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Research of dispersion degree of scale of die forging steel 18X2H4MA after fine crushing in tumbling mill

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Abstract
Dispersion degree and shape of die forging scale after fine crushing in spherical tumbling mills are investigated. It is determined that when crushing scale within 60, 120 and 180 minutes, dispersion degree of scale mass fraction is changed slightly, and in case of crushing time reduction to 30 minutes, the share of coarse fraction increases sharply. The dependence of scale crushing level depending on time is developed.
Key words: SCALE, GRINDING, FRACTION

Introduction

The machine-building branch is high on the list of waste generation. The strategic objective of the modern science is waste application in production. Recycling or production of new products from such materials provides not only economic benefits, but also environment protection against their impact. The detail study of this problem makes it possible to draw a conclusion that such problem is partially solved due to recycling of several types of waste, remelting and their use in certain technological processes.

Problem statement

The quantity and growth rates of scale formation set one thinking on methods of its application in production. Currently, the methods of processing, recycling and using of scale for different products and semi-finished products have been suggested [1, 2, 3]. However, scale as raw material requires additional purification, separation, water removal and fine crushing. Consequently, the use of such waste is possible only in case of their preliminary preparation. Therefore, the research of scale crushing methods impact on its dispersion degree and particles shape is currently the main objective.

References analysis

In paper [4], the results of researches of selection of rational method of obtaining iron-bearing element of forming and core sand iron phosphate **cold hardening mixtures** of different dispersion degree by means of spherical mills, and also impact of components dispersion degree on durability of mixtures of this type are presented. As primary components, the polluted ferriferous wastes of foundry and metallurgical production (slime, dust, scale) of non-constant chemical and phase composition were used. Authors have analyzed the tests of scale of rolling production and have investigated the impact of scale dispersion degree on iron phosphate compounds durability. Results of researches show that rather high strength of samples takes place when using of scale crushed to specific surface 2300-2500 m^2/g that is reached by its crushing in spherical mill within 20 minutes. However, the results of scale particle-size distribution according to fine crushing modes are not considered.

The scale was suggested to be used as component for melting of FH025 by authors [5]. Such method of scale use is perspective, as it is possible to use a big quantity of it and to achieve the considerable economic effect. The scale of fraction 0,1... 0,4 mm is applied for research.

In case of application of scale in different spheres, it is necessary to develop some recommendations on selection of the modes of scale preparation aimed at obtaining of raw materials with controlled properties. The paper [6], in which the mathematical model of crushing of ShH15 steel powders has been developed, is a basis for researches. The model of crushing cycle control is provided; it is reduced to ensuring of the mill maximum productivity in case of specified granulometric characteristic of the crushed class.

Statement of the basic material.

In the paper, change of shape and size of scale particles of steel 18X2H4MA of die forging of PJSC "Kovelsilmash" after fine crushing in vibratory tumbling mill [7] in different time periods is investigated. Primary scale is gray ferriferous plate shaped substance with sharp edges of the different size. Chemical composition of scale of steel 18X2H4MA is as follows: 58-59% of iron oxide, 40-48% of iron (ferrite) and 1.5-2.0% of alloying elements oxides [6].

Fine crushing is carried out in vibratory tumbling mill with the offset axis of rotation. Time of crushing is 30, 60, 120 and 180 minutes. For reliability of the obtained results, three tests were studied for each of intervals of time. As scale is brittle material, the mode of the free settling was observed when crushing. The frequency of mill rotation is determined by a formula [8, p. 8]:

$$n_w = (0{,}6...0{,}8)n_{cr} \text{ r/min}, \qquad (1)$$

where $n_{cr} = \frac{42{,}4}{\sqrt{D_{in}}}$, - critical number of mill rotations, r/min; D_{in} - the inner diameter of mill body, cm. The size of balls for crushing was Ø18 mm and was calculated by the empirical formula according to [8, p. 9]:

$$D_{ball} = 4{,}8(\lg d_s)d_{init}, \quad (2)$$

where d_{init} - initial diameter of the crushed particles, mm, d_s the size of particles after crushing, mm. Mass of material charging is determined by a ratio of mass of balls to the mass of powder and is 0,75:1. The particle size distribution of powder in fractions in relation to its total mass was selected as criterion of crushing degree. Selection was conducted by the method of screen test with use of vibration screen 029 No 124-85 according to GOST 18318-94. In the Figure 1, the general view of scale after one-hour crushing is shown. In the Figure 2, the general view of scale after 2 hours of crushing is shown.

(a) (b) (c)

Figure 1. General view of scale samples after one-hour crushing in case of increase x 50: a – scale of fraction 1 – 1,2 mm.; b – scale of fraction 0,4 – 0,315 mm; c – scale of fraction 0,2 – 0,16 mm

(a) (b) (c)

Figure 2. General view of scale samples after two-hours crushing in case of increase x 50: a – scale of fraction 1 – 1,2 mm.; b – scale of fraction 0,4 – 0,315 mm; c – scale of fraction 0,2 – 0,16 mm

Apparently from Figures 1 and 2, the form of particles almost is not changed after both one and two hours of crushing. Scale particles are of plastic form and thickness of 100-200 microns with sharp edges and subdivided surface. Projections and roughnesses lead to increase of interparticle friction and reduction of dense loaded density. In case of composition of such powder with powder of lower dispersion degree, the dense loaded density, density and mixing level are increased. It takes place due to distribution of smaller particles between bigger ones.

