BINDER FRACTION REDUCTION IN NON-FERROUS METALS CONCENTRATES BRIQUETTING PROCESS

The research results on a method of reducing the amount of binder applied during formation of metal concentrates are presented. Research was done on a model copper concentrate, which was mixed in assumed mass fraction with binder, as well as binder with addition of waste polyols. Such mixtures were formed and tested using static compressive strength, both immediately after forming and after the assumed seasoning times: 24, 96, 192 and 336 hours. The results confirm the possibility of binder dose lowering using high-efficiency system of binder dispersing with small addition of waste polyols and by homogeneous mixing of the binder with the material. In all examined cases increase in seasoning time influenced mechanical strength of the formed shapes advantageously.

Key words: metallurgical process, non-ferrous materials, cooper, waste polyols, briquetting

INTRODUCTION

Long-term activity aimed at lowering of metals processing costs in extraction metallurgy processes is still observed. These are oriented, for example, on utilization of cheap carbon-rich waste materials as alternative fuels [1-5], whereas in case of metal concentrates briquetting rather on reduction of process costs through reduction of binder fraction or elaboration of a new, cheap binder. Important factor potentially responsible for reduction of binder consumption is high homogeneity degree in a mixer. It can be achieved through turbulent flow conditions in a mixer, what provides proper dispersion of the mixed components and eliminates presence of, so called, dead zones. During mixing the components present in large disproportions, like in case of binder dosing, developing of large contact surface area is necessary. In case of liquid binder using it can result from generation of high liquid phase dispersion in high-efficiency dosing nozzles. Droplet's diameter d_{km} achievable in the nozzles, besides pressure and nozzle diameter d_o, is also strongly dependent on viscosity μ_l and surface tension s of binder solution, presented mathematically as [6]:

$$\frac{d_{km}u_w^2\rho_g}{\sigma} = 0,61\left(\frac{u_w\mu_l}{\sigma}\right)^{2/3}\left(1+10^3\frac{\rho_g}{\rho_l}\right)\left(\frac{d_o\rho_l\sqrt{u_1\mu_g}}{\mu_l^2}\right)$$

where: d_{km} / m – droplet's diameter; d_o / m – nozzles diameter; u_w / m/s – liquid and gas relative velocity; u_1 / m/s – liquid velocity; ρ_g / kg/m³ – gas density; ρ_l / kg/m³ – liquid density; μ_g / Pas – gas viscosity; μ_l / Pas – binder viscosity; s / N/m – binder surface tension.

M. Jodkowski, J. Łabaj, J. Brzóska, D. Jama – Silesian University of Technology, Katowice, Poland

Thus heated binder, as well as some additives are dosed effectively lowering the surface tension. The example of typical nozzle applied to spraying binder solution is presented in Figure 1.

There are five types of such forces intermolecular attractive forces, surface intermolecular forces, the forces of adhesion and cohesion, crystalline bindings and capillary pressure. Each of these forces is important in different types of thickened solids. In the case of forming without a binder, the bonding of the particles with each other is explained based on the theory: bitumen, capillary, colloidal and attraction forces. An increased intermolecular interaction can be achieved by
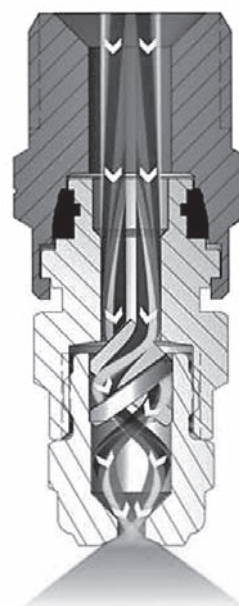

Figure 1 Quick FullJet Nozzles – Spraying Systems Co.

the application of colloidal binder containing very fine grain fractions.

Moreover using small amount micronized coal fractions as additive increasing strength of formed shapes was confirmed, both in the case of forming without the binder and with the addition of dispersed binder. This can be explained by the fact of the increase in the number of small particles, which fill the free space between the larger particles, thereby increasing the strength of intermolecular interactions, and thus the density of briquettes [7]. The strength of briquettes depends on the forces that bind the coper particles together.

