THE EFFECT OF LUBRICATION AGENT IN FABRICATION OF RECYCLED STEEL POWDER USING BALL MILLING FROM MACHINING STEEL CHIPS

M.W.M. Fitri, C.H. Shun, S.S. Rizam, M.Z. Ruhiyuddin
[1]*School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), P.O Box 77, d/a Pejabat Pos Besar, 01007 Kangar Perlis, Malaysia*

Abstract
A feasibility study for producing recycled steel powder from steel scrap by ball milling was carried out. Steel scrap from machining was used as a raw material and was milled using ball milling for 40 hours. It was found that during ball milling, steel scrap were laminated to each other, elongated by micro-forging of the falling balls, fragmented into small pieces of foil and finally formed into spherical powder. A mixed ball is more beneficial to the milling of steel scrap into the spherical powder due to the large impact energy during the falling of the ball. Intermediate stops during milling produced a finer spherical steel powder than non-stop milling for up to 40 hours due to cooling of the vial. A larger amount of lubricating agent reduces friction between the foil or the balls and vial wall, thus give less mi

Keywords: Steel, recycling, ball milling

Introduction

Among all scrap from machining, steel and cast iron scrap are the most important if we consider the volume and quantity produced. This fact brings out the necessity and interest in finding an economical way to reprocess them by other alternative methods, that does not include remelting in furnace since this process provides low efficiency and causes problem related to ambient pollution generated during the burning of oil lubricant which is impregnated in the chip particles [3]. The increasing of starting material costs used in the powder metallurgy process and also the increasing of the energy costs in the last few years have stimulated the researchers to develop new methods that allows to reuse the scrap providing a low-cost starting material, in the powder form, which is appropriated to fabricate several sintered components and parts. The objectives of this paper is to study the effect of lubrication agent on the fabrication of recycled steel powder from machining steel chips by using planetary ball milling.

Experimental Procedure

Machining steel chips were used as raw material in this study to produce powder. Steel scrap in chip form was cut into small pieces and was then cleaned by silica sand. After that the mixture was separated between the silica sand and steel chips. The remaining steel chips after the separation were sieved to remove rust, thus cleaner steel chips were obtained. Milling was carried out using a planetary high energy machine (Retsch PM100). The milling was performed for 40 hours at a rotational speed of 500 rpm. The ratio of grinding media to the input was fixed to 10:1. Lubrication agent was varied from 1.5% to 3% of weight percent to study the milled powder. JEOL JSM 6460 LA SEM was used to observe the particle shape. Mastersizer S, Malvern particle size analyzer was used to measure particle size and its distribution.

Results and Discussion

Figure 1 shows the ball milling process for converting steel scrap into recycled steel powder with 1.5% lubrication agent. During the milling until 20 hours, the steel scrap was micro-forged by the falling of the balls and deformed plastically into an elongated shape and fragmented into small pieces of recycled steel chips. Figure 1(b) shows large laminated powder and coarse flake powder milled for 20 hours. Steel scrap was milled into coarse laminated powder, cracked in a local area of the laminated powder, and then separated into smaller pieces of laminated powder. As shown in figure 1(c), coarse flake powder was changed into smaller spherical powder, or a laminated form occurs with crack nucleation and growth in the laminated spherical powder after milling for 30 hours. As the milling time increases up to 40 hours, the powders is work hardened, and fragmented into fine spherical powder, as shown in figure 1(d).

Figure 2 shows the particle size with lubrication agent content during milling for up to 40 hours. Within 3 wt. % lubrication agent after 10 hours milling, most of the steel scrap had retained its original shape without changing its size. It means that too much amount of lubrication on the steel scrap decreases the friction coefficient between the scrap and ball, and enables their sliding over each other, with less plastic deformation in the initial milling process. All of the scrap was changed into coarse steel powder, even in the vial with 3 wt. % lubrication agent, after milling for 20 hours. The 20 hours milled steel powder with 1.5 wt. % lubrication agent has a fine particle size. The result shows that coalescence of the

powder is prevented by the lubrication agent on the powder and the amount of solid solution of carbon in the powder increases with the addition of lubrication agent during the milling, and causes hardening and diminishing of the powder size [4]. However, the steel powder with 3 wt. % lubrication agent had larger size or increase in particle size with milling time than that for 1.5 wt. % lubrication agent due to the lubrication effect between the powder or balls and the wall of the vial. The use of lubricants could help attaining high packing density, but problems may arise with agglomeration or size segregation [1]. Thus, the optimal wt. % of lubrication agent was between 1.5 – 3 wt. % for milling steel scrap.

