Green Solvents for Precision Cleaning

Heather Grandelli, Phillip Maloney, Robert DeVor, Jan Surma and Paul Hintze

NASA Kennedy Space Center, FL, USA

Introduction

Aerospace machinery used in liquid oxygen (LOX) fuel systems must be precision cleaned to achieve a very low level of non-volatile residue (< 1 mg/0.1 m²) to prevent explosive oxidation of contaminants. Currently Vertrel-MCA, a blend of decafluoropentane and trans-dichloroethylene, is used in the precision cleaning process at the Kennedy Space Center. Fluorinated compounds are persistent in the environment and according to the manufacturer’s MSDS, Vertel-MCA can decompose to hydrofluoric and hydrochloric acids at high temperatures. This has now led to the development of new processes in the precision cleaning of aerospace components.

Approach

Highlighted is a cleaning process which employs supercritical CO₂ to dissolve and remove the contaminant from metal parts. A fluorinated aerospace grease, Krytox 240AC, was investigated as a model fluorinated contaminant and aluminum coupons were used as model aerospace components in preliminary investigations. A stirred-batch process [Fig. 1] was employed in which the effects of cleaning temperature, pressure, exposure time and stir rate were examined and optimized using the Taguchi method [Table 1].

Results

The Taguchi method results showed that the parameter effecting the cleaning efficiency the greatest is pressure, followed by temperature, exposure time and then impeller speed. The results were further analyzed using the Pearson product moment correlation, which showed that lower temperatures, higher pressures and shorter exposure times all resulted in improved contaminant removal. This is illustrated in the contour plots in Figure 2. Figure 3 shows the dependence of the cleaning efficiency on the CO₂ density, which was acquired from the P / T information.

Conclusions

Temperature and pressure were found to have the most significant impact on the cleaning efficiency. This preliminary work has provided a foundation for ongoing studies of cleaning using supercritical CO₂. Ongoing studies focus on the use of the CO₂ recycling module, inline detection of contaminant concentration and the use of co-solvent to further improve cleaning efficiency, if needed.