# Chapter IV

# Results

## 4.1 Pre-tests results

### 4.1.1 Results from individual raw materials

For the samples of sand and feldspar, resistivity curves seem to be straight lines at the entire temperature range up to 900 $^{o}C$. However, it shows a sharp drop when the temperature approaches 100 $^{o}C$. This is caused by the water evaporization in the system. The temperature curve, too, shows an abrupt change in slope when approaching this temperature (this indicates the occurrence of endothermic reaction). As for the dolomite sample, a similar behavior is seen at the begining, however, a strong endothermic effect occurres in the temperature range 700-750 $^{o}C$. This perfectly coincides with the decomposition temperature of this compound (730 to 760 $^{o}C$). The decomposition equation can be written as,

$$MgCa(CO_3)_2 \text{ -----> } MgCO_3 + CaCO_3$$

Resistivity behavior of soda ash corresponding to temperature is shown in figure 4.1

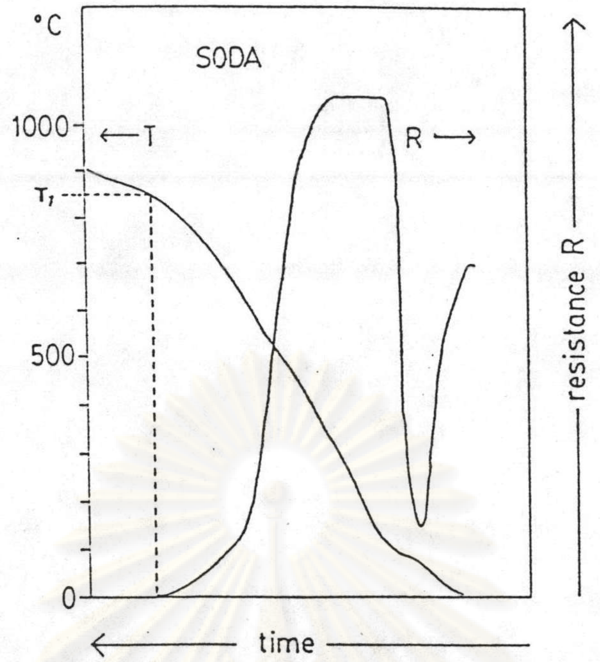


Fig. 4.1 Resistivity-temperature dependence as a function of time in soda ash.

Maximum drop of resistivity occurs at temperature $T_1$ = 851 °C which exactly coincides with the liquidus temperature of this compound (as listed before in table 2.2 in the theoretical part).

4.1.2 Results from combinations of two raw materials

Firstly, consider the behavior of 1:1 mixture of soda ash and limestone on heating up to 900 °C which is shown in figure 4.2. When temperature approaches 100 °C, again the moisture effect is seen. Fairly low resistivity is already reached at the eutectic temperature $T_2$ = 785 °C. However the maximum drop does not occur until 817 °C, i.e., the temperature of $Na_2Ca(CO_3)_2$ formation which makes an endothermic effect as shown in the temperature curve.

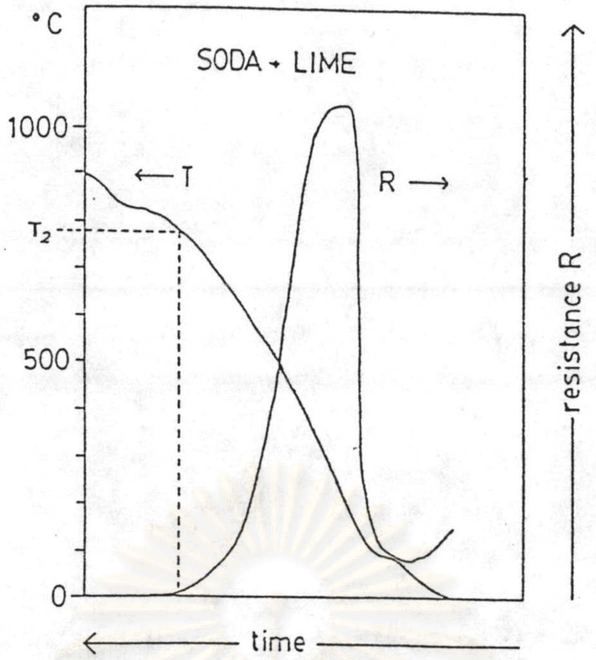


Fig. 4.2 Resistivity-temperature dependence as a function of time in 1:1 ratio of soda and lime mixture.