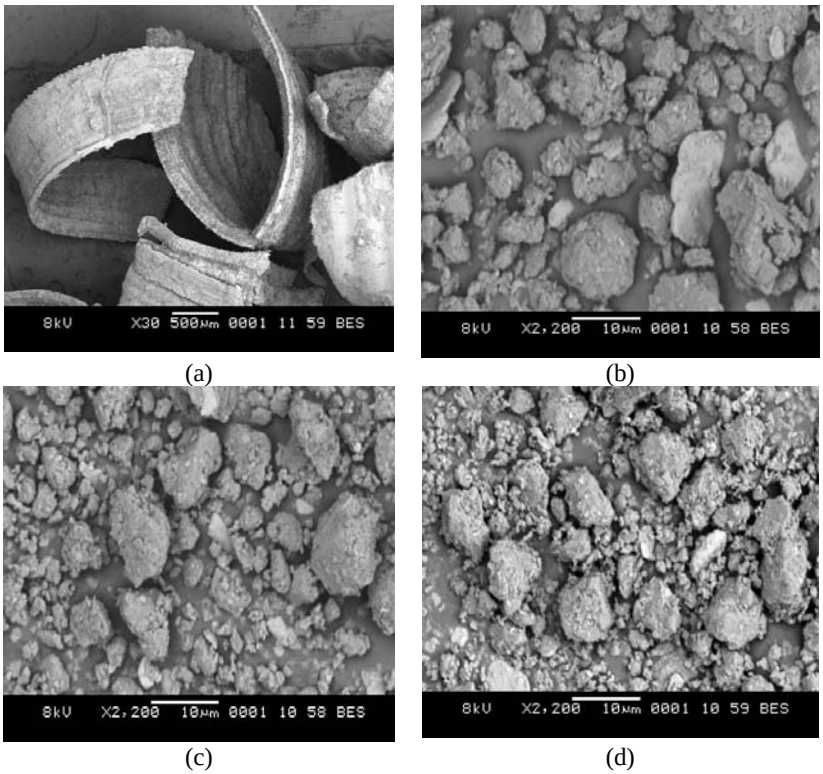

Figure 1: Manufacturing of steel powder from steel scrap: (a) cut steel scrap; (b) scrap steel milled for 20 hours (c) powder milled for 30 hours and (d) powder milled for 40 hours

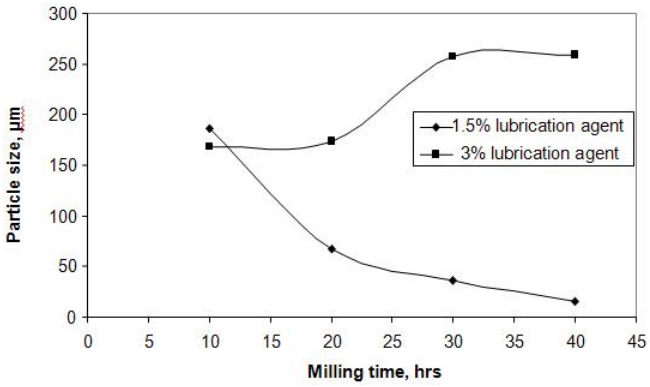

Figure 2: Effect of amount of lubrication agent on particle size in the milling of steel scrap.

Conclusion

Recycled steel powder can be produced using steel scrap in the planetary milling process. During the milling, the scrap is laminated, micro-forged, cracked continuously, and then finally formed into a spherical shape powder. The size and shape of the spherical powder produced depend on the milling time and the amount of lubrication agent. Increasing the milling time will reduces the size of the powder and

produces spherical-like powder. The optimum amount of lubrication agent is important to help attaining high packing density without any agglomeration or size segregation occurs. Lubricating agent of 1.5 wt. % gives better result in producing finer recycled steel powder.

References

[1] Cesar Edil da Costa, Walter Contreras Parucker and Moises Luiz Parucker, (2003). Characterization of casting iron powder from recycled swarf, *Journal of Materials Processing Technology* 143-144, pp. 138-143.

[2] S.H.Hong, D.W.Lee and B.K. Kim, (2000). Manufacturing of aluminum flake powder from foil scrap by dry ball milling process, *Journal of Materials Processing Technology*. 100, pp. 105-109.

[3] Y. Trudel, (1998). Metal Powder Production and Characterizaion, In: *Powder Metal Technologies and Application*. Ch. 2, ASM International, USA

[4] A.K. Sinha, (1992). Recent Developments in Iron and Steel Powder Production for High Performance P/M Components, In: *Production of Iron, Steel and HIgh Quality Product Mix*. Ch. 2, ASM International, USA

[5] Randall M. German, (1994). *Powder Metallurgy Science*.2nd, Metal Powder Industries Federation, USA.