A GAS-DYNAMIC TEST STAND FOR THE INVESTIGATION
OF NOZZLES USED IN THE ATOMIZATION OF MOLTEN METALS
PART I

Yu A. Lastivnyak and O. S. Nichiporenko

In the manufacture of metal powders by the method of atomization of melts with a gas stream, the key factors determining the resultant powder particle size are the gas-dynamic parameters of the atomizing nozzle [1, 2]. Among these, the most important are the pressure, velocity, and direction of flow of the atomizing gas. Some theoretical and experimental data have already been published in the literature making it possible quite accurately to predict the particle size of atomized powder as a function of blast parameters, which in turn are determined by the nozzle design [3, 4].

In order to establish unique relationships between these blast parameters and the design of an atomizing unit, it is first of all necessary to study the gas-dynamic characteristics of the nozzle, namely, the blast pressure, velocity, and direction.

To facilitate comprehensive studies of this nature, the authors have designed and constructed a gas-dynamic test stand (Fig. 1) in which gas stream parameters are measured by a shadow technique. Since at present increasing use is being made of nozzles from which the atomizing gas emerges at supersonic velocities [5, 6], the test stand is provided with equipment enabling tests to be carried out in both the sub- and supersonic velocity ranges.

The gas-dynamic test stand comprises two basic systems, gas-dynamic and optical. The gas-dynamic system enables the conditions of operation of atomizing nozzles to be varied and control to be exercised over their parameters - the rate of flow, temperature, direction, and static and dynamic pressure components of the emerging gas. The optical system serves to make a supersonic gas stream visible during the measurement of its parameters and also ensures reproducibility of conditions in the testing of nozzles of different designs.

The gas-dynamic system of the stand, which is designed specifically for the use of compressed air as the working fluid, consists of the compressor 1 (Fig. 2), the receiver 2, the filter 3, the moisture separator 4, the reducing valve 5, and the throttle valve 6, with the aid of which compressed air is fed into the nozzle chamber 7.

The rate of flow of air is measured by the Venturi tube 8 and the differential manometer 9. The manometer 10 measures the pressure, while the thermocouple 11 and the potentiometer 12 measure the temperature of the air entering the nozzle. The air gauges 13, the manometer 14, and the differential manometer 15 enable the parameters of the air issuing from the nozzle to be measured.

The optical shadow system (Fig. 3) comprises an illuminator (consisting of the light source 1—a 400-W movie projector bulb, the condenser 2, and the objective 3), the lens 4 transforming a divergent light beam into a parallel one, the lens 5 producing the opposite effect, the Foucault knife 6, and the screen 7, on which is projected an image.
Fig. 2. Gas-dynamic system of stand. For description see text.

Fig. 3. Optical shadow system of stand. For description see text.

Fig. 4. Air gauges for measuring nozzle blast parameters: A) angle-measuring gauge; B) receiver of static pressure; C) receiver of full drag pressure.

As a result of successive measurements of the direction of the velocity vector, static pressure, and full drag pressure of an air stream at a chosen point in the atomization zone, it is possible to determine the dimensionless velocity \( M \) at this point, using Rayleigh's formula [7]:

\[
\frac{P_1}{P_{02}} = 2 \left( \frac{4k \cdot M_1^2 - 2(k - 1) \frac{1}{k-1}}{(k + 1) \frac{1}{k-1} \cdot M_1^{k-1}} \right)
\]

where \( k \) is the adiabatic expansion index (for air, \( k = 1.4 \)) and \( M_1 = v_1/a_1 \) (\( a_1 \) being the velocity of sound at that point and \( v_1 \) the stream velocity to be determined).

In our tests on nozzles we began our measurements of the air stream parameters at a given point by determining the direction of the velocity vector, so as to be able to place air gauges B and C precisely along stream lines during the subsequent static pressure and full drag pressure measurements. Full and static pressures measured one after the other under the same conditions of operation of a nozzle make it possible to determine the dynamic pressure component and, consequently, the air stream velocity at the point chosen.