For the study of dispersion degree, test of the crushed scale weighing 100 g is poured into the top sieve, covered, and the set of sieves was fixed in the analyzer site. As a result of screen sizing, powder of scale was distributed in accordance with the size of sieve. After screen sizing process completion, the scale, which is on a sieve, was weighed and residual portion in sieve is determined (Table 1).

Table 1. Scale particle-size distribution

No sample	Sieve size, mm								
	1	0,63	0,4	0,315	0,2	0,16	0,1	0,063	Bottom
30 min									
1	23,66	19,0	23,48	7,43	11,57	6,22	3,37	1,33	0,12

2	19,64	20,22	25,45	8,92	12,63	5,38	2,2	0,27	0,17
3	21,3	20,72	22,97	6,42	10,93	7,15	4,36	0,38	0,09
Average	21,53	19,98	23,96	7,59	11,71	6,25	3,31	0,66	0,12
60 min									
1	1,7	11,86	28,58	11,66	20,2	4,98	7,83	4,18	2,8
2	1,65	10,3	26,97	10,28	21,43	5,32	8,35	6,96	3,74
3	2,87	8,53	27,15	12,69	22,89	5,48	7,79	6,11	4,39
Average	2,07	10,23	25,56	11,37	21,5	5,26	7,99	5,73	3,64
120 min									
1	1,73	4,23	24,16	11,96	26,18	8,1	10,32	7,12	5,05
2	1,2	4,11	18,72	11,05	25,75	10,07	13,45	9,02	4,13
3	1,53	5,39	21,03	10,2	25,23	8,76	12,18	9,74	2,03
Average	1,48	4,57	21,3	11,07	25,72	8,97	11,98	8,62	3,83
180 min									
1	1,53	2,18	18,37	9,42	21,13	11,75	15,4	8,26	6,82
2	2,8	4,03	20,08	8,34	23,41	9,69	12,43	10,05	4,15
3	1,29	3,29	18,92	10,68	20,54	13,23	11,95	9,77	4,72
Average	1,87	3,16	19,1	9,84	21,69	11,55	13,26	9,51	5,26

Apparently from the obtained results, the mass fraction of the thin dispersible scale is increased with increase in time of crushing. Diagrams of distribution of scale particles after fine crushing within 30, 60, 120 and 180 minutes are given in Figures 3, 4, 5 and 6 respectively.

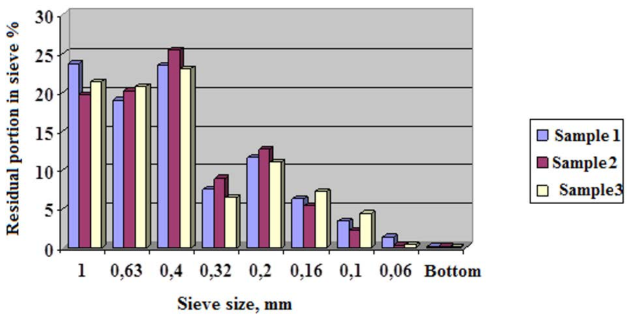

Figure 3. The particle-size distribution of scale as a result of crushing in spherical mill within 30 minutes

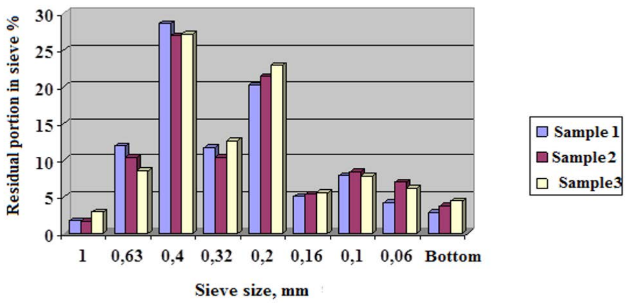

Figure 4. The particle-size distribution of scale as a result of crushing in spherical mill within 60 minutes

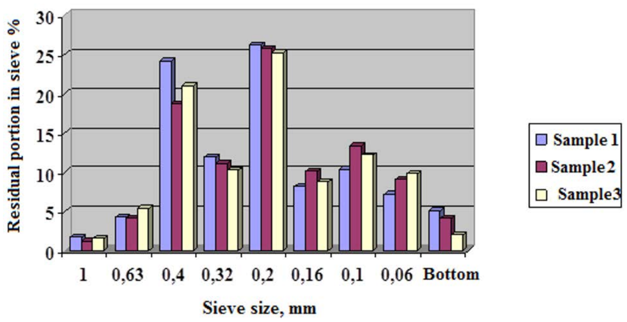

Figure 5. The particle-size distribution of scale as a result of crushing in spherical mill within 120 minutes

