INFLUENCE OF BORON OXIDE ON VISCOSITY AND CONDUCTIVITY OF CaO-SiO_2-Al_2O_3-MgO-MnO SLAGS

O. Sariev, M. Tolymbekov, A. Akberdin, A. Kim

Chemical-Metallurgical Institute, 100009, Kazakhstan, Karaganda, Ermekov str. 63, hmi_science@mail.ru

ABSTRACT

The influence of boron oxide on physical properties of manganese slags at varying basicity was studied in the work.

It was determined that variation of boron oxide concentration in slag allows to control its viscosity and conductivity holding them in the desired range. Thus, use of boron oxide would allow working at higher slag basicity creating favorable conditions for manganese oxides reduction.

1 INTRODUCTION

An amount of heat produced by electric current passing through the liquid phase in the electro-thermal process depends on conductivity of liquid slag. Conductivity, in turn, depends on viscosity of slag and amount of cations – major carriers of electric current[1].

Numerous research works cover conductivity and viscosity of ferromanganese slags of various composition[2-4]. However, little attention was paid to influence of boric oxide on physical properties of slags.

2 EXPERIMENTAL PROCEDURE

The objective of the present work is investigation of boric oxide influence on viscosity and conductivity of ferromanganese slags containing up to 2,44% of B_2O_3. Experiments were carried out in a Tamman resistance furnace with an electrovibrating viscosimeter. Viscosity measurement technique[5] used in the research allows to determine viscosity and conductivity of slags in a wide temperature range. Prior to experiments, the viscosimeter was calibrated by heavy fluid made on the base of "Clerichi" solution with initial density of 4,2-4,5 g/cm^3. In order to achieve the density of 2,7-2,8 g/cm^3 (close to slag density) it was diluted with glucose at 80°C. Viscosimeter probe submerged into the melt to a depth of 10 mm and molybdenum crucible containing the melt were used as electrodes in conductivity measurements. RF current produced by audio-frequency oscillator was applied[6] to decrease polarization on slag-electrode interface. Current frequency was varied depending on temperature and composition of slag.

Results of the research and chemistry of slags are represented in the figures 1 - 2 and table 1.

