MECHANOCHEMICAL REACTION IN PROCESS OF GRINDING GOLD ORE①

Yi Nangai, Xu Xiaohe
Department of Mining Engineering, Northeastern University, Shenyang 110006

ABSTRACT Because gold ore had undergone the action of powerful and lengthy mechanical force, the gold in ore concentrated in iron powder in the process of grinding. Observing the phenomenon through experiment and X-ray diffraction analysis, the result showed that mechanochemical reaction had taken place and it led to the mechanical combination between gold and iron.

Key words ball mill mechanochemistry mineral processing

1 INTRODUCTION

Many substances, such as organic matter, inorganic matter and metal mineral, can undergo the changes of physical and chemical properties, as well as chemical reactions under the action of mechanical force such as compressing, cutting, rubbing, striking, expending and curving. This kind of phenomenon is called mechanochemical reaction[1]. A lot of gangue gold ore need grinding to a certain size before mineral processing, but most pulverizers are ball mills. Gold ore has undergone the action of many kinds of powerful and lengthy mechanical force during the process of grinding, and a few minerals in gold ore must undergo the changes of physical and chemical properties, even promote its mechanochemical reaction[2]. The research result shows that the phenomenon of gold concentration in iron powder has taken place during the process of grinding, and mechanical combinations between gold and iron has occurred.

2 THE CONCENTRATING PHENOMENON DURING THE PROCESS OF GRINDING

Before mineral processing the great part of gangue gold ore need be crushed and ground, but most pulverizers are ball mills. In the process of grinding, most people think that the ore is shattered by a synthetical force such as lashing, cutting, rolling, grinding. It was found that the phenomenon of gold concentration in iron powder appears during the process of grinding. The degree of concentration is related to the grinding time.

The researches of unprocessed and processed iron powders by cyniding have revealed that this phenomenon is universal. The iron powder came from 5 processing plants of 5 mines which use cyanidation to process gold ore. The magnatosubstances containing iron powder can be obtained from the raw-ore and tailing-ore. The magnatosubstances can be carefully chosen by combination of gravity separation, floatation and magnetic separation to get the iron powder without foreign matter. This part of iron powder come from the steel ball and steel liner of the ball mill.

After chemical test and analysis of the refined iron powder, the data in Table 1 has been obtained, in which, the gold grade in the refined iron powder is still very high. It shows that this part of gold in the iron powder becomes difficult to dress.

In order to confirm this phenomenon, the iron powder was soaked in hot hydrochloric acid, and followed by the cyanide process. In this

① Received Nov. 18, 1994; accepted Nov. 29, 1995

Table 1 The iron content and gold grade in iron powder

Sampling mine	total iron content/ %	
	frome raw ore	from talling ore
mine 1	84.7	84.8
mine 2	81.6	81.8
mine 3	82.4	81.7
mine 4	80.9	81.3
mine 5	79.5	80.3
Sampling mine	pure iron content/ %	
	frome raw ore	from talling ore
mine 1	71.2	80.6
mine 2	72.5	71.4
mine 3	68.9	67.3
mine 4	70.2	69.1
mine 5	69.4	67.9
Sampling mine	gold grade/ $g \cdot t^{-1}$	
	frome raw ore	from talling ore
mine 1	36.2	21.3
mine 2	37.8	23.4
mine 3	28.8	20.1
mine 4	31.7	19.8
mine 5	30.5	18.2

condition, the chemical reaction took place between iron powder and hydrochloric acid, and would result in $FeCl_2$, $FeCl_3$ which are easy to separate because of their easy ionization. But for the other substances, such as SiO_2, Fe_2O_3 and Fe_3O_4, it is difficult for chemical reaction to take place when mixed with hydrochloric acid. The cyanide leaching rates of the gold in iron powder between soaked and unsoaked ones with hydrochloric acid are shown in Table 2. From the data in Table 2, it is shown that the gold in iron powder unsoaked with hydrochloric acid is difficult to leach with cynide, but the gold in iron powder soaked with hydrochloric acid is easy to leach with cyanide. This illustrates that the iron powder protects the gold from the cyanide leaching. Perhaps some actions take place between iron and gold or some iron particles parcel gold particle to form an including.

In order to further research the relation between the degree of concentrating gold and grinding time, the gold ore samples from five

Table 2 The cyanide leaching rate of gold in iron powder soaked and unsoaked with hydrochloric acid

Sampling mine	the cyanide leaching rate of gold in iron powder came from raw-ore/ %	
	unsoaked	soaked
mine 1	41.1	97.9
mine 2	35.5	96.8
mine 3	30.3	97.4
mine 4	37.5	95.2
mine 5	40.3	96.3
Sampling mine	the cyanide leaching rate of gold in iron powder came from talling-ore/ %	
	unsoaked	soaked
mine 1	21.4	96.9
mine 2	17.3	97.2
mine 3	19.7	95.4
mine 4	19.2	96.3
mine 5	17.6	94.8

mines were ground in the laboratory. The iron powder was extracted from every specimen that is ground at different times, and then tested and analysed. The relation between the degree of gold concentrated in iron powder and grinding times is given out, as seen in Fig. 1.

