Ewa Tuliszka-Sznitko
Politechnika Poznańska

Badanie numeryczne lokalnego i globalnego momentu obrotowego w przepływie Taylora-Couetta z tarczami

DNS/SVV

$$\rho\frac{\partial V}{\partial \tau}+\rho(V\cdot\nabla)V+\rho\Omega\times(\Omega\times R)+2\rho\Omega\times V=-\nabla P+\mu\Delta V$$

$$\nabla\cdot V=0$$

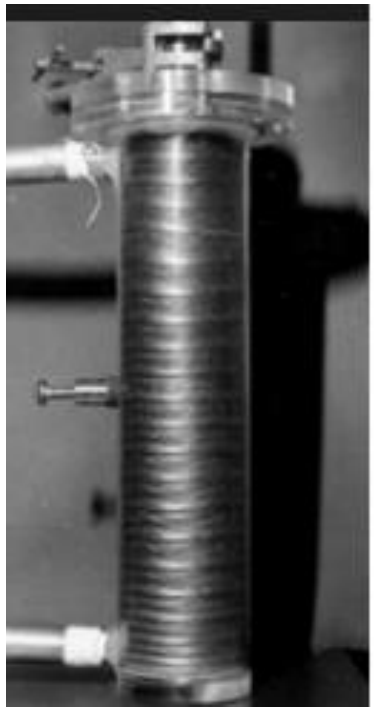
$$\Psi(r,\varphi,z)=\sum_{k=-N^{\varphi}/2}^{N^{\varphi}/2-1}\sum_{n=0}^{N^{r}-1}\sum_{m=0}^{N^{z}-1}\hat{\Psi}_{nmk}T_n(r)T_m(z)e^{ik\varphi}$$

$$-1\le r,z\le 1,\quad 0\le\varphi\le 2\pi$$

$$Re=\Omega(R_2-R_1)R_1/\nu$$

$$\Gamma=H/(R_2-R_1)$$

$$\eta=R_1/R_2$$



Torque

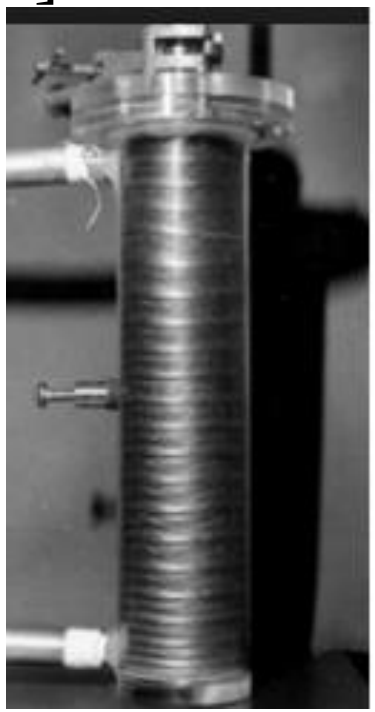
Uśredniony moment obrotowy

$$G = J^{\omega} / \nu^2 = T / [2\pi(2h)\rho\nu^2]$$

$$J^{\omega} = < j^{\omega}(R, \varphi, Z, t) >_{A(R),t} = R^3 [< UV/R >_{A(R),t} - \nu\partial(< V/R >_{A(R),t}) / \partial R]$$

$$Nu^{\omega} = G / G_{lam}$$

$$G_{lam} = 2\nu R_1^2 R_2^2 \Omega / (R_2^2 - R_2^2)$$



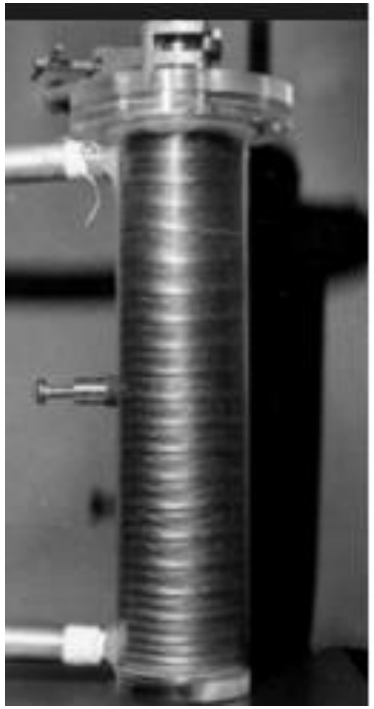
Uśredniona prędkość kątowa i uśredniony moment pędu

$$< (V/R)/(V/R)_1 >_{A(R),t}$$

$$< (VR)/(VR)_1 >_{A(R),t}$$

Precyzja obliczeń

H. Brauckmann, B. Eckhardt, *Direct numerical simulations of local and global torque in Taylor-Couette flow up to Re D 30000*, J. Fluid Mech., **718**, 398, 2013.



Re=2475	ΔR_2^+	ΔR_1^+	$(R_2 \Delta\varphi)^+$	$(R_1 \Delta\varphi)^+$	Δz_2^+	Δz_1^+
(50,250,201)	0.176	0.089	43.143	19.693	0.006	0.010
(100,300,201)	0.04349	0.02349	36.2210	17.6095	0.00677	0.01032
(150,300,201)	0.01905	0.01079	35.9458	18.3226	0.00681	0.01030
(100,400,201)	0.04311	0.02438	26.9254	13.7079	0.00681	0.01030
(100,400,301)	0.04393	0.02423	27.4383	13.6234	0.00302	0.00454

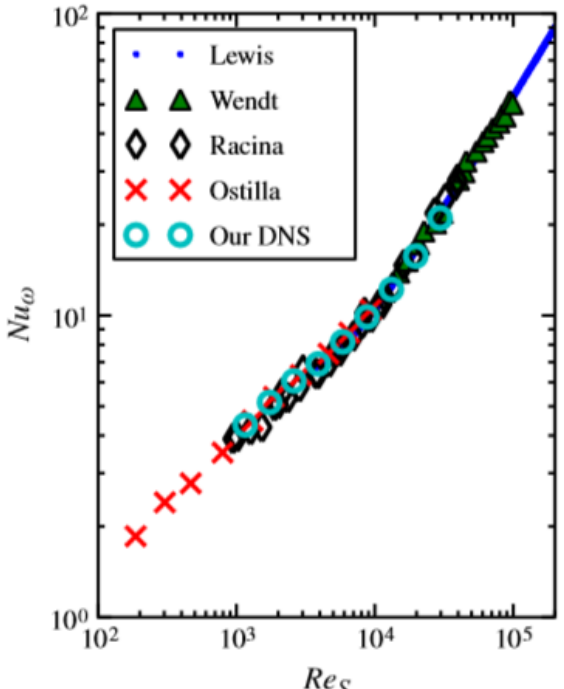
$$\Delta R_2^+ = \Delta R \, u_\sigma / \nu$$

