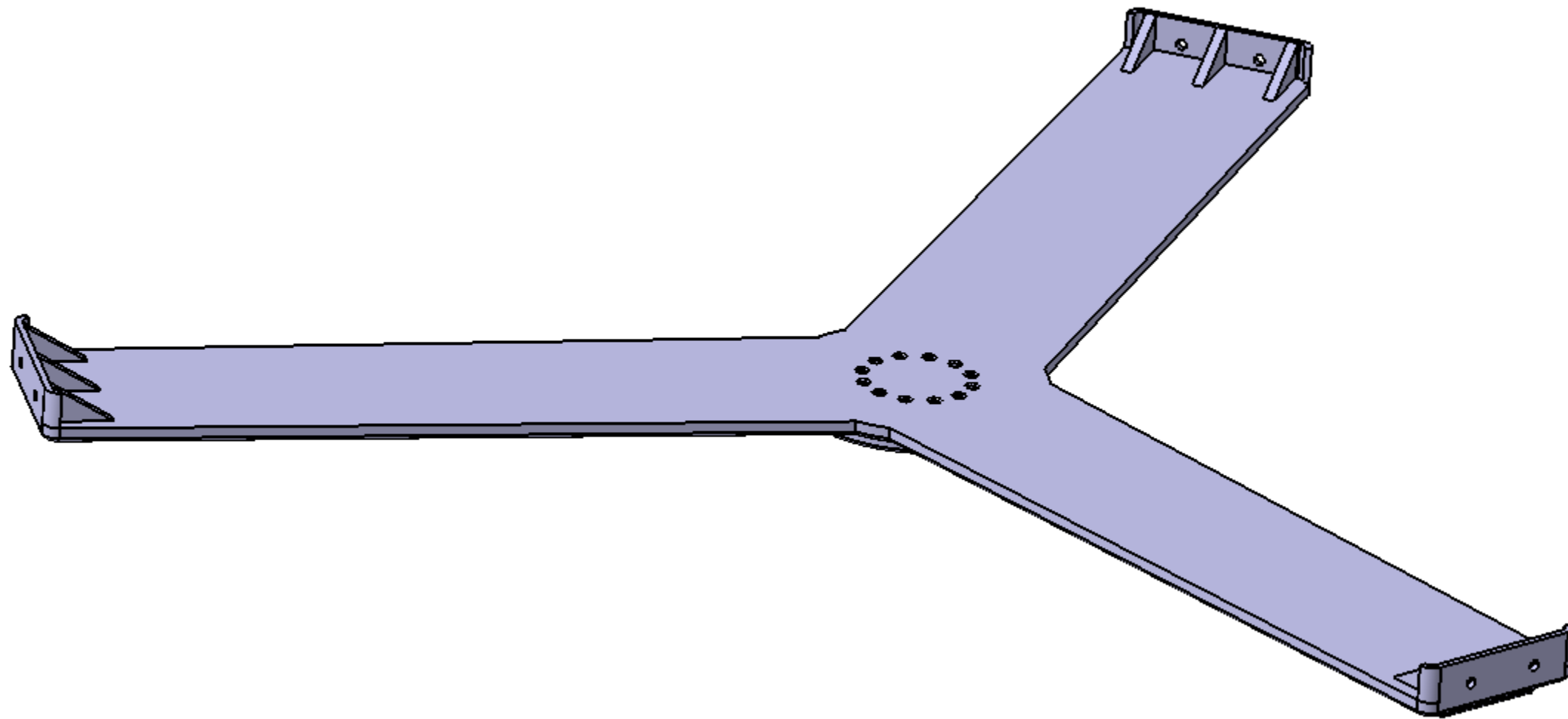
NACA 63215

Corda = 2 m

CAD - Suporte das pás superior



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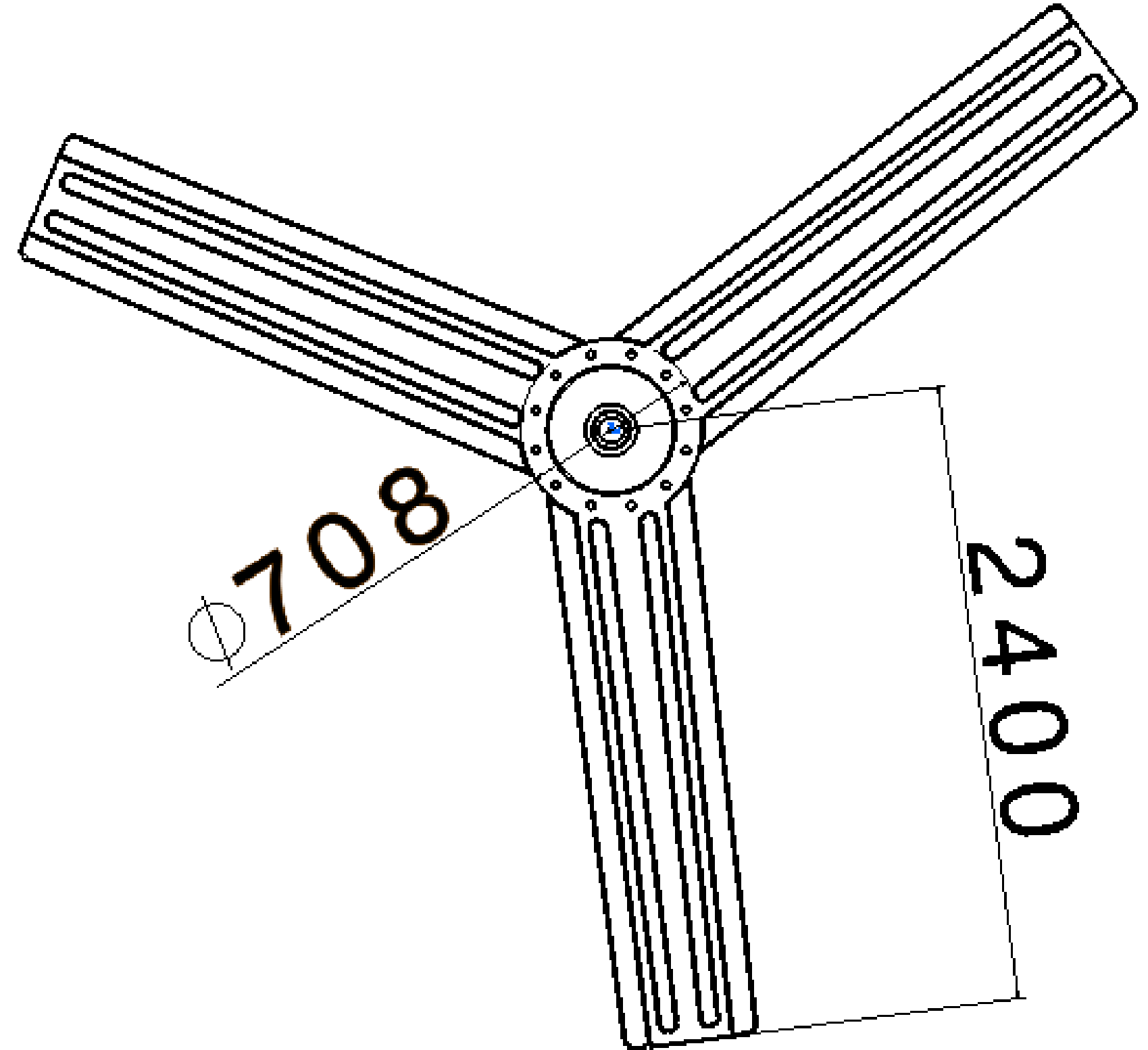
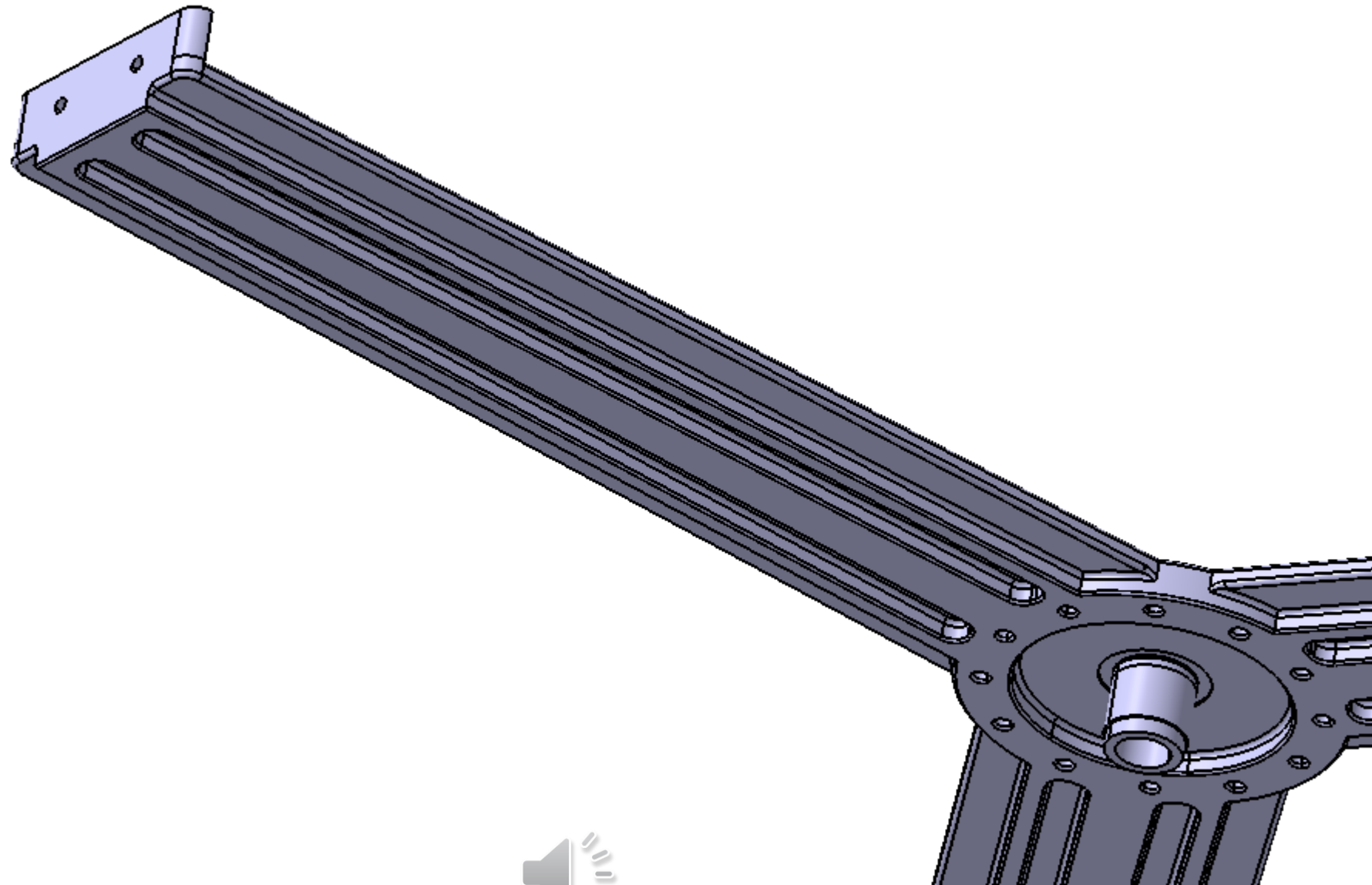
Bottom view
Scale: 1:10