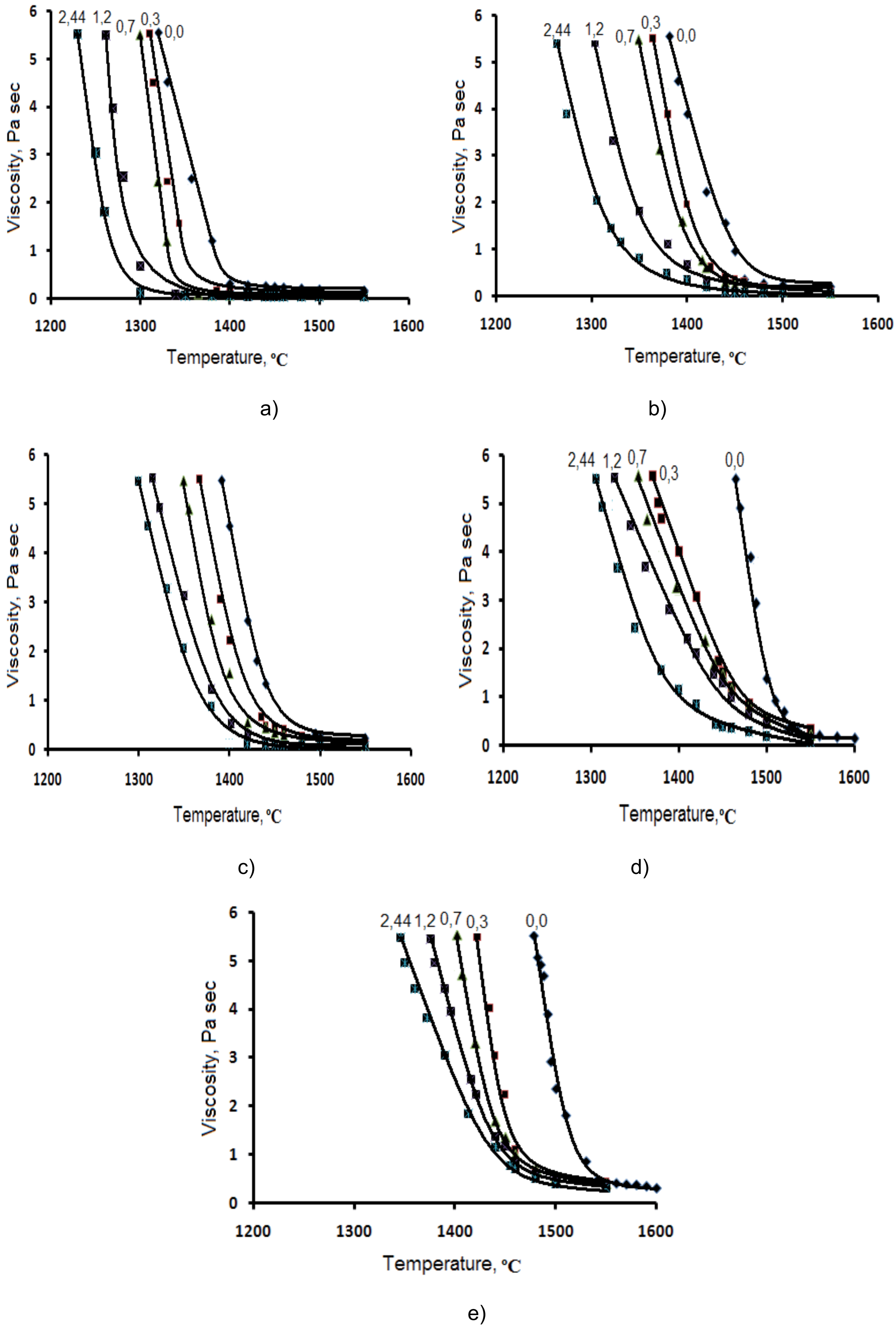

Figure 1: Polythermal viscosity curves of slags with various basicity: a) 1,3; b) 1,5; c) 1,6; d) 1,8; e) 2,0; numbers at the curves are boric oxide content, wt %)