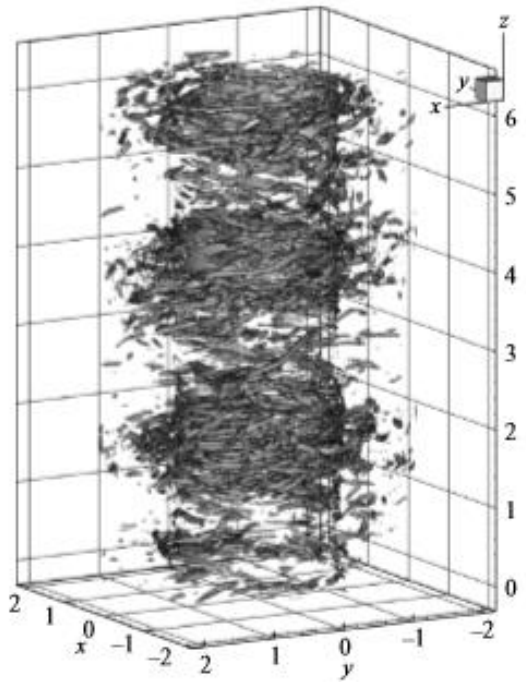
Badania symulacyjne momentu obrotowego

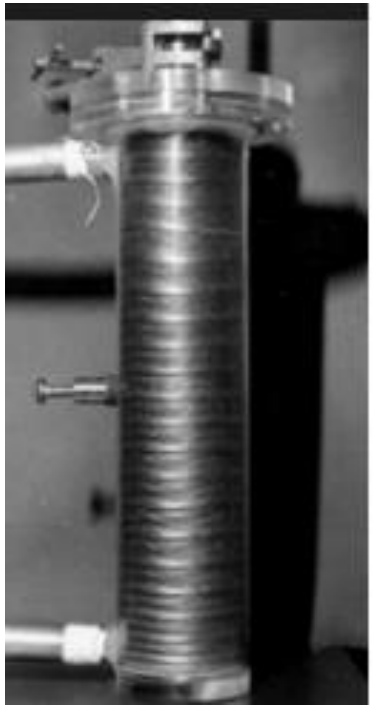
H. Brauckmann, B. Eckhardt, *Direct numerical simulations of local and global torque in Taylor-Couette flow up to Re D 30000*, J. Fluid Mech., **718**, 398, 2013.

B. Eckhardt, S. Grossmann, D. Lohse, *Torque scaling in turbulent Taylor–Couette flow between independently rotating cylinders*, J. Fluid Mech., **581**, 221–250, 2007

$$\mathrm{Re} = \Omega(\mathrm{R}_2 - \mathrm{R}_1)\mathrm{R}_1 / \nu \cong 30000$$

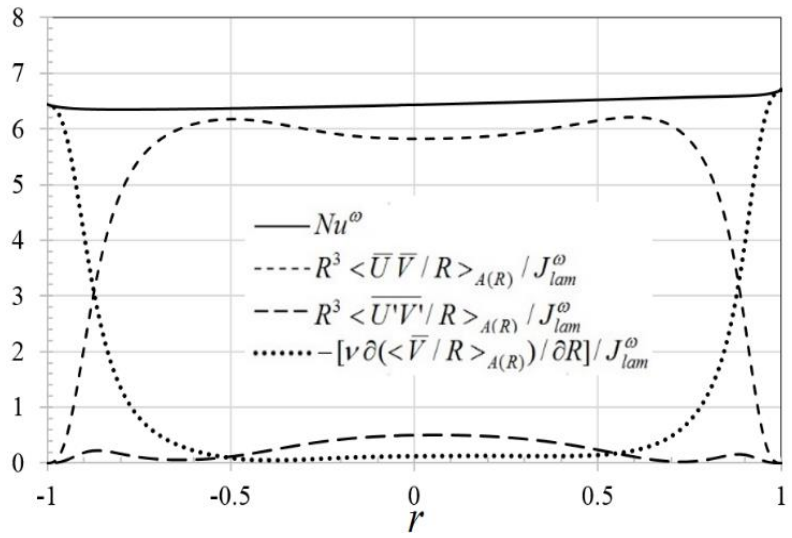


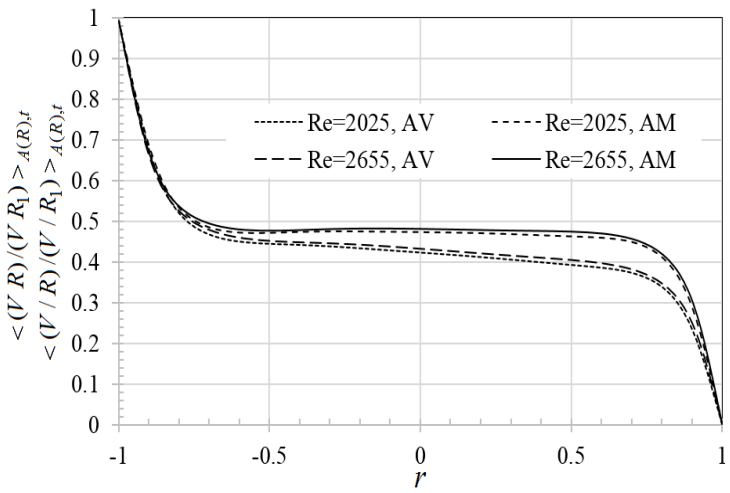


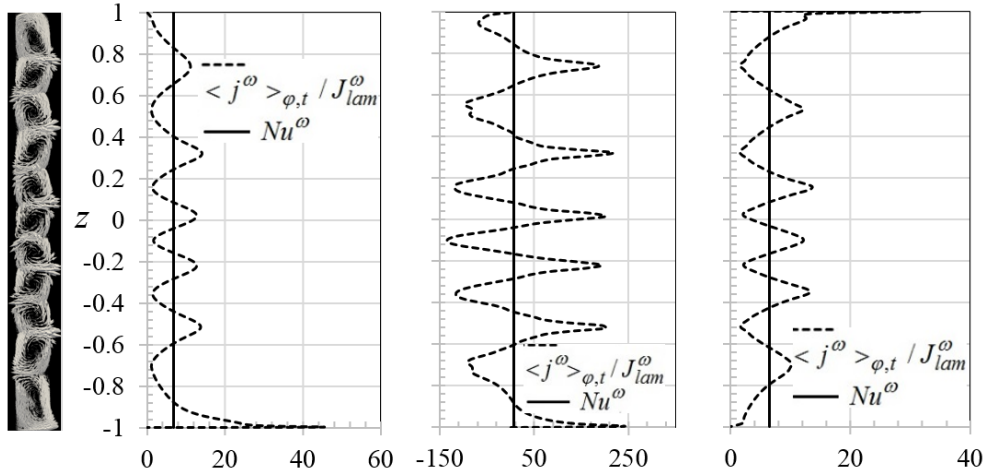


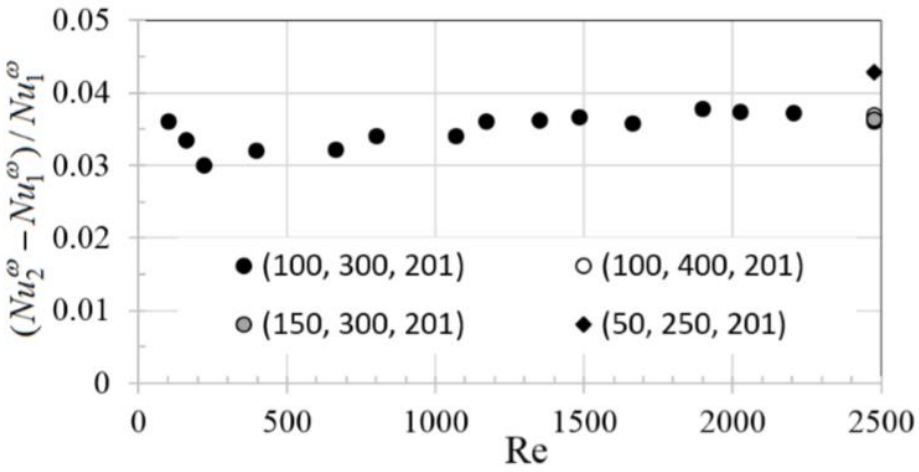
S. Dong, *Direct numerical simulation of turbulent Taylor-Couette flow*, J. Fluid Mech., **587**, 373, 2007.