CAD - Suporte das pás inferior



WIND WAY

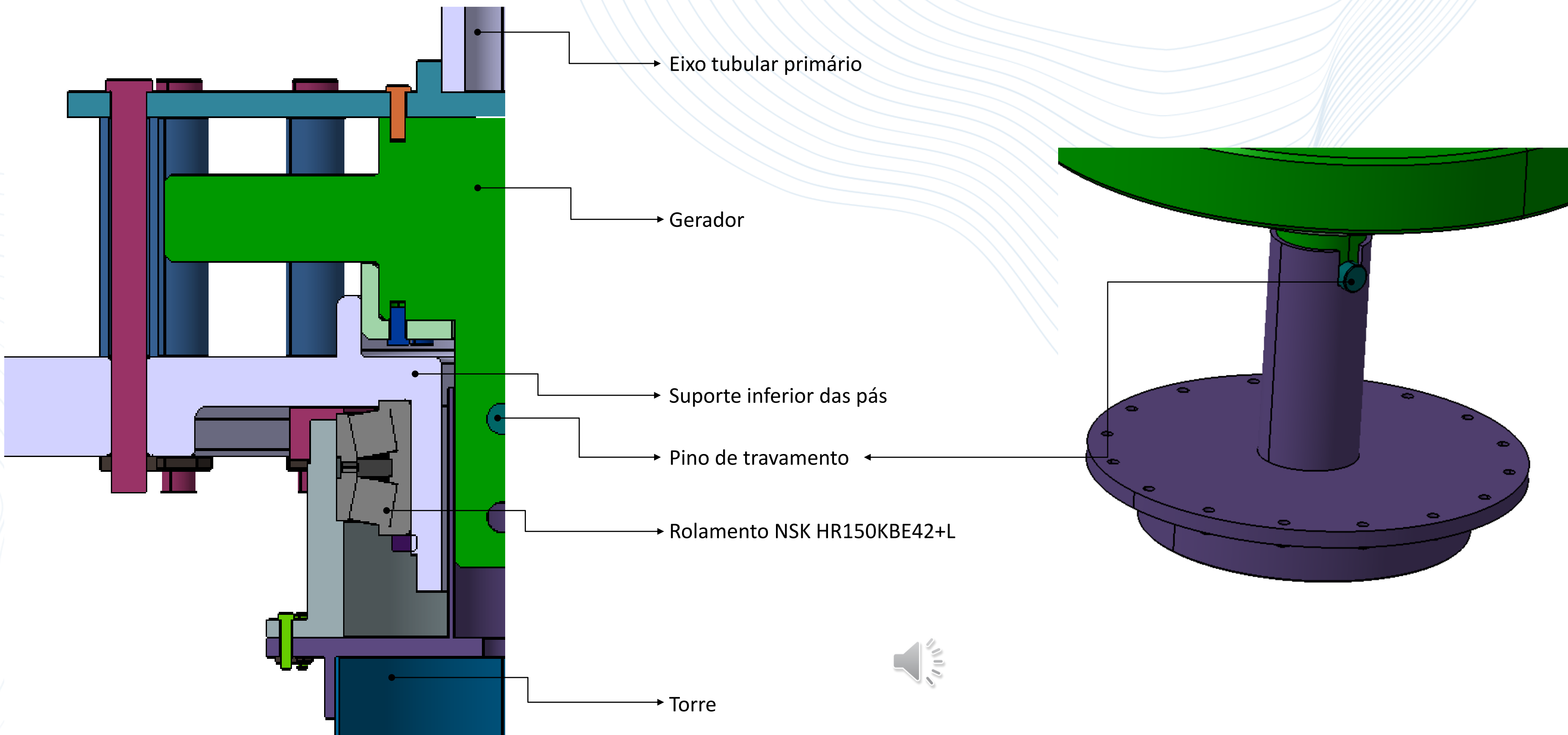


Rear view
Scale: 1:15

CAD - Acoplamento mecânico + gerador



WIND WAY



Rolamento - NSK HR150KBE42+L



WIND WAY



$$F_r = 2,7 \text{ kN} \quad F_a = 40 \text{ kN}$$

$$\frac{F_a}{F_r} = 14,8 > e = 0,44$$

$$\therefore P = 0,67 * 2,7 + 2,3 * 40$$

$$P = 93,8 \text{ kN}$$

$$L_{10} = \left(\frac{8,3e5}{9,38e4} \right)^{3,33}$$

$$L_{10} = 1432,56 \text{ milhões de revoluções}$$

$$L_h = \frac{1e6}{60 * n} * 1432,56$$

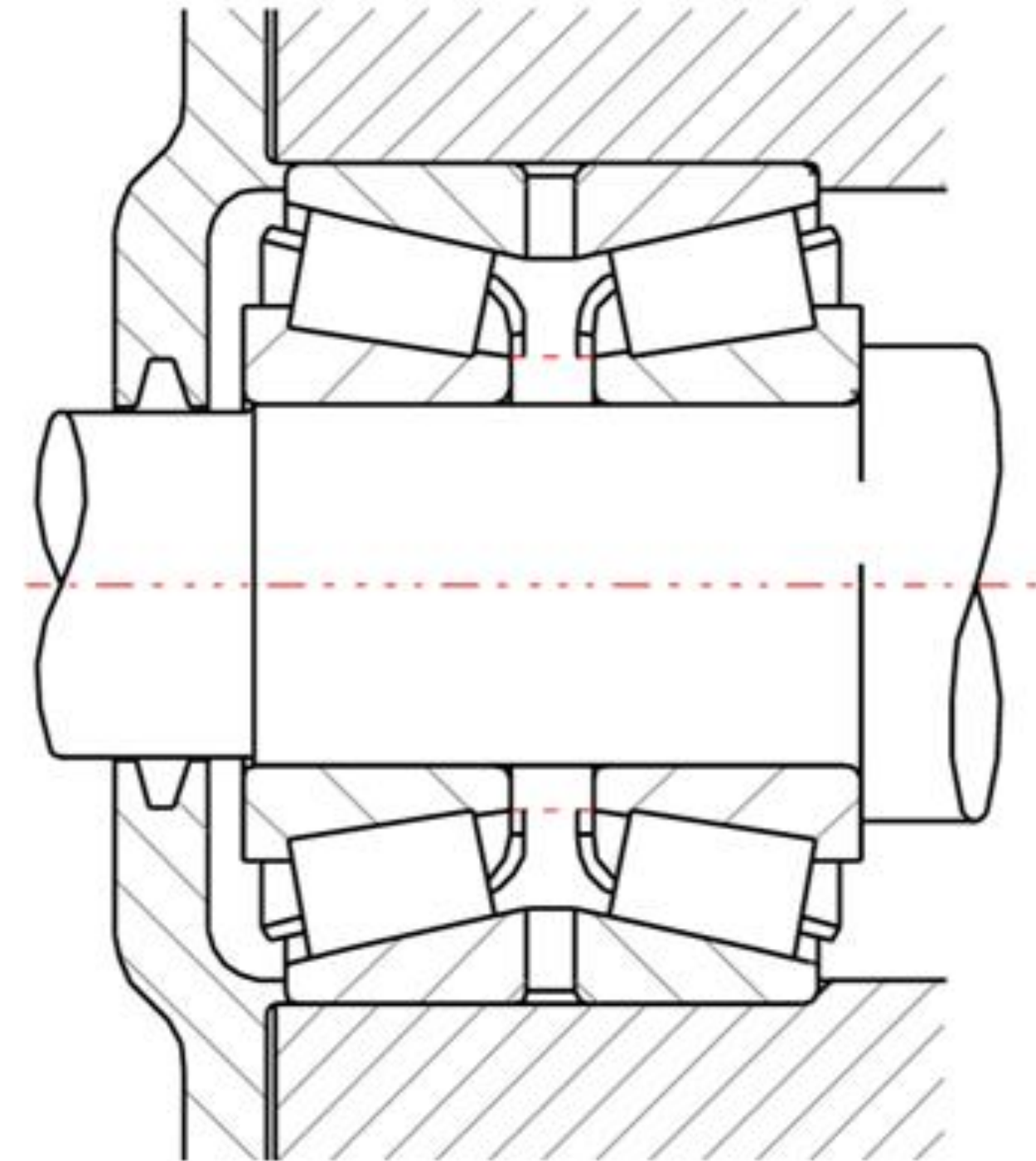
$$L_h = 101600 \text{ h} = 11,6 \text{ anos}$$



Rolamento - NSK HR150KBE42+L



WIND WAY



- Vantagens de boa lubrificação:
 - Redução de atrito e desgaste;
 - Dissipação de calor;
 - Dificulta a entrada de partículas; e
 - Previne o desenvolvimento de corrosão.
- Graxa ou óleos;
- Graxa - mais carga e menos manutenção;
- Exemplo no mercado: MOLYKOTE BR-2 Plus High Performance Grease da DuPont.



Fonte: vibralign.com



CFD - Setup



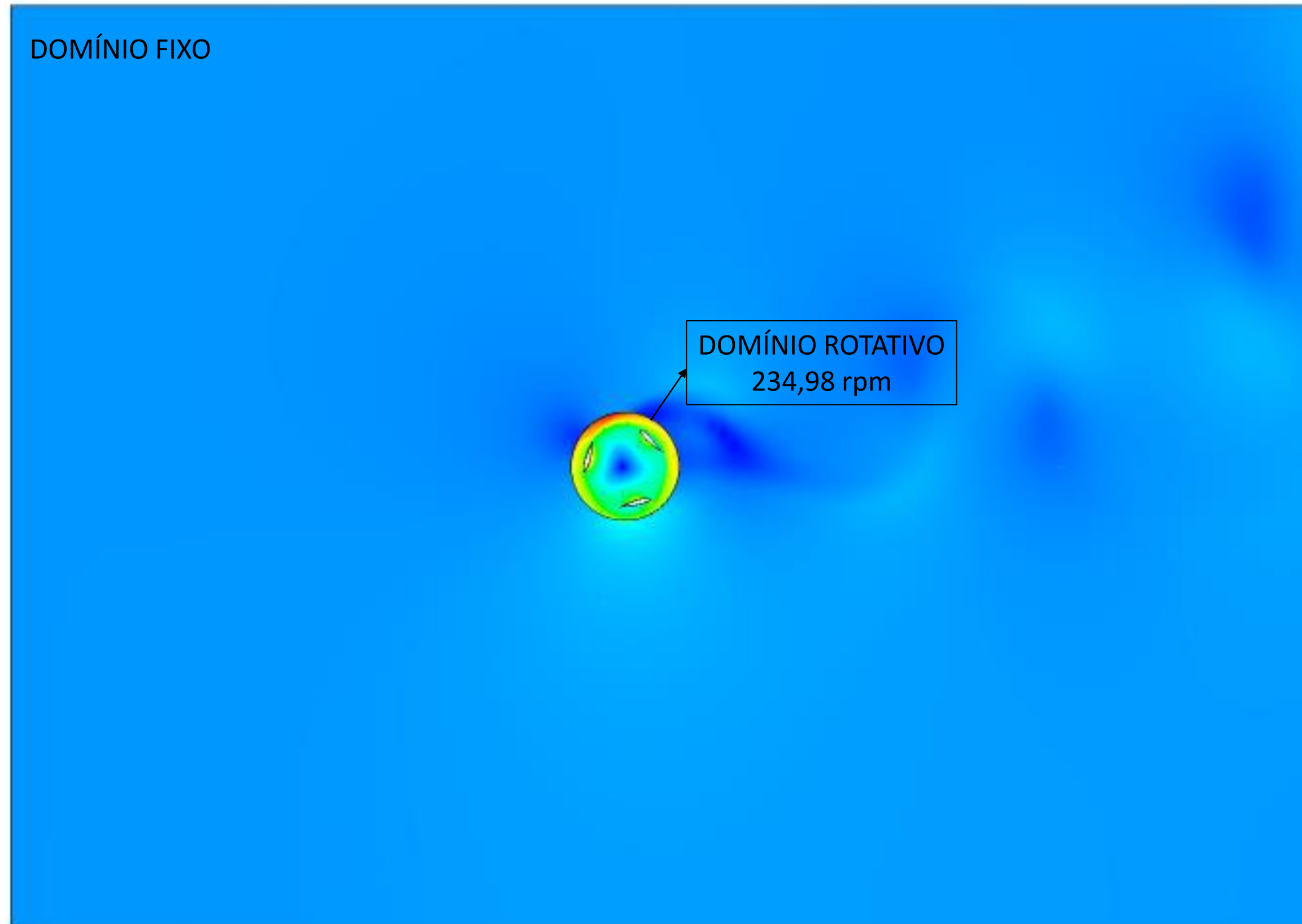
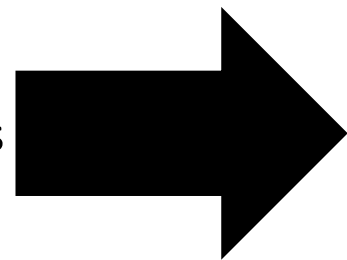
WIND WAY



PAREDE "ZERO-SHEAR"

$$TSR = \lambda = \frac{\omega R}{v_{\infty}}$$

ENTRADA: 12 m/s



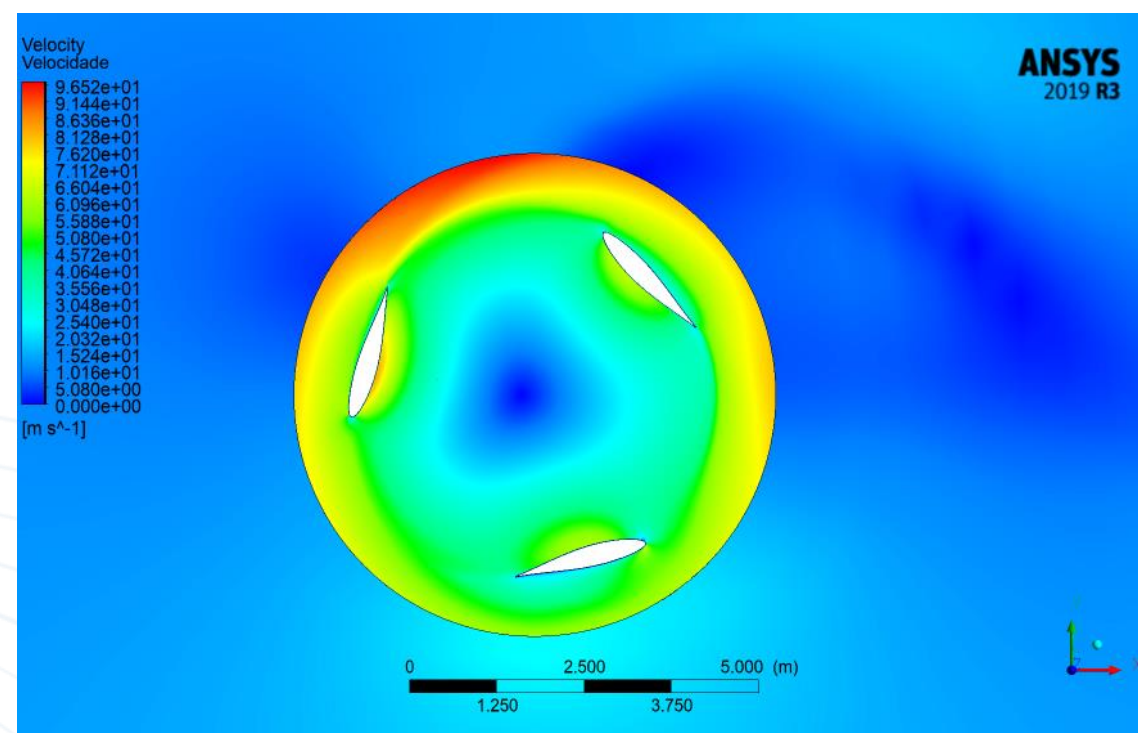
SAÍDA: 1 atm



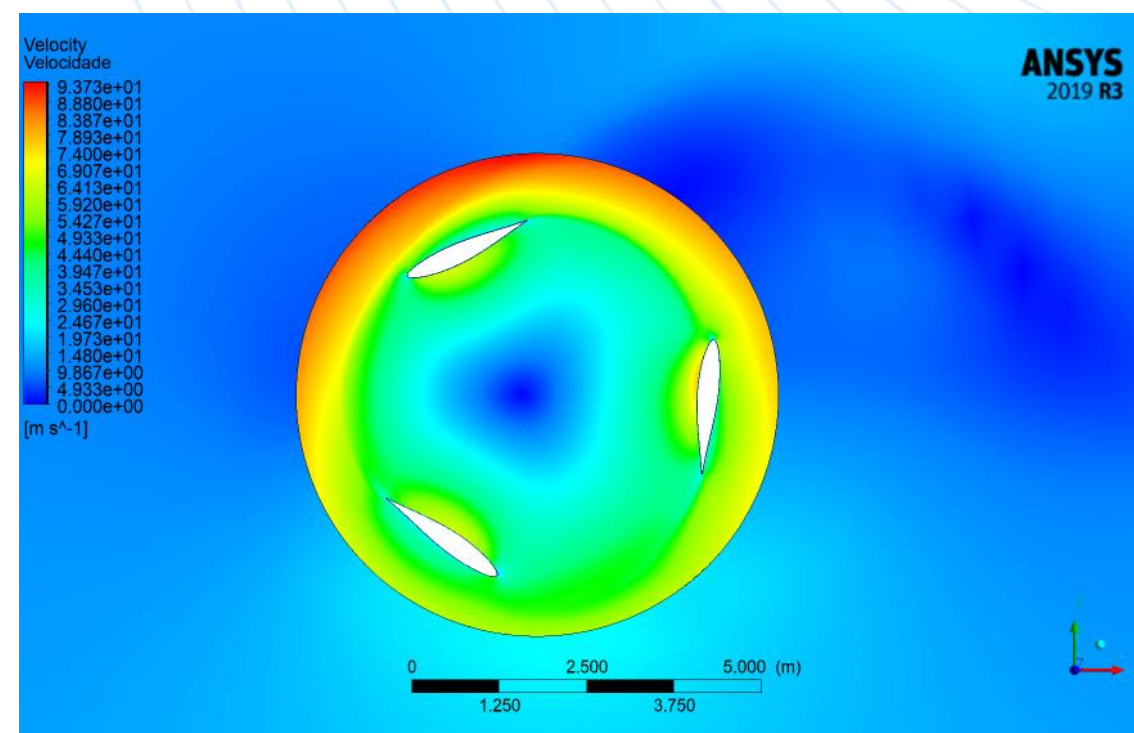
PAREDE "ZERO-SHEAR"

Fonte: Autor.

