STUDIES ON ROASTING OF MOLYBDENITE PARTICLES DURING FLASH COMBUSTION

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ABSTRACT

The combustion behaviour of individual particles of molybdenite concentrates has been measured using a two-walenght pyrometer. The most important parameters in flash combustion were nominal temperature and oxygen potential and they were studied from 923°K to 1173°K and from 50% to 100%, respectively. In these range, particles reached temperatures from 1370°K to 3000°K and energy pulses recorded suggest different combustion behaviours of the individual particles.

INTRODUCTION

In flash processes , fine particles of dry sulfide concentrate suspended in oxygen-enriched air are introduced into the top of the reaction shaft, forming a turbulent divergent jet. Particles are dispersed down along the turbulent flow and ignite at some distance from the burner. The temperature at which ignition occurs determine the reactor lenght since almost no reaction occurs before that.

The high vapour pressure and low boiling point (Kubaschewski, 1979) and the fast reaction kinetics above 800°C suggested than a direct path of oxidation-volatilization to obtain pure molybdenum trioxide will be a more practical form to oxidize the sulfide (Wilkomirsky, 1975, 1995)

Previous experimental studies on the oxidation kinetics and determination of ignition temoperature of molybdenite concentrates have been done by Patiño et al, 1997. On the basis of these results a mathematical model is being developed to describe the flash oxidation of molybdenite concentrates.

A number of investigations of the combustion of individual particles has been conducted using non intrusive pyrometry techniques. Jorgensen and coworkers have examined the combustion of metal sulfides; Themelis and Gauvin studied the reduction of iron oxide and coal combustion has been investigated by several resarchers. In most of the previous studies, however accurate temperature variations of the individual particles during reaction have not been measured. No information on individual temperatures during molybdenite reaction has been reported.

Comparison between experimental results and modelling, it is necessary to measure of temperature reached by molybdenite individual particles during combustion-ignition process.

In the present study, the combustion behavoir of individual particles of mineral sulfides has been measured using a fast two-wavelenght radiation pyrometer. The popularity of this technique arises from its nonintrusive nature and its supposed ability to determine temperatures without knowing either the object size or emissivity. In reality, great care must be taken in interpreting the results because the underlying assumption of a temperature independent emissivity ratio can, in certain instances, lead to very large measurement errors.

EXPERIMENTAL

The tests were realized in Centre for Metallurgical Process Engineering, University of British Columbia. The furnace used is decribed elsewhere by Tuffrey, (1995), and consisted of a 76 mm i.d.x 400 quartz tube surrounded by a "clam shell" furnace which was left ajar to allow the particles combustion to be viewed.

Molybdenite concentrate produced at Chuquicamata (35-53 µm size) was subjected to the hot sulphatation to remove the iron and copper and were feeded into a combustion furnace at very low rate (1 g /minute) and were carried by the downward flowing gas (15 l / minute) in the reactor tube past the pyrometer lens. Chemical analyses of concentrates were showed by Patiño, 1997.

The energy of pulses sensed and registered by pyrometer at two wavelenght were processed to calculate particle temperature in function of time of exposure by :

$$T_{(°K)} = \frac{2500}{\ln\left(\frac{V_{810}}{V_{710}}\right) + 1.92}$$

This equation is derived from the general laws of radiation and the test of calibration of pyrometer (Baker,1961).

RESULTS

Figure 1 shows typical energy traces from the two pyrometer detector recorded during the combustion of molybdenite in a gas flux containing 50% of oxygen and nominal temperature of 923°K. Note, that the time of exposure is about miliseconds. It can see pulses characteristics of operation conditions of no-ignition, i.e. low nominal temperature and medium oxygen content. This kind of curve is clasified as type A-1.

Figure 2 shows the temperature profile generated by combustion of molybdenite particle which is calculated by equation (1) using a treatment of data obtained in Figure1.Temperature increases at rate of $0.75 \cdot 10^5$ °K / s , reaching a value very near to boiling temperature of trioxide of molybdenum (1428°K). The rate of heat lost is lower than rate of hot.The output pulses showed in Figure 3 are relatively low and the both rate of heating nd ooling is about $0.7 \cdot 10^{5}$ °K/ s as is presented in Figure 4.