Γ=11.75, η=0.9 (Re do 3000)





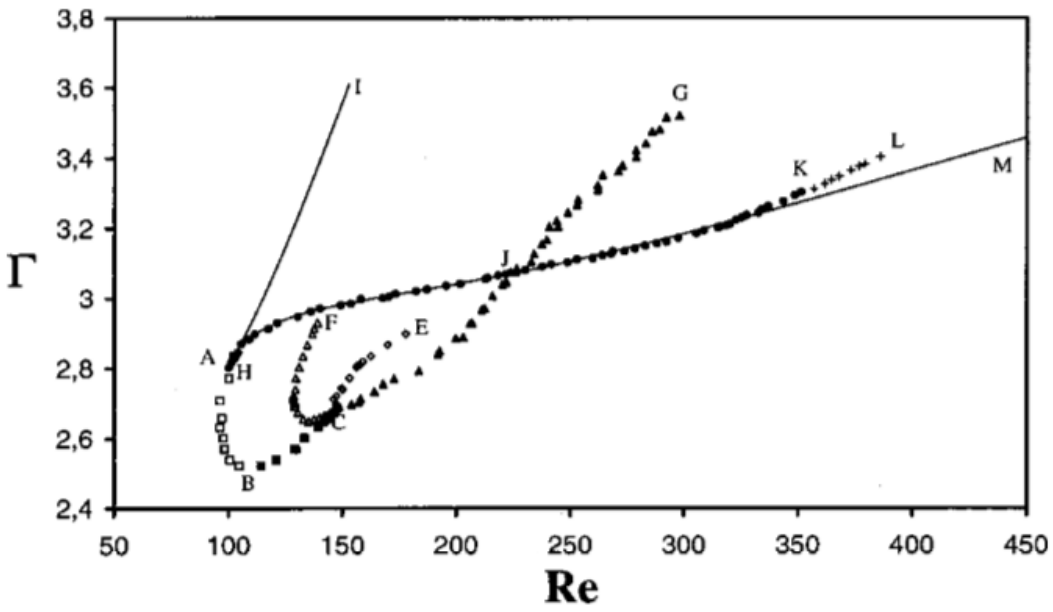


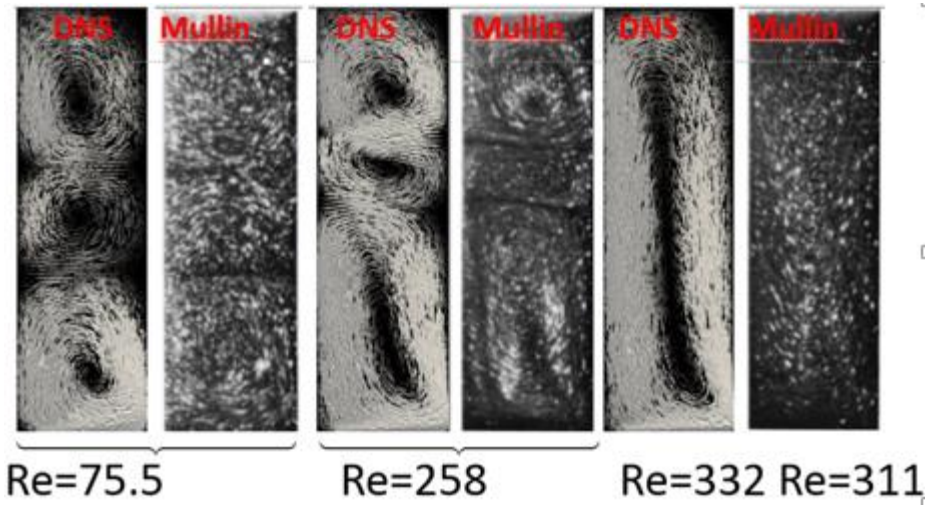


Literatura

T. Mullin, C. Blohm, *Bifurcation phenomena in a Taylor-Couette flow with asymmetric boundary conditions*, Phys. Fluids, **13**, 136, 2001.