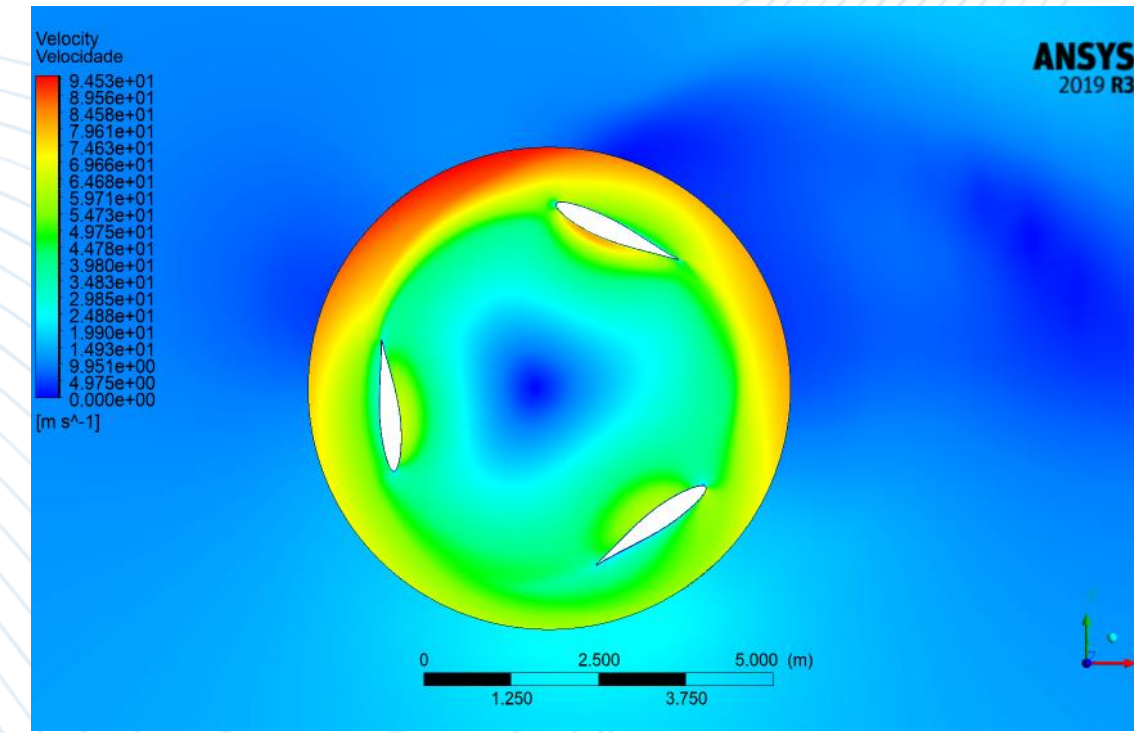
CFD – Velocidade



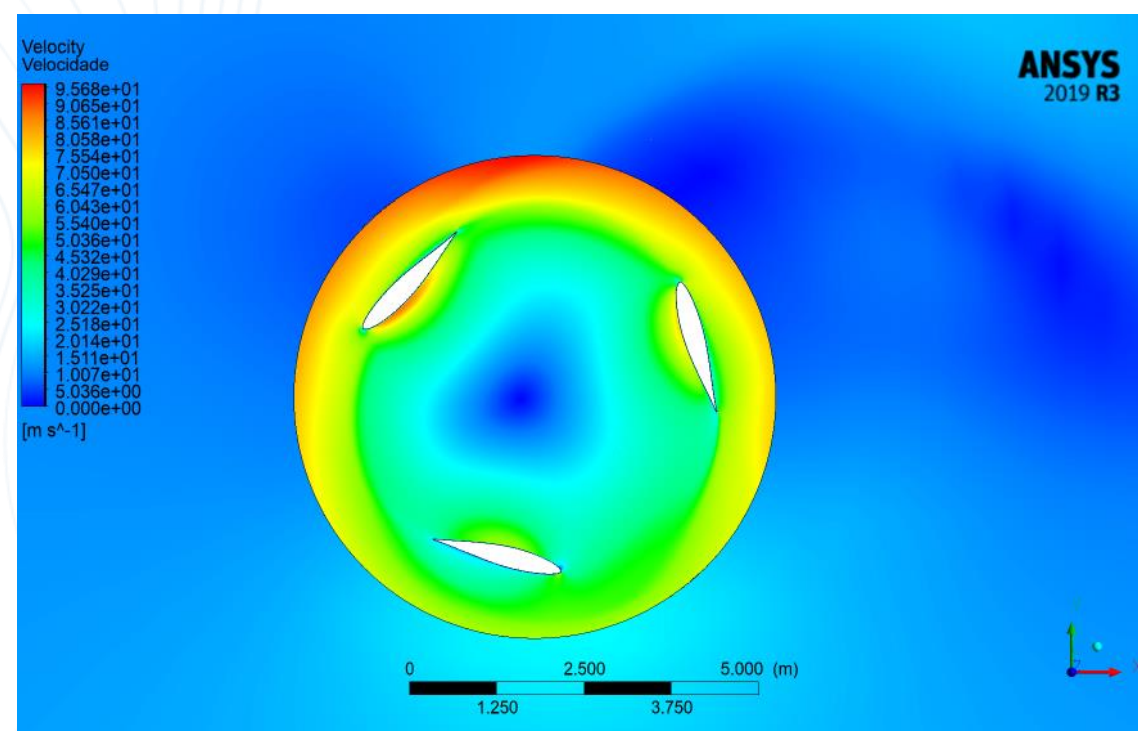
0°



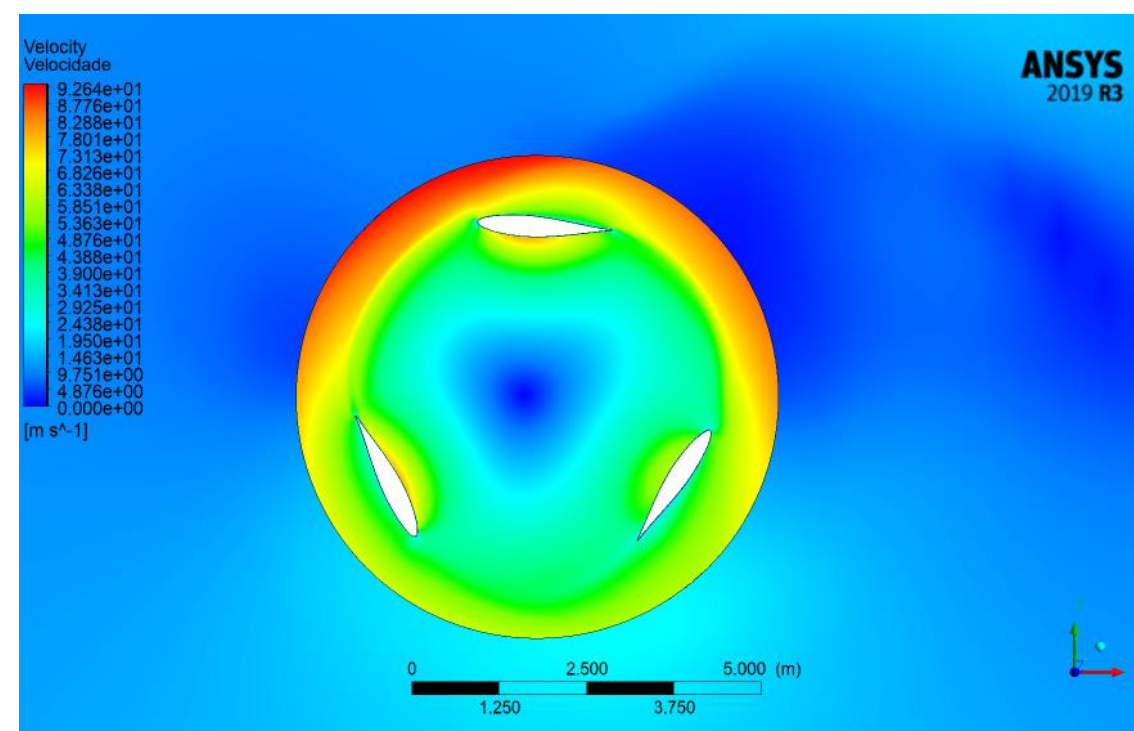
70°



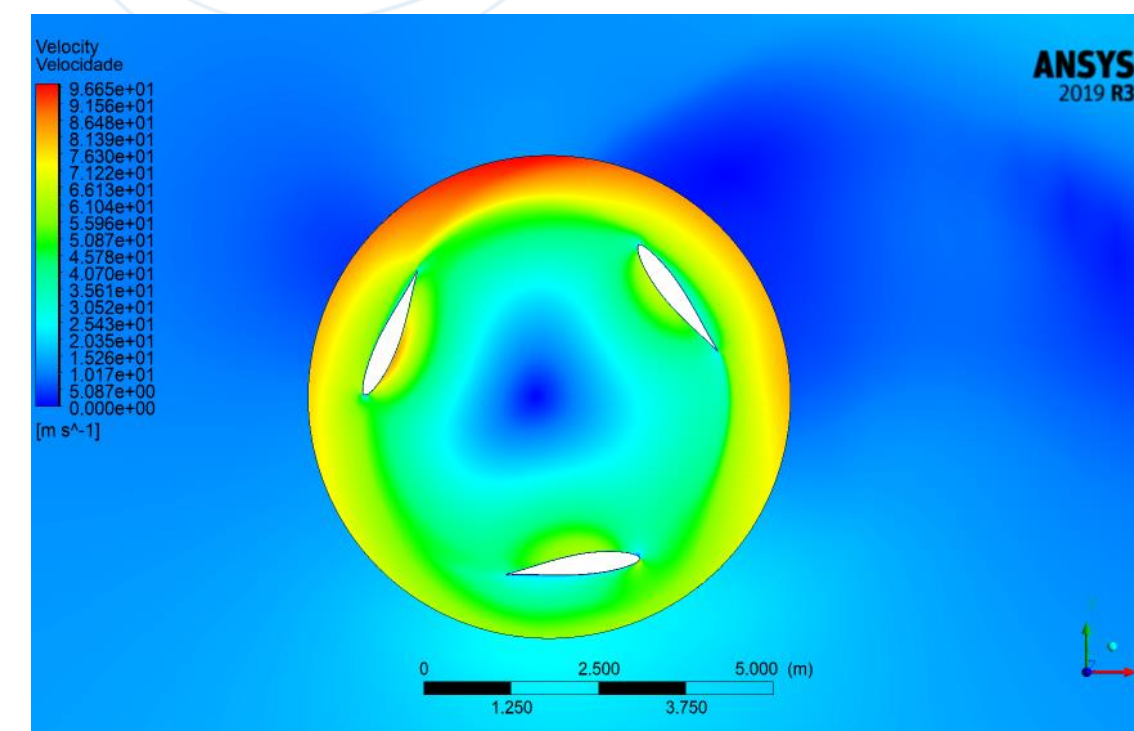
140°



210°



280°



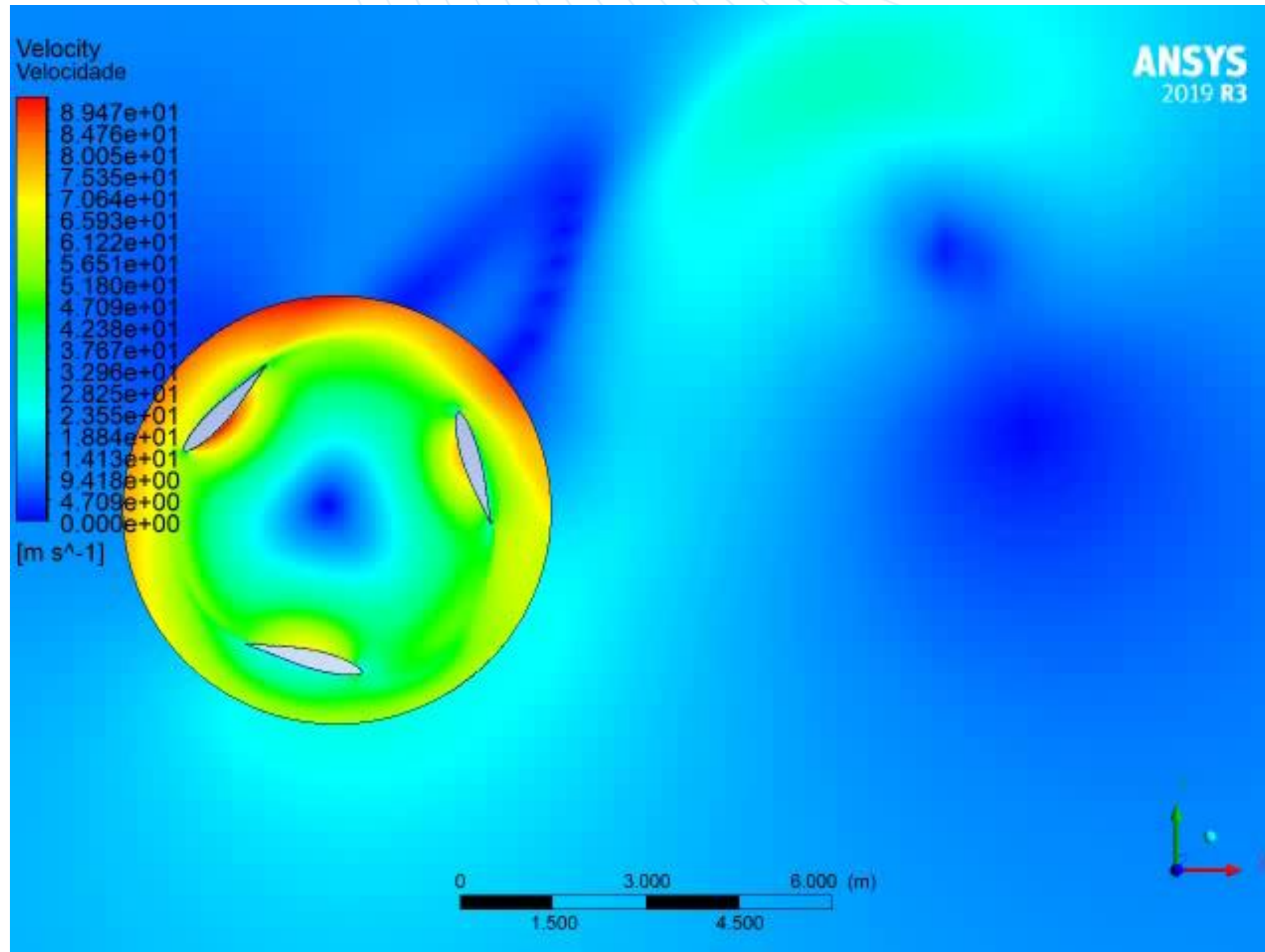
350°



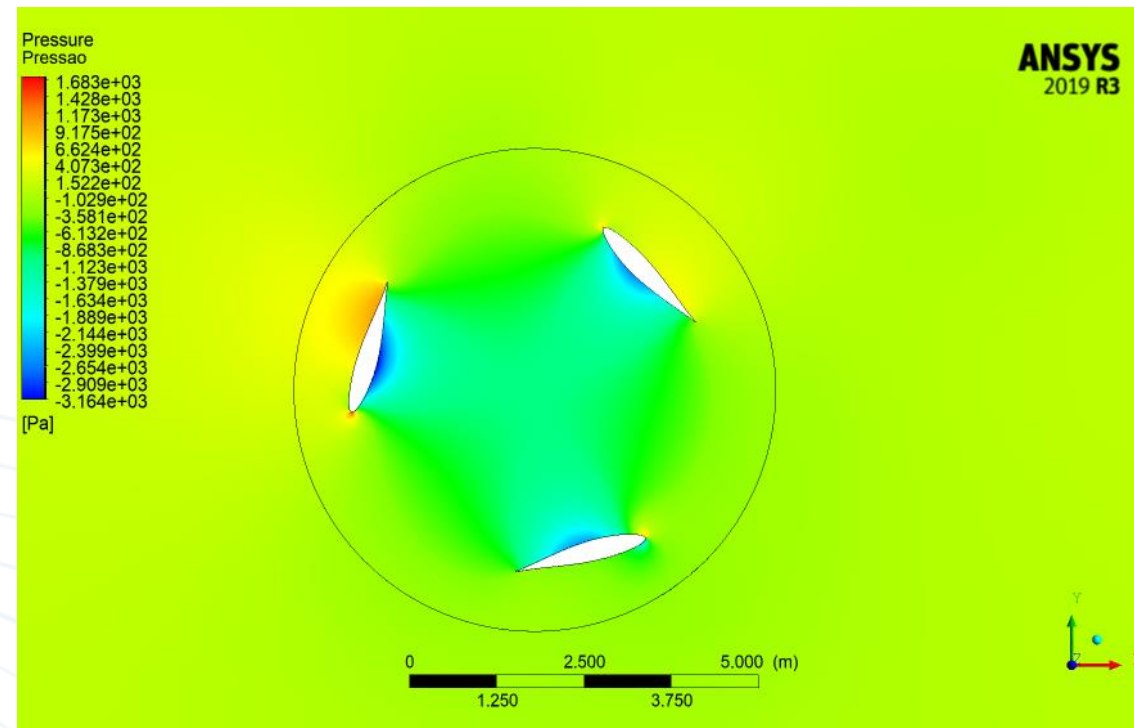
CFD - Velocidade



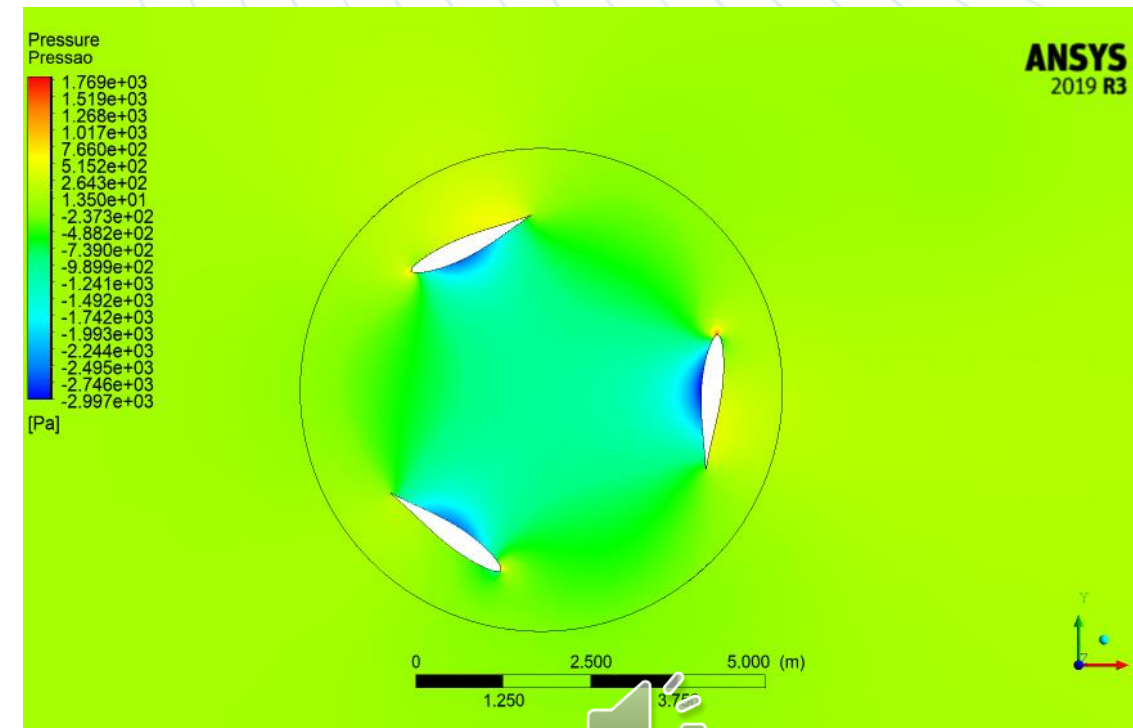
WIND WAY



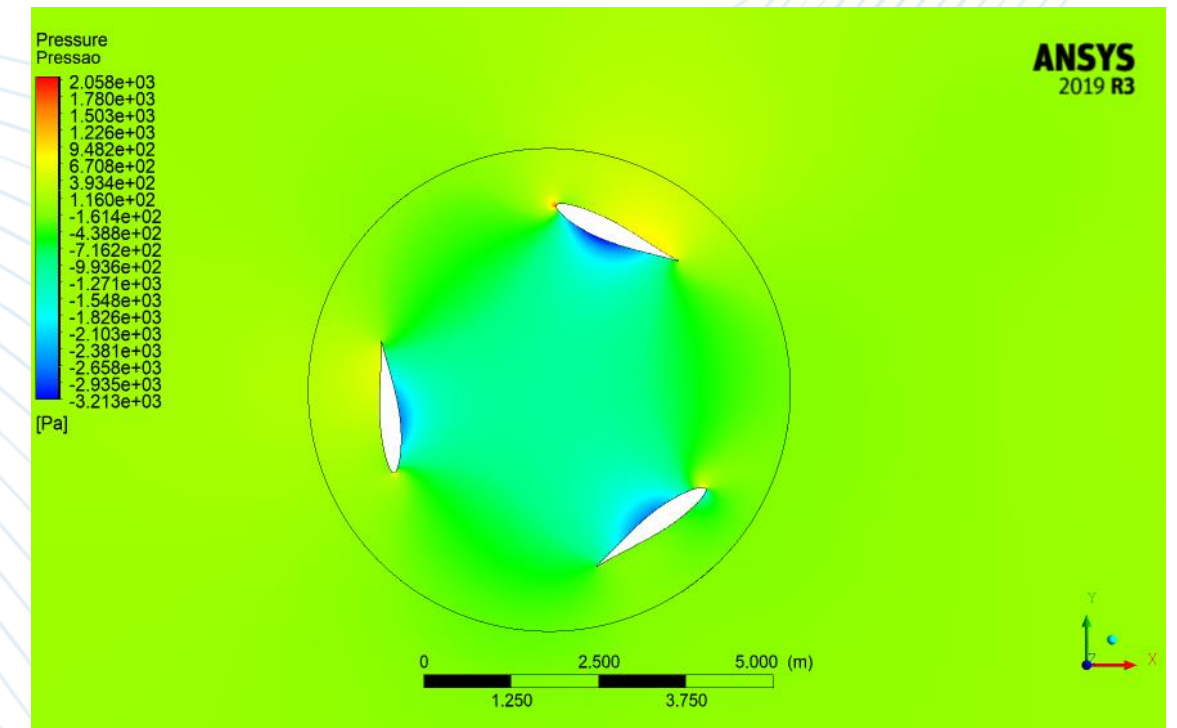
CFD – Pressão



