Books & Reports

Simulations of Evaporating Multicomponent Fuel Drops

A paper presents additional information on the subject matter of "Model of Mixing Layer With Multicomponent Evaporating Drops" (NPO-30505), *NASA Tech Briefs*, Vol. 28, No. 3 (March 2004), page 55. To recapitulate: A mathematical model of a three-dimensional mixing layer laden with evaporating fuel drops composed of many chemical species has been derived. The model is used to perform direct numerical simulations in continuing studies directed toward understanding the behaviors of sprays of liquid petroleum fuels in furnaces, industrial combustors, and engines. The model includes governing equations formulated in an Eulerian and a Lagrangian reference frame for the gas and drops, respectively, and incorporates a concept of continuous thermodynamics, according to which the chemical composition of a fuel is described by use of a distribution function. In this investigation, the distribution function depends solely on the species molar weight. The present paper reiterates the description of the model and discusses further in-depth analysis of the previous results as well as results of additional numerical simulations assessing the effect of the mass loading. The paper reiterates the conclusions reported in the cited previous article, and states some new conclusions. Some new conclusions are:

1. The slower evaporation and the evaporation/condensation process for multicomponent-fuel drops resulted in a reduced drop-size polydispersity compared to their single-component counterpart.
2. The inhomogeneity in the spatial distribution of the species in the layer increases with the initial mass loading.
3. As evaporation becomes faster, the assumed invariant form of the molecular-weight distribution during evaporation becomes inaccurate.

This work was done by Josette Bellan and Patrick Le Clercq of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30641

Formation Flying of Tethered and Nontethered Spacecraft

A paper discusses the effect of the dynamic interaction taking place within a formation composed of a rigid and a deformable vehicle, and presents the concept of two or more tethered spacecraft flying in formation with one or more separated free-flying spacecraft. Although progress toward formation flight of nontethered spacecraft has already been achieved, the document cites potential advantages of tethering, including less consumption of fuel to maintain formation, very high dynamic stability of a rotating tethered formation, and intrinsically passive gravity-gradient stabilization. The document presents a theoretical analysis of the dynamics of a system comprising one free-flying spacecraft and two tethered spacecraft in orbit, as a prototype of more complex systems. The spacecraft are modeled as rigid bodies and the tether as a mass-less spring with structural viscous damping. Included in the analysis is a study of the feasibility of a centralized control system for maintaining a required formation in low Earth orbit. A numerical simulation of a retargeting maneuver is reported to show that even if the additional internal dynamics of the system caused by flexibility is considered, high pointing precision can be achieved if a fictitious rigid frame is used to track the tethered system, and it should be possible to position the spacecraft with centimeter accuracy and to orient the formation within arc seconds of the desired direction also in the presence of low Earth orbit environmental perturbations. The results of the study demonstrate that the concept is feasible in Earth orbit and point the way to further study of these hybrid tethered and free-flying systems for related applications in orbit around other Solar System bodies.

This work was done by Marco B. Quadrelli of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30730

Two Methods for Efficient Solution of the Hitting-Set Problem

A paper addresses much of the same subject matter as that of "Fast Algorithms for Model-Based Diagnosis" (NPO-30582), which appears elsewhere in this issue of *NASA Tech Briefs*. However, in the paper, the emphasis is more on the hitting-set problem (also known as the transversal problem), which is well known among experts in combinatorics. The authors' primary interest in the hitting-set problem lies in its connection to the diagnosis problem: it is a theorem of model-based diagnosis that in the set-theory representation of the components of a system, the minimal diagnoses of a system are the minimal hitting sets of the system. In the paper, the hitting-set problem (and, hence, the diagnosis problem) is translated from a combinatorial to a computational problem by mapping it onto the Boolean satisfiability and integer-programming problems. The paper goes on to describe developments nearly identical to those summarized in the cited companion *NASA Tech Briefs* article, including the utilization of Boolean-satisfiability and integer-programming techniques to reduce the computation time and/or memory needed to solve the hitting-set problem.

This work was done by Farrokh Vatan and Amir Fijany of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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Refer to NPO-30584, volume and number of this NASA Tech Briefs *issue, and the page number.*