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Pulses of combustion showed in Figure 5 present signals of type spike with a short duration. It can be atributed to the little fragment of molybdenite generated by explosion of original particle, which move on the face of pyrometer. This curve is characterized as A-3 by Tuffrey et al, 1995. Figure 6 shows the temperature profile of individual particles during combustion which indicates a heating rate of $4 \cdot 10^5$ °K/s and reaches maximun temperature about 2400°K and the cooling rate is about $2 \cdot 10^{5}$ °K/s. This value of temperature, the spikes of signal and the high heating rate suggest ignition phenomenon.

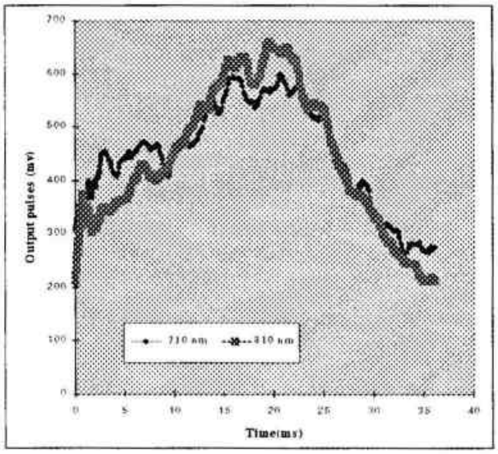

Figure 1 : Pulses during combustion. 50% O2, 923°K

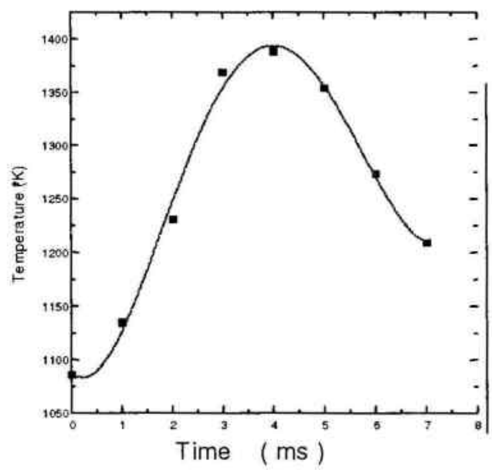

Figure 2: Temperature profile. 50% O2 and 923°K

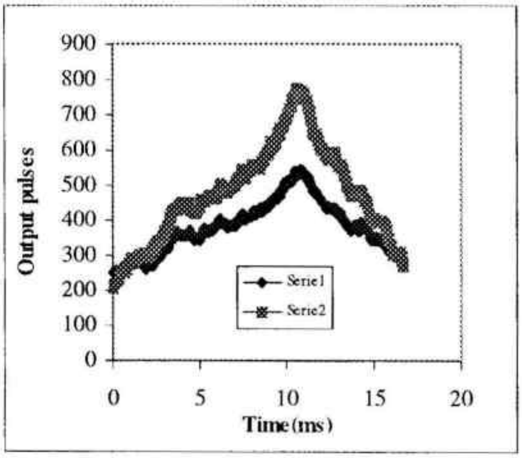

Figure 3: Pulses during combustion. 25% O2 and 973°K

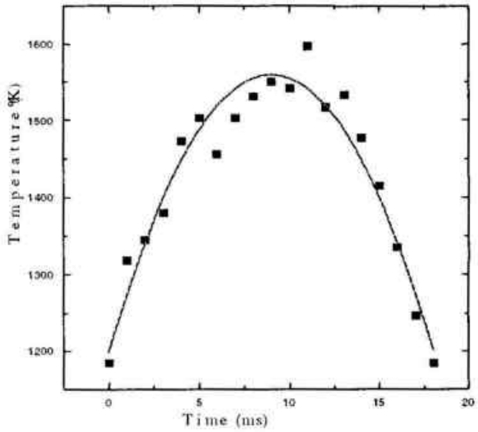