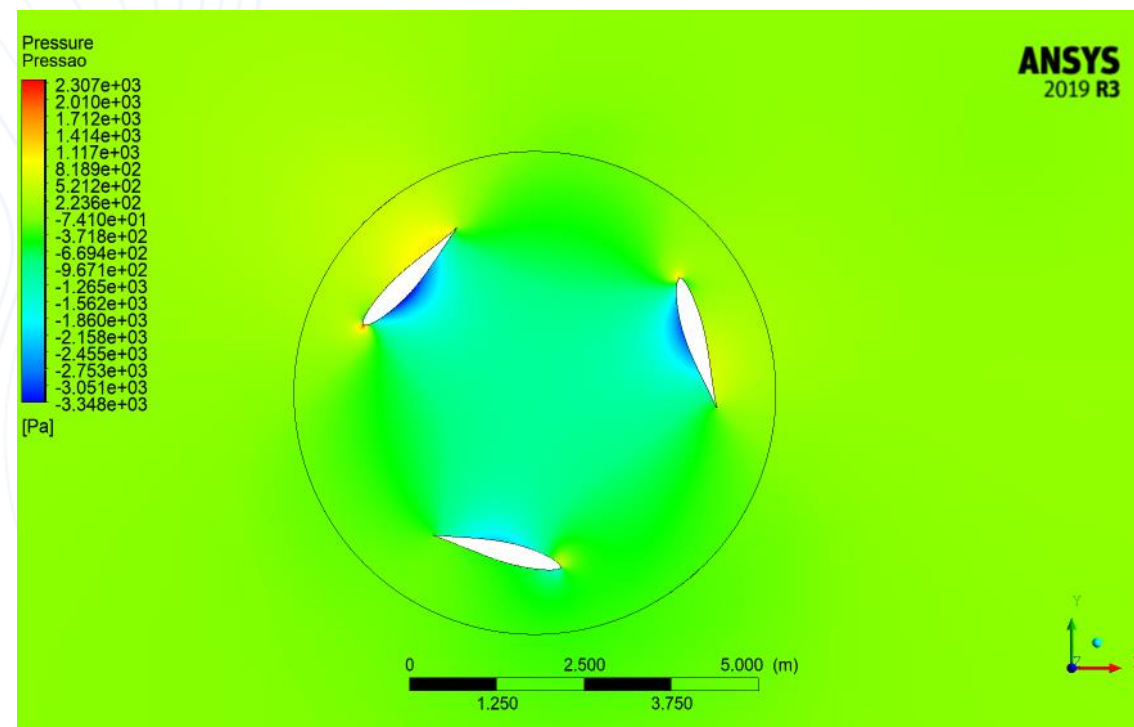
0°



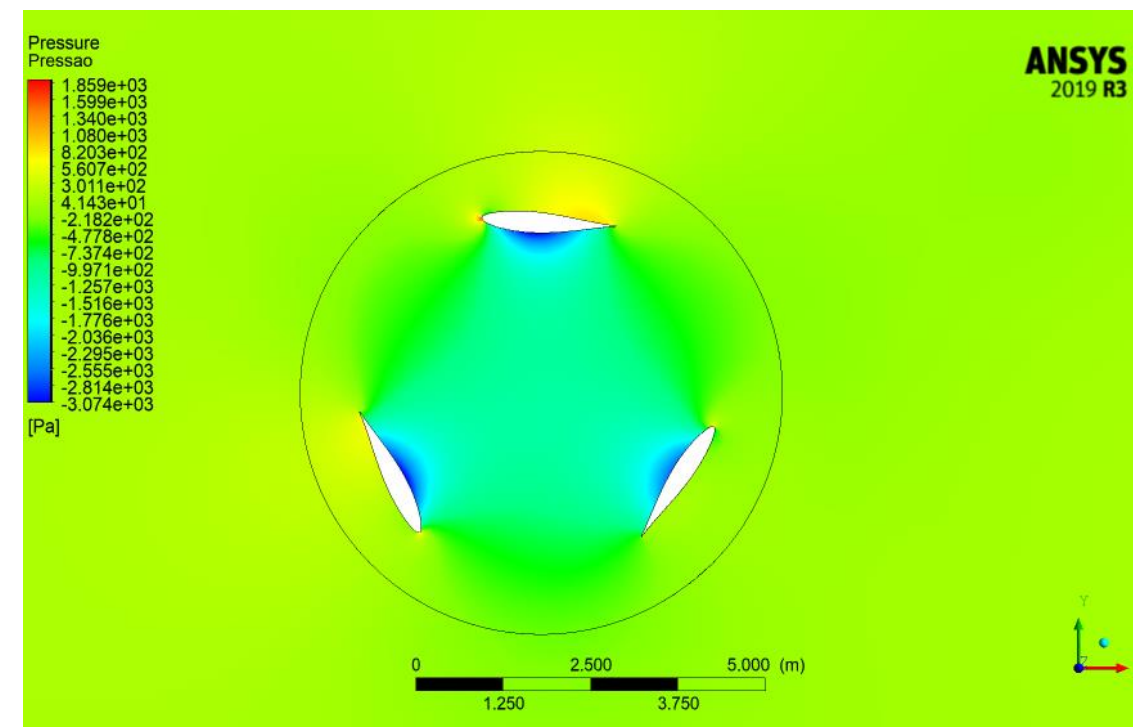
70°



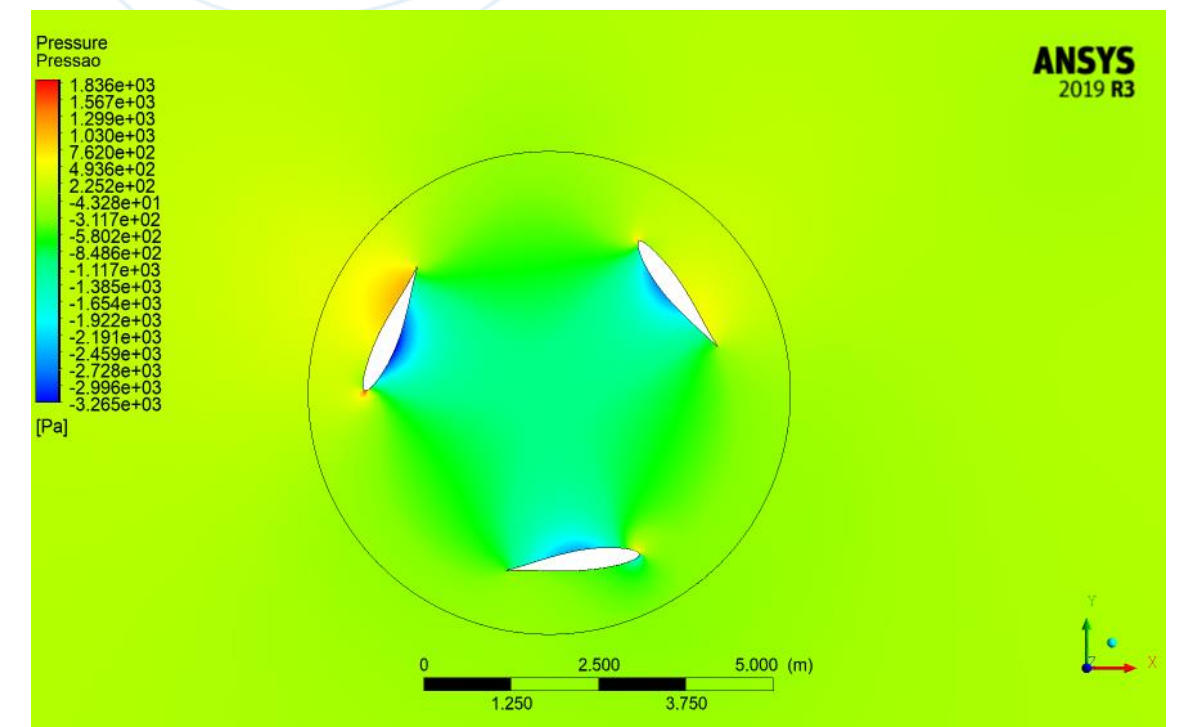
140°



210°



280°



350°

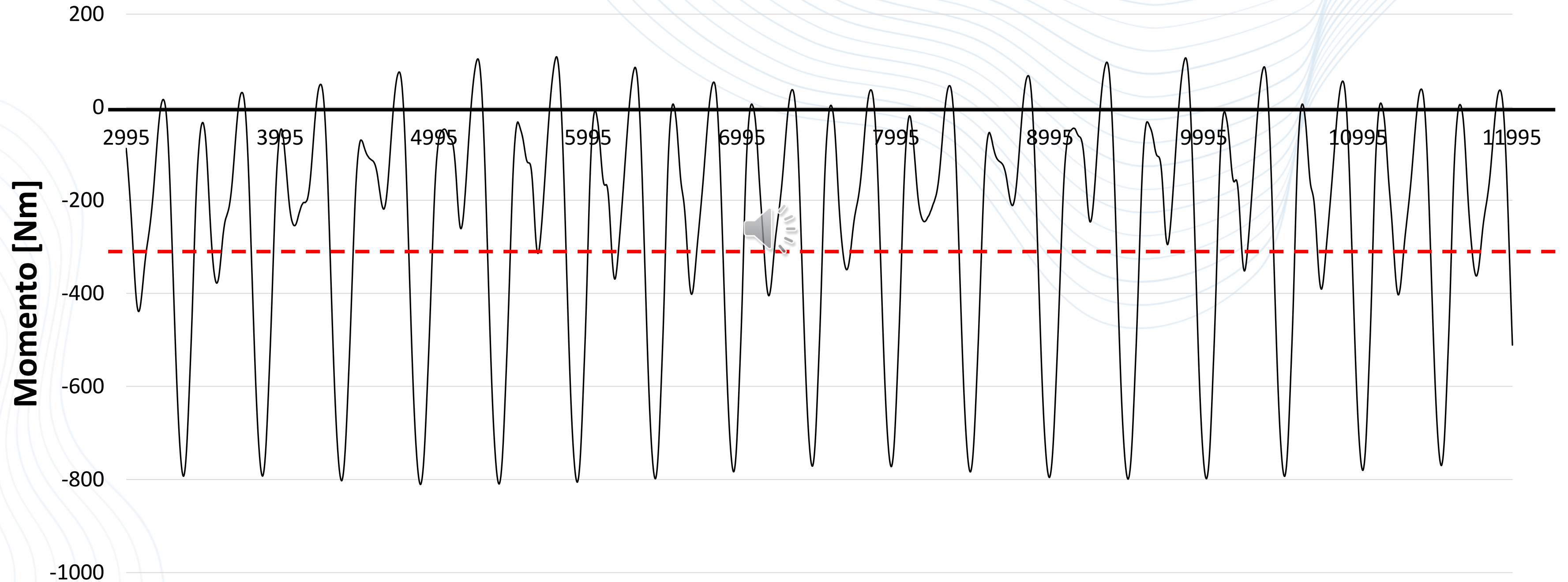
CFD - Momento



WIND WAY



Momento 1

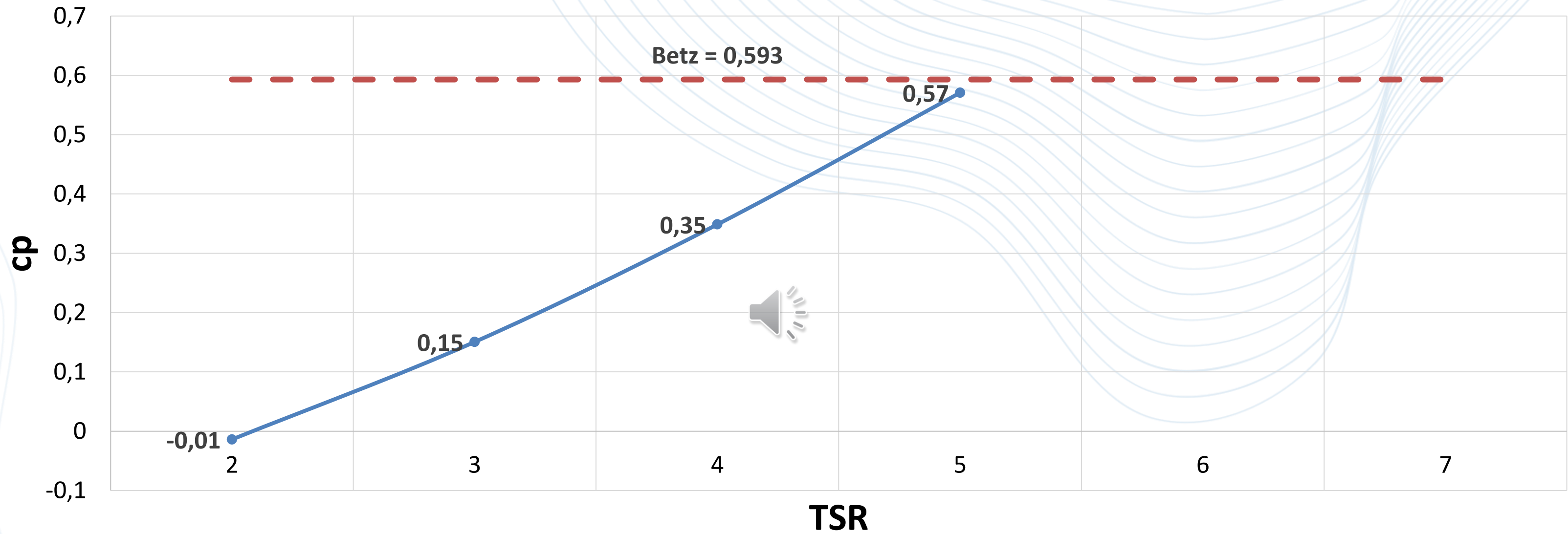


--- Média = - 285,45 Nm



$$P = w \cdot M = 24,48 \cdot 3.285,45 = 17,1 \text{ kW}$$

CFD - Eficiência



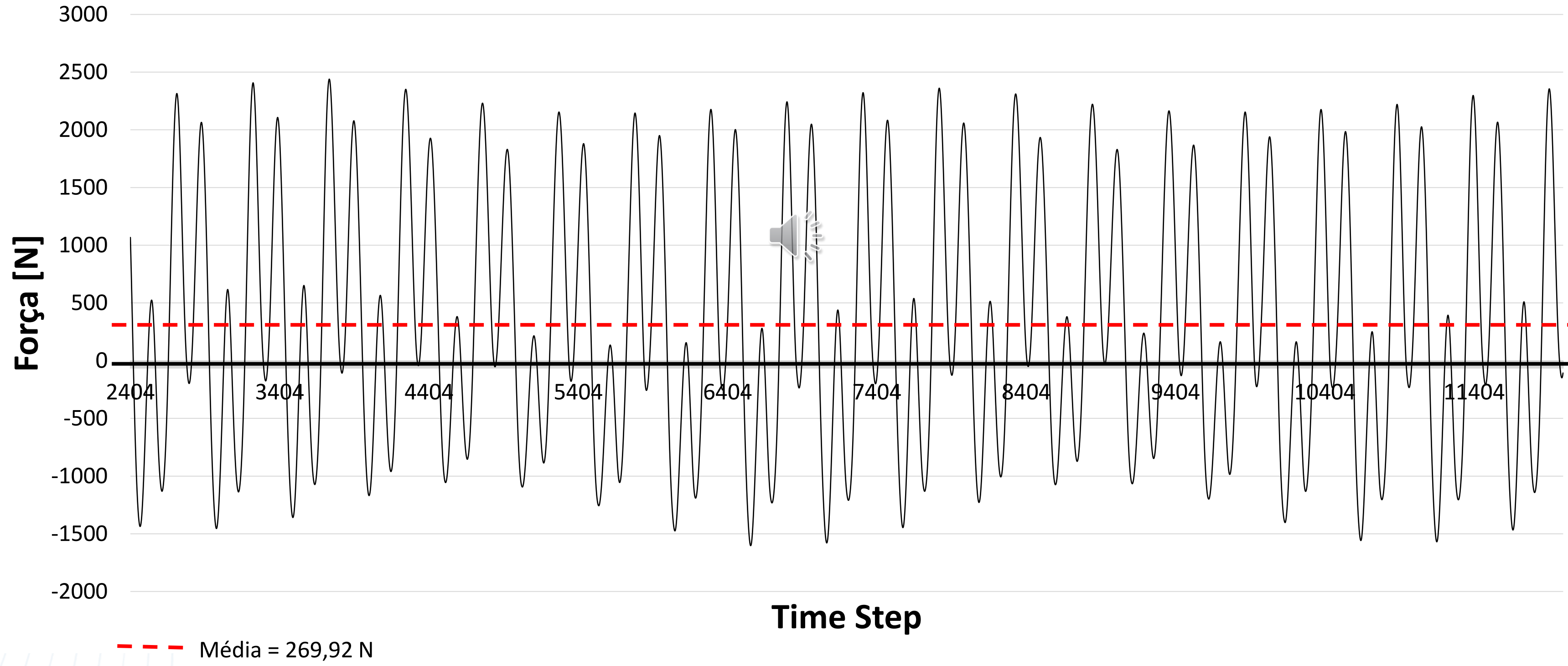
