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Experimental and numerical study of tornado-like vortex formation

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Swirling [U+FB02]ows of [U+FB02]uids in vortex chambers have been extensively studied because they are widely used in various technical devices [A. K. Gupta, D. G. Lilley, and N. Syred, Swirl Flows (Abacus Press, 1984)]. However, most of these investigations have been devoted to the swirling [U+FB02]ows in steady-state regimes, while basic questions concerning the formation of tornado-like vortices remain unanswered. The determination of the laws of vortex formation is also of considerable practical signi[U+FB01]cance, since swirling [U+FB02]ows can be used, for example, for the rapid removal of atmospheric contaminations. The laws of tornado-like vortex formation in a closed chamber have been experimentally and numerically studied as dependent on the air volume [U+FB02]ow rate and swirl intensity. A physical interpretation of the obtained empirical relationships is proposed. It is established that a flow regime can exist in which the impurity mass transfer along the vortex core is accompanied by mass exchange between the core and surrounding atmosphere. This exchange has the form of spiral formations ejected regularly out of the vortex core. This process takes place under stationary conditions at the chamber input and output, which implies an autooscillatory character of the flow in the system studied. Also it is shown that the time of tornado-like vortex formation weakly depends on the air[U+FB02]ow swirl parameter and approximately inversely proportional to the air[U+FB02]ow rate. In the case when the vertical and horizontal chamber dimensions are close, this time is approximately equal to the characteristic time of air renewal in the chamber. The established laws and numerical models can be used for evaluating the time of formation of the vortex [U+FB02]ows of this type and for the development of theoretical models of the formation of tornado-like vortices.