Experimental determining parameters of Kohlrausch regression dependence for porous compacts from waxy powder compositions

© S.G. Zhilin, O.N. Komarov, D.A. Potyanikhin, A.A. Sosnin

Institute of Machinery and Metallurgy of the Far Eastern Branch of the Russian Academy of Sciences, Komsomolsk-on-Amur, 681005, Russia

Producing casting blocks with improved dimensional geometric characteristics is an important production problem. The investment casting method allows ensuring the production of complex configuration castings, and also makes it possible to combine individual parts into solid-cast assemblies. Due to the multistage process and the high cost of materials, rejects are unacceptable, however in some cases the total value of rejects may reach a third, because of deformation processes caused by technological features of production and the properties of the materials used. One of the options for reducing the stress-strain state of the investment pattern structure is the compaction of model mass powders. However, the total effect of the relaxation of the components of the pressed investment pattern after unloading results in compact dimensions increase. At the same time, the distortion of the resulting product dimensions will be significantly lower than when it is made by pouring a liquid waxy material. To find the optimal mode for obtaining a pressed waxy model with a small size distortion, it is necessary to perform a series of experiments determining the rheological characteristics of the materials. Relaxation of stress under conditions of constant compression deformation is described by the Kohlrausch equation. In the course of the experiment, the relationship between the stresses that arise when compacting the waxy body formed from the powders of various fractions and porosity of the compacts was obtained. Assessing the strength of compacts with stresses that appear during their manufacture, difference in stresses is found and the parameters of the Kohlrausch equation for a compact from a model material are determined. The obtained results allow predicting the final dimensions of the compact sections, and in the future they can be used to compile a mathematical model for the process of obtaining porous pressed investment patterns from the model materials used in foundry.

Keywords: *paraffin, powder, stress, casting, investment pattern, rheology, strength, compact, porosity, elastic response*

REFERENCES

[1] Ozerov V.A., ed. *Litye po vyplavlyaemym modelyam* [Investment casting]. Moscow, Mashinostroenie Publ., 1994, 448 p.

[2] *GOST* 25347–82. *Osnovnye normy vzaimozamenyaemosti. Edinaya sistema dopyskov i posadok. Polya dopuskov i recomenduemye posadki* [State Standard 25347–82. Basic norms of interchangeability. Unified system of tolerances and fits. Tolerance zones and recommendable fits]. Moscow, 1983.

[3] Sapchenko I.G., Zhilin S.G., Komarov O.N. *Upravlenie strukturoy i svoystvami poristykh kombinirovannykh udalyaemykh modeley* [Control of the structure and properties of porous combined removable models]. Vladivostok, Dalnauka Publ., 2007, pp. 138.

[4] Ospennikova O.G. *Liteynoe proizvodstvo — Foundry. Technologies and Equipment*, 2016, no. 10, pp. 26–28.

[5] Taşcioğlu S., Akar N. *Materials and Manufacturing Processes*. 2003, vol. 18, no. 5, pp. 753–768.

[6] Leushin I.O., Ulyanov V.A., Leushina L.I. *Steel in Translation*, 2013, vol. 43, no. 11, pp. 681–683.
[7] Uglev N.P., Poilov V.Z., Merzlyakov K.S., Zvezdin V.L., Shilov A.V., Ordin D.A. *Liteynoe proizvodstvo — Foundry . Technologies and Equipment*, 2015, no. 3, pp. 17–20.
[8] Sapchenko I.G., Zhilin S.G., Potianikhin D.A., Komarov O.N. Mesomechanics of Technological Properties of Powdered Polymer Compacts in Lost Wax Casting. *AIP Conference Proceedings*, 2014, vol. 1623, pp. 543–546.
[9] Zhilin S.G., Sapchenko I.G., Komarov O.N. *Vestnik Chuvashskogo gosudarstvennogo pedagogicheskogo universiteta im. I.Ya. Yakovleva. Ser. Mekhanika predelnogo sostoyaniya — Bulletin of the Yakovlev Chuvash State Pedagogical University. Series: Mechanics of Limit State*, 2015, no. 4 (26), pp. 163–168.
[10] Vinokurov G.G., Popov O.N. *Izvestiya Samarskogo nauchnogo tsentra RAN – Izvestiya of the Samara scientific center of RAS*, 2011, vol. 13, no. 1–3, pp. 553–557.
[11] Zhilin S.G., Komarov O.N., Potyanikhin D.A., Sosnin A.A. *Vestnik Permskogo natsionalnogo issledovatelskogo politekhnicheskogo universiteta. Ser. Mashinostroenie, materialovedenie — Bulletin of Perm national research polytechnic university. Series: Mechanical engineering, materials science*, 2016, vol. 18, no. 4, pp. 48–59.
[12] Burenin A.A., Kovtanyuk L.V., Panchenko G.L. *Prikladnaya matematika i mekhanika — Journal of Applied Mathematics and Mechanics*, 2016, no. 2, pp. 265–275.
[13] Malkin A.Ya., Chalykh A.E. *Diffuziya i vyazkost polimerov* [Diffusion and viscosity of polymers]. Moscow, Khimiya Publ., 1979, 304 p.
[14] Galperin A.M., Shafarenko E.M. *Reologicheskie raschety gornotekhnicheskikh sooruzheniy* [Rheological analysis of mining structures]. Moscow, 1977.
[15] Pavlov V.I., Askadsky A.A., Slonimsky G.L. *Mekhanika polimerov — Polymer Mechanics*, 1965, no. 6, p. 15.

Zhilin S.G. (b. 1977) graduated from Komsomolsk-on-Amur State Technical University in 1999. Cand. Sc. (Eng.), Assoc. Professor, Leading Research Fellow, Laboratory of Chemical and Phase Transformations in Materials, Institute of Machinery and Metallurgy of the Far Eastern Branch of the Russian Academy of Sciences. Author of 170 research publications and patents in the field of special kinds of casting, processes of obtaining steel and alloys by alumotermy, mechanics of deformable bodies.
e-mail: zhilin@imim.ru; sergeyzhilin1@rambler.ru

Komarov O.N. (b. 1979) graduated from Komsomolsk-on-Amur State Technical University in 2001. Cand. Sc. (Eng.), Assoc. Professor, Head of the Laboratory of Chemical and Phase Transformations in Materials, Institute of Machinery and Metallurgy of the Far Eastern Branch of the Russian Academy of Sciences. Author of 140 research publications and patents in the field of special kinds of casting, processes of obtaining steel and alloys by alumotermy, mechanics of deformable bodies.
e-mail: olegnikolaevitsch@rambler.ru

Potyanikhin D.A. (b. 1984) graduated from Far Eastern National University in 2007. Cand. Sc. (Phys.-Math.), Senior Research Fellow, Laboratory of Chemical and Phase Transformations in Materials, Institute of Machinery and Metallurgy of the Far Eastern Branch of the Russian Academy of Sciences. Author of 30 research publications and patents in the field of mechanics of deformable bodies, mathematical simulation of metallurgical processes. e-mail: potyanikhin@mail.ru

Sosnin A.A. (b. 1986) graduated from Komsomolsk-on-Amur State Technical University in 2009. Cand. Sc. (Eng.), Research Fellow, Laboratory of Problems of Metal Technologies, Institute of Machinery and Metallurgy of the Far Eastern Branch of the Russian Academy of Sciences. Author of 30 research publications and patents in the field of mechanics of deformable bodies, of the engineering materials science and processes of metal structure formation. e-mail: sosnin@imim.ru