$$M = C_{MR} \cdot \frac{\rho}{2} \cdot v_w^2 \cdot A \cdot R$$

$$TSR = \lambda = \frac{\omega R}{v_\infty}$$



$$C_{PR} = \lambda \cdot C_{MR}$$

Força X Total



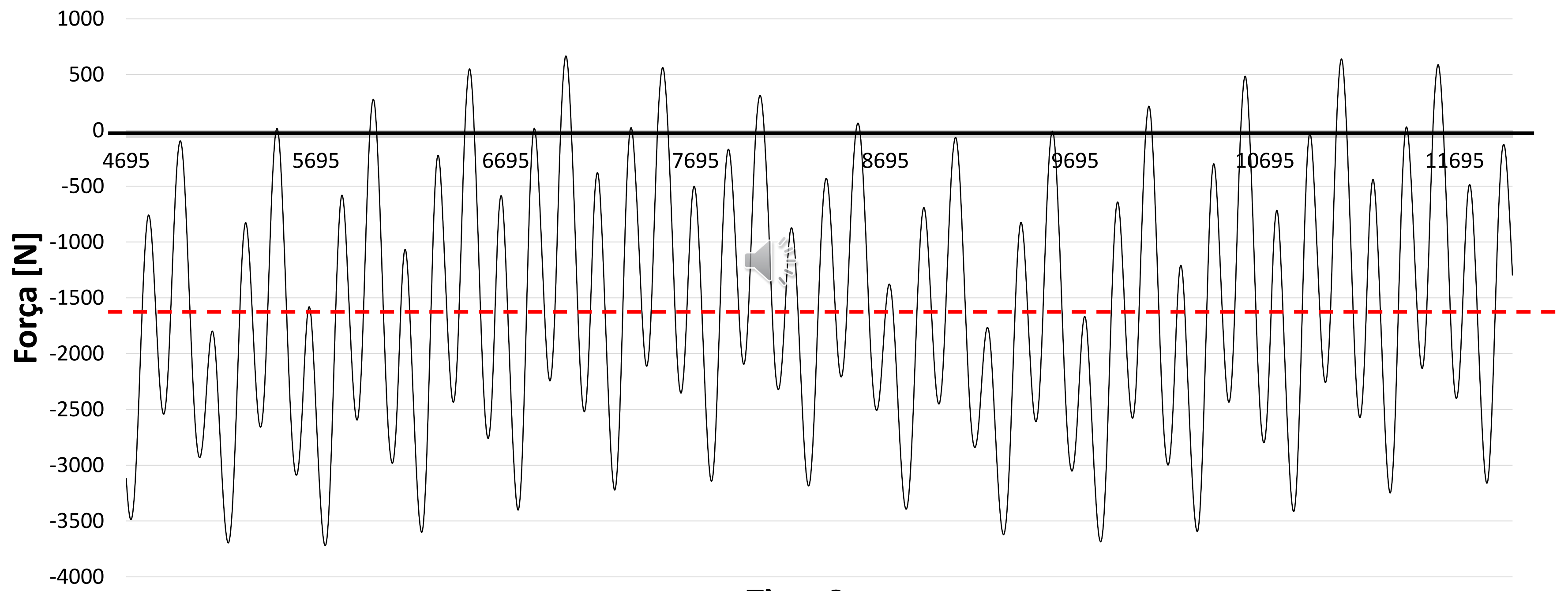
CFD – Forças



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Força Y Total



--- Média = -1604 N

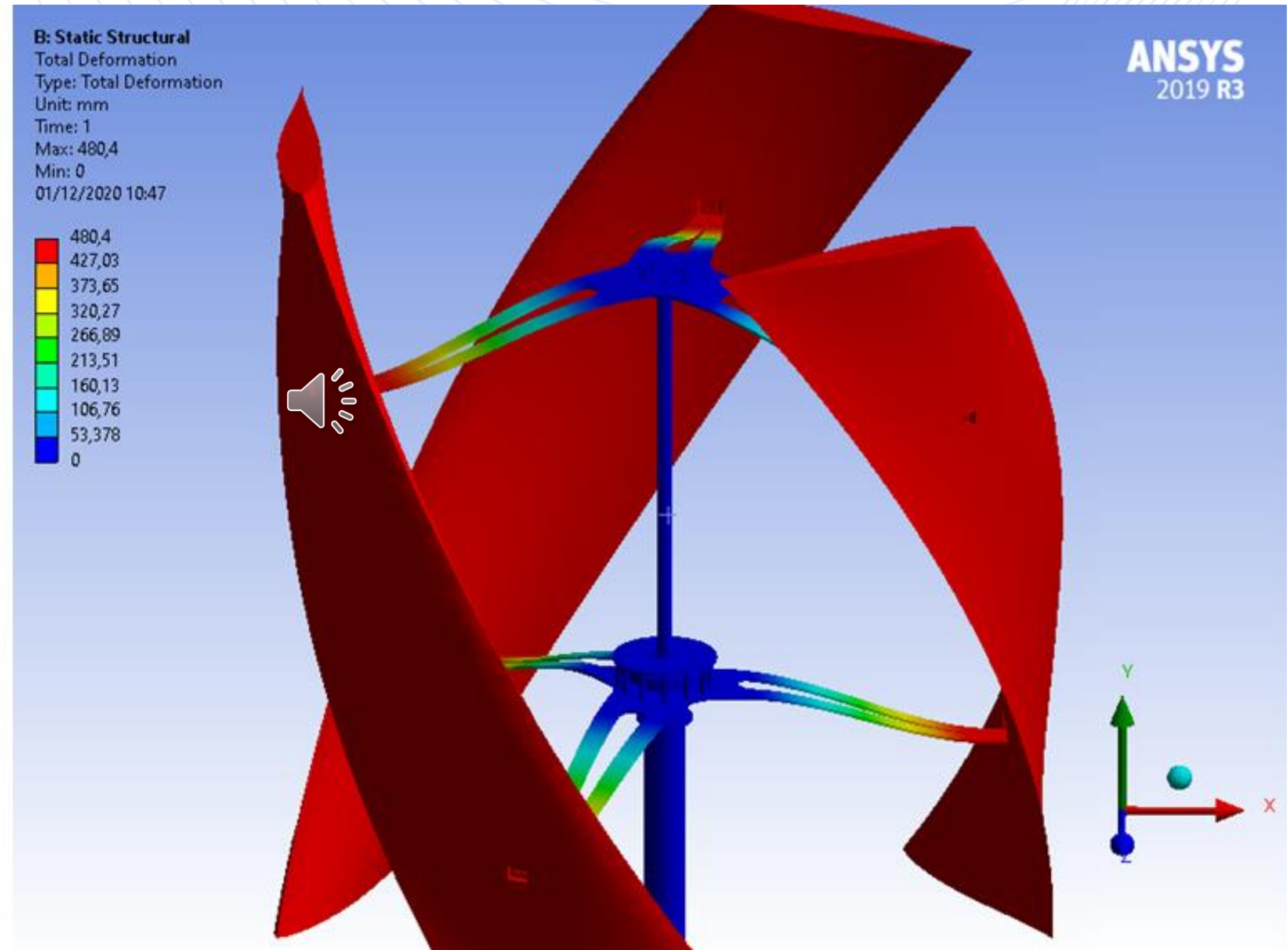
Simulação estrutural - suportes



WIND WAY



- Primeira simulação:



Fonte: Autor.