Figure 4: Temperature profile. 25% O2 and 973°K

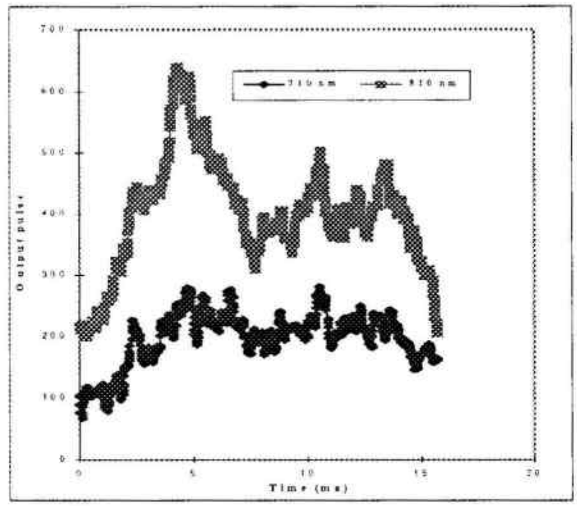

Figure 5: Pulses during combustion.100% O2 and 973°K

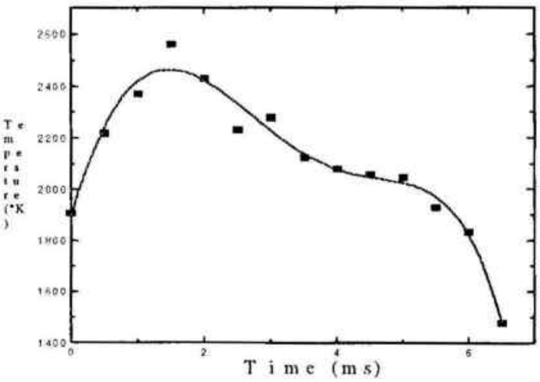

Figure 6: Temperature profile. 100% O2 and 973°K

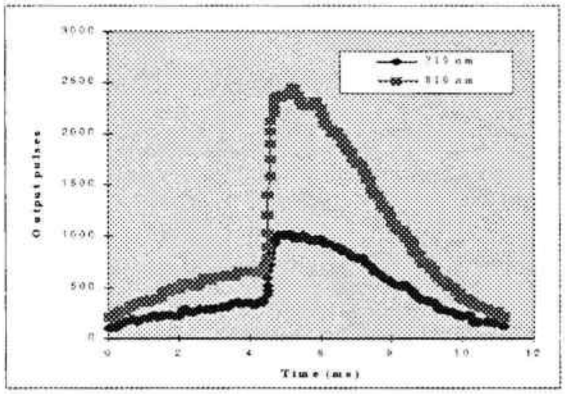

Figure 7: Pulses during combustion.25%O2 and 1173°K

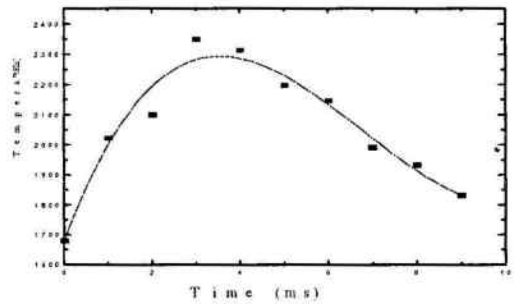

Figure 8: Temperature profile. 25% O2 and 1173Figure 5: Pulses during combustion.100% O2 and 973°K

Figure 7 shows output pulses emitted by molybdemte particles during combustion at 50% $O_2$and 117°K. Output pulses present a sudden incressing of the radiation which is almost 4 times greates than showed in Figure 1. This skind Table I – Maximun temperature reached by individual particles during combustion of behaviow is associated to expulsion or desintegration of and 1173°K

Table 1 presents results of the experiments realized.

Nominal Temperature	% O2	Maximun Temperature
923	50	1370
973	25	1550
973	100	2550
1173	25	2400
1173	50	2900
1173	100	3000