RESEARCH METHODOLOGY

Copper concentrate was used as a raw material in the research tests. It was mixed with addition of liquid binder in a form of sulphite liquor, as well as mixture of sulphite liquor with polyols. Composition and codes of individual mixtures are presented in Table 1. Components, in the assumed proportions, were introduced into mixer where were subject of homogenisation.

During mixing liquid binder was dosed in a highly disperged form. After reaching the required homogeneous mixture the 40 g sample was prepared, which was subject of drying with microwaves till ca. 3,5 mass % of moisture remained. Resulting material was formed at the assumed pressure of 150 MPa. Temperature of mass forming was circa 70 °C. Resulting shapes were then subject of ultimate compressive strength tests immediately after forming and after: 24, 96, 192 and 336 hours.

Quasi-static compression tests of the briquettes were done using the stand for ultimate compressive strength tests INSTRON 4469. Rate of weight stamp travel was 5 mm/min. Operating range of gauge head compressive strength measurement was 50 kN.

RESULTS AND DISCUSSION

The research results of conventional ultimate compressive strength concerning the model shapes formed are presented in Table 1 and graphically in Figure 2. In Table 2 and in Figure 4 conventional ultimate compressive strength values for shapes demonstrating optimal dose of binder (3 mass %) together with polyols additive are presented.

Table 1 **Mixtures composition / dry mass %**

Mixture code	Component		
	Ore concentrate	Lignosulphonate	Polyol
	/ dry mass %		
M1	94,0	6,0	0,0
M2	96,0	4,0	0,0
M3	97,0	3,0	0,0
M4	98,0	2,0	0,0
M5	96,6	3,0	0,4
M6	96,3	3,0	0,7
M7	95,8	3,0	1,2

Table 2 **Conventional compression strength of formed shapes / MPa**

Mix-ture code	Time after forming / hours				
	0	24	96	192	336
	Conventional compression strength / MPa				
M1	7,91	8,25	9,07	10,20	14,44
M2	7,89	8,14	9,13	10,19	14,36
M3	7,93	8,17	9,14	10,12	14,35
M4	4,83	4,99	5,58	6,22	8,86

Analysing the results (Figure 2) one can notice, that providing ideal mixing conditions and dosing of highly disperged binder result that conventional ultimate compressive strength for the shapes showing binder concentration of: 6, 4 and 3 mass % is similar and the M1, M2 and M3 curves overlap. Figure 3 illustrated small part of Figure 2 diagram. Analysing the Figure 2 can notice, that the M1, M2 and M3 curves are laying close to each other. Only at concentration of 2 mass % (Figure 2) conventional ultimate compressive strength strongly decreases. However, for all four mixtures conventional ultimate compressive strength increases with their seasoning time. It can be explained as further consolidation of binder networking structures.

In case of mixtures with polyols addition, for M5 and M6 samples one can observe higher, by circa 5 and
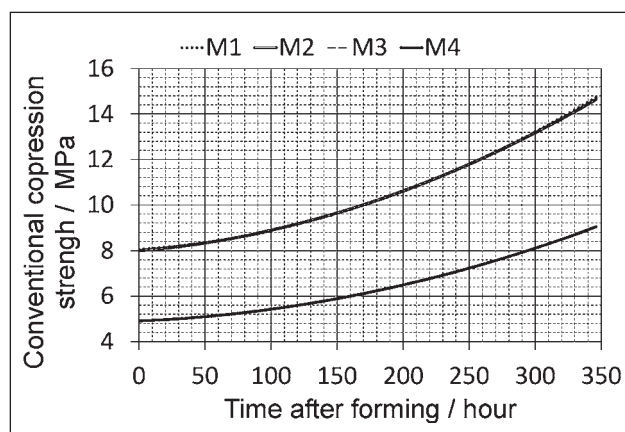

Figure 2 Conventional compression strength of formed shapes M1, M2, M3 and M4
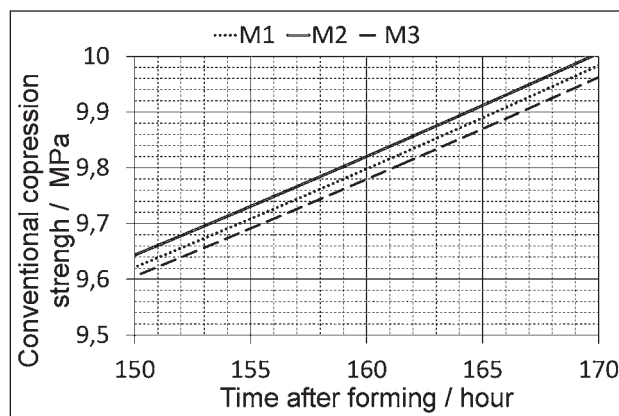