η=0.5



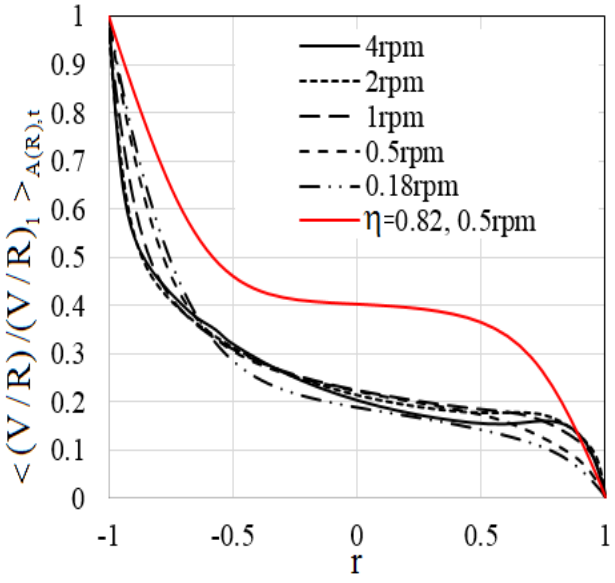


η=0.375-0.82, Γ=3.76

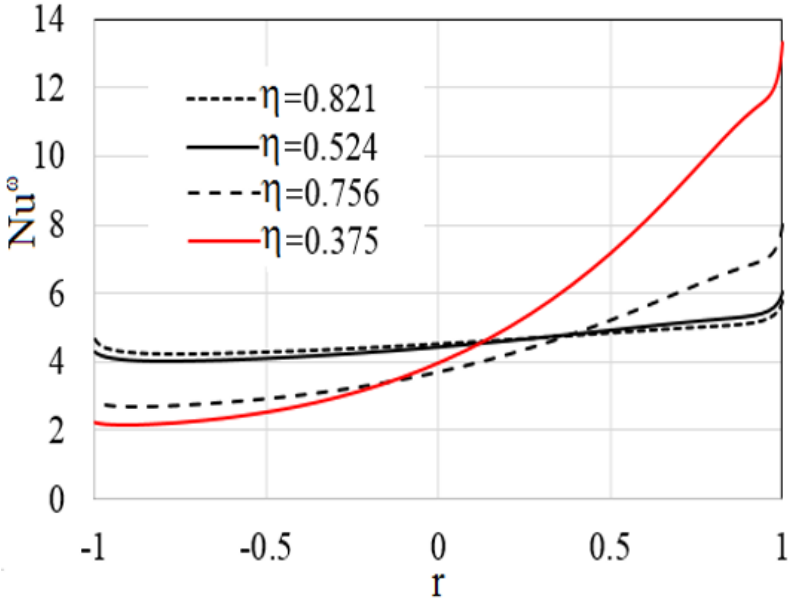
0.735rpm, Re=720, $\lambda 2$=-0.6

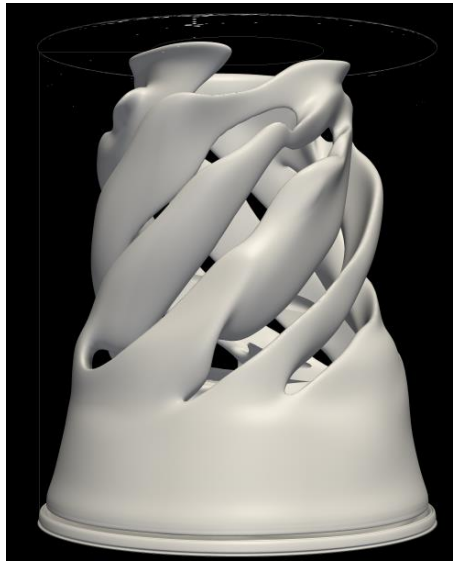
4.7rpm, Re=4600, $\lambda 2$=-0.6

$< (V/R)/(V/R)_1 >_{A(R),t}$

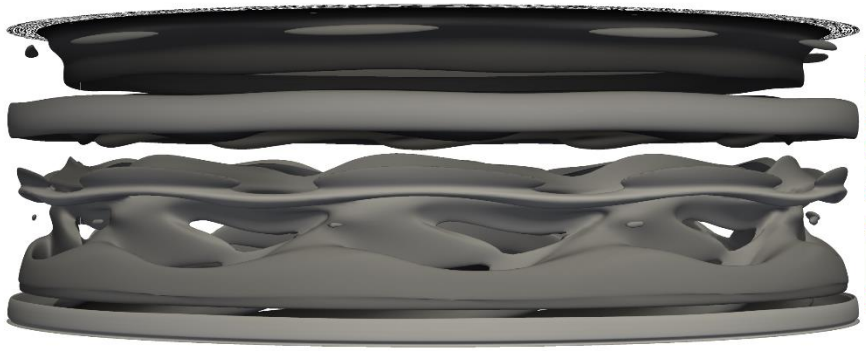


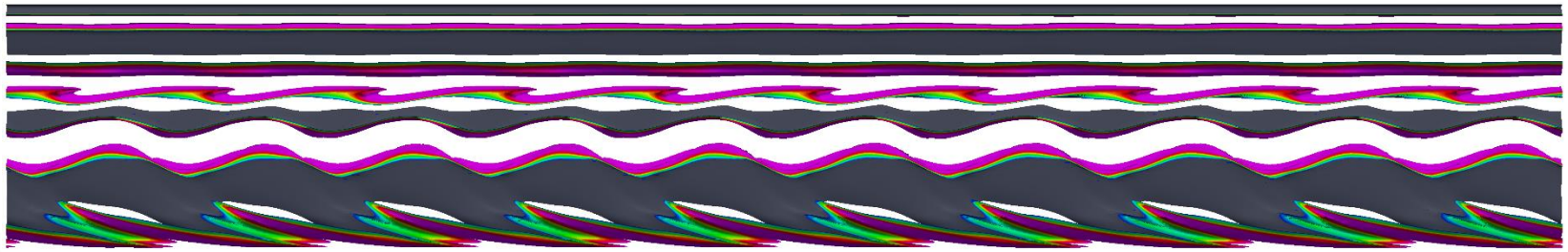
Nu^{ω}





Re=1000, $\lambda 2$=-0.6

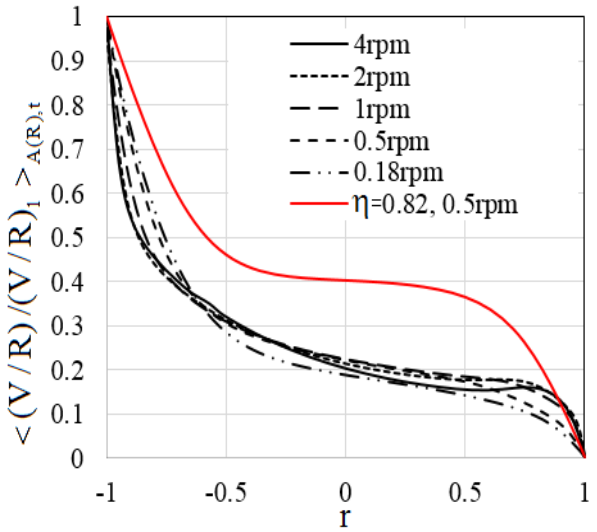


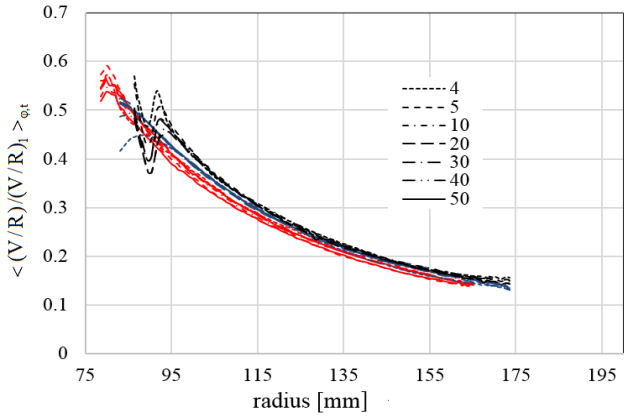


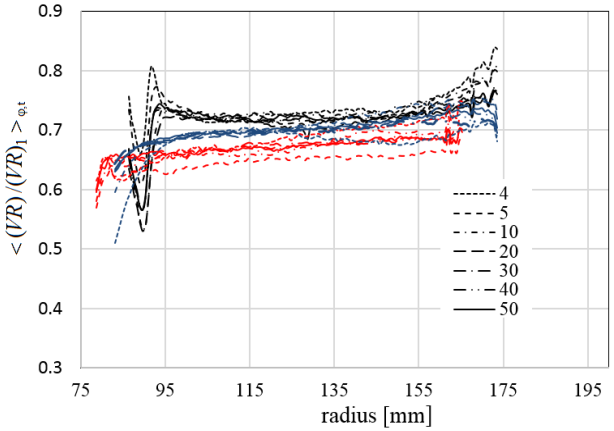
