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Influence of divergent length on the gas-particle flow in dual hose dry ice blasting nozzle geometry

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ABSTRACT

A numerical simulation study was performed to examine the effect of nozzle geometry and divergent length on gas-particle flows in dual hose dry ice blasting. The simultaneous model of mass momentum and energy exchange between two phases was solved iteratively. The phases are solid dry ice particle and compressible air fluid as a working medium. The results were presented in the gas flow field along the nozzle centerline. The results showed that increasing divergent length decreases the gas-particle density along the centerline; and the density development along the nozzle centerline decreased along the length. Eddy viscosity of the nozzle cavity was steady for length of 0.25 m, but increased drastically for higher values. The substantial increase in eddy viscosity after that position is due to the mixing flow between dry ice pellet and compressed gas which is diverging out from the nozzle outlet area. Thus, the mixing flow experienced back pressure from the atmospheric pressure. The particle mass concentration decreased by increasing nozzle centerline coordinates. The pressure increased along the length; however, it dropped at the end due to the reverse pressure. The temperature increased steadily because of conversion of turbulence to internal thermal energy. The characteristics of gas-particle flow in the nozzle cavity provide better understanding of multiphase flow in turbine and jet engine flow analysis.

1. Introduction

Dry ice blasting does little harm to the environment. It is a form of carbon dioxide (CO_2) cleaning process in which dry iceor the solid form of CO_2 is accelerated in a pressurized air stream and directed toward contaminated surfaces. The cleaning process using dry ice blasting can be categorized into three active mechanisms which are thermal, mechanical and sublimation effect (Fig. 1).

Mechanisms of surface removal are described as follows:

- The thermal effect happens due to difference in the thermal coefficient between surface contaminant and substrate, which causes brittle detachment of the contaminant.
- Mechanical effects are derived from the kinetic energy of the blasting, which is capable of achieving supersonic speed upon the surface impact.
- The sublimation effect occurs due to the ability of CO_2 to change from solid to a gaseous phase, resulting in 800 times volume increase [1]

In terms of primary advantages, dry ice blasting is a relatively low-abrasion blasting. In addition, it is environmentally friendly because the blast media immediately disappears upon impact and returns to its natural state in the atmosphere. Therefore, it produces little waste other than the contaminant being removed. In addition, the carbon dioxide released from the dry ice blasting process is not a new carbon dioxide. Thus, it does not increase CO_2 concentration in the atmosphere.

Nozzle geometry plays an important role in optimizing the cleaning performance of surface treatment [2,3]. The optimum

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