INDUSTRIAL SAFETY

EFFECT OF THE GRANULOMETRIC COMPOSITION OF POWDERED FERROALLOYS ON THEIR FLAMMABILITY AND EXPLOSIVENESS

L. S. Strizhko, A. K. Toleshov, S. K. Uandykova, and È. B. Kudryavaya

In order to be able to predict and evaluate the fire and explosion hazard posed by the processes involved in the preparation and use of powdered ferroalloys, it is necessary to determine their normative characteristics: the lower concentration limit for flame propagation (LCFP), the ignition point of the powder in an aerosol (T_i), and the temperature of spontaneous combustion of the powder in a bed (T_{sc}). These characteristics should be included in standards for the powders and incorporated into the specifications.

In rating rooms and buildings with respect to the danger of fire and explosion on the basis of fire safety norms (NPB 105-95), it is necessary to take into account the quantity of combustible materials present and their flammability. In accordance with the standards, the flammability of a substance is determined on the basis of results of tests or calculations. The use of handbook data is also permitted. For combustible materials in the form of dust-sized particles (in calculations of excess blast pressure), these standards take into account the fraction of dust particles smaller than the critical size at which an aerosol becomes explosive, i.e. incapable of propagating a flame.

The information on the particle size above which an aerosol of a given powdered ferroalloy no longer poses a danger of explosion is extremely limited and is not found in handbooks. In the scientific literature, we are restricted mainly to information on the smallest fraction 0-50 μm. This fraction is regulated by the norms of GOST 12.1.044-89.

In the investigation we conducted, we established normative characteristics of the fire and explosion hazard presented by powders of ferroalloys. The powders were classified into the narrow fractions 0-40, 40-63, 63-80, 80-100, and 100-200 μm using the set of screens of a "Rotap-2M" unit. The powders were obtained by comminution in a laboratory vibrating mill and a crusher.

To study the effect of particle size on the fire and explosion danger of combustible materials, we selected the following ferroalloys: calcium-silicon, barium-silicon, ferrotitanium, ferromanganese, an inoculant, and a master alloy. Dozens of instances of fire and explosion have been recorded in the preparation of these materials under industrial conditions, and the explosion of inoculant FSMg was the cause of a major industrial accident. We also studied powders of silicomanganese and PAM-4.

The LCFPs of particles of different sizes were determined in accordance with GOST 12.1.004-89 on a laboratory unit. Values of T_i and T_{sc} were determined using the facilities at the Moscow Institute of Steel and Alloys: in a vertical kiln with dispersal of the powder from the bottom to the top, and in a differential thermal analyzer in a stream of air.

All of the above-mentioned powdered ferroalloys turned out to be capable of propagating a flame in aerosol form and supporting combustion in a bed with different particle sizes. The test results are shown in Tables 1-4.

The fire and explosion danger of the investigated powders is determined by the nature and concentration of the active component (calcium, barium, magnesium, titanium, manganese, etc.) in the alloy, as well as the type of equipment used for comminution. In every case, the danger of fire and explosion increases markedly after vibrational milling when compared to the danger from a material obtained by crushing. The level of danger decreases with an increase in the size of the particles of the powder. This is particularly true of powders prepared by crushing, when particle size is 40-63 μm (the LCFP exceeds 1000 g/m^3). In the case of vibrational milling, the same result can be obtained for active materials when particle size is...
within the range 100-200 μm. Screening out the 0-40 μm fraction increases the LCFP of milled materials by a factor of 2-3 while reducing explosiveness. After long storage of powdered PAM-4, the LCFP for the indicated particle sizes had values of 80, 120, 260, 360, and 680 g/m³. It can be seen from Table 1 that the LCFPs of powdered calcium-silicon and ferromanganese are close to these values. The LCFP of the investigated powders increases with the transition from these bulk alloys to the master alloy, the inoculant, and silicomanganese.

Determination of the temperature conditions for the ignition of the powdered ferroalloys, i.e. determination of $T_i$ for aerosols and $T_{sc}$ for beds, shows that ferrotitanium and ferromanganese are more flammable than calcium-silicon and barium-silicon throughout the range of fractions examined.

Flammability tends to increase in aerosols and beds in which particle size is within the ranges 80-100 and 100-200 μm. Values of the LCFP determined by the standard method indicate that such materials are incapable of propagating a flame. This relationship is especially evident for ferroalloy powders obtained by crushing.

<table>
<thead>
<tr>
<th>TABLE 1. LCFPs of Powders of Ferroalloys Obtained by Vibrational Milling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SK-30</td>
</tr>
<tr>
<td>SB-30</td>
</tr>
<tr>
<td>FTi-70</td>
</tr>
<tr>
<td>FMn-1.5</td>
</tr>
<tr>
<td>Master alloy C: (FS-30ZRM-15)</td>
</tr>
<tr>
<td>FSMe-9</td>
</tr>
<tr>
<td>FTi-30</td>
</tr>
<tr>
<td>SMn-20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2. Values of $T_i$ and $T_{sc}$ for Powders of Ferroalloys Obtained by Vibrational Milling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SK-30</td>
</tr>
<tr>
<td>SB-30</td>
</tr>
<tr>
<td>FTi-70</td>
</tr>
<tr>
<td>FMn-1.5</td>
</tr>
<tr>
<td>FTi-30</td>
</tr>
<tr>
<td>SMn-20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 3. LCFPs of Powders of Ferroalloys Obtained by Crushing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SK-30</td>
</tr>
<tr>
<td>SB-30</td>
</tr>
<tr>
<td>FTi-70</td>
</tr>
<tr>
<td>FMn-1.5</td>
</tr>
<tr>
<td>FTi-30</td>
</tr>
<tr>
<td>SMn-20</td>
</tr>
</tbody>
</table>