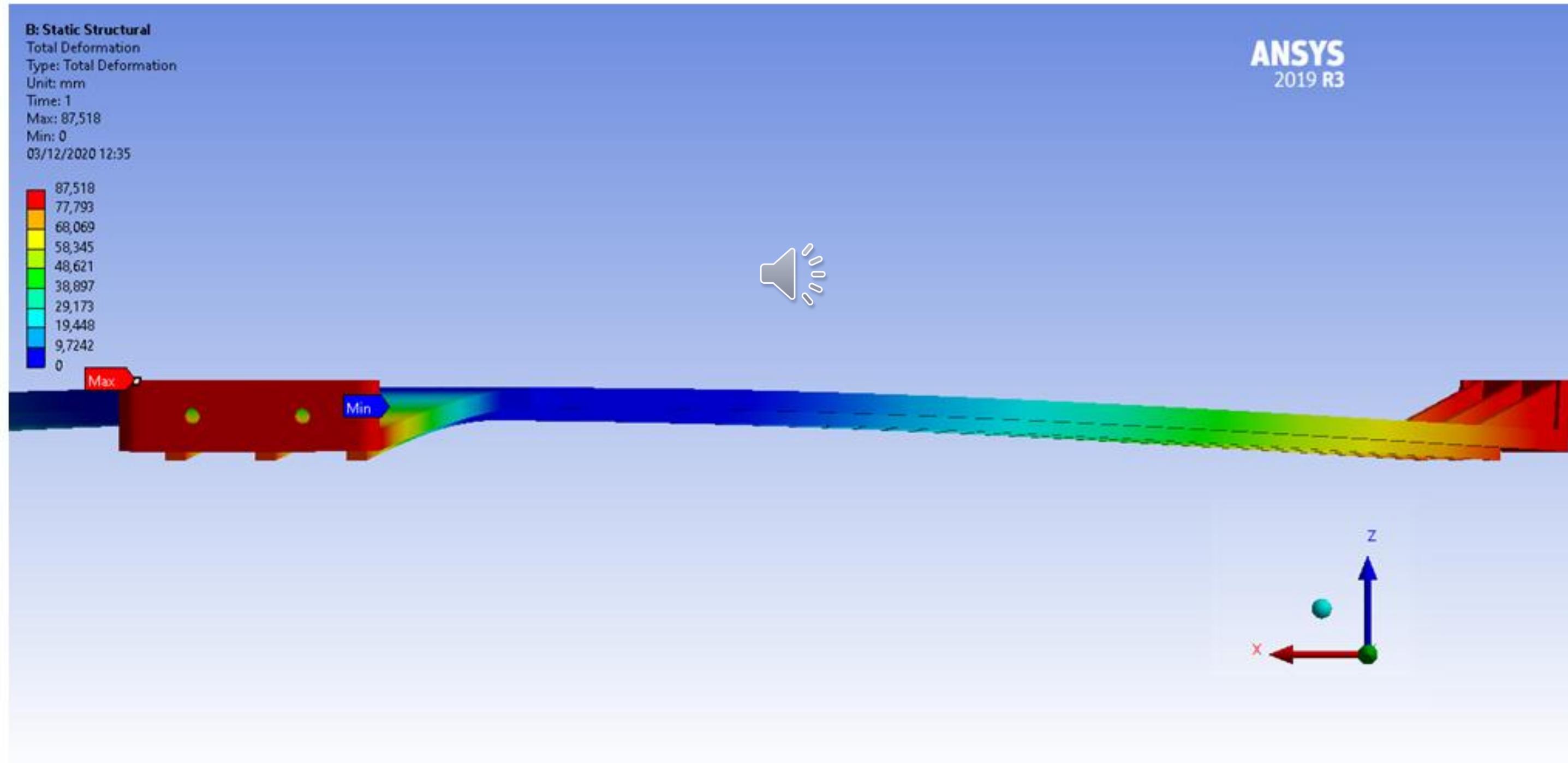
Simulação estrutural - suportes



WIND WAY



- Segunda iteração:



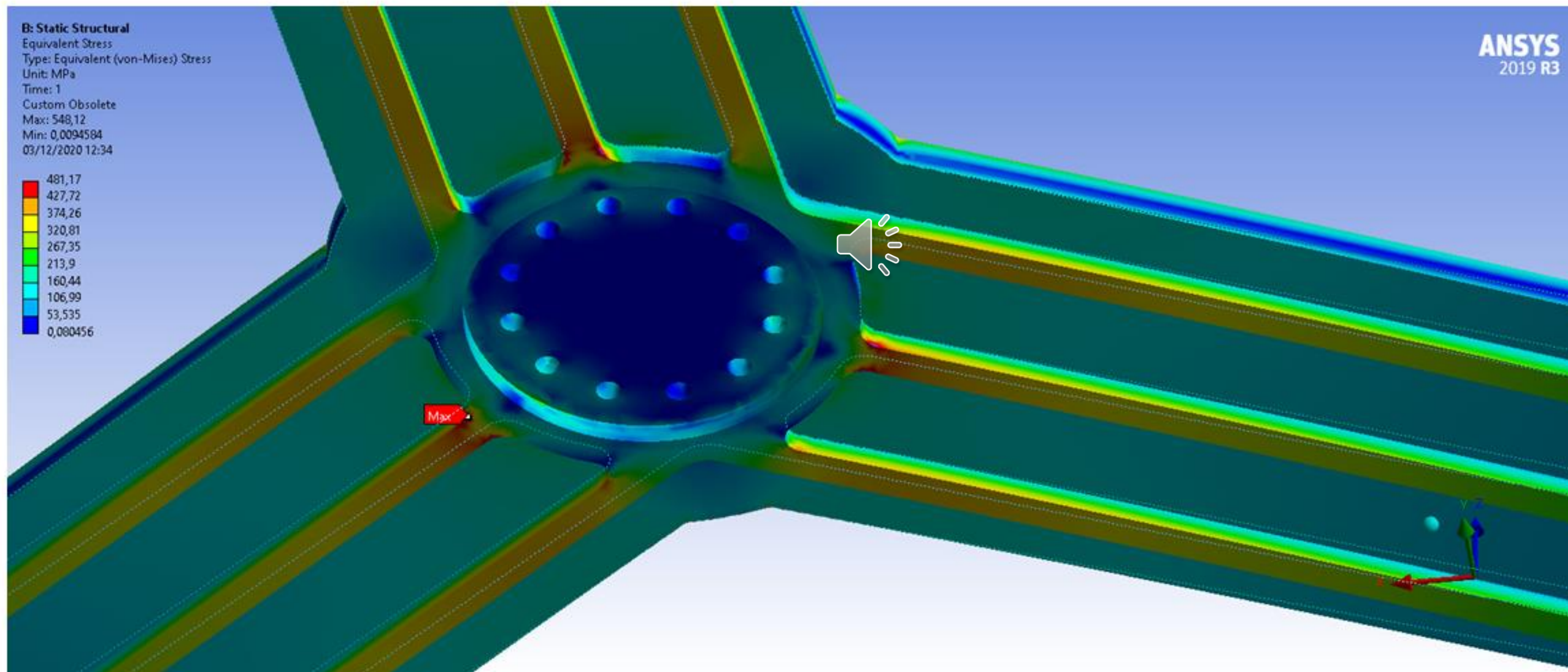
Simulação estrutural - suportes



WIND WAY



- Segunda iteração:



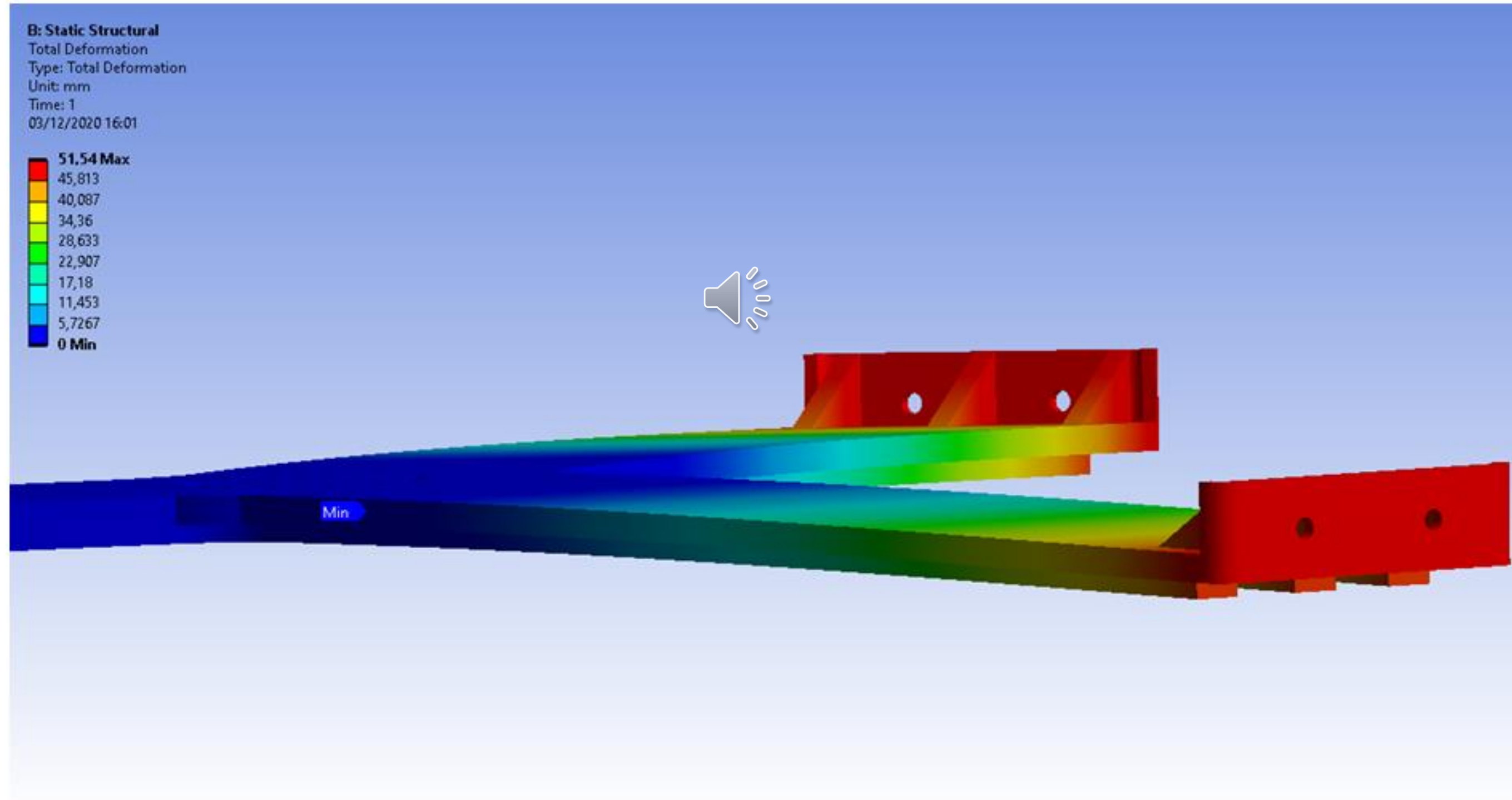
Simulação estrutural - suportes



WIND WAY



- Terceira iteração:



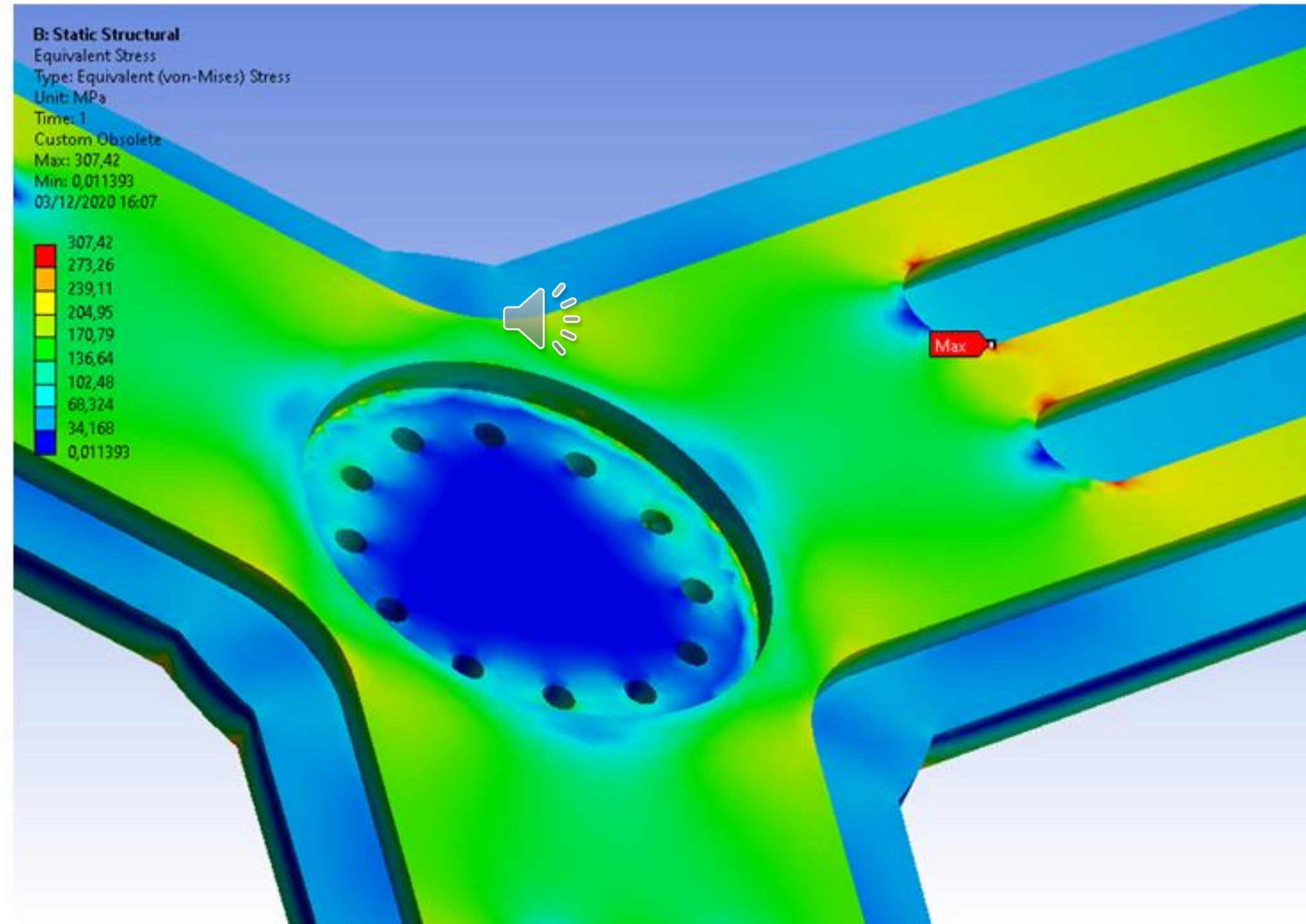
Simulação estrutural - suportes



WIND WAY



- Terceira iteração:



Fonte: Autor.

