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SHAPING OF THE THERMO GAS KINETIC TUBES OF THE STRIPED OR FINNED BAYONET TYPE IN TURBULENT CONDITIONS

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Abstract

In the paper the principles of shaping of the thermo gas kinetic tubes of the Bayonet type – stripped or finned – in turbulent conditions are presented. The paper also deals with the solving of the equations of the eddy and also deals with the viewing of the folders with the specialized Phoenics software.

***Key words**: tube, heat, transfer, Field, exchanges*

To shape the heat exchange in turbulent conditions a specialised programme called Phoenics is used.

To shape the Field (Bayonet) tube in turbulent conditions, the domain option of shaping is used, considering only half of the studied tube, resulting in the domlis.bmp (fig.1) folder for the striped Field tube and domnerv.bmp (fig.2) for the finned Field tube.

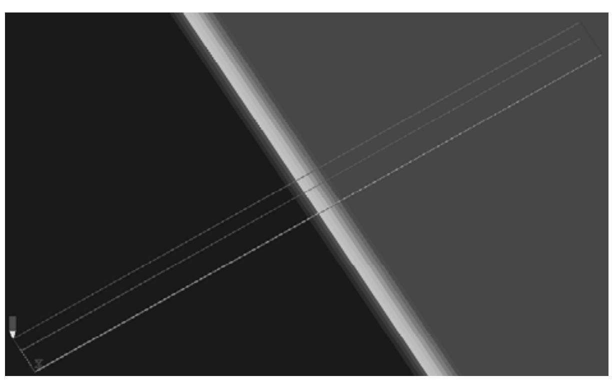

Fig.1 Domlis

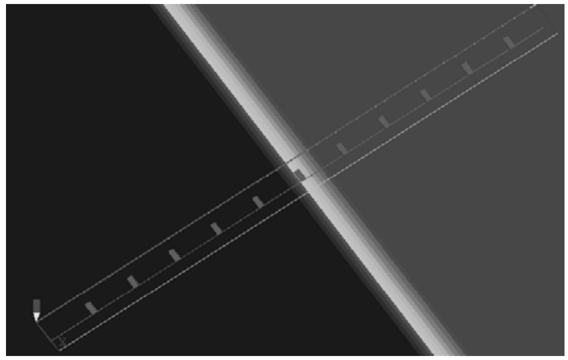

Fig.2 Domnerv

The vitlis.bmp (fig.3 and fig.4) for the striped Field tube and vitnev.bmp (fig.5) for the finned Filed tube folders are used to shape speed field.

