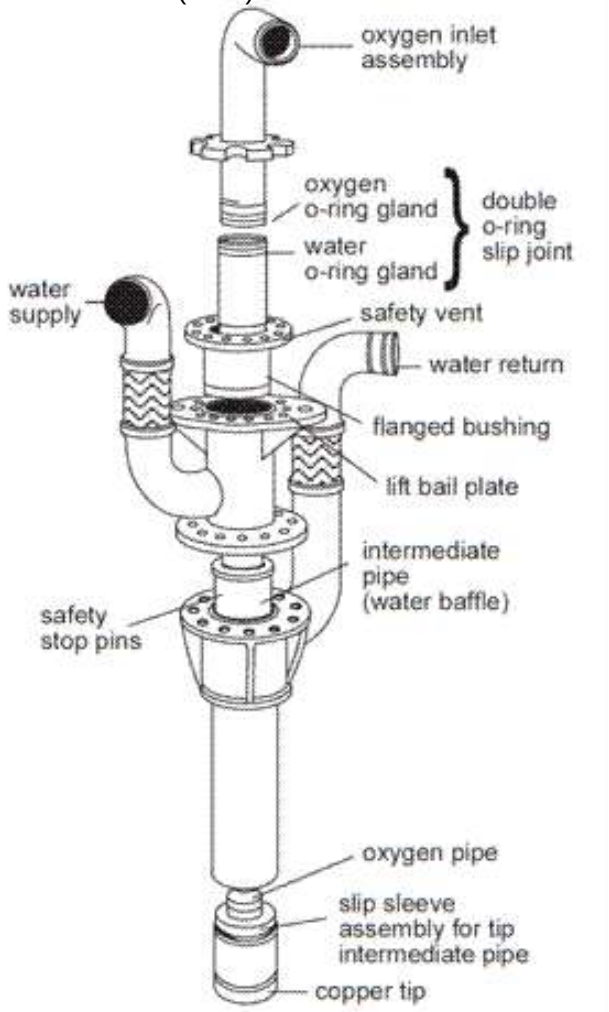
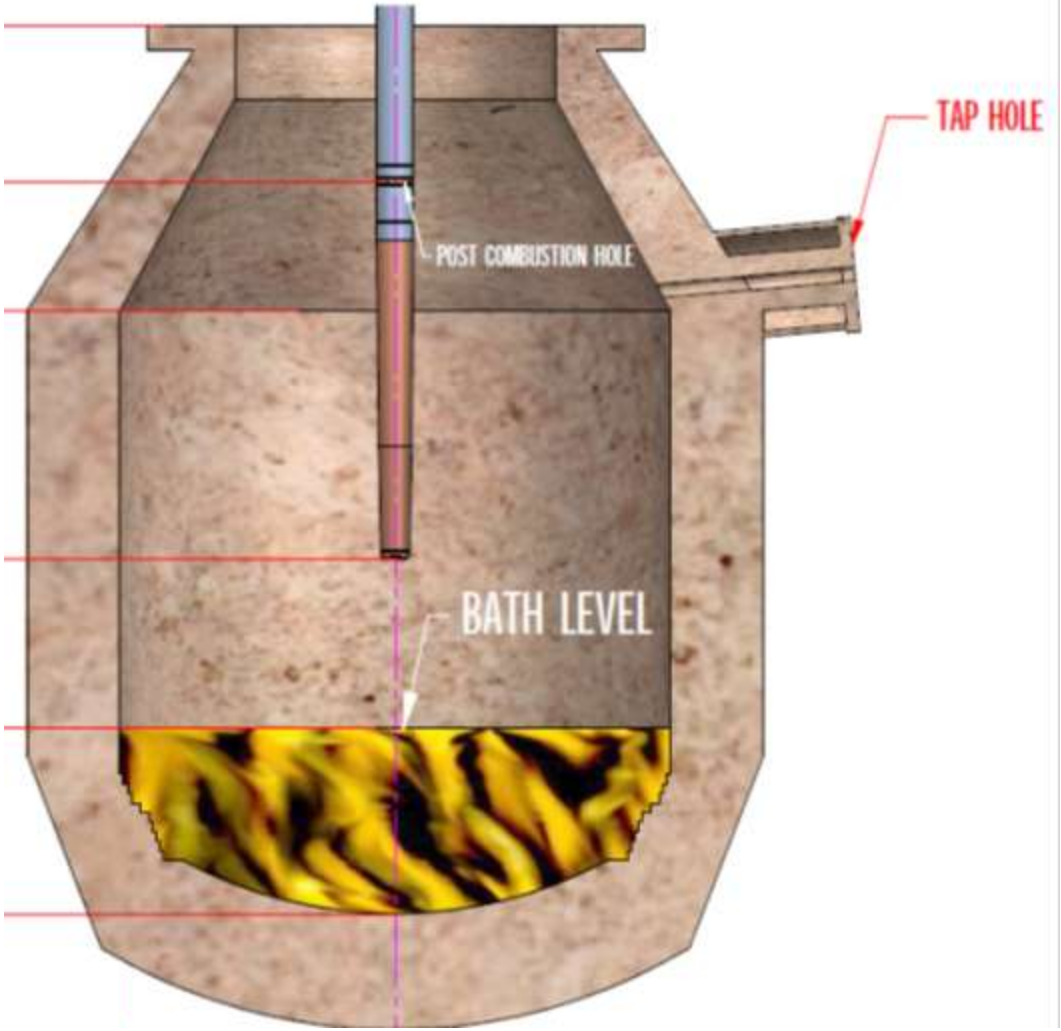
CFD Simulations for Water Flow in Lance to BOF