Figure 3 Conventional compression strength of formed shapes M1, M2 and M3 for time from 150 to 170 hour after forming

8 %, respectively, conventional ultimate compressive strength values.

Table 3 **Conventional compression strength of formed shapes / MPa**

Mix. code	Time after forming / hours				
	0	24	96	192	336
	Conventional compression strength / MPa				
M5	8,17	8,28	9,91	11,26	14,83
M6	8,51	8,62	10,19	11,27	15,49
M7	5,51	6,56	6,42	8,21	9,98

Polyols provide better transfer of binder particles between hydrophobic particles of material formed, providing better networking thus higher strength. Moreover, these also decrease surface tension of liquid binder what favors better dispersion of binder on nozzles.

SUMMARY

The research tests point to possibility of decrease of required binder amount, even down to 50 %. However, design of a specific binder dosing system, providing proper droplets dispersion seems to be necessary. Moreover, using of small amounts of waste polyols is advantageous. It influences decrease of both viscosity and surface tension of liquid binder, resulting in generation of its smaller droplets, significantly increasing contact surface area between liquid binder and waste material.

Acknowledgements

REFERENCES

[1] J. Lipart, T. Matuła, M. Niesler, L. Blacha, J. Filipczyk, Wastes from the coal-enrichment process as alternative re-ducers for lead smelting from lead-acid accumulator scrap, Metalurgija 52 (2013) 4, 493-496
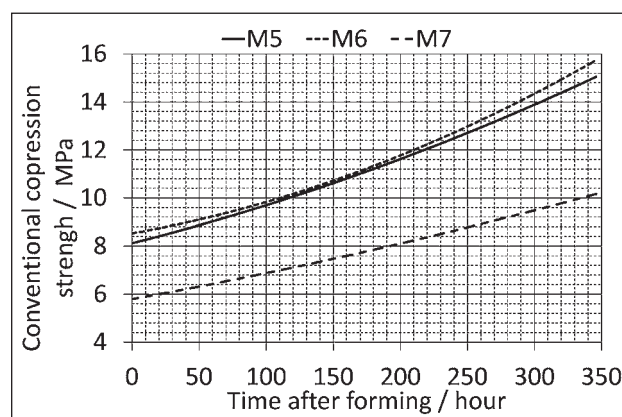[2] M. Niesler, J. Stecko, L. Blacha, B. Leksiek, Application of fine-grained coke breeze fractions in the process of iron sintering, Metalurgija 53 (2014) 1, 37-40
[3] Lutyński A., Szpyrka J., Zagospodarowanie drobnoziarni-stych odpadów ze wzbogacania węgla kamiennego, Gór-nictwo i Geo-inżynieria 34 (2010), 4/1, 155-164
[4] Hycnar J., Foltyn R., Olkuski T., Blaschke S., Kierunki energetycznego wykorzystania drobnoziarnistych odpadów z wydobycia i wzbogacania węgla, Materiały konferencyjne „Kompleksowe i szczegółowe problemy inżynierii środowiska", Kraków 2005, 639-650
[5] Giemza H., Gruszka G., Hycnar J., Józefiak T., Kierma-szek K., Technologie odzysku drobnoziarnistych mate-riałów i odpadów węglowych na potrzeby produkcji paliw, Materiały konferencyjne „Zagospodarowanie surowców energetycznych i energii w gospodarce krajowej", Zakopa-ne 2009, 51-59
[6] J. Warych, Mokre Odpylanie Gazów, Wydawnictwa Nau-kowo Techniczne, Warszawa 1979, 119 – 123.
[7] M. Jodkowski, Properties of new formed fuels for iron ore sintering process Hutnik 81 (2014), 12, 807 – 810.

Figure 4 Conventional compression strength of formed shapes M5, M6 and M7