In present-day engineering, use is made of powders with different coatings, graphite being often employed as the base material. Some methods of graphite powder coating have been described in the literature [1, 2], but generally this problem has so far received little study.

In the present investigation, a study was made of the diffusional impregnation of graphite powders with some carbide-forming elements from the gaseous phase. The principle of the proposed method is as follows. A graphite powder is mixed with metal particles 2-5 mm in size, and the mixture is placed in a cylindrical reaction chamber, which is heated in an electric furnace. During the process, metal halides are passed through the chamber, an inert gas or hydrogen being used as the carrier. The halides react in the reaction space with the metal particle surface according to the formula:

\[(n - 1) \text{Mett}_a \rightarrow \text{Me} \rightarrow n\text{Met}_a{n-1}\]

A reaction resulting in carbide formation takes place on the graphite powder surface. To ensure that a uniform layer is formed on the powder, the reaction chamber is periodically rotated. Liquid bromine is used as the halogen. Bromides are formed when bromine vapors react with the heated chips or lumps of the coating metal. This system permits easy process control, and simplifies the apparatus compared with the use of prepared chlorides or hydrogen chloride with hydrogen. Experiments have shown that deposit quality is approximately the same regardless of which halide is used and how it is fed.

The investigation was made with the installation shown diagrammatically in Fig. 1. In this installation, a special quartz reactor tube is introduced into a Silite (silicon carbide heating element) furnace. Metal chips or pieces 5-8 mm in size are placed in chamber I. Chamber II is a quartz ampoule with tapered ends, which is sealed into a quartz tube of a larger diameter. The powder mixed with metal particles is charged through the orifice. Bromine vapors enter chamber I with helium from the cylinder, which is bubbled through liquid bromine in the Tishchenko flask. Initially, moisture and oxygen are removed from the helium by passing the latter through sulfuric acid and heated magnesium turnings. The metal reacts with the bromine vapors in chamber I, resulting in the formation of bromides, which then pass into chamber II. The flow of helium is measured with the flow-meter. To ensure that the bromine is at constant temperature during saturation, the bromine flask is placed in water whose temperature is thermostat controlled. The helium feed is regulated with the cock. During the heating and cooling of the reaction space, helium is fed without bubbling through bromine.

In the investigation, a study was made of the effect of temperature, process duration, bromine consumption, and amount of powder charged on the thickness of a chromized layer. Experiments were made at temperatures between 1000 and 1200°C (at 100 deg C intervals) and process durations of up to 90 min. The ratio of the amounts of helium and bromine, \(\alpha = \frac{Q_{\text{He}}}{Q_{\text{Br}}}\), was determined experimentally at different helium flow rates and bromine temperatures of 25 and 30°C.

The ratio of the metal charge and graphite powder weights, \(\beta = \frac{G_{\text{Me}}}{G_{\text{gr}}}\), was varied between 3.3 and 15, at a constant graphite weight of 0.6 g. A 60 mesh graphite fraction was used in all tests, while the chromium particle size was 2-5 mm. Metallographic analysis was carried out on microsections obtained by mixing the coated powder with an air-setting plastic and polished in the usual manner. The thickness of the powder coating layer in each experiment was determined as the mean value of measurements in two directions on 20-25 grains. The measurements were made on the etched slide of a MIM-7 microscope at a magnification of 1000 diam. with immersion.
Graphs were plotted on the basis of mean layer-thickness values from 3-5 experiments for each plot point. First, the effect of temperature and bromine and helium feed rates on coating thickness was determined. Figure 2 shows the relationships between bromine temperature and the thickness of the diffused layer during chromizing. It can be seen from the test data that, both at 1100 and 1200°C, the layer thickness increases as the temperature rises to 25°C and subsequently remains unchanged. For this reason, a bromine temperature of 25°C was used in the following experiments. In addition, a study was made of the effect of bromine feed rate on coating thickness. It was found that, as the helium feed rate is raised beyond 7 ml/sec, giving a bromine feed rate of more than 0.05 ml/min, the layer thickness remains constant.

In subsequent experiments, diffusional impregnation was performed at a bromine feed rate of 0.05 ml/min. Figure 3 shows the effect of process temperature and duration on the layer thickness. As can be seen from the graph, the growth of the layer thickness follows a parabolic relationship. The character of the curves points to a purely diffusional process of surface layer formation on graphite. The layer thickness increases with increasing process duration and temperature, and may range between a few and some tens of microns. The greatest influence on the coating thickness is exerted by temperature.

The layer thickness is strongly affected by the ratio of the metal charge and powder weights. Figure 4 shows the effect of the ratio \( \beta \) on the layer thickness at 1100 and 1200°C. The layer thickness increases as the amount of metal rises to a ratio of 6, after which it remains practically unchanged as the ratio rises to 9. This may be attributed to a marked increase in the activity of the gaseous phase and to the fact that, at higher values of \( \beta \), the diffusion of chromium and the reverse diffusion of carbon, rather than the amount of metal fed toward the surface, constitute the limiting processes.