Homogenization of the turbulence inside autoclaves by using randomly localized velocity perturbations

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This work analyzes the turbulent features inside the chamber of industrial size autoclaves typically used for thermal treatment of carbon fiber-based materials adopted in the aerospace industry. The state-of-the-art design of these machineries causes a highly anisotropic

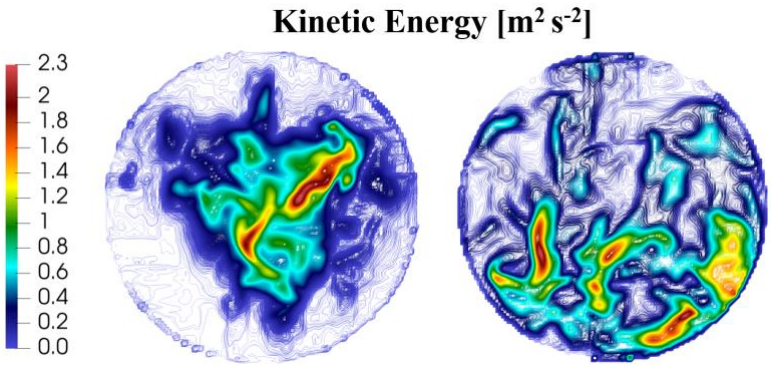

Figure 1: Instantaneous kinetic energy contour plots of a transversal section of the chamber (Diameter = 1.32 m) composed of around 10000 points, without (left) and with (right) three randomly added perturbations of the velocity field.

turbulent flow, which negatively influences the temperature distribution within the chamber, which ultimately leads to a non-optimal treatment of the materials. The aim of this work is, then, the proposal of an innovative design to homogenize the turbulence inside a 16 m^3 industrial size autoclave. The design includes the addition of three contemporary localized velocity perturbations, randomly chosen from a set of six possible sources located at the walls of the chamber. The impact of these sources has been examined by LES simulations conducted on an hexahedral grid composed of 8 10^6 cells; They have been conducted by using the open-source software PLUTO 4.4.2 [1, 2]. The major target variables will be the mapping of the kinetic energy inside the system and the distribution of a tracer within the chamber.

A preliminary example of the positive impact of the perturbations is proposed in Figure 1, where contour plots of the kinetic energy on a transversal section of the autoclave have been proposed after 3.5 s of simulation: the addition of random velocity perturbations already decreases, even if still mildly, the internal anisotropy of the fluctuations of the system and it “spreads” turbulence in sections of the domain otherwise completely stagnant. Future research steps will be a complete control of the homogenization of the flow and temperature characteristics inside the chamber by optimizing the total number of perturbation sources, the fraction of them being randomly activated at the same time and the time interval between different perturbation configurations.

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