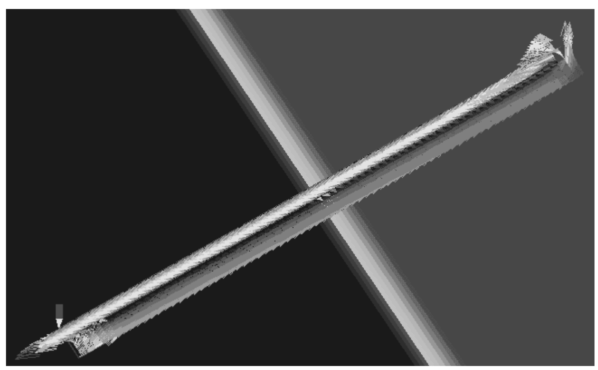

Fig.3 Vitlis1

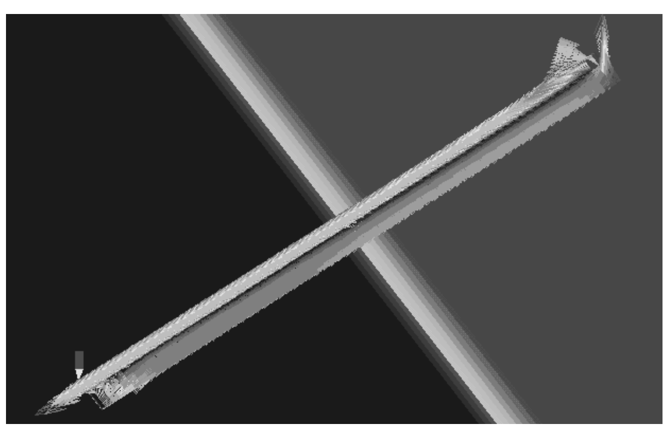

Fig.4 Vitlis2

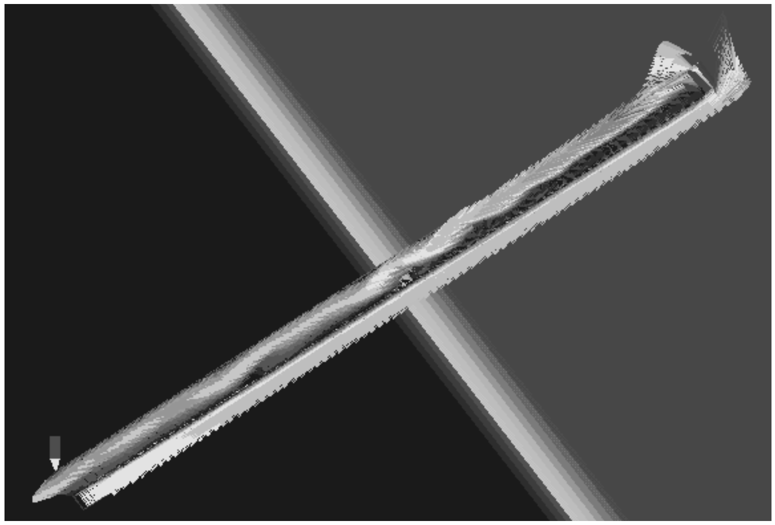

Fig.5 Vitnev

Finally temperature gradient is shaped with the help of tplis.bmp (fig.6 and fig.7) folders for the striped Field tubes and the tpnerv.bmp folders for the Finned Field tubes (fig.8).

