Enhancement of Dry Media Depaint Process – Development of the Infinity Nozzle

Background:

The depainting or paint stripping of aircraft using plastic media blasting (PMB) is a technology the Air Force has used for many years. In this process, a dry plastic abrasive media is accelerated through a nozzle driven by the differential pressure between a high-pressure reservoir (or compressor station) and atmospheric pressure. Typically, the differential pressure is approximately 0.24 MPa (or 35 psig). The air speed exiting the nozzle achieves a velocity of approximately Mach 2 (or 600 m/s), and particle velocities range from 360 m/s to 260 m/s for particle diameters of 200 micron to 800 micron. The fact that the particle velocities are as much as 50% less then the air velocity is indicative of the inefficiency of these nozzles to fully accelerate a particle. The reduced particle velocities then translate into reduced paint stripping rates, and larger mass flux of dry media per unit area of painted surface.

To support the development of more efficient nozzles for acceleration of the plastic particles, the CTIO initiated a project to develop new nozzle design concepts. In this effort, computational and experimental tasks were performed. The computational tasks simulated the flow of particles and air from the nozzle inlet, through the nozzle interior, and to particle impact on a surface placed 30 to 60 cm from the nozzle exit. A Computational Fluid Dynamics (CFD) code was used in which the airflow and Lagrangian particles were resolved. To complement the simulations, an experimental study was performed. In this task, Laser Doppler methods were used to measure air and particle velocities, and particle distributions in the jet flow field. In addition, baseline testing of the performance of a typical circular nozzle and the candidate nozzle developed here was completed and depaint rates were determined

Project Sponsor/Customer: Air Force ALCs
Period of Performance: Sep 96 – May 99

Objective:

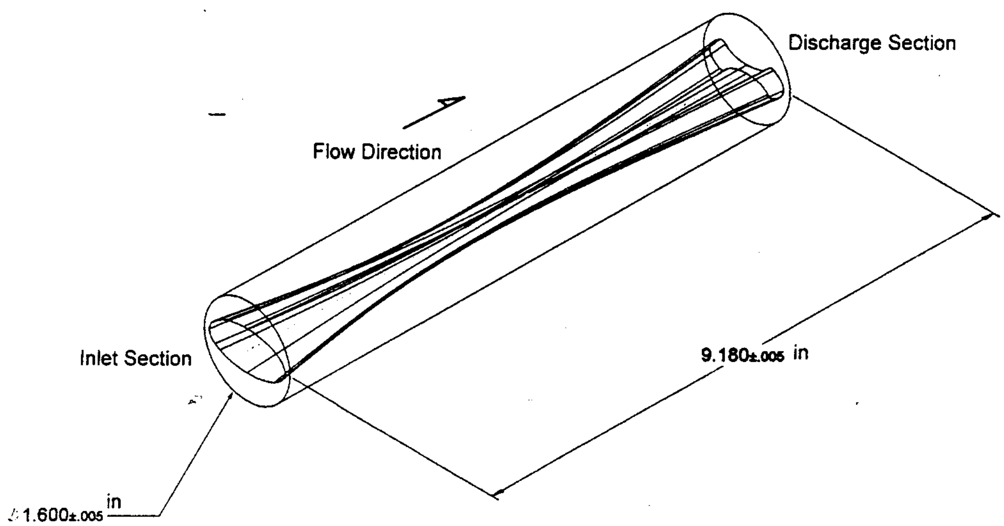
The objective of this development program was to develop a nozzle which could demonstrate a 25% improvement in depaint rates, for the same operating conditions used with circular nozzles.

Status:

The complementary nature of computational simulations and experiments was essential to the successful completion of this program, since neither technique alone can provide a complete picture of the details of the flow field. For example, the opaque nature of the dry spray makes it difficult to obtain accurate velocity measurements near the core of the flow, but computational simulations can provide data for this region. However, the experiments are required to provide a validation point to insure that sufficient grid resolution and appropriate models are being used to obtain accurate simulation results.

Through the use of simulation and experimentation, a new candidate nozzle for enhanced dry media paint stripping was developed. The majority of nozzles used in paint stripping are classic Laval nozzles (e.g., convergent/divergent nozzles) with circular cross-sections. They produce a circular footprint, and create a Gaussian distribution of particles in the flow stream. This focused distribution of particles results in a significant number of the particles not contributing to the depaint process, since they are likely impacting a surface region already impacted by previous particles. The apparent limitations of circular nozzles are: (1) small depaint footprint, (2) inefficient acceleration of particles, (3) an inefficient distribution of particle momentum across the depaint footprint, and (4) insensitivity to process parameters such as pressure and mass flow rate of media. To overcome these limitations a new type of nozzle was developed and designed using computational fluid dynamics tools and verified through a prototype study. This new nozzle is called the "***Infinity Nozzle,***" and based on experimental verification, generates a depaint or strip rate which is approximately *two times greater* than that of a traditional circular nozzle operating at the same process conditions (e.g., pressure, stand-off, and angle).

The Infinity Nozzle uses elliptic shapes to create a complex flow channel resulting in a gas and particle jet with a semi-rectangular distribution. Based on baseline experiments, the Infinity Nozzle has demonstrated an 80% improvement in depaint rates. An invention disclosure for the Infinity Nozzle has been prepared and submitted for filing a patent on this technology.



Final Report: Titled: “Enhancement of Dry Media Depaint Process: Development of the Infinity Nozzle”
Dated: May 99
Author: Dr. Christopher J. Freitas
As of Date: Apr 01