η=0.375, Γ=3.76, weryfikacja

Uśrednione wartości prędkości kątowej DNS/SVV

$$<(V/R)/(V/R)_1>_{A(R),t}$$

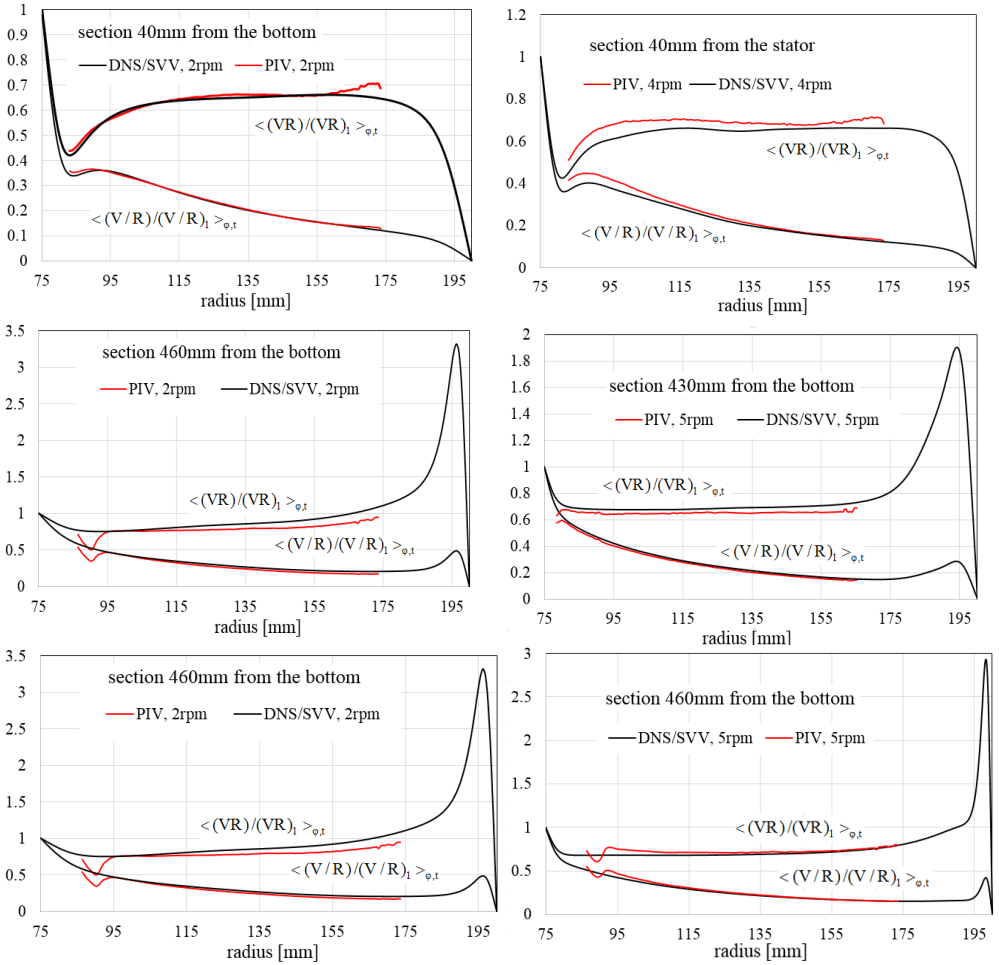






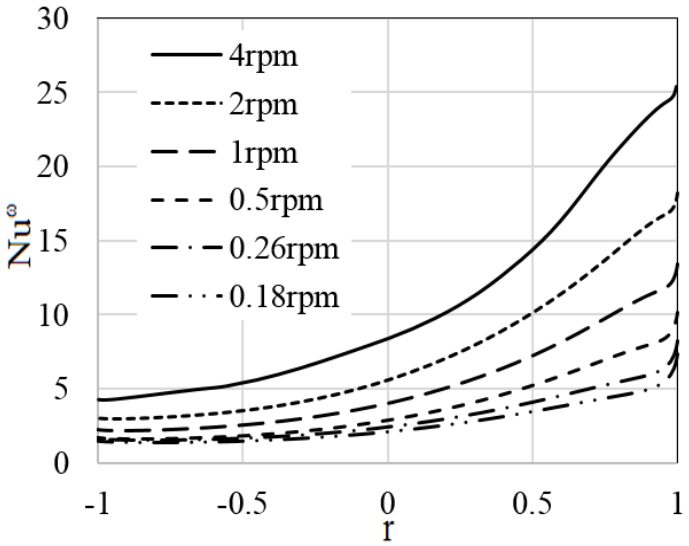
Uśrednione wartości prędkości kątowej i momentu pędu

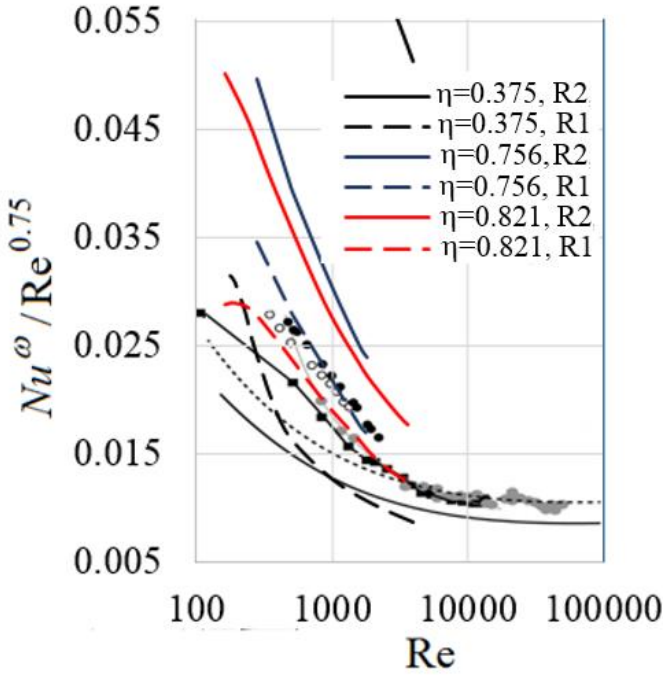
$$<(V/R)/(V/R)_1>_{\varphi,t} \quad <(VR)/(VR)_1>_{\varphi,t}$$

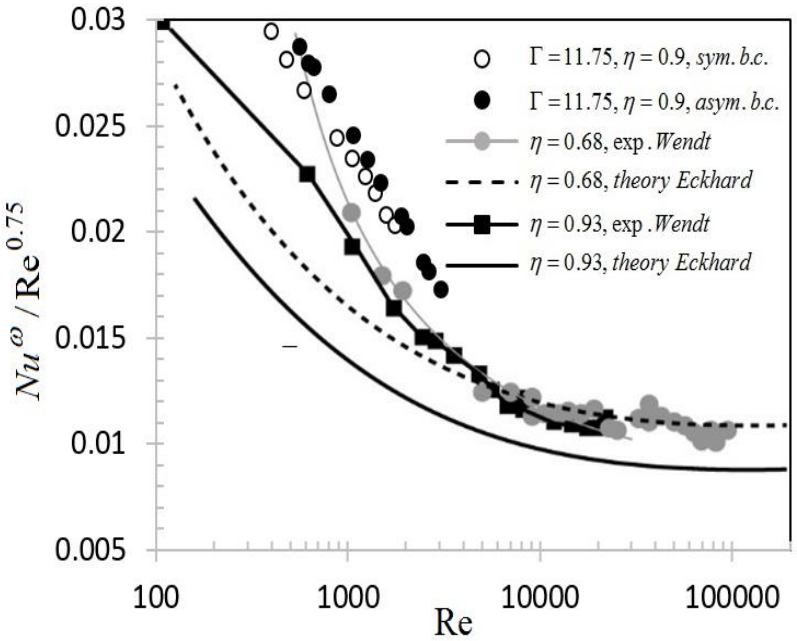


Zmiana Nu ze wzrostem Re

Γ=3.76, η=0.375

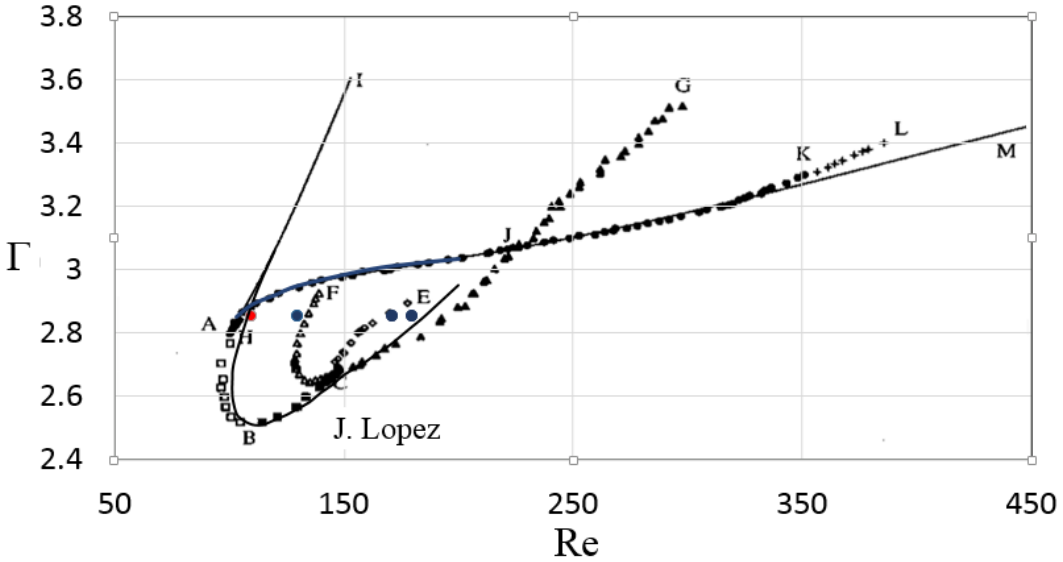






$\eta=0.5$:

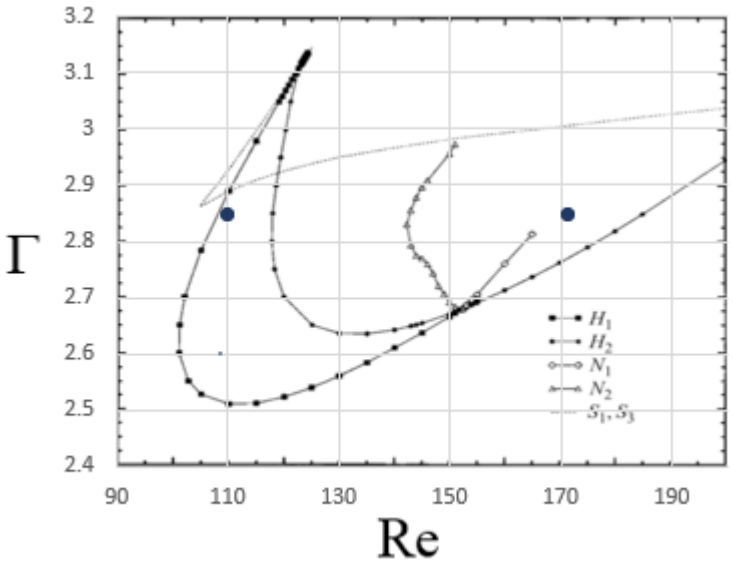
T. Mullin, C. Blohm, *Bifurcation phenomena in a Taylor-Couette flow with asymmetric boundary conditions*, Phys. Fluids, **13**, 136, 2001.



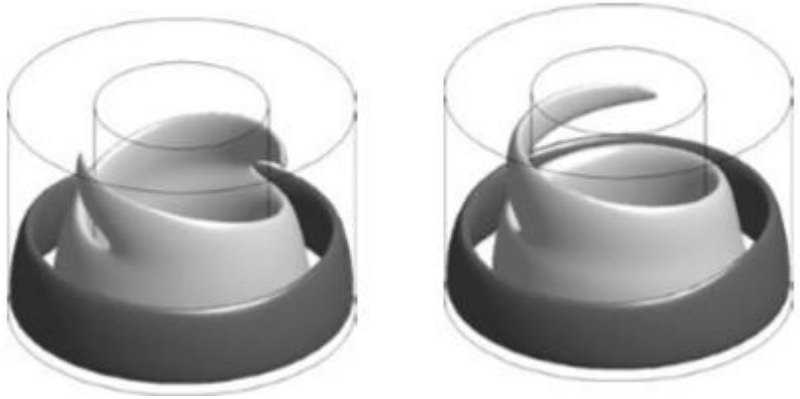
J. Fluid Mech. (2004), *vol.* 501, *pp.* 327–354. © 2004 Cambridge University Press
DOI: 10.1017/S0022112003007493 Printed in the United Kingdom

Complex dynamics in a short annular container with rotating bottom and inner cylinder

By J. M. LOPEZ[1], F. MARQUES[2] AND J. SHEN[3]

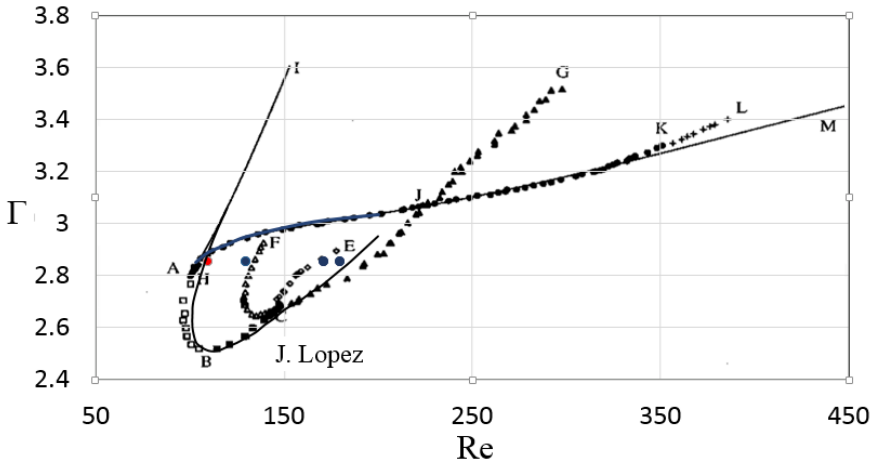


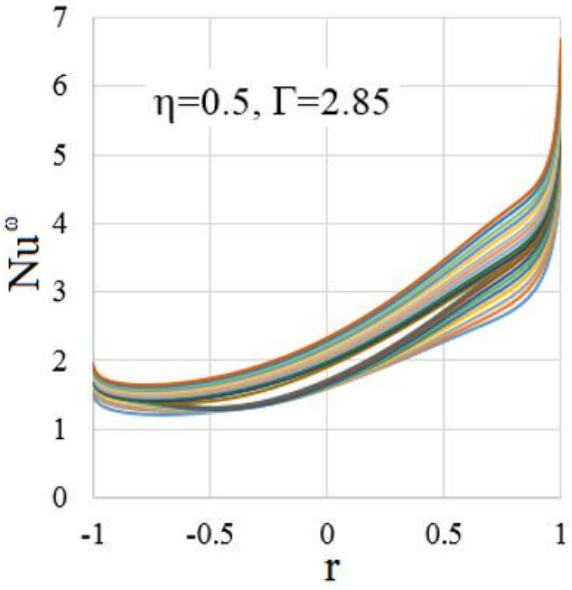
$Re=150,\ \eta=0.5,\ \Gamma=2.7$

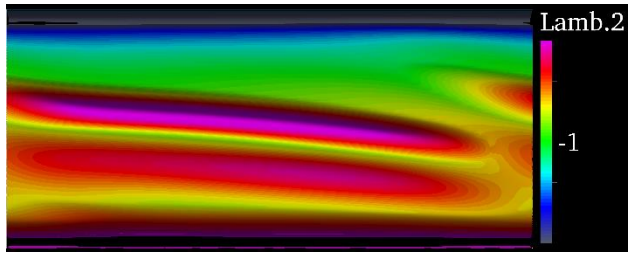


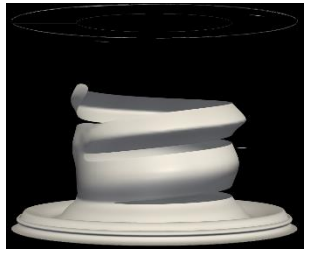
η=0.5 (struktury i profile uśrednionego mementu obrotowego)