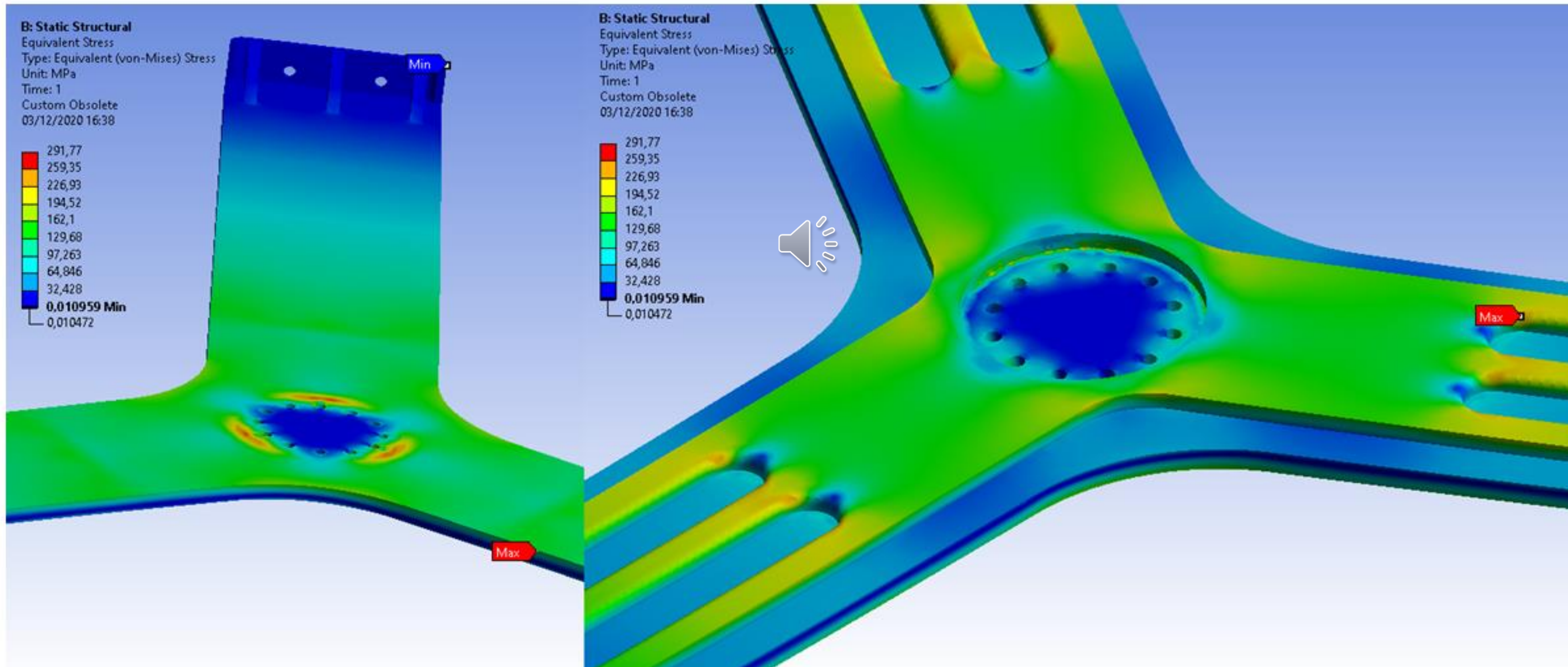
Simulação estrutural - suportes



WIND WAY



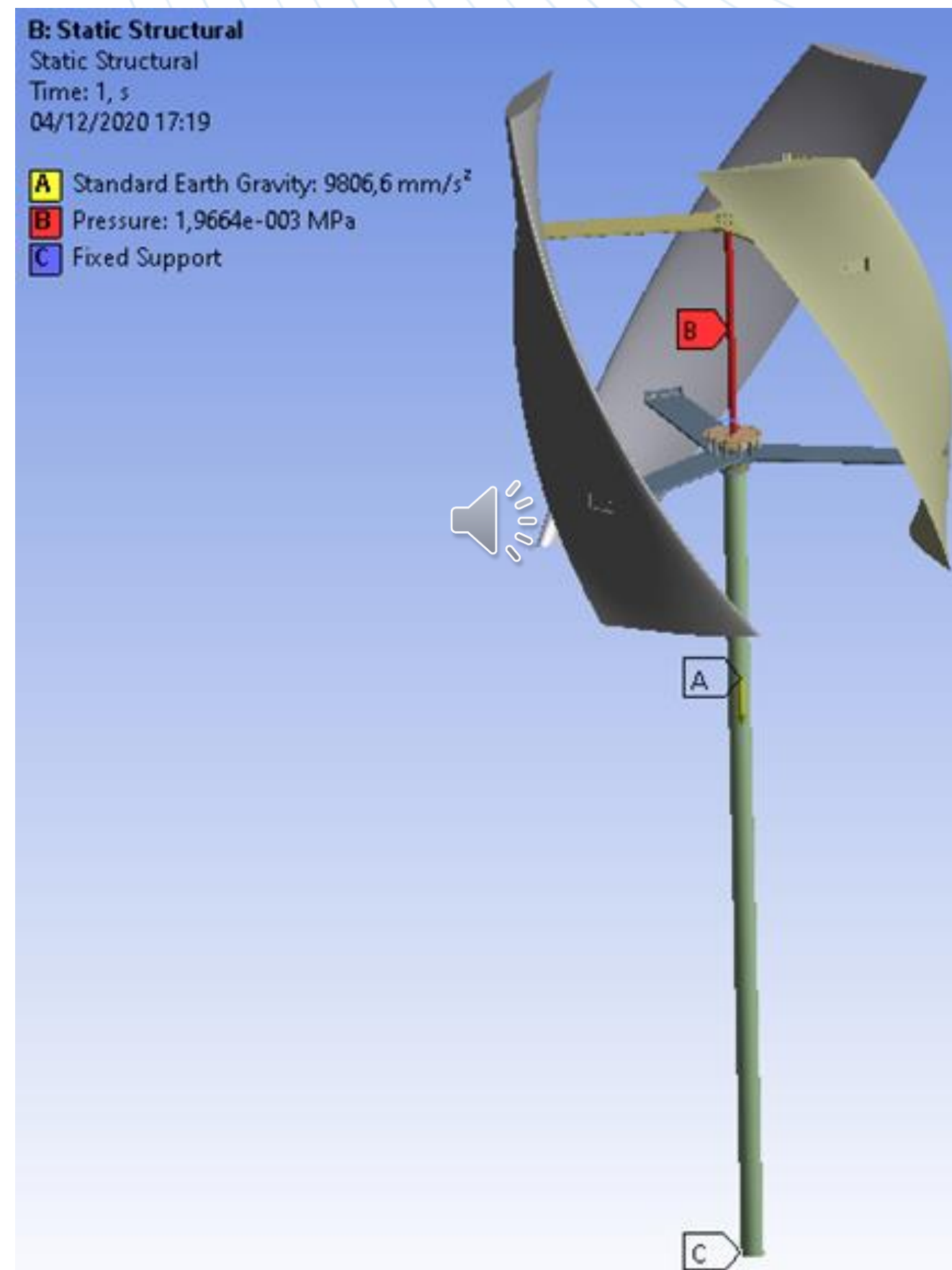
- Quarta iteração:



Simulação estrutural - montagem



WIND WAY

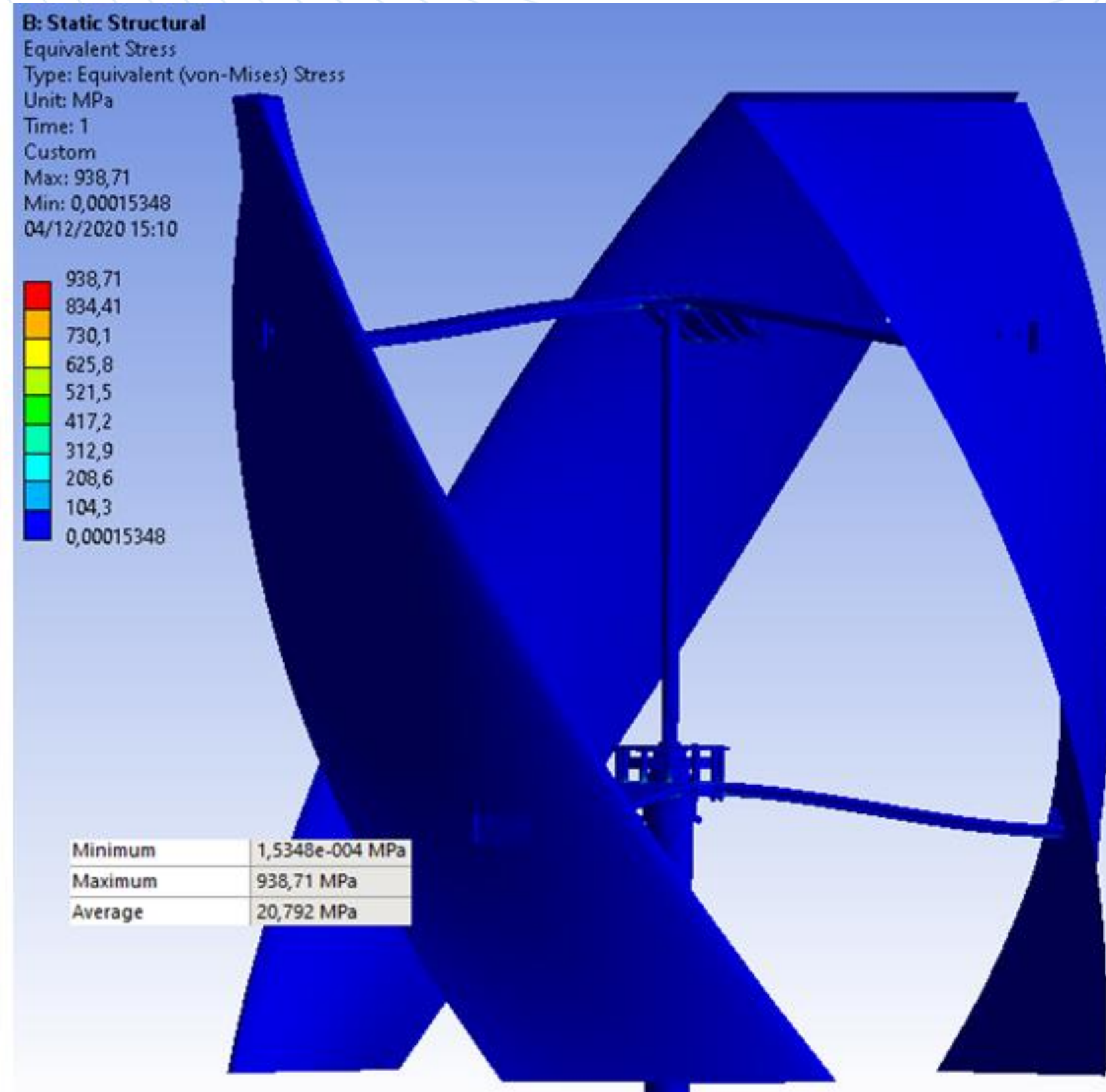
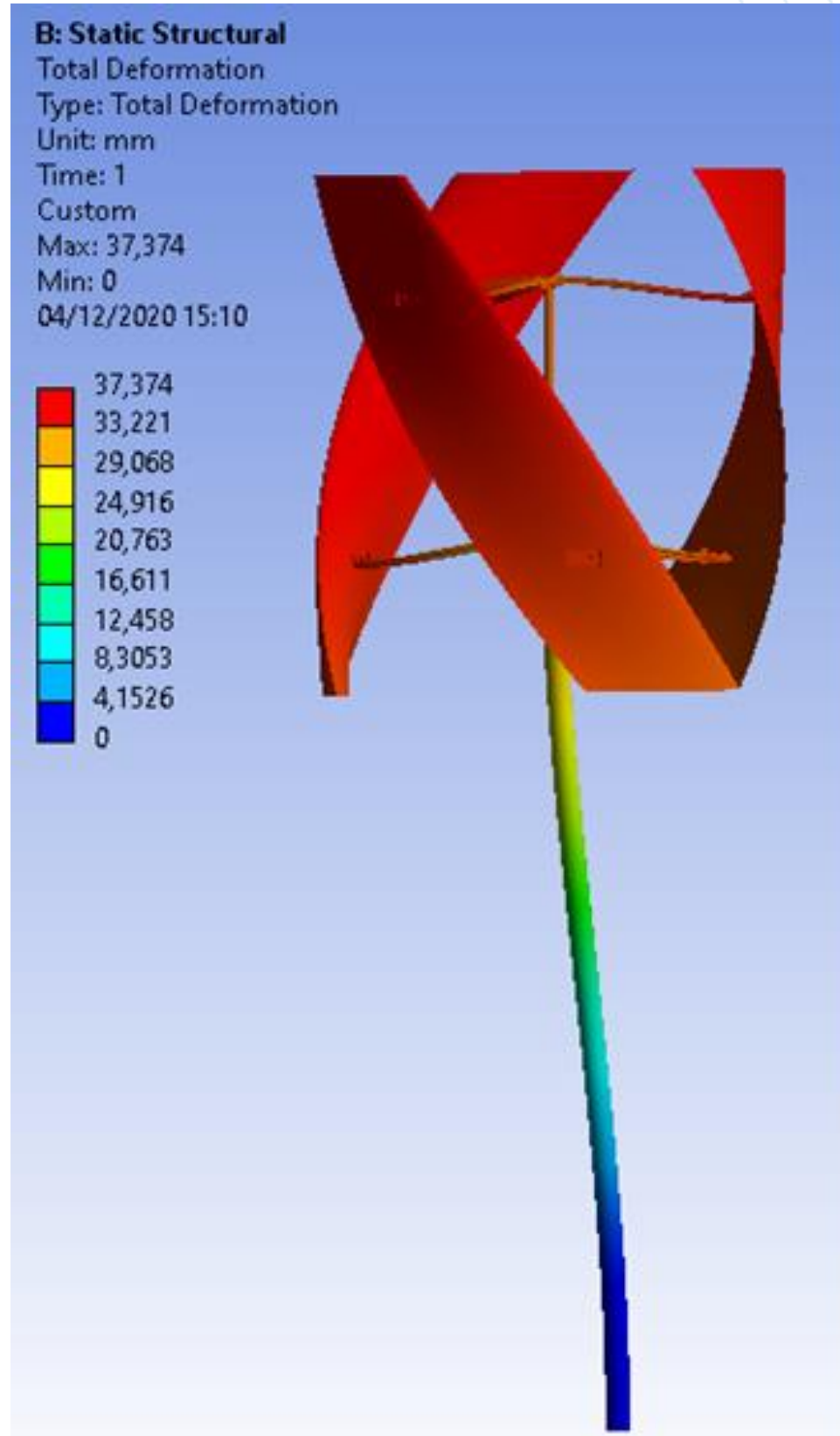


Fonte: Autor.

