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Modeling of cavitation peening: jet, bubble growth and collapse, micro-jet and residual stresses

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Abstract

Surface treatment methods like shot peening are used to introduce compressive residual stresses in metals and alloys. The presence of compressive stresses prevent the initiation and growth of cracks and hence improve the fatigue life of mechanical parts. Cavitation peening is a similar surface treatment process which acts by the generation of cavitating bubbles in front of the workpiece surface. The modeling of this process is challenging because of the complexity of cavitation phenomenon. The main difficulty is the prediction of the mechanical loading at the surface of the material. One of the key process parameters is the pressure within the reservoir where cavitation is generated. A strategy based on the modeling of a single cavitating bubble is proposed. Spherical and aspherical collapse of bubbles close to a solid surface are studied first analytically and then numerically. These two sources of mechanical loading are compared and it is shown that the pressure pulse impact due to the collapse of a spherical bubble near a wall is much greater than the one resulting from a micro-jet impact. A comparison with experimental data is made and it is found that the magnitude of the residual stresses within the treated material produced by the collapse of a single bubble matches. However the impact of one pressure wave is not sufficient to represent the entire process because of the low compressive depth generated. Finally, a macroscopic cavitation model has been derived by

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