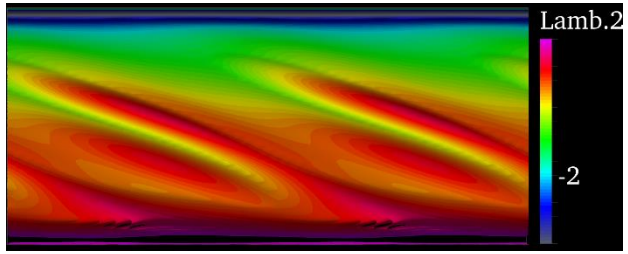
$$Nu^{\omega} = R^{3}[< UV/R >_{A(R),t} - \nu\partial(< V/R >_{A(R),t})/\partial R]/J^{\omega}_{lam}$$

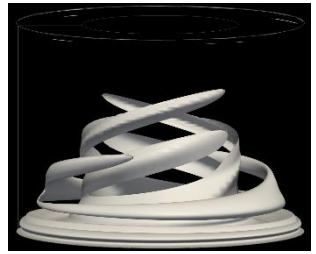


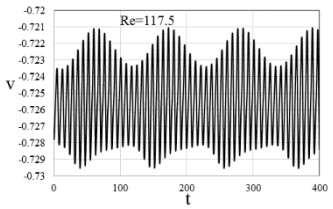


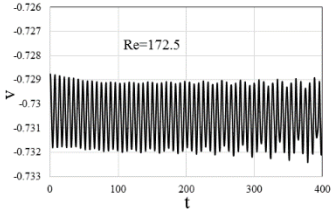


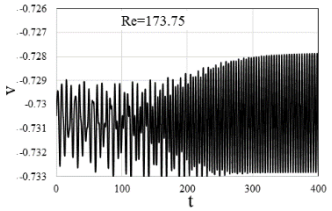


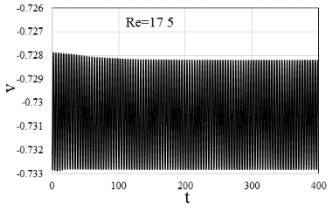


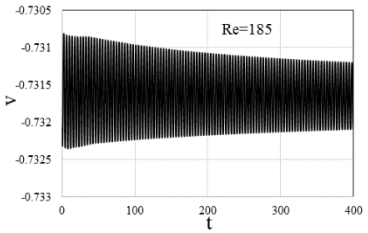




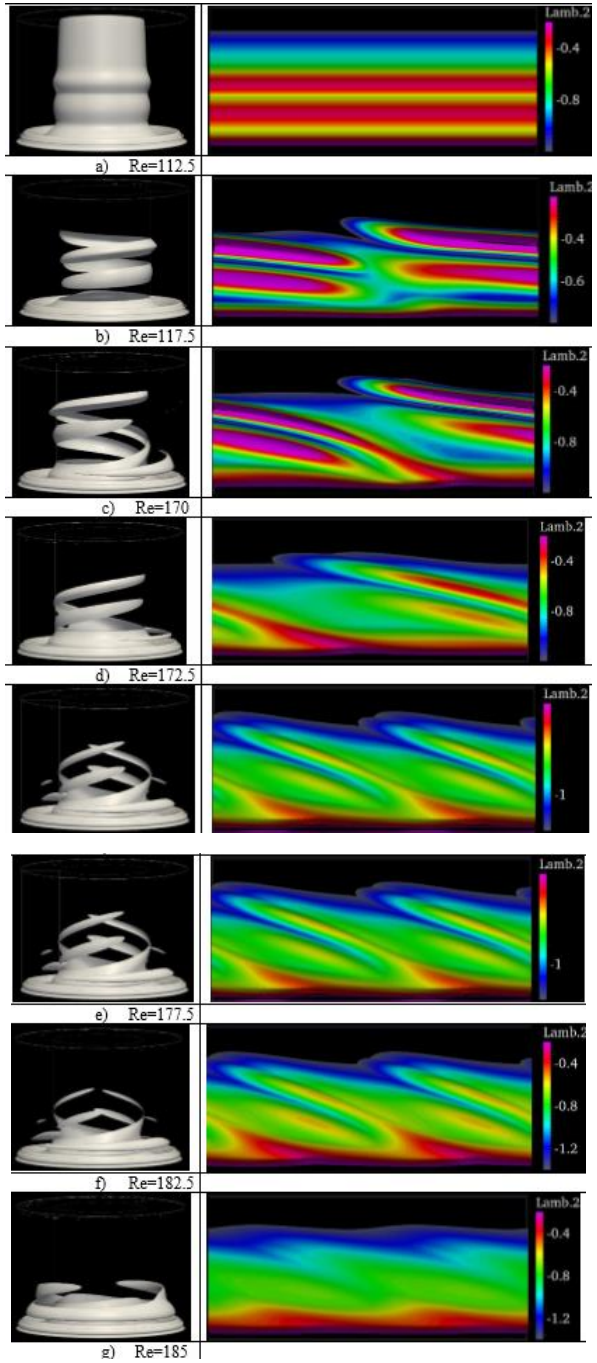






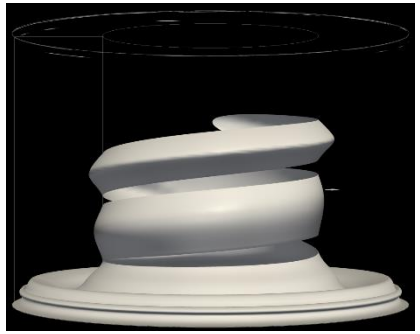


$\eta=0.5,\ \Gamma=2.85$

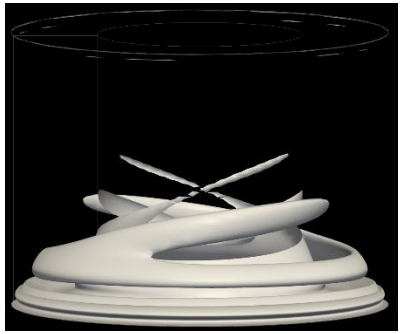