Fig. 1 illustrates that the gold concentration has taken place during the process of grinding gold ore by ball mill. The degree of gold concentration is directly related to grinding time. The more grinding times, the more gold concentrates in iron powder. The reason of gold concentration in iron powder is probably that some kinds of reactions have taken place, or that the mechanochemical combination between gold and iron has taken place under the action of many kinds of powerful and lengthy mechanical force.

3 THE MECHANISM OF GOLD CONCENTRATION

Amorphous Cu-Ti alloy can be prepared by mechanical alloying[3]. The process of preparation is finished in a ball mill. A certain proportionate mixture of Cu and Ti powder is placed into the ball mill to grind, then a small sample of

powder is taken at scheduled intervals to be detected by X-ray diffraction for a diffraction pattern. After the X-ray diffraction patterns of MA $Cu_{43}Ti_{57}$ powder have been obtained, it is ground again and the process is repeated at different times, as seen in Fig. 2, which illuslrates that the polycrystalline peak in the X-ray diffraction pattern almost disappears and the piles of broad amorphous characteristic peaks and a little sharp tiny crystal characteristic peak emerge after grinding for 10 h. After grinding for 15 h, the tiny crystal characteristic peak disappears, and the amorphous characteristic peak is formed. The research result shows that the $Cu_{43}Ti_{57}$ alloy powder will become amorphous as well as other compositions alloy, such as $Cu_{55}Ti_{45}$, $Cu_{70}Ti_{30}$ after grinding for 15 h. In view of the above, it can be infered that the cause of gold concentration in iron powder is related to the action of mechanical force, and a combination reaction occurs between gold and iron powder under the action of mechanical force during the process of grinding gold ore.

In order to research the mechanism of gold concentration in iron powder, a certain proportionate mixture of pure gold and iron powder is put into a ball mill to grind and a small sample powder is taken at scheduled intervals to be detected by X-ray diffraction for a diffraction pattern. Fig. 3 shows the X-ray diffraction patterns after grinding at different intervals. The research resultpoints out that the relative strength of each peak in the X-ray diffraction patterns gradually changes as the grinding time increases. After grinding for 50 h, the location of the main peak obviously changes. At the same time, the strength of each peak in the X-ray diffraction pattern gradually weakens, and the width of half height increases. This illustrates that the combination reaction between gold and iron has taken place during the process of grinding.

This combination reaction is a result of repetitive and alternating reform, pulverization and cold welding that take place due to many kinds of powerful and lengthy mechanical actions during the process of grinding[4]. At the same time, as a result of the action of mechanical force, the surface crystalline structure of the crystalline particle is strongly destroyed to form a noncrystalline layer. The noncrystalline layer becomes thicker and thicker as the grinding process continues. After grinding for a period of time, the whole crystalline particle will become amorphous[5].

Because the soaking liquid is alkaline, the gold in the powder alloy of gold and iron is difficult to cyanide.

4 PROSPECTS OF MECHANOCHEMICAL APPLICATION IN MINING

The mechanochemical reaction which takes place during the process of grinding gold ore is

Fig. 1 The relation between the gold concentration in iron powder and grinding time

15—Sampling No. from; $1^{\#}$ $5^{\#}$ mines

Fig. 2 The X-ray diffraction pattern of MA $Cu_{43}Ti_{57}$ powders by different ball milling time

Fig. 3 The X-ray diffraction pattern of gold and iron powder by different ball milling time

disadvantageous to the mineral processing, but it can be used in other aspects. By further research, it is hoped that mechanochemistry can be developed and applied in the following fields:

(1) Further research of the law of mechanochemical reaction and different pulverizing methods as well as different grinding-aids to affect the structure and activity of some substances in ore is necessary to raise the comprehensive recovery rate of the mineral processing and reduce the mineral processing cost.

(2) In the process of grinding ore, mechanochemical changes can make some substances become useful structures which can be selected to conduct special useful powder functional materials.

(3) After some substances in the ore have undergone the action of mechanical force, their structures will become distorted and their activity will be increased. These changes can be used widely in reprocessing and comprehensively applying mineral resources.

5 CONCLUSION

The phenomenon of gold concentrated in iron powder is resulted from the mechanical combination between gold and iron powder, taking place in the process of grinding gold ore. The degree of mechanochemical reaction is directly related to the strength of the mechanical force. After further research, the mechanism of mechanochemical reaction can be used to improve the comprehensive recovery rate of mineral processing and apply in the technology of processing rare-earth metal ore.

REFERENCES

1 Fu Zhengyi. Engineering Chemistry & Metallurgy, (in Chinese), 1988, 9(3): 61.
2 Chemical Tech Association. Particle Tech. Janpan: Zhen Book-shop, 1985.
3 Huang Zepei *et al*. Powder Metallurgy Technology, (in Chinese), 1992, 10(2): 99–102.
4 Qiu Guanghan *et al*. Joural of Central-South Institute of Mining and Metallurgy, (in Chinese), 1985, (1): 47.
5 Li Leng. Metallic Ore Processing Abroad, (in Chinese), 1991, 28(9): 36.

(Edited by He Xuefeng)