Because of its high melting point, excellent resistance against oxidation and attack by many chemical reagents, and low electrical resistivity, molybdenum disilicide is suitable for many applications in high-temperature engineering [1-3]. It is used for making such components as electrode sheaths of high-temperature thermocouples, heating elements, and crucibles.

Parts from MoSi₂ are usually prepared by compaction in steel dies or by die extrusion, using in either case such plasticizers as rubber, starch paste, or polyvinyl alcohol. However, these methods of formation lend themselves only to the manufacture of parts of small size, in the form of blanks of simple configuration and tubes. Parts of complex shape, both large and small, are easier to produce by slip casting, which is widely used in ceramics. It is characteristic that both solid and hollow components with uniform density distribution throughout their whole volume can be produced by this method. As this process does not call for expensive equipment, it may be employed both in laboratory and industrial practice at relatively low cost.

The slip casting of heating elements from MoSi₂ powder was reported by Kiyoshi Tamura [4], who produced castings from an aqueous slip with an addition of 1% polyvinyl alcohol at pH of 4.05.

In the present investigation, a study was made of the conditions of slip casting of shaped parts from MoSi₂ powder. The specimens cast included crucibles 30-50 mm high and 20 and 45 mm in diameter, protective thermocouple sheaths 160 mm long and 25 mm in diameter, and solid specimens 10 mm in diameter and 60 mm long. The solid specimens were cast with the object of determining the parameters influencing the properties of slips and castings.

Plaster of Paris Molds. Molding plaster of paris manufactured by the Korostensk Porcelain Factory to GOST 125-41-59 specifications was used for making plaster of paris molds. The optimum water plaster of paris ratio for this material, securing both adequate mold capacity and sufficient strength properties, was found to be 0.9 [5]. The molds readily adsorbed liquid and satisfactorily reproduced the outline of patterns. The mold density was 0.89 g/cm³, and the water absorption 0.35 g/cm³. Plaster of paris molds for casting crucibles, protective thermocouple sheaths, and specimens were produced with the aid of patterns consisting of two parts and divided along the pattern centerline.

Molybdenum Disilicide Powder. The powder was prepared by synthesizing a mixture of molybdenum and silicon powders at 1000°C in a gaseous protective atmosphere, and was then ground in steel ball mills for 40 h in alcohol and passed through a sieve with 40 μ apertures. The chemical composition of the powder was as follows: 64.2% Mo, 34% Si, 0.18% Fe, and 0.6% C.

As powders of different particle sizes were employed in this investigation, this powder will hereinafter be referred to as coarse, and a powder ground for 150 h in a porcelain mill with porcelain balls as fine. The coarse powder in water rapidly settled on the bottom without forming a stable suspension. A stable suspension in water was obtained with the fine powder. The particle size distribution of the coarse and fine powders is given in the table.

In view of the variation in particle size, the following formula [6] was used for calculating the mean-surface particle diameter as an over-all dispersion characteristic:

\[
d_{\text{mean}} = \frac{100}{\sum a_i d_i} [\mu],
\]
TABLE 1

<table>
<thead>
<tr>
<th>Amount of powder fraction, %</th>
<th>Particle size, μ</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>up to 2</td>
<td>2–4.18</td>
<td>4.18–8.36</td>
<td>8.36–12.54</td>
<td>12.54–16.72</td>
<td>16.72–21</td>
</tr>
<tr>
<td>MoSi₂ ground for 40 h</td>
<td>57.5</td>
<td>23.5</td>
<td>13.9</td>
<td>3.86</td>
<td>0.89</td>
<td>0.31</td>
</tr>
<tr>
<td>MoSi₂ ground for 150 h</td>
<td>74.6</td>
<td>14.8</td>
<td>7.7</td>
<td>2.12</td>
<td>0.53</td>
<td>0.25</td>
</tr>
</tbody>
</table>

where \( a_i \) is the amount of each individual fraction, and \( d_i \) the arbitrary mean diameter for the corresponding fraction, \( μ \). The values of \( d_{mean} \) were 1.5 \( μ \) for the coarse powder and 1.23 \( μ \) for the fine powder.

Dispersion Medium. As slip casting was performed in this investigation with powders differing both in particle size and ability to form stable suspensions, the following dispersion media were tried: water, aqueous solutions of polyvinyl alcohol, sodium alginate, and carboxymethyl cellulose, as well as an aqueous bentonite suspension. Water was employed for the slip casting of the fine powder, which was capable of forming a stable aqueous suspension. The remaining dispersion media were used for obtaining suspensions of the coarse MoSi₂ powder, in order to increase slip stability.

Aqueous 1, 2, 3, 5, and 7.5% polyvinyl alcohol solutions proved to be unsuitable as dispersion media, since, in spite of the increased viscosity of the liquid phase, the coarse MoSi₂ powder settled without forming a stable suspension even in the casting ranges (at pH of 4–5 and 9–11). Aqueous slips with sodium alginate, carboxymethyl cellulose, and bentonite additions in amounts of more than 1, 4 and 2%, respectively, formed relatively stable suspensions with the coarse MoSi₂ powder. In slips containing smaller amounts of these additions, the powder rapidly settled, and consequently such slips could not be used for casting. When the pH of slips containing sodium alginate and carboxymethyl cellulose additions was lowered by adding hydrochloric acid, the resulting increase in the thixotropic properties of these slips made them unsuitable for casting. Crucibles cast from slips containing carboxymethyl cellulose cracked during the first minutes of drying while still in the mold; in addition, mass buildup was very slow, and the resulting crucibles strongly adhered to the mold walls in spite of the presence of insulating films. Raising the pH value of such slips sharply lowered the stability of the latter, thereby precluding their use for casting.

Crucibles could be cast from slips containing sodium alginate and bentonite, but they generally cracked already during drying in the mold. The cracking was found to be due to the pronounced thixotropic properties of these slips. When thixotropic thickening during mass buildup was prevented, it became possible to slip cast crucibles without cracks. Thus, for slips containing bentonite in an amount of 6 wt. % of the MoSi₂ content, the viscosity rose from 13 to 15, 18, and 25 stokes after 3, 10, and 60 min of slip holding in a viscometer, respectively. When mass buildup was effected by several slip pouring operations with 2–3 min periods of holding in a plaster of parsl mold, the slip could not thicken thixotropically, and crack-free crucibles were obtained.

Aqueous MoSi₂ Slip. An aqueous slip was prepared by grinding MoSi₂ powder in a porcelain mill with porcelain balls in distilled water for 150 h. The powder formed a stable suspension. The casting properties of such a slip are directly related to its pH value, the solid/liquid ratio, casting temperature, deflocculating additions, and other factors.

When the pH value was changed from 0 to 14 by adding HCl and NaOH, the suspensions exhibited good casting properties in two distinct ranges (Fig. 1). These ranges, known as "casting ranges", lay between the pH limits of 4–5 and 9–11. Between these limiting values, a decrease of viscosity and an increase of stability were observed. Stability was determined by measuring the heights of slip and of the clear liquid layer formed above the slip in 2 h, and employing these values in the formula

\[ A = \frac{H - h}{H} \cdot 100, \]

where \( A \) is stability, %; \( H \) the height of the slip; \( h \) the height of the clear liquid layer. Such a layer appeared above the slip when the latter was held for a long period of time without agitation. Stability in acid media was higher than in alkaline ones, probably because the value of slip viscosity in the casting range on the right-hand side of the graph in Fig. 1 was lower than that on the left-hand side.