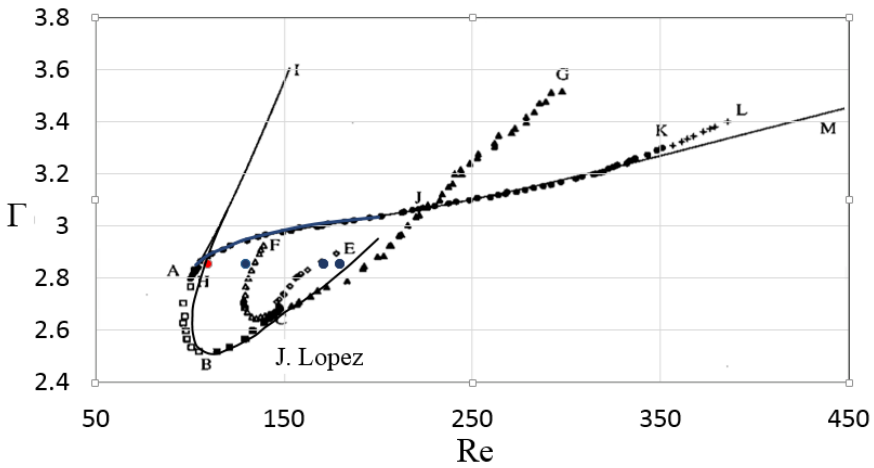
Struktury uzyskane dla:
η=0.5, Γ=2.7

Re=115



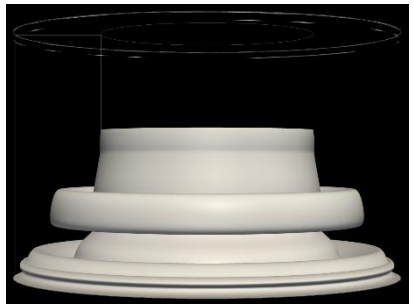
Re=181



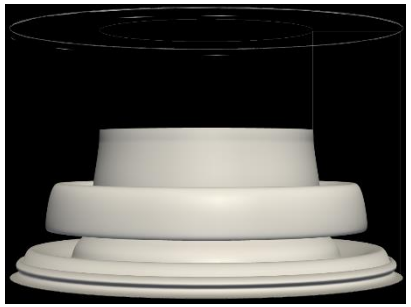


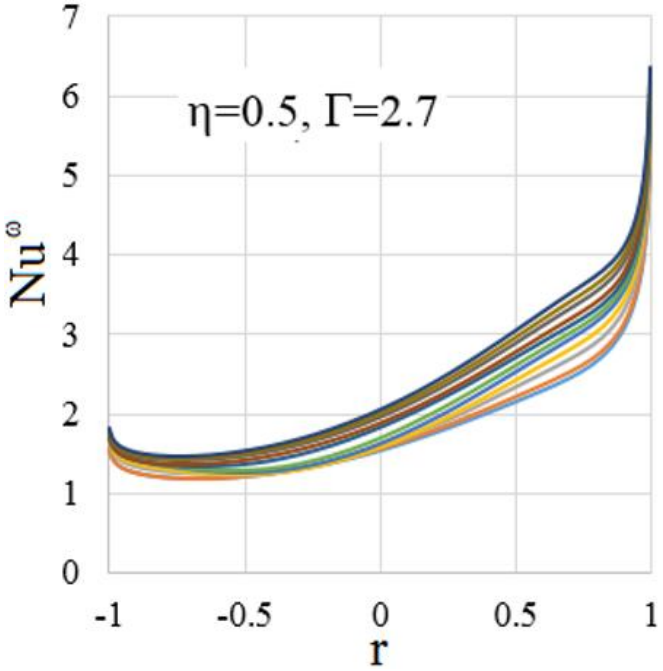
η=0.5, Γ=2.5

Re=115

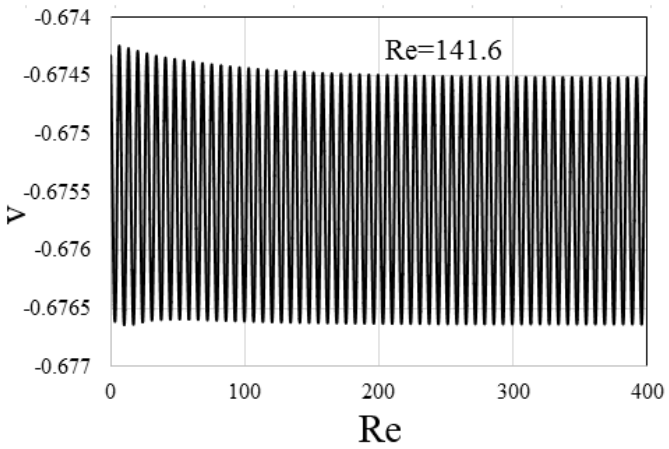


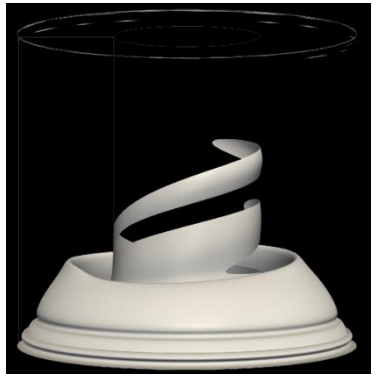
Re=121

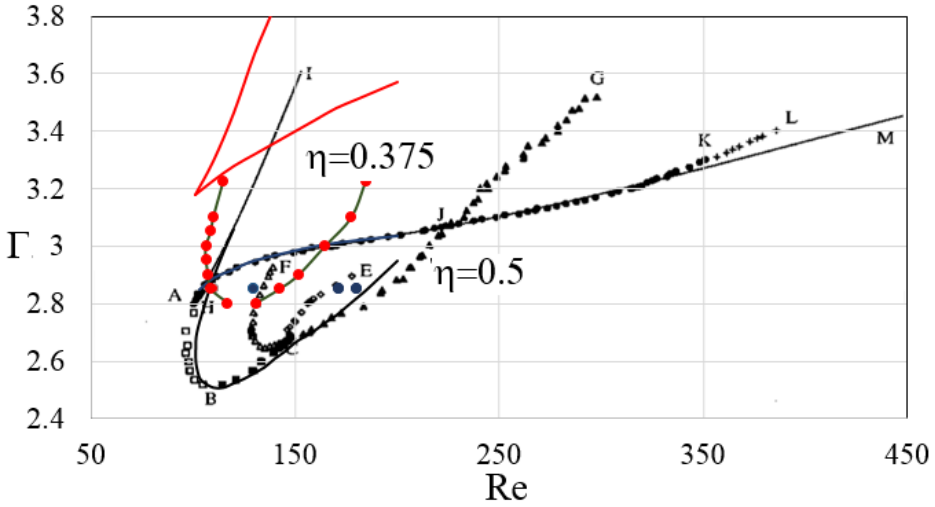




η=0.375

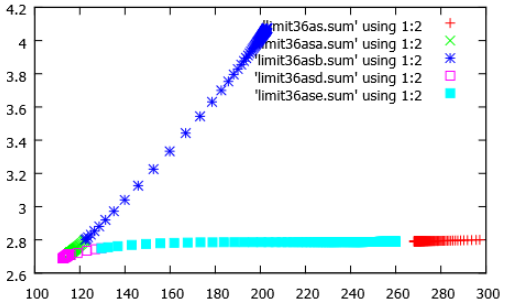


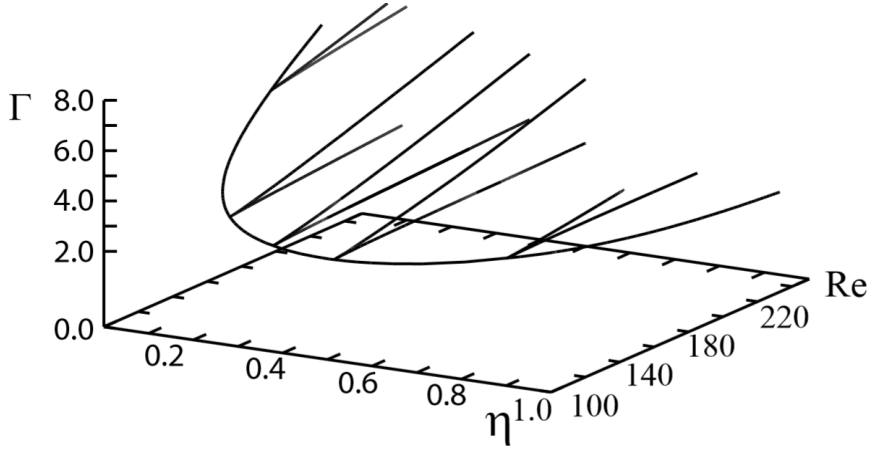




η=0.25 – *przepływ stabilny*

η=0.6?





Podsumowanie

Podziękowanie dla PCSS za umożliwienie prowadzenia obliczeń