Breno Totti Maia
Bruno Orlando de Almeida Santos
Fabrício Silveira Garajau
Marcelo de Souza Lima Guerra

Introduction
Lance

Source: Barker *et al* (1998)

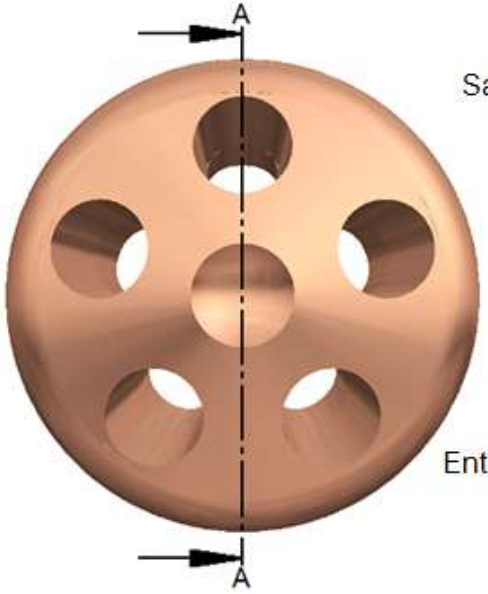


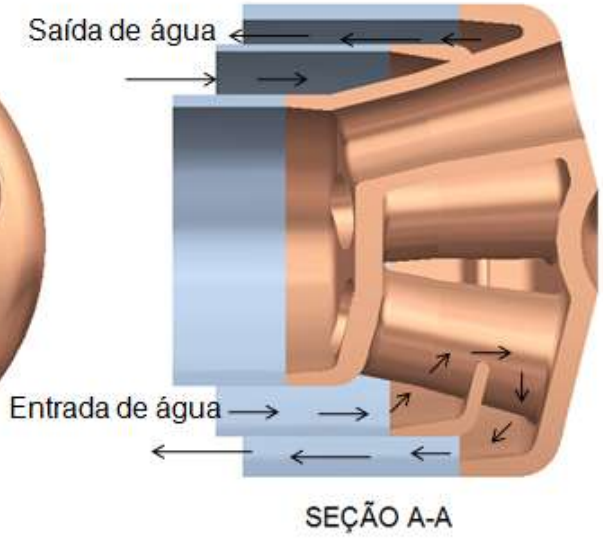


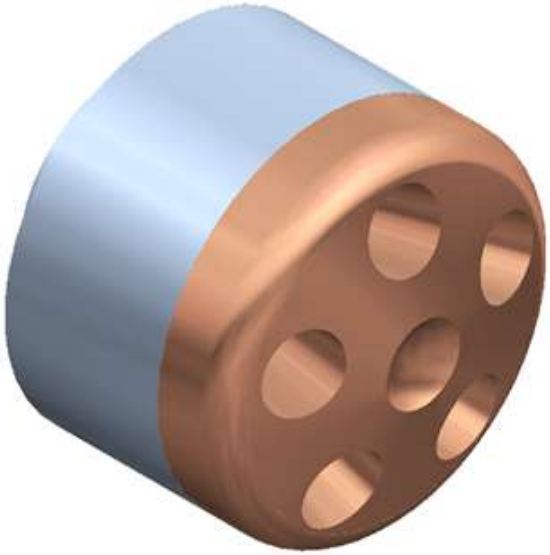
Introduction
Tip

Characteristics

- Support thermal expansion and contraction;
- Get maximum velocity of cooling water ;
- High heat transfers;
- Low pressure drop;







Methodology

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ANSYS®

Math Model
Conservative Equations

Mass

$$\frac{\partial \rho}{\partial t} + \nabla.\left(\rho \vec{U}\right) = S_m$$

Momentum

$$\frac{\partial}{\partial t}\left(\rho U\right) + \nabla.\left(\rho \vec{U}\vec{U}\right) = -\nabla p + \nabla.\left(\bar{\bar{\tau}}\right) + \rho \vec{g} + \vec{F}$$

Energy

$$\frac{\partial\left(\rho h_{tot}\right)}{\partial t} - \frac{\partial p}{\partial t} + \nabla.\left(\rho U h_{tot}\right) - \nabla.\left(k \nabla T\right) + \nabla.\left(U.\tau\right) + U.S_M + S_E$$

