Alloy steel and alloy powders are finding increasing application for the production of high-speed and die steels, elements of filtration units, and welding wires, for the deposition of wear- and corrosion-resisting coatings, as additions to welding electrode coatings and sintered brazing materials, etc. The quality of a metal powder depends on its particle size distribution and the shape and surface structure of its particles as well as on its chemical composition. These properties determine the flowability, apparent density, specific surface, and other characteristics of a powder.

One of the basic factors involved in the choice of method of manufacture of a metal powder is its maximum permissible oxygen content. While the requirements of GOST 9849-74 for PZh3, PZh4, and PZh5 iron powders* can be satisfied by atomizing molten metal with water or even air, higher grades of iron powder and high-quality alloy powders can be produced only in a nonoxidizing atmosphere. Oxidation of particles may be prevented by generating in the powder atomization and cooling zones a protective atmosphere consisting of a neutral gas which also acts as the energy carrier. In this article descriptions are given of atomization plants enabling metal powders to be produced with oxygen contents of 0.01-0.02%.

Experiments on the atomization of R6M5K5 high-speed steel† in a hermetic installation have shown that the oxygen content of the resultant powder is directly related to the oxygen content of the energy carrier. A powder with 0.01% oxygen can be produced using an energy carrier containing not more than 0.005% oxygen. These requirements are fulfilled by Grade A argon gas to GOST 10157-62 and chemically pure nitrogen gas to MRTU 6-02-375-66. Argon is used in the manufacture of powders in which the presence of nitrides is undesirable. In all other cases nitrogen is preferred not only because it is cheaper but also because it improves the quality of steels by reducing the extent of gas void formation in powder particles.

In [1] it is shown that, with a correctly designed nozzle unit, the particle size distribution of a powder is determined by the specific consumption of the energy carrier, which may vary from 0.3 to 2 m³ NTP per kilogram of metal. Nozzle units may operate under both subsonic and supersonic conditions, at pressures ranging from 3 to 60 kgf/cm². Power requirements may be considerably reduced by preheating the energy carrier [2].

In the atomization of steels and alloys satisfactory results have been obtained at the following values of parameters: metal flow rate 15-30 kg/min, specific energy carrier consumption 0.4-0.8 m³ (NTP)/kg, nozzle pressure 8-20 kgf/cm², energy carrier temperature 20-500°C, and oxygen concentration in the energy carrier 0.005%. These parameters can be ensured using various hermetic plant designs. The most economical, particularly where argon is employed, are hermetic plants with energy carrier circulation. The principal elements of such plants are a steel melting furnace (as a rule an induction furnace), an atomization chamber provided with an upper and a lower lock, a nozzle unit with a metal tundish, a powder receiver, and a gas supply system.

The design of the URZhM-2 hermetic plant (Fig. 1), which has an annual output of 120 tons of powder, was developed jointly with the GNIKhTEOS Institute†; the plant had its design finalized and was constructed at the Ukrainian Scientific-Research Institute of Special Steels, Alloys, and Ferroalloys. The energy carrier is supplied from a battery 11 through a system of gas reducing valves 12 to the nozzle 14, where atomization takes place. After leaving the atomization chamber 3, the energy carrier passes through a system of heat exchangers.

---

*Reduced iron powders of 98.0, 96.0, and 94.0% purities, respectively, to which no oxygen content restrictions apply—Translator.
†A high-speed steel containing, inter alia, 6% W, 5% Mo, and 5% Co — Translator.
‡V. V. Vavilov and V. G. Gerlivanov of the GNIKhTEOS Institute took part in the development of the design.

---

Fig. 1. Diagrammatic representation of URZhM-2 plant: 1) induction furnace; 2, 6) upper and lower locks, respectively; 3) atomization chamber; 4) separator; 5) heat exchangers; 7) powder receiver; 8) filter; 9) gas holder; 10) compressor; 11) battery; 12) gas reducing valve; 13) gas preheater; 14) nozzle; 15) metal tundish.

Fig. 2. Diagrammatic representation of direct-flow plant: 1) induction furnace; 2, 6) upper and lower locks, respectively; 3) atomization chamber; 4) heat exchanger; 5) gas cooler; 7) powder receiver; 8, 9) coarse and fine filters, respectively; 10) gas receiver; 11) nozzle; 12) metal tundish; 13) compressor; 14) throttle.

Fig. 3. Diagrammatic representation of discharge-type plant: 1) induction furnace; 2, 7) upper and lower locks, respectively; 3) atomization chamber; 4) nonreturn valve; 5) separator; 6) cooling chamber; 8) powder receiver; 9) metal tundish; 10) nozzle; 11) gas preheater; 12) gas receiver; 13) compressor; 14) gas reducing valve.

5 and filters 8 and collects in a cloth-reinforced rubber gas holder 9, from which it is pumped back into the battery 11 by a compressor 10. Plants of 60- and 160-kg furnace capacities based on this design can be assembled from Soviet-made equipment and units (Table 1). This plant design is unsuitable for larger furnace capacities, since the floor area occupied by the gas holders then becomes excessively large.

The operation of a direct-flow plant (Fig. 2) [3], which has an annual output of 3700 tons, consists in the following: The energy carrier is fed by a compressor 13 to the nozzle 11. From the atomization chamber 3 the spent energy carrier passes through a heat exchanger 4 and a system of coarse and fine filters to the compressor.

As the optimum atomization conditions in plants of any capacity are realized at commensurable metal and energy carrier flow rates, the use of this design for plants of low output necessitates an excessively high compressor power, with a compressor station occupying a large floor area. With a sufficient quantity of a cheap energy carrier (nitrogen) of suitable quality, capital outlay on the construction of plants can be substantially reduced. In such a case it is best to dispense with circulation and discharge the spent energy carrier into the atmosphere. Such plants, having annual outputs of 360 tons, may be based either on the direct-flow or the gas