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## ГІДРОДИНАМІЧНА КАВІТАЦІЯ В МАСООБМІННИХ ПРОЦЕСАХ. АНАЛІЗ ПАРОГАЗОВОЇ ФАЗИ

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## HYDRODYNAMIC CAVITATION IN MASS TRANSFER PROCESSES. ANALYSIS OF THE VAPOUR-GAS PHASE

In pursuing advancing technological processes and crafting efficient devices, considering mass transfer processes, mainly through hydrodynamic cavitation, is crucial for energy and resource conservation [1]. Empirical studies have explored mass transfer during the dissolution of solids under hydrodynamic cavitation, emphasizing its significance [1]. Controlled hydrodynamic cavitation has been assessed for biological hydrogen methanation, demonstrating its potential to enhance gas-liquid mass transfer rates [2]. The exploration of thermal and cavitation effects reveals the potential of cavitation to improve heat and mass transfer processes in multicomponent liquid media [3]. Hydrodynamic cavitation's influence extends to diverse applications, including non-immersed ultraviolet systems for processing liquid food products [4]. Notably, it efficiently amplifies mass transfer from liquid to solid surfaces, positioning it as an energy-efficient technology for food processing and process intensification [5]. The realm of hydrodynamic cavitation significantly impacts both internal and external mass transfer coefficients [6]. Experimental inquiries have scrutinized mass transfer during the dissolution of solids under hydrodynamic cavitation, dissecting the influence of cavitation on diffusion and kinetic-controlled processes [7]. Employing both acoustic and hydrodynamic cavitation, studies have elevated the mass transfer coefficient of ozone, indicating cavitation's capacity to shape mass transfer dynamics across diverse applications [8]. Engineered reactor geometries in controlled hydrodynamic cavitation systems aim to enhance gas-liquid mass transfer rates [5]. These findings accentuate the considerable influence of hydrodynamic cavitation on internal and external mass transfer coefficients, affirming its potential to refine mass transfer processes in various industrial applications [6]. The intricate dynamics of vapor-gas cavitation bubbles play a pivotal role in comprehending the nuanced phenomenon of energy discretization in cavitation. The formation of cavitation bubbles results from abrupt changes in fluid pressure induced by fluctuations or turbulence within the medium. When a localized drop in pressure is triggered by sudden accelerations or changes in direction, vapor bubbles emerge. These bubbles originate from minute vapor pockets within the dissolved liquid, manifesting at low-pressure levels. During dynamic pressure changes, these microscopic bubbles undergo expansion, transforming into gas and steam bubbles. The subsequent phase involves the implosion or oscillation of these bubbles with considerable energy, releasing substantial energy into the surrounding liquid. This intricate process generates high-frequency sounds and vibrations and induces discrete changes in energy distribution within the medium. This specific characteristic of vapor-gas cavitation bubble dynamics delineates a distinctive mechanism of energy discretization during cavitation.

The reverberations from this phenomenon have far-reaching implications, as they can be harnessed to optimize and enhance the efficiency of various technological processes. By understanding and manipulating the dynamics of vapor-gas cavitation bubbles, industries can unlock novel avenues for improving energy transfer, enhancing fluid dynamics, and refining the overall performance of diverse systems. This knowledge is a valuable tool for engineers and researchers seeking to harness the power of cavitation in a controlled and beneficial manner, thereby opening up possibilities for innovation across a spectrum of applications, from propulsion systems to industrial processes. The investigation delved into unraveling the intricate dance of cavitation bubbles within a static-type device featuring a tangential liquid supply [9]. The generation of bubbles through hydrodynamic cavitation was meticulously monitored using a high-speed camera capturing 125 frames per second, paired with a high-magnification lens. A strategic play of light sources behind the camera ensured optimal illumination for crisp imaging, while MATLAB's image analysis software sifted through 524 frames to detect and measure bubble sizes. Figure 1 offers a visual feast, showcasing the calculated bubble size distribution. In this visual exploration, we traced the cavitation zone's initiation and evolution, culminating in the mesmerizing moment of hydro-luminescence. At flow rates surpassing 35 m/s, cavitation materialized vividly—a choreography of a well-formed plume and the emergence of ethereal light. Beyond the cavitation bubbles, our observations extended to light phenomena within the narrow channel. A unfolded at a pressure drop of 1.9 MPa, revealing sparks along the downstream channel's central part. This investigation experimentally determined the vapor-gas phase—volume characteristics and average dimensions. The nuances of their evolution, tethered to the cavitation dynamics of the flow, were distilled into mathematical expressions, embodying the rhythmic heartbeat of this captivating, fluidic exploration.

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