Turbulent Kinetic Energy

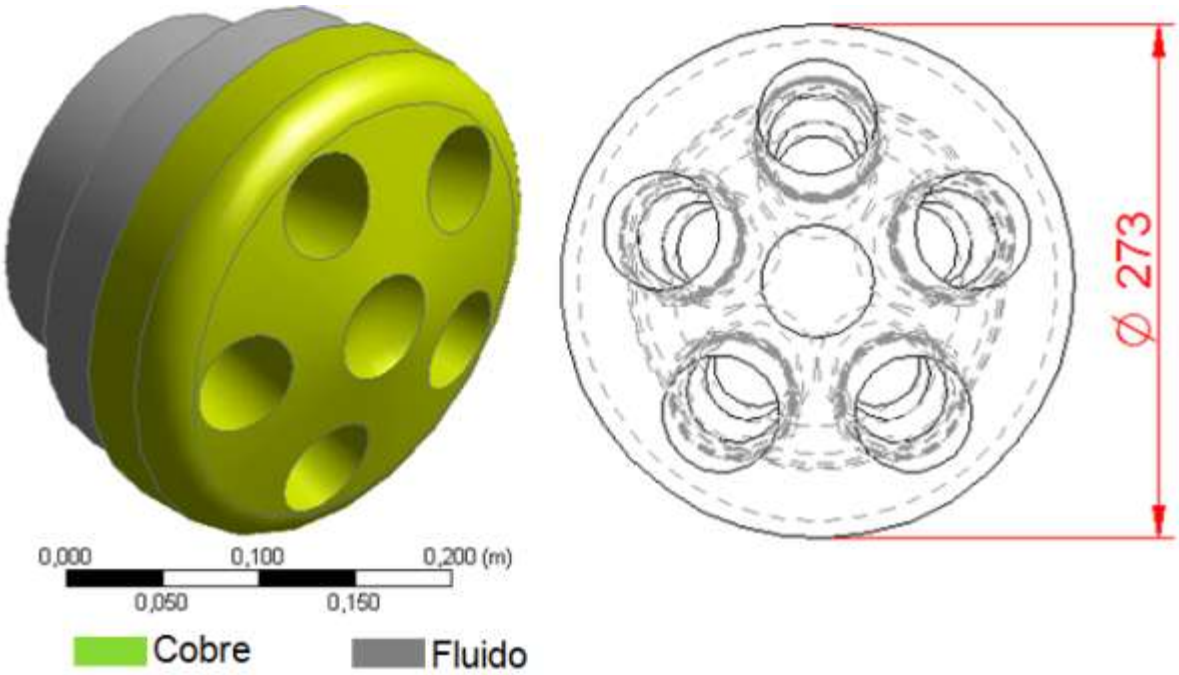
$$\frac{\partial\left(\rho k\right)}{\partial t} + \frac{\partial}{\partial x_j}\left(\rho U_j k\right) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] + P_k - \rho\varepsilon + P_{kb}$$

Eddy Kinetic Energy

$$\frac{\partial\left(\rho\varepsilon\right)}{\partial t} + \frac{\partial}{\partial x_j}\left(\rho U_j \varepsilon\right) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right] + \frac{\varepsilon}{k}\left(C_{\varepsilon 1} P_k - C_{\varepsilon 2}\rho\varepsilon + C_{\varepsilon 1} P_{\varepsilon b}\right)$$

Methodology

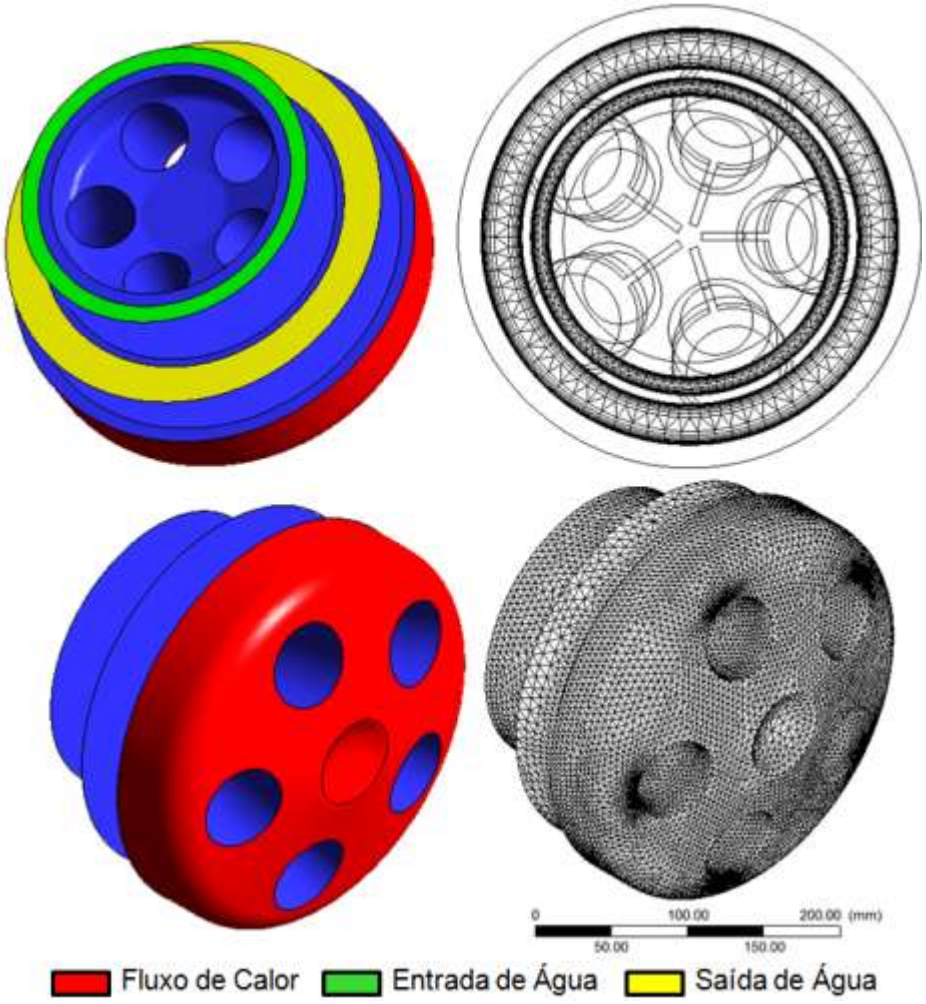
Numerical Model
Geometry and Boundary Conditions



Description	Values
Water flow	$170 m^3/h$
Inlet temperature of water	40ºC
Heat flow (tip Face)	$2,4 MW/m^2$

Methodology

Numerical Model
Geometry and Boundary Conditions



Fluid Region:

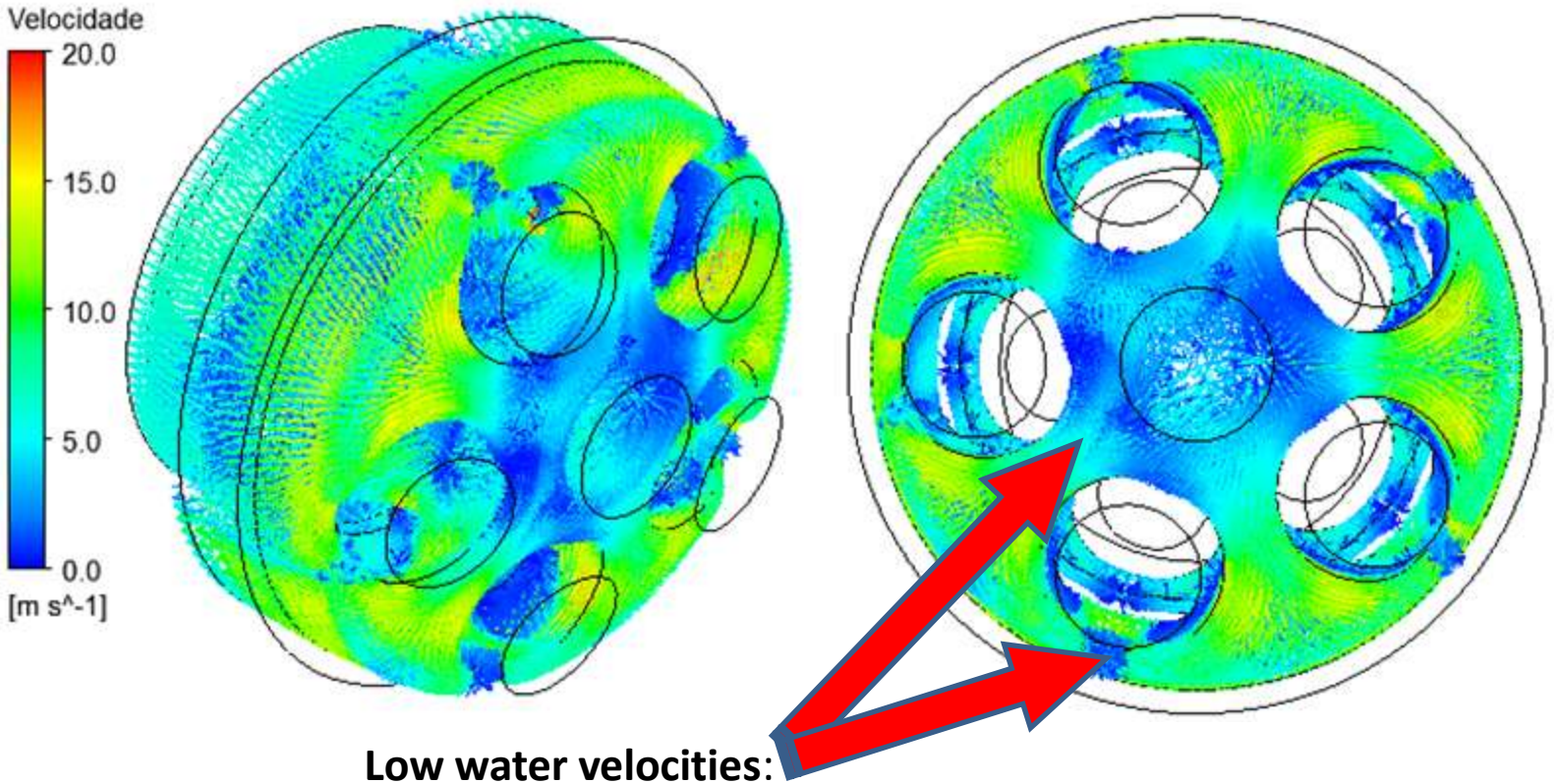
- Layers near of wall;
- Reproduce viscous effects and drop pressure;

Solid Region:

- Layer of elements for transfer:
  - Concentrations,
  - Temperature,
  - Strees along the thickness.