Simulação estrutural - montagem



WIND WAY

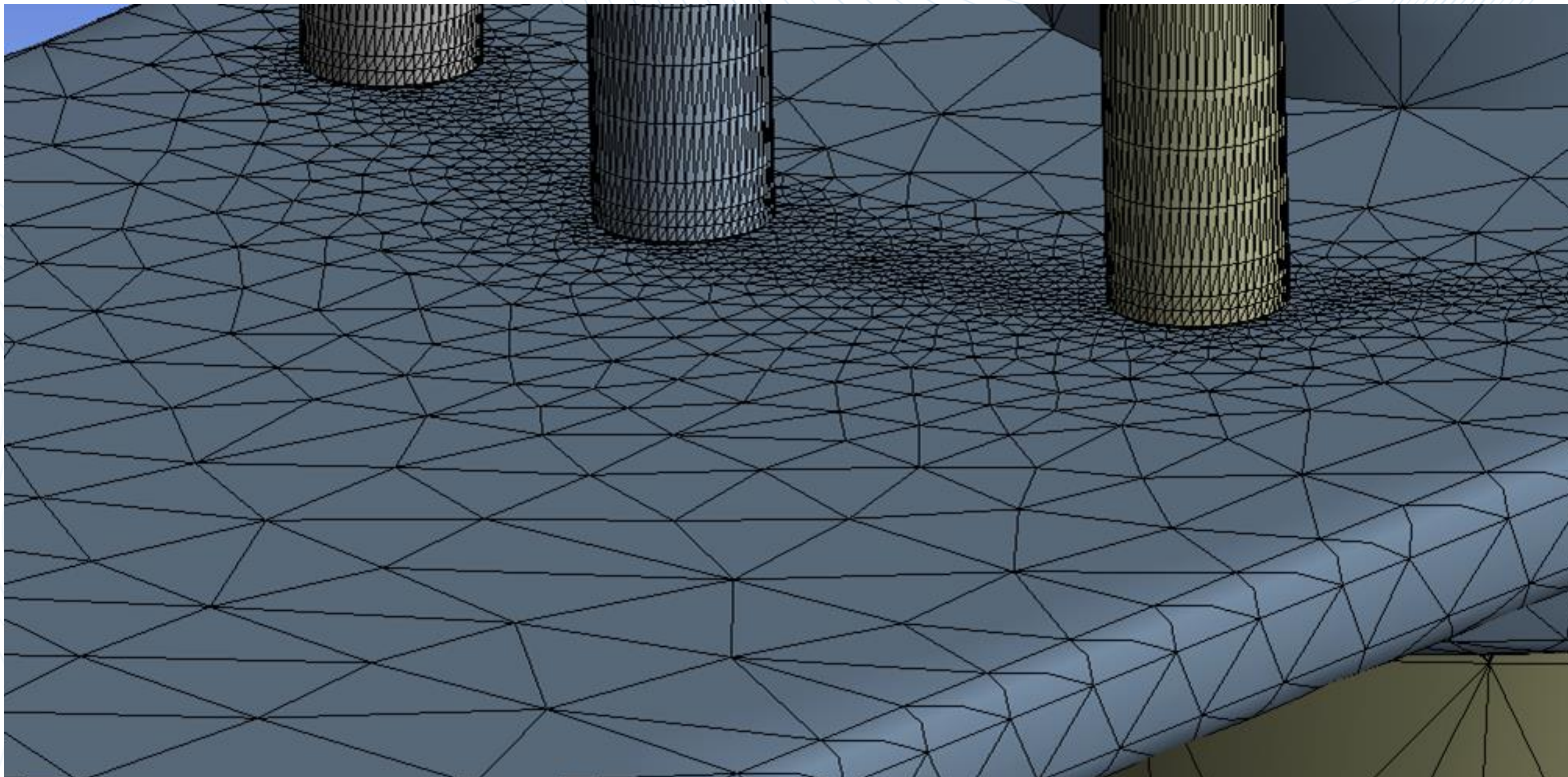


Fonte: Autor.

Simulação estrutural - montagem



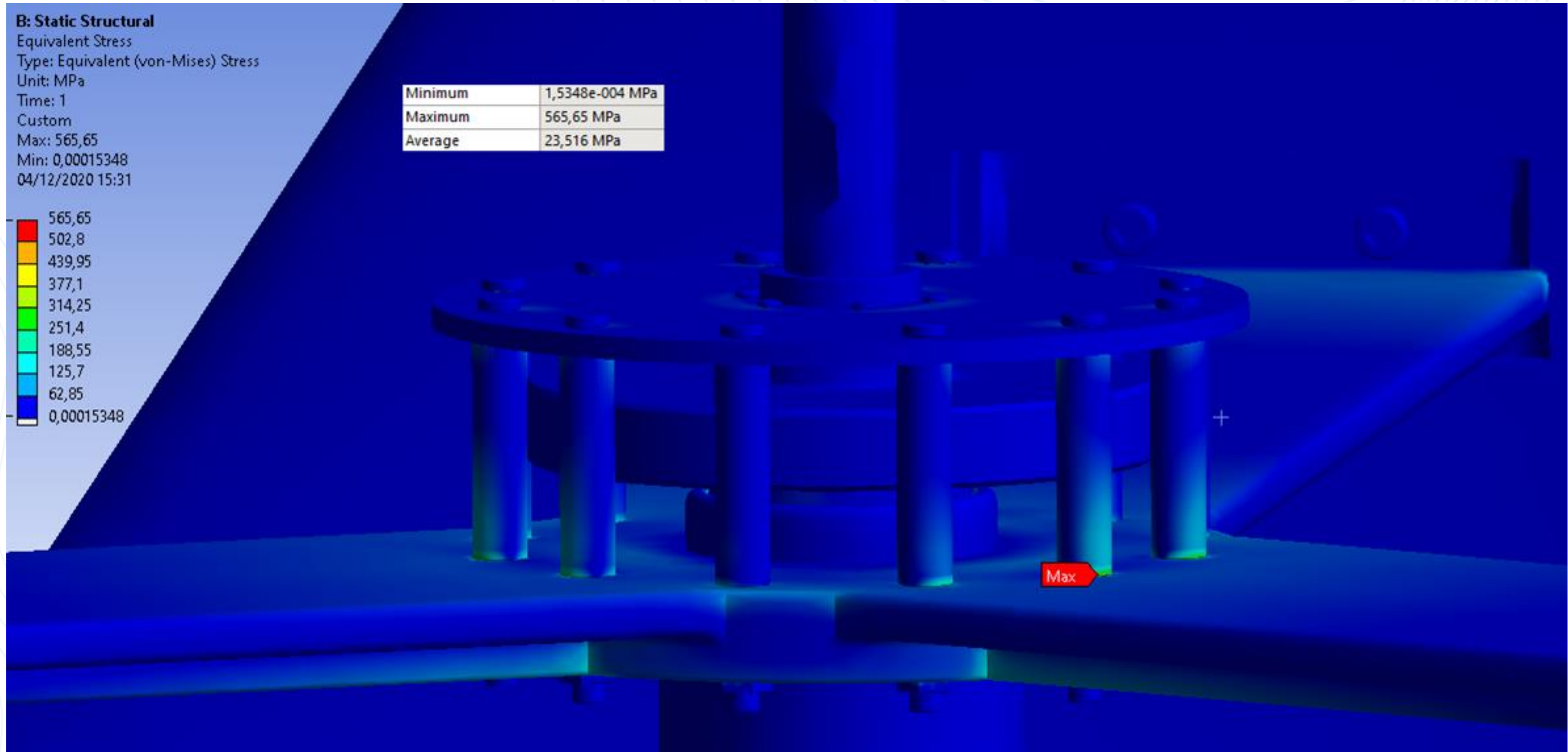
WIND WAY



Simulação estrutural - montagem



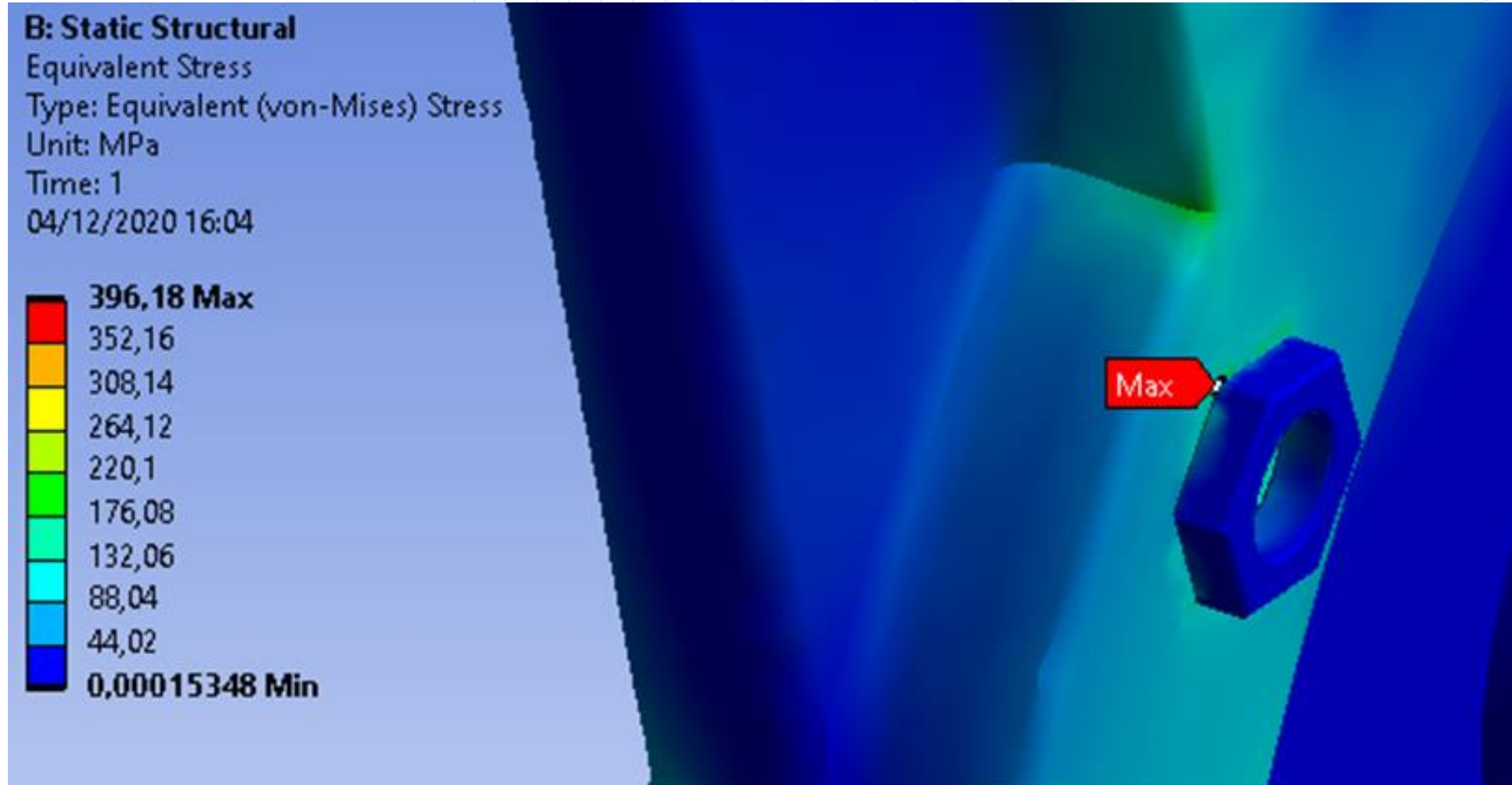
WIND WAY



Simulação estrutural - montagem



WIND WAY

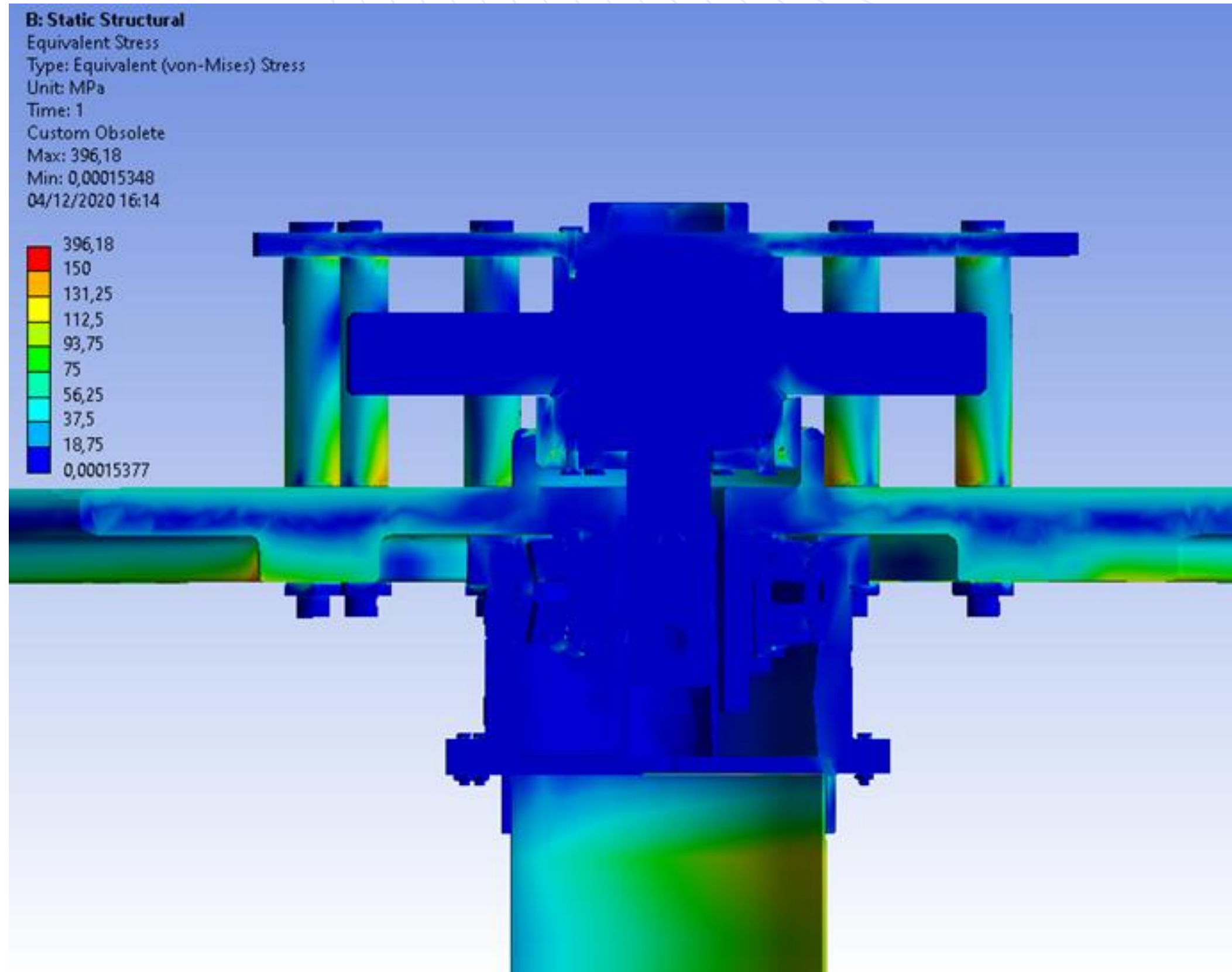


Minimum	1,5348e-004 MPa
Maximum	396,18 MPa
Average	27,936 MPa

Simulação estrutural - montagem



WIND WAY



Fonte: Autor.



EQUIPE E COLABORADORES

WIND WAY



Leticia Martins

RA: 12.116.041-0



Ricardo Barbosa

RA: 12.115.175-7



André Agüero

RA: 12.115.160-9



Rafael Pereira

RA: 12.115.271-4



Lucas Fuga

RA: 12.112.272-5



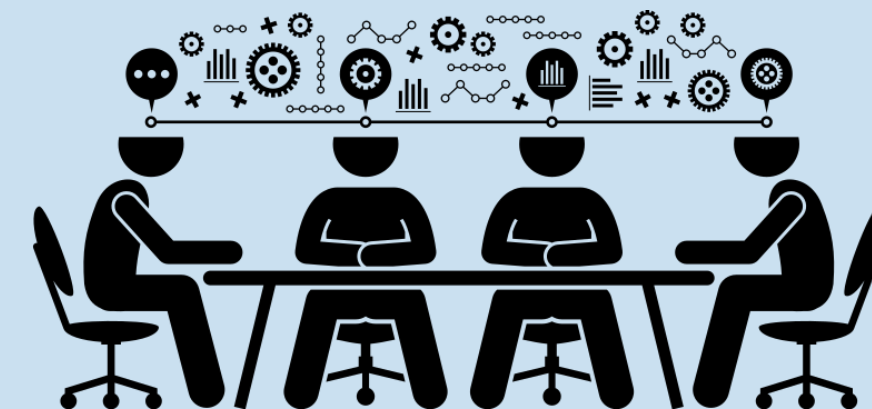
Lucas Pereira

RA: 12.117.485-8



Yasmin Andrade

RA: 12.117.485-8



Dezembro 04, 2020

OBRIGADO!

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