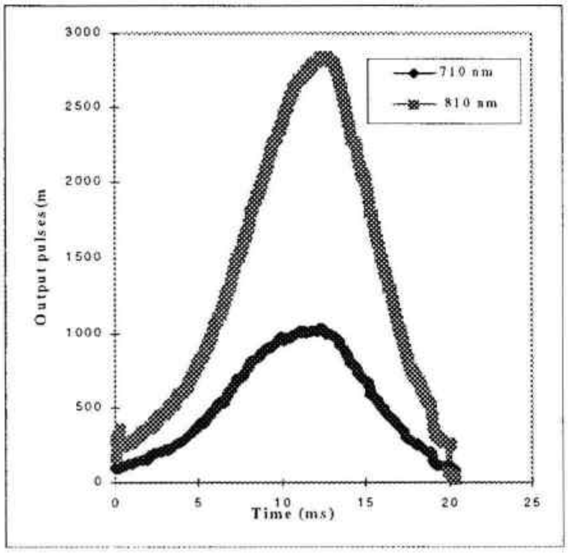

Figure 9: Pulses during combustion 25% O_2

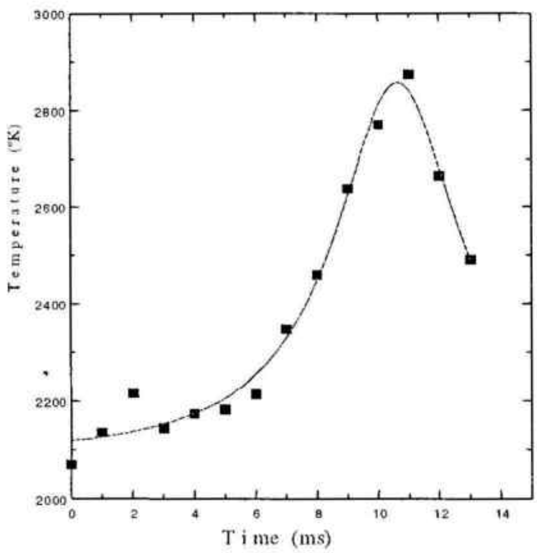

Figure 10: Temperature porfile. 50% O2 and 1173°K.

Figure 9 shows output pulses emitted by molybdenite particles during combustion at 50% O_2 and 1173 °K. The form of this curve is very similar that Figure 7 but with a difference in increasing of the level of recorded radiation. The rate of heating is the same of that of cooling and it is besides, the highest rate registered during experiments: 10^6 °K/s. Figure 10 shows the temperature profile calcuted by equation (1) which reaches 2900°K as maximun.

CONCLUSIONS

1. Oxygen potential and nominal temperature of reactor are important parameters which influence the maximun temperature reached by individual particles
2. The maximun temperature reached by individual particules during combustion increasing at high oxygen potential and nominal temperature.
3. The effect of nominal temperature on the temperature of individual particles is greatest at low oxygen potential.
4. The effect of oxygen potential on the temperature of individual particles is greatest at low nominal temperature to operate at high.
5. Nominal temperatures is prefereable supply fluxes with a medium oxygen potentials (50%) whereas a low nominal temperature is recomendable supply fluxes high oxygen potentials.

REFERENCES

Baker,H.D.,Ryder, E.A. and Baker, N.H. Temperature Measurement in Engineering, John Wiley & Sons, Inc. New York, Vol I, 1961.

Jorgensen, F.R.A. On the Maximun Temperatures Attained During Single particle Combustion of Pyrite. Trans. Inst. Min. Metall. (Sect. C: Mineral Proces. Extr. Metall.) 90, pp C10-C16, 1981.

Kubaschewski, O. And Alcock, C.B. Metallurgical Thermochemistry. 5th Edition, Pergamon Press, 1979.

Patiño, E., Otero, A. and Wilkomirsky, I. Ignition Temperature and Reaction Mechanism of Molybdenite Oxidation Under Flash Conditions, 5th Southern Hemisphere Meeting on Mineral Technology, pp 233-236, Bs As Argentine, 1997.

Themelis, N.J. Trans IMM, vol 96, pp C179-C184, 1987.

Tuffrey, N.E., Richards, G.G. and Brimacombe,J.K. Two Wavelenght Pyrometer Study of the Combustion of Sulfide Minerals: Part I. Apparatus and General Observations. Metallurgical and

Materials Transactions B, Vol 26B, pp 929-941, October 1995.

Wilkomirsky, I. Direct production of high purity MoO3. Technical Report C.I.C. No 2.10.24.University of Concepcion, 1975.

Wilkomirsky, I. High temperature oxidation of molybdenite in a cyclone reactor. IV Meeting of the

Southern Hemisphere on Technology, vol III, pp 359-375, 1995.

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