Results and Discussions

Velocity Profile

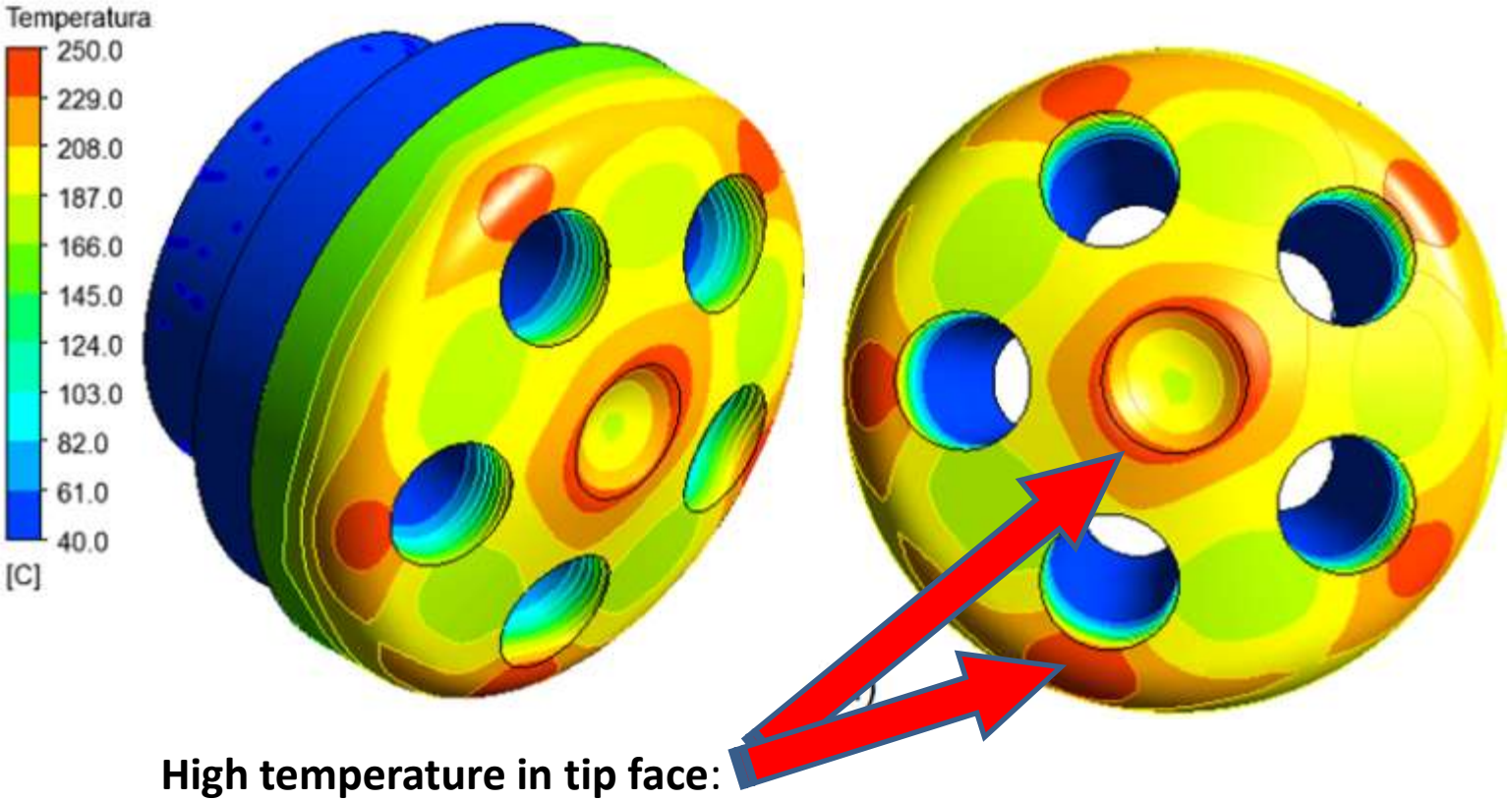


Low water velocities:

- Low coefficients heat transfer;
- Low thermal transfer
- High temperature in tip face;
- Contribute for erosions and abrasions effects during blow

Results and Discussions

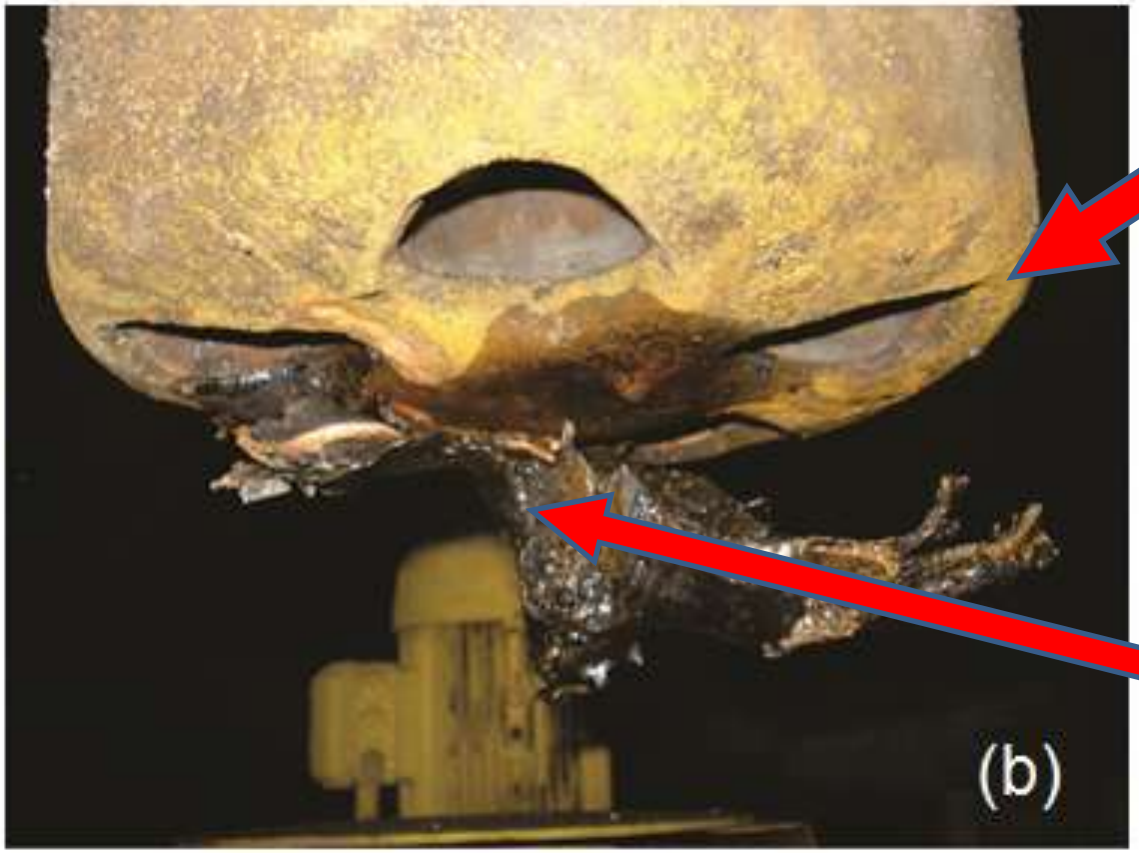
Temperature Profile



High temperature in tip face:

Results and Discussions

Temperature Profile
Tip Life = 166 heats

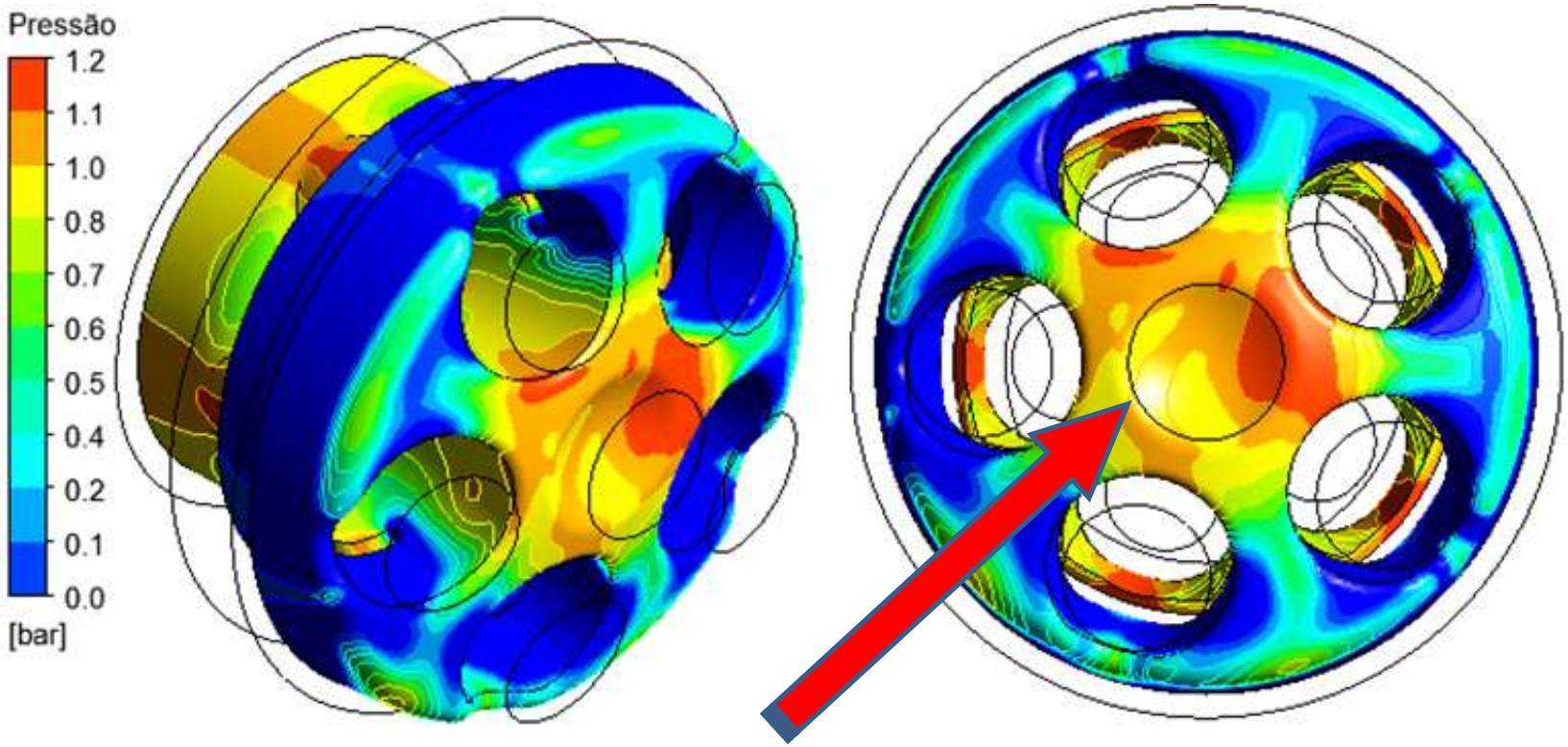


Intensive wear

Failure – Melt point

Results and Discussions

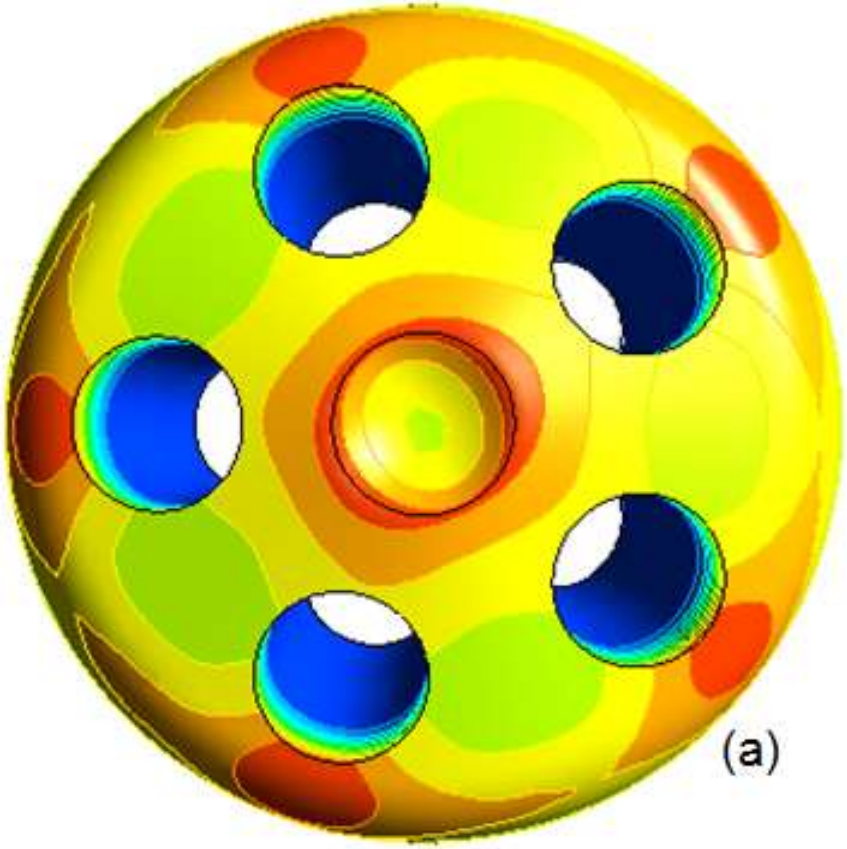
Drop Pressure

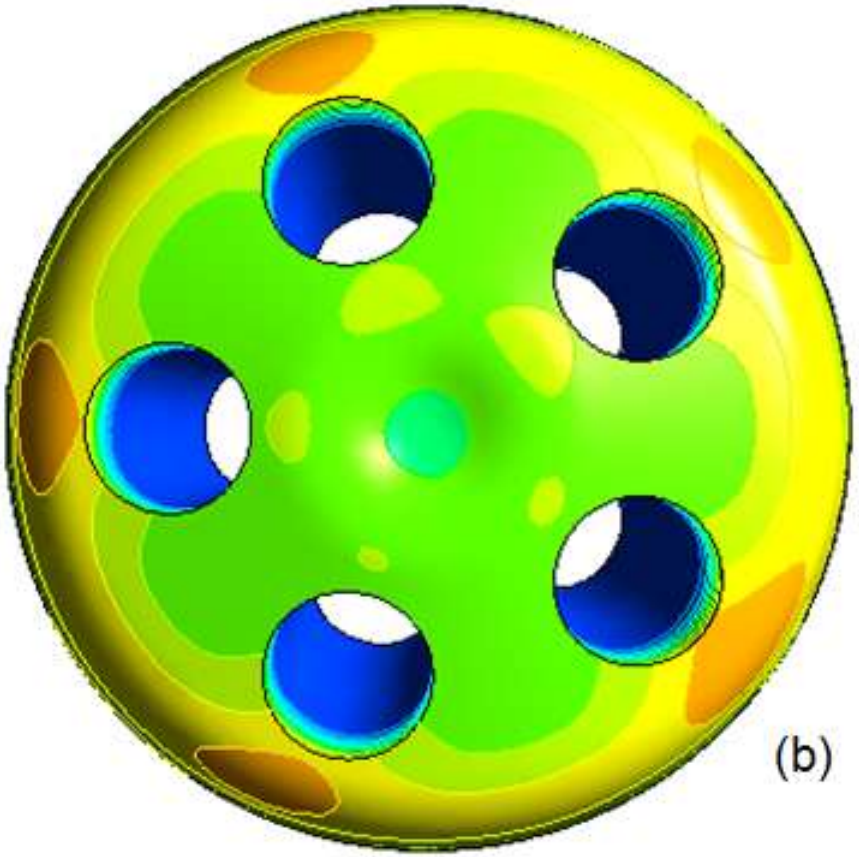


High drop pressure

Results and Discussions

TIP FACE - COMPARATIVE TEMPERATURE



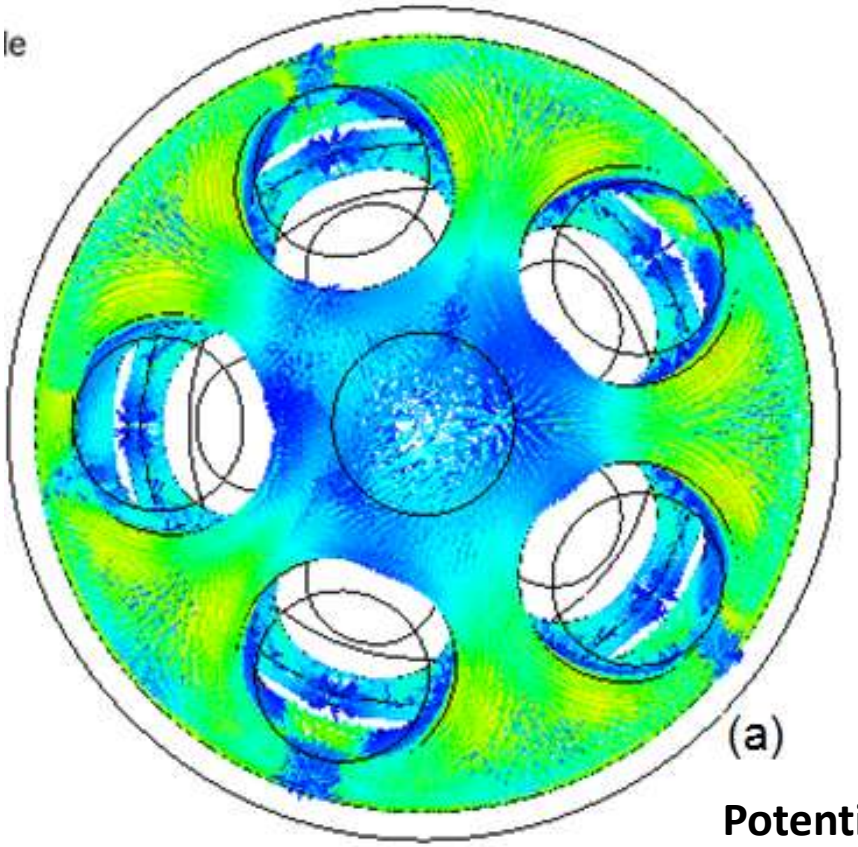


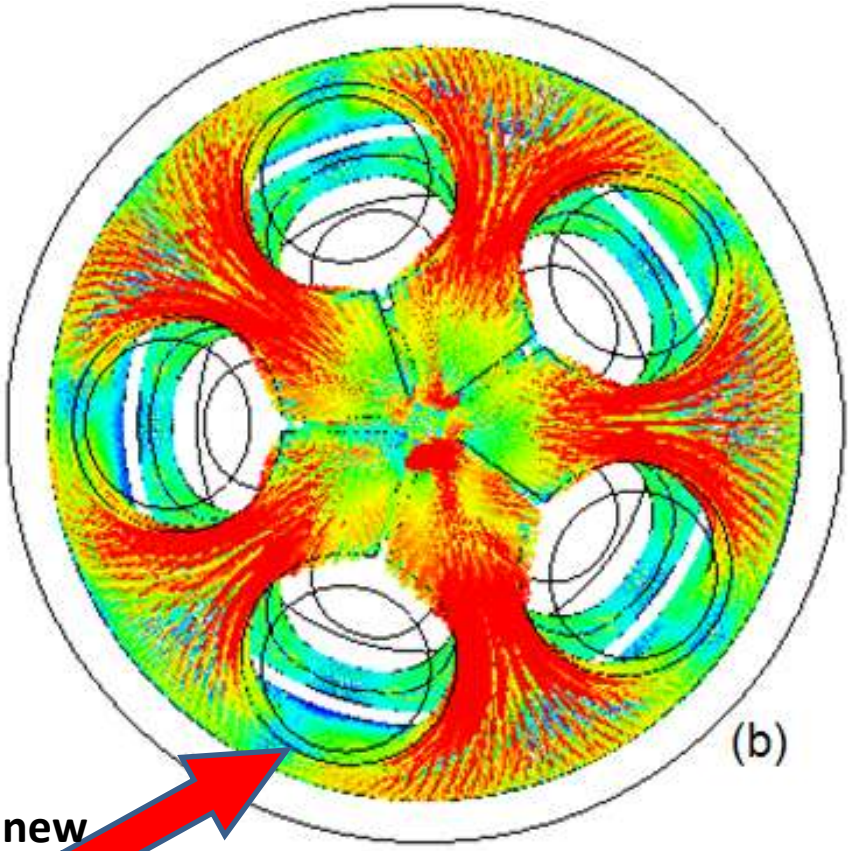
OLD DESIGN

NEW DESIGN

Results and Discussions

