DEVELOPMENT OF THE MANUFACTURING CAPABILITIES OF THE HYDROSTATIC EXTRUSION PROCESS

by

R. J. Fiorentino, J. C. Gerdeen, W. R. Hansen,
A. M. Sabroff, and F. W. Boulger

HYDROSTATIC EXTRUSION STUDIES

INTRODUCTION

The purpose of the present research program is to develop the manufacturing capabilities of the hydrostatic extrusion process with the aim of extruding high-quality shapes from materials of interest to the Air Force. It is a continuation of the recently completed program on Contract No. AF 33(600)-43328. The current program is divided into two phases with the following general objectives:

Phase I. Process-Development Studies

Part 1. (a) To study the effect of critical process variables on pressure requirements and surface quality in hydrostatic extrusion of AISI 4340 steel, Ti-6Al-4V titanium alloy, and 7075 aluminum alloy.

(b) To correlate all available hydrostatic-extrusion-pressure data with material properties wherever possible in order to assist direction of the experimental effort and maximize the information developed in the present program.

Part 2. To explore the hydrostatic extrudability of TZM molybdenum alloy (cast and wrought), beryllium, Cb-752 columbium alloy, powder compacts, and other materials to be selected later in the program.

Part 3. To conduct a design study for high-temperature, high-pressure hydrostatic extrusion tooling based on
(1) estimated pressure requirements for high-ratio extrusion of materials of interest to the Air Force,
(2) latest high-pressure-vessel technology, and
(3) latest tooling materials available.

Part 4. To conduct a process economic study on the construction, installation, and operation of equipment with the same operational and size requirements as the tooling developed in the previous program on Contract No. AF 33(600)-43328.

Phase II. Process-Application Studies

Part 1. To evaluate the application of the hydrostatic extrusion process for sizing and finishing conventionally hot-extruded (or rolled) structural shapes by various combinations of drawing and extruding. Primary emphasis will be on AISI 4340 steel, although some effort will be devoted to Ti-6Al-4V, 7075 aluminum, and selected refractory metals.

Part 2. To determine the feasibility of producing wire and filaments from TZM molybdenum alloy and beryllium by combinations of hydrostatic extrusion and drawing.

Part 3. To develop tooling and define process parameters necessary for the reduction of tube blanks to finish tubing from AISI 4340 and a selected columbium alloy.

Experimental trials to study the critical variables (Part I of Phase I) of the hydrostatic extrusion process were resumed during this quarterly period. In addition, initial experimental trials to fabricate tubing (Part 3 of Phase II) were conducted. A total of 87 extrusion trials were made, including extrusion of AISI 4340, Ti-6Al-4V, and 7075 Al into rounds, and extrusion of AISI 4340 and 7075 Al into T-sections and tubing. Important variables investigated included lubrication, stem speed, extrusion ratio, die design, and billet surface finish. Most of the conclusions drawn thus far must be considered tentative, however, until necessary quantitative evaluation of the physical, mechanical, and metallurgical properties of the extrusions is completed.

In addition to this experimental work, the complete results of the analytical study made on several container design concepts for high pressure are included in this report.

EQUIPMENT AND EXPERIMENTAL PROCEDURE

The hydrostatical extrusion tooling being used in the present program is that developed and fabricated in a previous Air Force program(1). The general details of this tooling design are shown in a cross sectional view in Figure 1. Because a low-cycle-fatigue liner failure had been experienced after about 370 pressure cycles, the container design was revised such that the liner was replaced by two cylindrical rings which occupy the same volume as the liner. Details of the stress analysis for the design revision are contained in Interim Report No. 2(2). The tooling is designed for use at fluid pressures up to 250,000 psi at room temperature and up to about 220,000 psi at 500 F. Specific details of the tooling and experimental procedure are given in Reference (1) and Interim Report No. 1(3).

A list of billet lubricants evaluated during the present report period is given in Table 1.