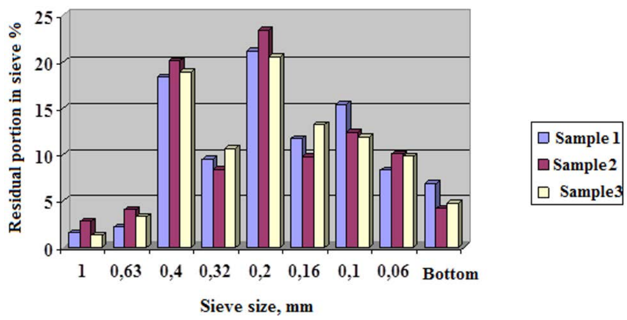

Figure 6. The particle-size distribution of scale as a result of crushing in spherical mill within 180 minutes

From figures 3, 4, 5 and 6, it is seen that regardless of fine crushing time there is more mass fracture of the weight 0.4 mm. With increase in crushing time from 30 to 60 minutes, the quantity of particles of 1 and 0,63 mm in size is increased, and of 0,4 mm in size and less is reduced. In case of increase in crushing time up to 120 minutes, the increase in fraction of 0,2 mm in size is also observed. However, when crushing within 180 minutes, the increase in mass fraction of fine fraction of 0,16, 0,1 and 0,063 mm is observed.

The dependence of the appropriate mass fraction of scale can be derived depending on crushing time in case of the specified modes (Figure 7).

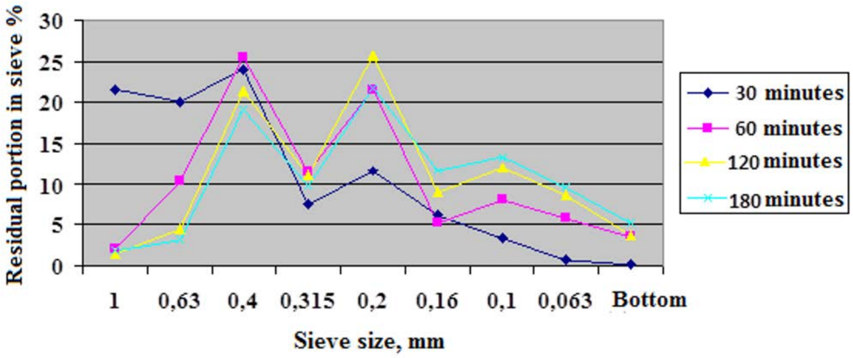

Figure 7. Dependence of distribution of scale powder particles on crushing time

From dependence 7, it is possible to draw a conclusion that tests of scale have explicit character in case of crushing time of 60, 120 and 180 minutes. From dependence, it is seen that grinding time from 60 to 180 minutes affect insignificantly the change of particles size. However, in case of reduction of crushing time to 30 minutes, we observe the significant increase in a share of higher dispersion degree while the smallest particles are reduced.

Conclusions

In the paper, dispersion degree of scale of steel 18X2H4MA is investigated depending on crushing time. The optimum modes for crushing of scale according to specifications of the initial material are determined.

As a result of the conducted researches, it has be established that regardless of fine crushing time there is more mass fracture of the weight 0.4 mm. When crushing within 60, 120 and 180 minutes, the particle size distribution of scale is not changed significantly. However, the increase in a share of coarse particle scale is observed in case of reduction of crushing time to 30 minutes.

References

1. Rud V.D., Povstiana Yu.S., Samchuk L.M., Saviuk I.V. *Metalotermia yak sposib pererobky vidkhodiv mashinobuduvannia*. [Metallothermy as method of waste processing of mechanical engineering]. Materials of VIII international conference of young scientists and experts. Kiev 2015
2. Rud V.D., Povstiana Yu.S., Samchuk L.M., Saviuk I.V. (2015) Processing of iron scale by aluminothermic method. *NAUKOVI NOTATKI*. Luts'k No 50, p.p. 185-189.
3. Rud V.D., Povstiana Yu.S., Samchuk L.M., Saviuk I.V. (2014) New porous penetrating material. *Journal of National University of water management and nature resources use*. No 4(68), p.p. 242-249.
4. Selivorstov V.Yu., Loievska O.O., Dotsenko Yu.V., Dotsenko V.P. Features of influence of dispersion degree of rolling scale on strengthening properties of iron phosphatic CHM p.p. 58-65.
5. Mogilatenko V.G., Chaykovskyi O.A., Khasan O.S., Litvinets Ye.A., Sas A.S., Olshevskyi V.S. (2011) Use of a thermite mixture for melting of FH025. Journal of Donbass State Engineering Academy. No 4 (25), p.p. 122-126
6. Rud V.D., Galchuk T. N. Process of modeling of crushing of steel shkh15 powders obtained from waste of machine-building production in spherical mills. p.p. 121-126.
7. Patent of Ukraine. Vibratory tumbling mill. No 71264 from 10.07.2012.
8. Ivliev A.I., Kazimirenko Yu.O. *Metodychni vkazivky do laboratornykh robit z dystsypliny "Osoblyvosti vyrobnytstva poroshkovykh materialiv ta vyrobiv" chastyna 1*. [Methodical instructions to laboratory operations for discipline "Features of production of powder materials and products" part 1]. Mykolaiv, 2006