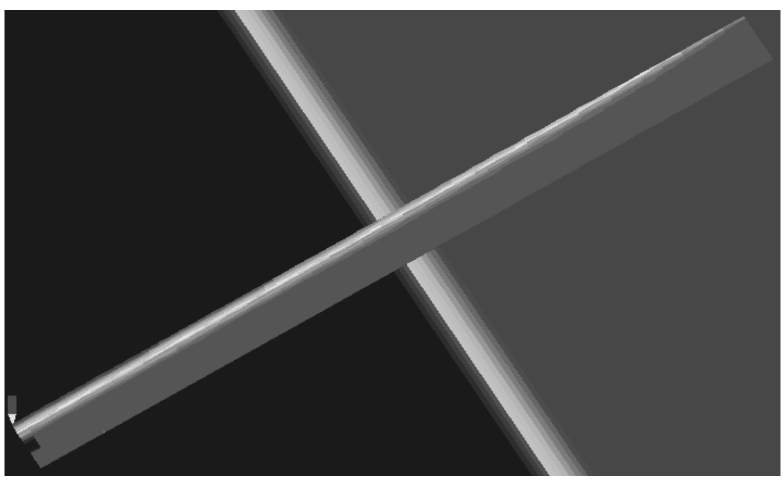

Fig.6 Tplis1

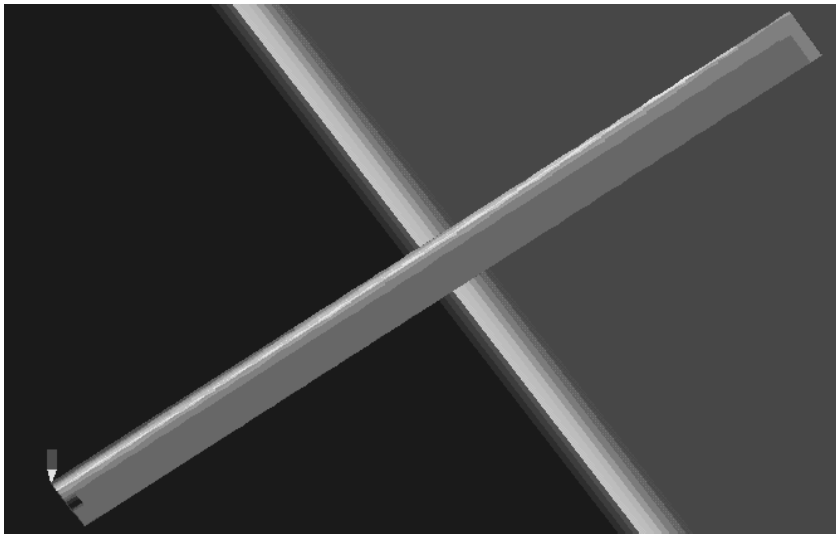

Fig.7 Tplis2

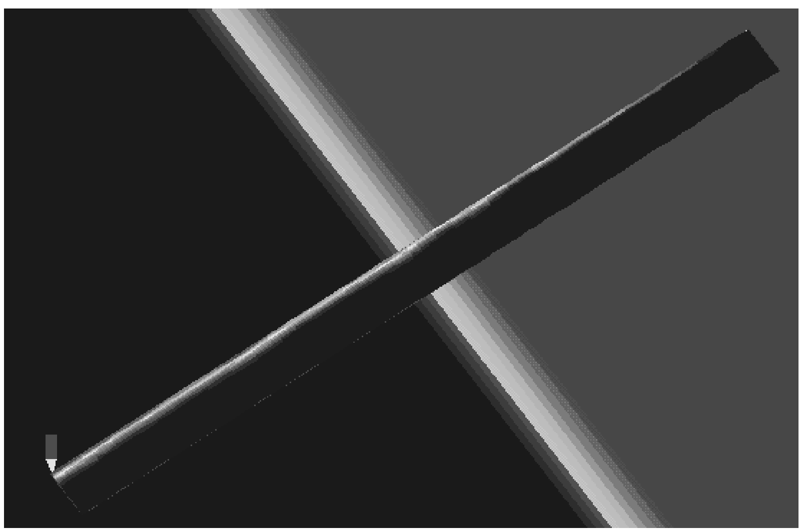

Fig.8 Tpnerv1

1. SOLVING OF THE EQUATIONS OF THE EDDY

The equations that describe this model of an eddy together with differential equations, are solved with the k – ε [www.cham.co.uk] the following way:

- The movement equation of viscous fluids:

$$\frac{\partial\rho\Phi}{\partial t}+\frac{\partial(\rho U\Phi)}{\partial x}+\frac{\partial(\rho V\Phi)}{\partial y}+\frac{\partial(\rho W\Phi)}{\partial z}=\frac{\partial}{\partial x}\frac{\mu_t}{\mathrm{Pr}_m}\frac{\partial\Phi}{\partial x}+\frac{\partial}{\partial x}\frac{\mu_t}{\mathrm{Pr}_m}\frac{\partial\Phi}{\partial y}+\frac{\partial}{\partial x}\frac{\mu_t}{\mathrm{Pr}_m}\frac{\partial\Phi}{\partial z}+S\Phi \quad (1)$$

- The continuity equation:

$$\frac{\partial\rho}{\partial t}+\frac{\partial(\rho U)}{\partial x}+\frac{\partial(\rho V)}{\partial y}+\frac{\partial(\rho W)}{\partial z}=0 \quad (2)$$

- The Navier-Stokes equations:
- In the x direction:

$$\begin{aligned}&\frac{\partial\rho U}{\partial t}+\frac{\partial(\rho UU)}{\partial x}+\frac{\partial(\rho VU)}{\partial y}+\frac{\partial(\rho WU)}{\partial z}=\\&-\frac{\partial p}{\partial x}+\frac{\partial}{\partial x}\mu_e\frac{\partial U}{\partial x}+\frac{\partial}{\partial y}\mu_e\frac{\partial U}{\partial y}+\frac{\partial}{\partial z}\mu_e\frac{\partial U}{\partial z}+\\&+\frac{\partial}{\partial x}\mu_e\frac{\partial U}{\partial x}+\frac{\partial}{\partial y}\mu_e\frac{\partial V}{\partial x}+\frac{\partial}{\partial z}\mu_e\frac{\partial W}{\partial x}-\frac{\partial}{\partial x}\frac{2}{3}\rho k\end{aligned} \quad (3)$$

- in the y direction:

$$\begin{aligned}&\frac{\partial\rho V}{\partial t}+\frac{\partial(\rho UV)}{\partial x}+\frac{\partial(\rho VV)}{\partial y}+\frac{\partial(\rho WV)}{\partial z}=\\&-\frac{\partial p}{\partial y}+\frac{\partial}{\partial x}\mu_e\frac{\partial V}{\partial x}+\frac{\partial}{\partial y}\mu_e\frac{\partial V}{\partial y}+\frac{\partial}{\partial z}\mu_e\frac{\partial V}{\partial z}+\\&+\frac{\partial}{\partial x}\mu_e\frac{\partial U}{\partial y}++\frac{\partial}{\partial y}\mu_e\frac{\partial V}{\partial y}+\frac{\partial}{\partial z}\mu_e\frac{\partial W}{\partial y}-\frac{\partial}{\partial y}\frac{2}{3}\rho k\end{aligned} \quad (4)$$

