

grooves along the entire length of this cylinder. The dimensions of these grooves are equal to the diameter of the heating wire of Kanthal. The Kanthal wire is tightly wound around the wooden cylinder keeping them inside the grooves. In the end, two long ends of the wire are left free, to be connected to a power supply, as will be described later. This process ensures a very uniform distance between the adjoining segments of the heating wires, and therefore ensuring the uniformity of the temperature in the furnace.

The next step is to cover the wooden cylinder with the heating wires wound around it with a thick paste of clay. The paste is prepared by mixing the dry clay with water. The upper and lower collars C1 and C2 (Fig. 3) serve as sharp boundaries between the clay and the wooden frame at the bottom as well as at the top.

After the clay had dried, the ends of the heating wire are connected to a Variac, which is energized through a voltage stabilizer. The electric current in the furnace is gradually increased till it leads to the burning of the entire wooden frame. This process leads to the inner surface consisting of exposed heating wires. A thin layer of clay is pasted on these and allowed to dry up. The basic part of the furnace is complete at this stage. It is placed inside a metal frame F and ends of the heating wires are taken out and connected to a small insulating sheet fixed with nuts and bolts, which enable connection of the furnace to a Variac. The space between the frame walls and the outer surface of furnace is filled with dry clay, which serves as the insulator. Fig. 4 shows a schematic diagram of the assembled furnace. The vertical as well as horizontal gradients in the furnace were ensured to be low.

2.5 The crystal pulling mechanism

Several varieties of pulling systems have been developed from time to time for growth of crystals from the melt. A small piece of the crystal of the material to be grown as a single crystal is used as a seed. The seed is fixed at the bottom of a metallic rod. The melt of the material to be grown is maintained at a temperature slightly above its melting point. The seed crystal is slowly dipped in the melt and the temperature is maintained in such a manner that it remains in equilibrium without significant change in its diameter. At this stage the pulling of the seed is started and the temperature is reduced slowly to increase the diameter of the growing crystal. Often necking is introduced to ensure low density of defects.

Fig. 4 — A schematic diagram of the furnace developed for crystal growth experiments. It shows 'the hot zone', 'the heating wires' and 'insulating material'

The pulling is continued after the desired diameter of the crystal has been achieved. Normally, electric motors, capable of providing variable speeds with suitable gear systems are employed to pull the crystals during growth from the melt. We report here a new ingenious mechanism, in which no electric motor is employed.

The basic principle of the new mechanism is quite simple. We have used a water container, which has a water tap fixed near its bottom, as shown in Fig. 1. When the water is filled in the container and the tap is opened, the water level in the container will keep on going down. The rate of fall of the water level depends on the opening of the tap, which is controllable. To make use of it in crystal growth experiment, a float of reasonable weight is allowed to float on top of the water. This is connected to the growing crystal with the help of two pulleys as, shown in the figure. The drainage from the tap is adjusted to obtain the desired pulling rate. Fig. 1 shows a schematic diagram of a system developed based on this principle and used for the melt growth of crystals.

3 Some Typical Results

The crystal growth system described above has been employed to grow good quality single crystals of potassium chloride. An alumina crucible of approximately 60 mm diameter was employed. It rested on a cylindrical clay spacer of diameter ~55

Table 1 — Comparison of the traditional crystal growth techniques and the new approach reported in this paper.

S. No.	Traditional Technique	New approach reported in this paper
1	Commercial furnaces comprise of a ceramic tube around which the heating wire is wound in an approximate equidistance manner	We have developed a technique which enables equidistant heating wires leading to high-level uniformity in temperature distribution.
2	The insulating material between the cover of the furnace and the heating tube is alumina or similar powders	We have utilized clays from local sources. Of course, the particle size and uniformity of clay was ensured
3	The crystals are pulled from the melt by using a suitable gear system coupled to an electric motor or a variable speed motor	We had coupled the growing crystal to a float, freely floating in a water reservoir, which had a tap to release water in a controlled manner to achieve the desired rate of growth
4	Commercially available thermocouples are used, which are enclosed in a thick ceramic tube	We had prepared thermocouples by a new spot-welding technique, which enable us to reduce the diameter of the same.



Fig. 5 — A photograph of a potassium chloride crystal grown on the newly developed system

mm and height of ~70 mm. The electrical power to the furnace was provided by a Variac, whose power source was a voltage stabilizer. To begin with we utilized a thin platinum wire fixed at the bottom of the seed holder to prepare a small seed. It was slightly dipped in the melt and slowly pulled up. A small drop of the melt, in this case potassium chloride was allowed to solidify into a small crystal. At this stage, the pulling is optimized by adjusting the rate of release of water from the container through the tap attached at the bottom. The temperature of the melt is decreased in a controlled manner till the size of the

growing crystal reaches the desired dimensions. Thereafter, the growth is continued till the desired length of the growing crystal is realized. Fig. 5 is a photograph of a typical potassium chloride crystal grown with a platinum wire used for initiating the nucleation of the seed crystal. This platinum wire is seen in the picture. The crystal has an approximate diameter of 10 mm and a length of about 80 mm. Crystals like this can become a source of seed crystals or platelets for different applications that are cleaved from it. In the next phase, we have grown potassium chloride crystals by employing single crystal seeds.

A comparison of the traditional methods and the techniques reported in this paper is given in Table 1.

4 Conclusions

In this paper we have described details of fabrication of a crystal growth system comprising of a high temperature furnace capable of operating at stable temperatures of up to 1000 °C. The temperatures in the furnace were monitored by chromel-alumel thermocouples fabricated in the laboratory by an innovative spot-welding technique. A novel pulling system has been developed which does not require any electric motor. The uniform diameter of the potassium chloride crystal grown on the system amply demonstrates the quality of the temperature control as well as the new low cost pulling method.

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