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BRIEF COMMUNICATION

EFFECT OF VISCOSITY ON DROP BREAKUP†

R. D. COHEN

Department of Mechanical Engineering and Materials Science, Rice University,
 Houston, TX 77251, U.S.A.

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1. INTRODUCTION

The subject of breakup of liquid drops has important implications in a variety of fields, namely, but not specifically, meteorology, aerosol and hydrosol science, and emulsification processes. As a result, an extensive literature, covering a wide spectrum of related theoretical and experimental works, has been generated over the years (Clift *et al.* 1978; Pilch & Erdman 1987; Hsiang & Faeth 1992 and references therein). A major goal of many of these studies has been to provide information on and explanations of how the external flow conditions affect the critical Weber number, We_{cr} , a quantity representing the minimum force or energy required to cause primary breakup of the liquid drop.

Numerous experimental investigations have dealt with the breakup of liquid drops in gases due to shocks. Here, in general, the Weber number, We , is defined as

$$We \equiv \frac{\rho_G U^2 d_0}{\sigma} \quad [1]$$

where ρ_G is the gas density, σ is the interfacial tension and U and d_0 are the initial relative gas velocity and drop diameter, respectively. An important finding in many of these works has been the existence of several regimes or modes of drop disintegration. These regimes, which are termed "bag", "multimode" and "shear", have been observed to occur at different levels of We . For a comprehensive description and analysis of these regimes, the reader is referred to Hsiang & Faeth (1992).

Of further interest to these studies has been the effect of drop viscosity on the breakup Weber number, We_{br} , for the different modes. All works dealing with this effect concluded that an increase in the drop viscosity leads to a rise in We_{br} ; the reason being that an additional amount of energy is needed to overcome the internal viscous dissipation, induced by drop deformation and mixing within the liquid phase.

To theoretically predict We_{br} in the presence of liquid-phase viscosity, the conventional approaches have, in one way or another, implemented the momentum equations (Kitscha & Kocamustafaogullari 1989; Tarnogrodzki 1993). The intention here, however, is different in that we focus on using energy-related arguments to provide a semi-empirical correlation relating We_{br} with viscosity and other properties. As we shall demonstrate, the resulting correlation could be applicable to a wide range of We , corresponding to the various modes of drop breakup by shocks.

2. PROBLEM FORMULATION

Following an energy approach similar to one taken earlier (Cohen 1991), we assume that the energy, E_{Tbr} , needed to break a viscous drop having an initial diameter d_0 equals the breakup energy

†This work was performed while the author was on leave at the Department of Chemical Engineering, Yale University, New Haven, CT, U.S.A.