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Yurii Goltvianitsa[1], Volodymyr Sazhnev[2], Yuriy Torba[3], Ruslan Bekhter[4],
[1] PhD student, MTF Dpt., NU «Zaporizhzhia Polytechnic»
[2] PhD, Dotsent, MTF Dpt., NU «Zaporizhzhia Polytechnic»
[3] PhD, ZMBDB «Progres» SE named after Academician O.G. Ivchenko
[4] ZMBDB «Progres» SE named after Academician O.G. Ivchenko

PREDICTION AND AVOIDING «DEBRIS» DEFECT IN INVESTMENT CASTINGS OF TURBINE BLADES APPLYING ANALYTICAL AND CONTROL METHODS

Improper values of the relevant parameters related to sub-processes of investment casting (wax making, shell making, dewaxing, melting etc.), and chemical composition of the alloy can lead to defects in the castings. These include ceramic inclusion, so-called «debris» (non-metallic particles embedded in casting), flash (excess metal fin), misrun (unfilled sections), shrinkage (porosity due to solidification), and slag inclusion. The occurrence of casting defects needs to be predicted and prevented by suitable changes in process parameters or alloy composition to achieve the desired quality assurance. Casting defects can probably be predicted using computer simulation of the physical phenomena involved, for a given set of process parameters, alloy composition, and part geometry along with methods design. There are a number of math models and even artificial intelligence algorithms involved in accurate prediction of defects.[1]

Investment molding results are evaluated only after examining the final product. Quality control techniques for work in stock, particularly molds, are lacking, which makes it difficult to assess the state of the ceramic shell for precision casting. This uncertainty can lead to the use of defective shells, resulting in product rejection during final inspection. One way to reduce this risk is to monitor all process parameters closely and maintain them within the desired operating range. Automated methods, such as photogrammetry, thermal imaging, and computed tomography, can be used for operational control without human intervention. [2]

The known findings in computer-based prediction could be compared with the result of similar experiment using Radiographic examination. And it shows that there is excellent agreement between computer predicted data and the result from Radiography as the defects occur at the same predicted locations.[3]

To reduce defects in casting, identifying and controlling relevant parameters through comprehensive domain knowledge is essential. However, it's a challenging task as the parameters can vary widely, and determining the range of values to avoid defects is difficult. One approach is to use a Bayesian inference-based methodology to analyze and reduce casting defects. Data on process parameters, chemical composition of alloys, and defective castings are collected from a foundry. Bayesian inference is used to compute the posterior probability of each input parameter, identifying the most influential parameters and the range of their avoidable values. [4]

Precise manufacturing methods like investment casting require detailed monitoring to identify and eliminate critical points that could impact final quality. Researchers have evaluated these points and proposed recommendations for improvement. [5]

Complete solution of the indicated problem of debris defects lies not only in diagnosing the possible causes, but also in timely avoidance of them during the technological process. This means, it is necessary to analyze the process step-by-step, and insert such proactive control method(s) that will allow us to stop the process, make corrections or repair, make some changes to comply with the created conditions in a better, minimum or zero-defect way. The methodology of the research lies in the study of defective castings, which obviously must be preserved and not reused until the end of the study.

REFERENCES

1. Sata, Amit (2016) Investment casting defect prediction using neural network and multivariate regression along with principal component analysis. *International Journal of Manufacturing Research*, vol. 11.4, pp. 356-373.

2. Zaba, K., et al (2014) Application of non-destructive methods to quality assessment of pattern assembly and ceramic mould in the investment casting elements of aircraft engines. *Archives of* Metallurgy and Materials vol. 59.4, pp. 1517-1525.

3. Ng Chuan Huat, Sulaiman Hassan, Sulastri Sabudin, Saparudin Ariffin (2005) Defect analysis of investment casting using computer prediction. Proceedings of the *International Conference on Information and Communication Technology (Cairo, Egypt, December 5-6, 2005),* Piscataway, N.J.

4. Sata, Amit, and B. Ravi (2017) Bayesian inference-based investment-casting defect analysis system for industrial application. *The International Journal of Advanced Manufacturing Technology*, vol. 90, p. 3301-3315.

5. Herman, A., O. Vratny, and I. Kubelkova (2018) Monitoring of manufacture stability of large turbine blades using Infrared Thermography (IRT) in investment casting technology. *Archives of Foundry Engineering*, vol. 18.4, pp. 9-14.