The system of 1:1 soda sand mixture is shown in figure 4.3. Low resistivity already occurred at a temperature compatible with the liquidus temperature of $Na_2O.SiO_2$ compounds, $T_3$ = 874 $^oC$. However, the maximum drop does not occur yet. It is expected to occur above 900 $^oC$.

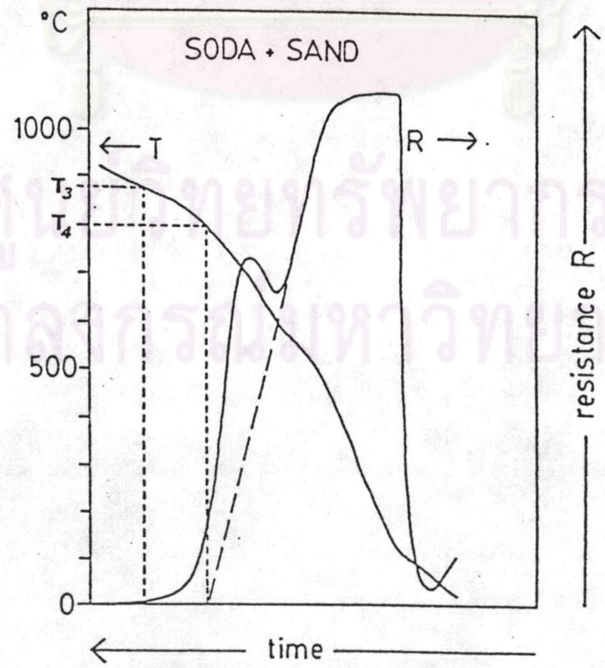


Fig. 4.3 Resistivity-temperature dependence as a function of time in 1:1 ratio of soda and sand mixture.

The most interesting in this mixture behavior is the extension of initial resistivity drop which perfectly coinciding with the eutectic temperature of the sub-system $Na_2O.2SiO_2$-$SiO_2$, $T_4$ = 800 °C and the consecutive increase reaches its maximum at 700 °C, equal to the sub-liquidus stability of the system. It may be premature to speculate on the meaning of this two-step pattern of melting.

### 4.1.3 Results from the soda-lime-sand system

The system soda-lime-sand is shown in figure 4.4. It also shows the feature in sub-systems. The extrapolation of the initial drop again matches with the eutectic temperature of sodium silicate, $T_5$ = 800 °C. The maximum drop does not occur at one of the ternary eutectics ($T_6$ = 755 to 756 °C) but at the liquidus temperature of the resulting glass at about 900 °C.

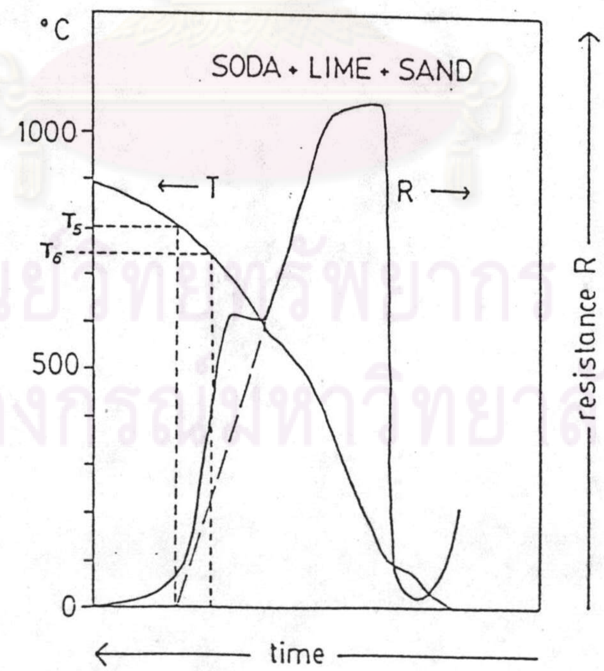


Fig. 4.4 Resistivity-temperature dependence as a function of time in soda-lime-sand system.