- in the z direction:

$$\begin{aligned}&\frac{\partial\rho W}{\partial t}+\frac{\partial(\rho UW)}{\partial x}+\frac{\partial(\rho VW)}{\partial y}+\frac{\partial(\rho WW)}{\partial z}=\\&-\frac{\partial p}{\partial z}+\frac{\partial}{\partial x}\mu_e\frac{\partial W}{\partial x}+\frac{\partial}{\partial y}\mu_e\frac{\partial W}{\partial y}+\frac{\partial}{\partial z}\mu_e\frac{\partial W}{\partial z}\\&+\frac{\partial}{\partial x}\mu_e\frac{\partial U}{\partial z}+\frac{\partial}{\partial y}\mu_e\frac{\partial V}{\partial z}+\frac{\partial}{\partial z}\mu_e\frac{\partial W}{\partial z}-\frac{\partial}{\partial z}\frac{2}{3}\rho k\end{aligned} \quad (5)$$

- k – ε model of turbulencs:

$$\begin{aligned}&\frac{\partial\rho k}{\partial t}+\frac{\partial(\rho Uk)}{\partial x}+\frac{\partial(\rho Vk)}{\partial y}+\frac{\partial(\rho Wk)}{\partial z}=\frac{\partial}{\partial x}\frac{\mu_t}{\mathrm{Pr}_k}\frac{\partial k}{\partial x}+\\&\frac{\partial}{\partial y}\frac{\mu_t}{\mathrm{Pr}_k}\frac{\partial k}{\partial y}+\frac{\partial}{\partial z}\frac{\mu_t}{\mathrm{Pr}_k}\frac{\partial k}{\partial z}+P-\rho\varepsilon\end{aligned} \quad (6)$$

$$\begin{aligned}&\frac{\partial\rho\varepsilon}{\partial t}+\frac{\partial(\rho U\varepsilon)}{\partial x}+\frac{\partial(\rho V\varepsilon)}{\partial y}+\frac{\partial(\rho W\varepsilon)}{\partial z}=\frac{\partial}{\partial x}\frac{\mu_t}{Pr_\varepsilon}\frac{\partial\varepsilon}{\partial x}+\\&\frac{\partial}{\partial y}\frac{\mu_t}{Pr_\varepsilon}\frac{\partial\varepsilon}{\partial y}+\frac{\partial}{\partial z}\frac{\mu_t}{Pr_\varepsilon}\frac{\partial\varepsilon}{\partial z}+\frac{\varepsilon}{k}(c_1P-c_2\rho\varepsilon)\end{aligned} \quad (7)$$

- The P turbulence equation:

$$P = \mu_t^2\left[\left(\frac{\partial U}{\partial x}\right)^2 + \left(\frac{\partial V}{\partial y}\right)^2 + \left(\frac{\partial W}{\partial z}\right)^2 + \left(\frac{\partial U}{\partial y} + \frac{\partial V}{\partial x}\right)^2 + \left(\frac{\partial U}{\partial z} + \frac{\partial W}{\partial x}\right)^2 + \left(\frac{\partial V}{\partial z} + \frac{\partial W}{\partial y}\right)^2\right] \quad (8)$$

- where:

$$\mu_t = c_\mu \rho \frac{k^2}{\varepsilon};\ \mu_\varepsilon = \mu_l + \mu_t \quad (9)$$

are the turbulence coefficients.

2. FACTORS REGARDING THE PROGRAMMING ON THE DIGITAL COMPUTER OF THE THERMO GAS KINETIC PROCESSES SPECIFIC TO THE TURBULENT CONDITIONS

The progamme I used is Phoenics, a simulatro of the thermo flow and transfer processes. The grid I used was an 80 node one in an axial sense and a 50 node one on the quadrature axis. The subrelaxation coefficient was 10^{-4} and approximately 500 iterations were necessary to obtain the convergence of the problem.

3. CONCLUSIONS

It is observed that at passing from the laminar field to the transitory one, the end phenomenon has as result and consequence the inhencement of the turbulence and the break of the boundary layer, it leads to the intensification of the thermo transfer for the Field tubes, a well emphasised phenonmenon, though the representation is dimensionless. At high speeds, the Field tubes are more eficient from the point of view of the thermic performances than the classic tubes, but with substantial growth of the friction coefficient. This phenomenon is visualised in the vitlis2.bmp folder from figure annex D7, where the field of speeds is shaped.

4. REFERENCES

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