ABSTRACT

Casting industry is an essential part of today's manufacturing stream. It includes mainly Automobile, Aerospace, Railroad, Valve, Pumps, Power generation, jewelry etc. Casting industry is always growing and in need of more research work for more profitability by fewer rejections, reduction in rework, reduction in labor. These all categories come under one title and is called COQ or Cost of Quality. Many industries are looking for automation techniques that can be used at every stage of casting process for reduction cost of quality. Automation not only saves time, labor, but is a very good tool to determine optimal values of variables involved with automation. This will certainly give possible best results and efficiency of the process as variability is already minimized by automation techniques. Automation is expensive sometimes for small scale industries and invention of cheaper automation techniques are always welcome for them. Investment casting manufacturing process is known for its precision and quality of castings. It is mainly used for Aerospace and Automobile precision parts. Lots of automation is used and focused in shelling area of the investment casting process. Pouring process area needs equal or more attention in this type of casting manufacturing. Gravity casting, vacuum pour are some of the techniques are in use at some large scale foundries. Most of the small scale industries are still using conventional manual labor oriented ladle pouring.

Bottom pour is already widely used in cast iron, aluminum and brass sand casting industry and has advantages like flow control, slurry related inclusions etc. It is not yet used for production level for investment casting process. The main reason is that investment casting mainly use alloys with Nickel and Chromium or similar elements. Melting point of these alloys is higher compared to cast iron and silicon based carbon or aluminum alloys. Also these additions give rapid cooling rate when getting from molten to solid phase than cast iron or silicon based carbon or aluminum alloys. Also bottom pour is efficient and cost effective with large ladle sizes. So far, least ladle size used for production bottom process is of 1500 kg. Slower cooling rate for cast iron or similar alloys allows longer time for metal to change its phase from melt to solid phase allowing longer tie pour. In this study, work is done to verify the feasibility of bottom pour ladler in investment casting process using lower thermal masses (<400kg) with some modifications to current conventional bottom pour process used in other types of casting process and other types of metal with slower cooling rate. SS 304 alloy is used in this experimentation. Modifications are done and experimentation is done for major pour variables in investment casting process namely, melt temperature (tm), preheated shell temperature (tpst) and pour height (hp). $2^3$ factorial design is used and regression analysis is done to optimize values of these variable in terms of reduction in defects like inclusions and cold shuts. Also effect of bottom pour is analyzed to see it effect on mechanical properties like hardness, tensile strength and surface finish. Correlation results obtained from initial regression are further
optimized using Genetic Algorithm technique giving optimized values of experimental variables melt temperature (tm), preheated shell temperature (tpst), pour height (hp) and corresponding values of outputs/responses.

This will definitely give methodology to use bottom pour for other alloys similar to SS 304 (Steel grades with low carbon) for lower thermal masses and optimize the main variables in the investment casting process. In this work it is found that with modification to conventional bottom pour ladle it is possible to pour SS 304 steel with higher cooling rate. Improvement can be done to decrease critical defects like cold shuts and inclusion same as conventional bottom pour process. Similar methodology as used for SS304 steel grade can be followed to reduce defect/scrap rejection in small scale casting industries. This also will be helpful for consistency of casting properties as hardness, surface finish and tensile strength as analyzed in this work.