## 4.2 Main-tests results

Results from the main-tests are recorded as temperature and resistivity distribution at different positions in the batch blanket (the positions $P_1$ to $P_5$ were explained in the experimental part). According to the measurement of resistivities, we do not attempt to measure the "actual resistivity" but we only use this results as the indicator of an occurrence of the primary liquid phase in the batch. The unit of time, temperature, and resistivity are given in min., $^oC$, and mV. From results acquired, temperature vs. time, resistivity vs. time, and resistivity vs. temperature were plotted. In this part, for the sake of readability, only examples of results are given, however, the rests are compiled in appendix F, G and can be interpreted by the reader with detailed interest in specific data.

### 4.2.1 Temperature distribution in the batch blanket

An example of temperature distribution at different positions in the batch blanket which was plotted as a function of time is shown in a figure 4.5. Label $P_1$, $P_2$, $P_3$, $P_4$, or $P_5$ at each line is the position of thermocouple and electrode alignement (see fig. 3.5 in the experimental part). According to this curve, we will find that the temperature at the position $P_4$ which is placed nearest to the blanket surface reaches the maximum temperature fastest ($P_5$ is placed above the batch blanket).

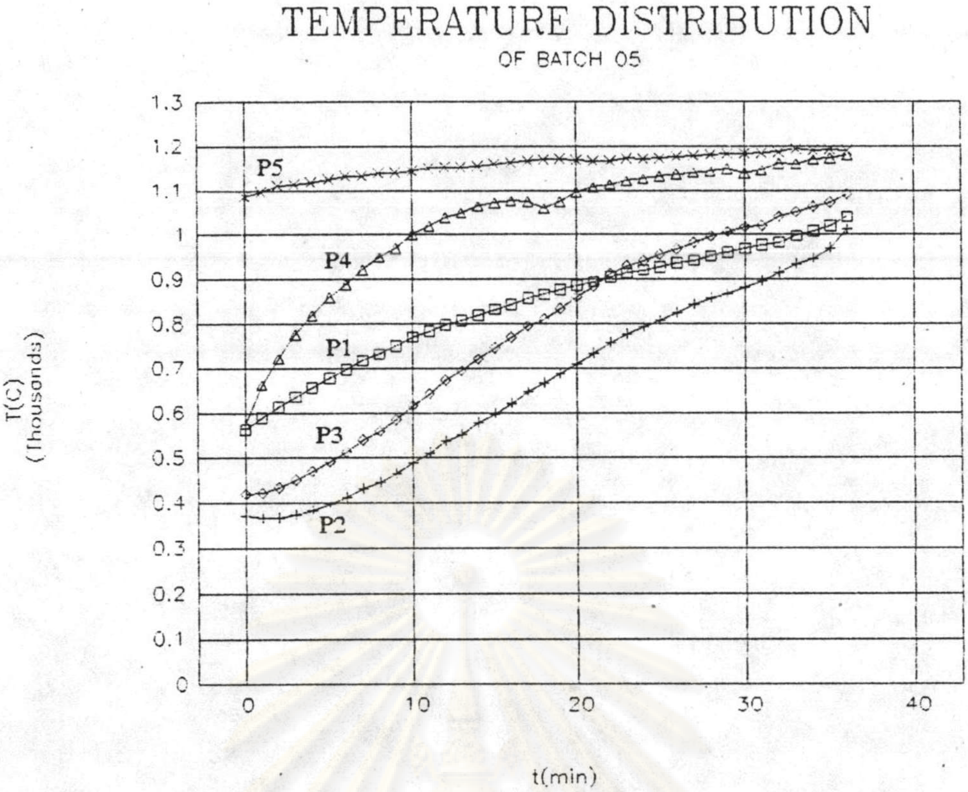


**Fig. 4.5 Temperature vs. time plot for positions $P_1$ to $P_5$ in the blanket of batch (05) during melting.**

**4.2.2 Resistivity distribution in the batch blanket**

**Example of resistivity vs. time curve is shown in figure 4.6 at the next page (given in mV). Beside this, the results are re-plotted between resistivity and temperature of each position in the batch blanket to determine $T_{on}$ and $T_{end}$ which refer to the temperature at which the abrupt changes in resistivity and the maximum drop of resistivity occurred. Firstly, resistivity at all positions in the batch blanket are relatively high, however, it will show a significant drop when the liquid phase is being formed. The decrease in the resistivity of $P_4$ is very fast when compared with the others; this occurrence implies that the liquid phase is first formed at the position nearest to the glass melts below the batch blanket.**

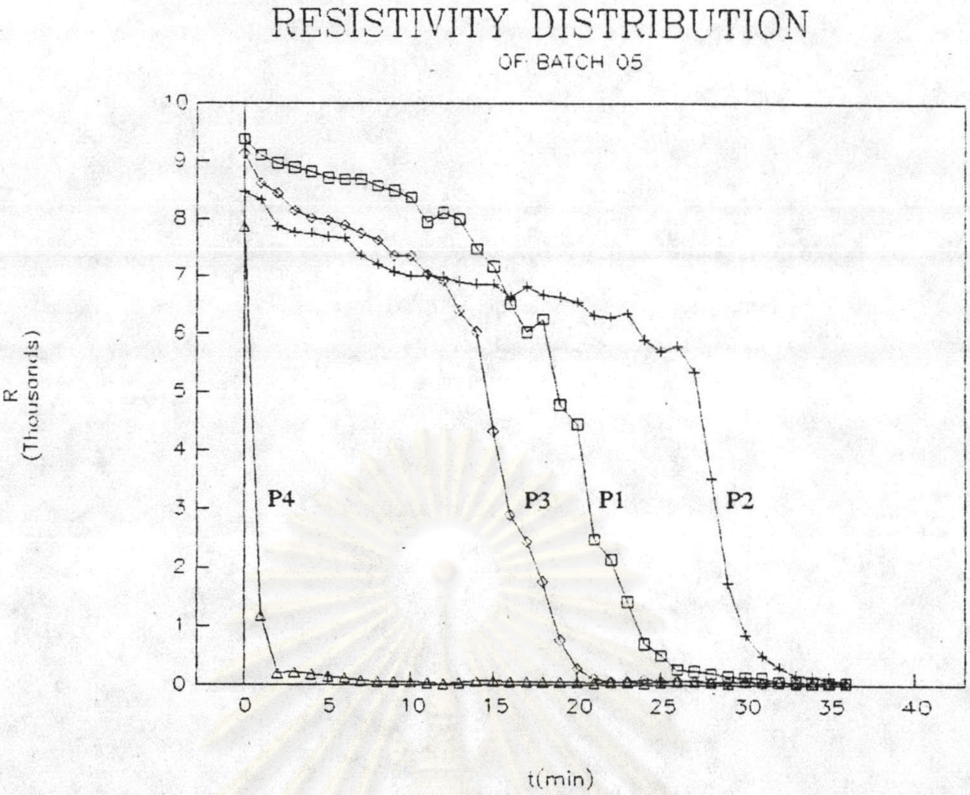


**Fig. 4.6 Resistivity vs. time plot for positions $P_1$ to $P_4$ in the blanket of batch (05) during melting; resistivities (R) given in mV voltage drop.**