TIP FACE - COMPARATIVE VELOCITIES





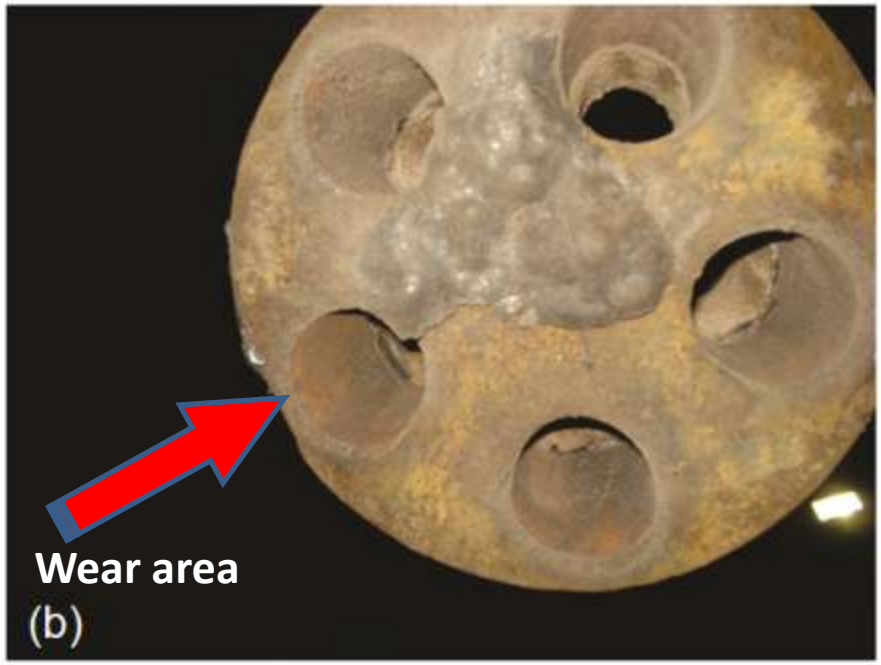
Potential new failure point

OLD DESIGN

NEW DESIGN

Results and Discussions

TIP FACE - COMPARATIVE LIFES



166 Heats

990 Heats

Conclusions

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•The CFD models are able to prevent and develop new performance of lance tip;

•Lance tips needs to have high velocity in the hot region or face of the tip;

•High velocity promote increase in the coefficient heat transfer;

•High coefficient heat transfer guarantee the mechanical properties of the solid materials for longer time;

•This work was applied practically into the steel shops and the results showed increase at the lance tip life by 6 times.

Thanks!

LUMAR · METALS

North America

ted.leczo@lumarmetals.com.br

+

South America

breno.totti@lumarmetals.com.br

+55 9399 3200

Asia

raju.psjkk@lumarmetals.co.in

+91 99 80 111933

AISTECH – Booth 2144

www.lumarmetals.com.br