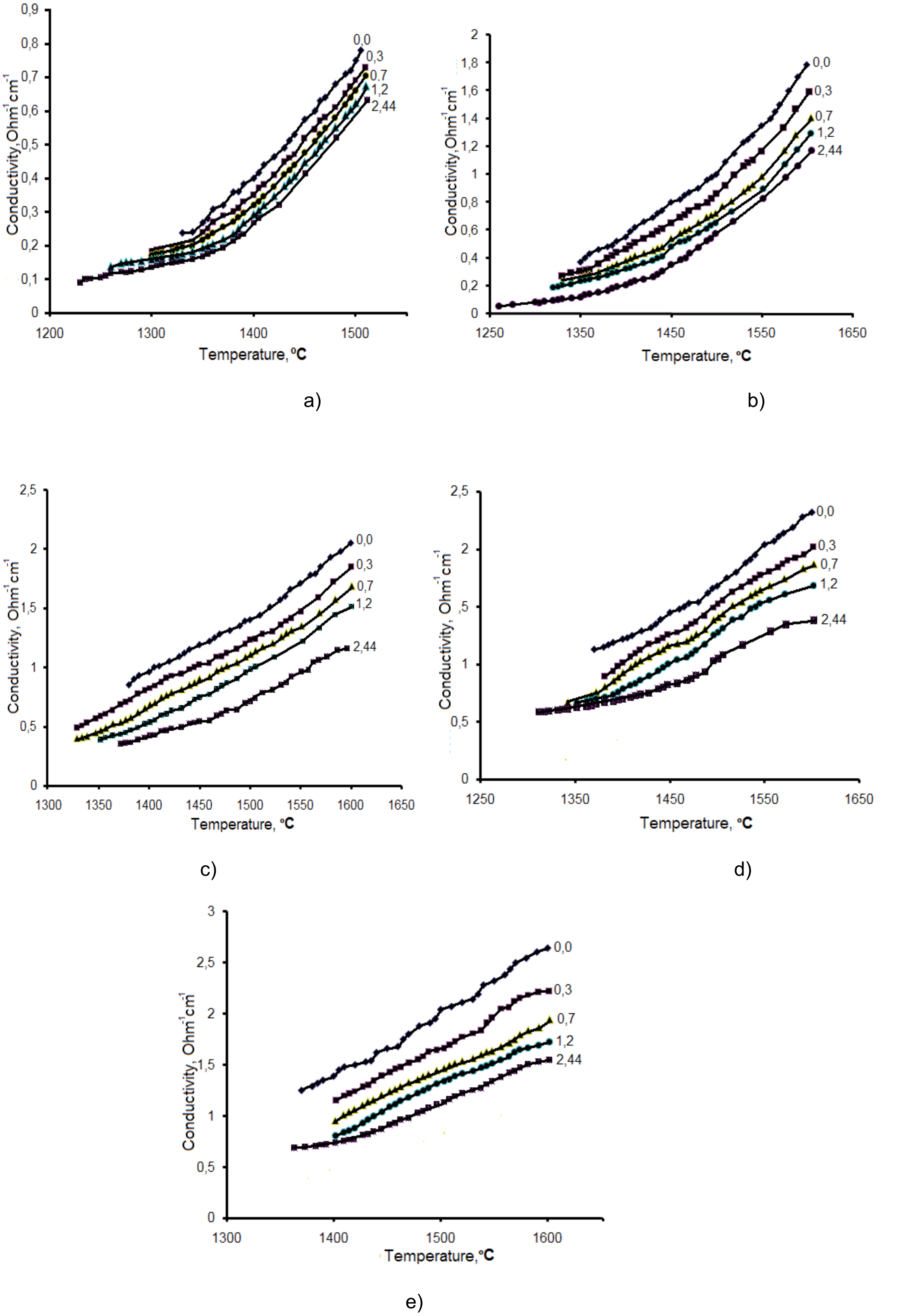

Figure 2: Dependence of slags conductivity on basicity a) 1,3; b) 1,5; c) 1,6; d) 1,8; e) 2,0; and temperature (numbers at the curves are boric oxide content, wt%)

Table 1: Chemical composition of slags, wt%

№	MnO	CaO	MgO	SiO_2	Al_2O_3	$\frac{CaO}{SiO_2}$
1	18,91	38,03	1,89	29,37	11,80	1,3
2	17,83	41,54	1,78	27,70	11,15	1,5
3	17,35	43,12	1,73	26,95	10,85	1,6
4	16,46	46,03	1,64	25,57	10,30	1,8
5	15,29	49,87	1,52	23,75	9,57	2,0

3 DISCUSSION

As shown in the figure 1, addition of boric oxide decreases viscosity (**η**) of manganese slags but absolute values of viscosity reduction depend on slag basicity. It is explained mainly by phase formation processes[7]. Influence of boric oxide on slags conductivity (**æ**) is ambiguous. On the one hand, addition of B_2O_3 results in reduced viscosity and lower crystallization point[8], on the other hand – it causes higher BO_3^{3-} anions content in the melt. The latter prevails in our case leading to lower **æ** of slags studied. The difference is more distinct at a higher temperature, where boric oxide exerts weaker influence on viscosity and crystallization point.

According to our calculation, average activation energy of viscous flow ($E_η$) of boron-free slags of $CaO-SiO_2-Al_2O_3-MgO-MnO$ system amounted 155 kJ/mole and average activation energy of conductivity ($E_æ$) – 114 kJ/mole. The ratio of these parameters ($E_η/E_æ$) is 1,35. It determines an exponent (n) of conductivity in an equation $æ^n·η$=const. For boron-containing slags, $E_η$ =94 kJ/mole; $E_æ$ =79 kJ/mole; n=1,19; i.e. addition of boric oxide exerts a stronger influence (39%) on viscous flow energy than on conductivity (30%). On the other hand, comparison of parameters "n" indicates that at growing temperature the decrease of viscosity of boron-free system goes faster than that of boron-containing system. In order to maintain the product $æ^n·η$ constant, conductivity of the former system is to be raised to a higher power (1,39) than that of the latter (1,19). It is clearly seen in the fig. 1.

4 CONCLUSION

Thus, analysis of the research results shows that addition of boric oxide into the high-carbon ferromanganese slag increases its technological effectiveness helping to retain viscosity and conductivity in a desired area. It allows to widen the optimal range of slags composition and to work at higher slag basicity, which is necessary to increase manganese extraction and reduce its loss with slag.

5 REFERENCES

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