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Optimization of Wax Tank Parameter to Improve the Quality of Wax Pattern in Investment Casting

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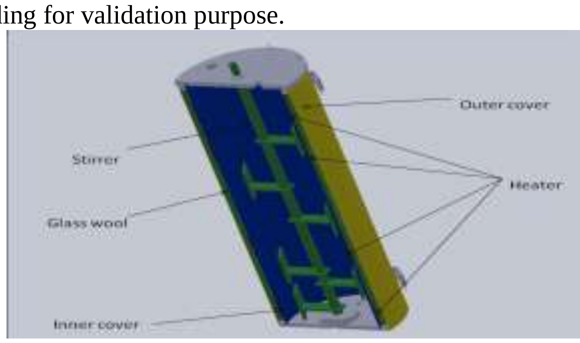
Abstract:- The injection molding is one of the most efficient processes where mass production through automation is feasible and products with complex geometry are easily attained. Making of wax pattern is important process for investment casting. Detailed review of injection molding is presented in this paper. It is observed that the process parameter such as mould Temperature, Wax Temperature and cooling time have more influence on quality of wax pattern.

I. INTRODUCTION

Investment casting is basically a metal shaping technique. It is a foundry practice by which high precision castings are manufactured. This is a specialized foundry technology and is considered a high - tech area. This process has gained popularity on the basis of the superior quality of the castings produced. In addition, more important is the fact that, the cost of a finished component produced by the investment casting process is less than or comparable to that of the conventional production techniques. It is common knowledge that new technologies gain recognition and popularity only if they offer considerable technical advantage along with commercial gain as compared to the existing conventional methods. This is precisely why Investment casting, which has both advantages, has become a much favored production technology and popular foundry practice of today. Investment casting caters to a substantial commercial market and competes directly with powder metallurgy, pressing, machining, drop forging, etc …

II. LITERATURE SURVEY

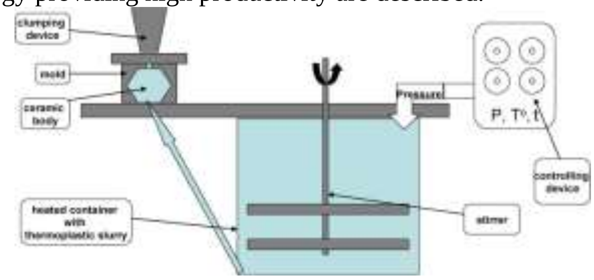
H.K.Patel, A.H.Makawana and S.M.Patel have analyzed in investment casting is basically a metal shaping technique. This is a specialized foundry technology and is considered a high - tech area. This process has gained popularity on the basis of the superior quality of the castings produced. Making of wax pattern is important process for investment casting. Wax pattern is made by wax injection molding machine. For making wax pattern the one important issue is temperature of wax. The temperature of wax is maintained 60c for obtain the best result. Temperature of wax in wax injection molding machine is maintain uniform in wax tank. The band heater are placed around the wax tank for maintain the uniform temperature of wax. The stirrer also available for rotating the wax in wax tank. In this paper the CFD analysis of wax tank is present and result is compared with practical reading for validation purpose.



Wax Tank drawing in solid works

P.K. Bharti and M. I. Khan have studied that injection molding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. Faced with global competition in injection molding industry, using the trialand- error approach to determine the process parameters for injection molding is no longer good enough. Factors that affect the quality of a molded part can be classified into four categories: part design, mold design, machine performance and processing conditions. The part and mold design are assumed as established and fixed. During production, quality characteristics may deviate due to drifting or shifting of processing conditions caused by machine wear, environmental change or operator fatigue. Determining optimal process parameter settings critically influences productivity, quality, and cost of production in the plastic injection molding (PIM) industry. Previously, production engineers used either trial-and-error method or Taguchi's parameter design method to determine optimal process parameter settings for PIM. However, these methods are unsuitable in present PIM because of the increasing complexity of product design and the requirement of multi-response quality characteristics. This article aims to review the recent research in designing and determining process parameters of injection molding. A number of research works based on various approaches have been performed in the domain of the parameter setting for injection molding. These approaches, including mathematical models, Taguchi method, Artificial Neural Networks (ANN), Fuzzy logic, Case Based Reasoning (CBR), Genetic Algorithms (GA), Finite Element Method(FEM),Non Linear Modeling, Response Surface Methodology, Linear Regression Analysis ,Grey Rational Analysis and Principle Component Analysis (PCA) are described in this article. The strength and the weakness of individual approaches are discussed. It is then followed by conclusions and discussions of the potential research in determining process parameters for injection molding.

E. Medvedovski and M. Peltsman summarizes and reviews the industrial manufacturing experience of ceramic components with custom designed complex shapes using low pressure injection moulding technology during a number of years. This technology is successfully used for manufacturing advanced ceramics with different compositions and for different applications. A production level is achieved with hundreds of pieces/day or week or higher. The major principles of this technology are reviewed based on the extensive processing experience. Some processing features, which affect the quality of ceramics and processing yield, are pointed out, particularly for industrial processing. Semi- and automated equipment for low pressure injection moulding technology providing high productivity are described.



Omkar Bemblage and D. Benny Karunakar have studied that investment casting is known for its ability to produce components of excellent surface finish, dimensional accuracy and complex shapes. Inadequate surface finish, hardness and excessive shrinkage of the wax pattern often result in poor quality of the finished casting. Hence, in the present study, an attempt has been made to produce a wax blend which could offer better surface finish, minimum shrinkage and moderate hardness. Experiments were conducted with different types of waxes namely Paraffin wax, Bees wax, Montan wax and Carnabua wax, varying their proportions and stirring time. In each case, properties of wax pattern like surface finish, percentage shrinkage and hardness were determined. An attempt was made to find out the set of input parameters, which could offer a set of ideal properties of the wax blend, using Taguchi method. The set of input parameters suggested by Taguchi method was experimentally verified and found to offer the set of desired optimal properties of the wax blend pattern.

Silicon rubber mould

Sarojrani Pattnaik, D.B. Karunakar, P.K. Jha studied the investment casting process involves the production of engineering castings using an expendable pattern such as wax. As it is growing in size and complexity, its properties need to be controlled. However, the quality of the final casting mainly depends on the quality of wax pattern and ceramic shell. This study highlights the application of a fuzzy logic analysis in combination with Taguchi's design of experiments for prediction of quality of wax patterns in terms of linear shrinkage, surface roughness and penetration in the investment casting process. Trial experiments were conducted to confirm this approach. It has been found that the method of fuzzy logic controller modeling not only simulates the operating experiments from parametric design strategy, but also demonstrates a simple, effective, and efficient way in developing a robust quality in the product.

Er. Charanjeet singh Sandhu and Er. Ajay Sharma has studied Investment casting process used for precision component manufacture calls for accurate method design. It gives good surface finish, high dimensional accuracy, and complex shape. But due to some defects produced by the wax patterns result in the poor quality of the final casting product. The some common defects are like Shrinkage, inadequate surface finish, improper dimensional accuracy in the wax patterns. So there is need to remove these defects. The wax pattern handled during the melting, injecting will reflect the quality of
wax pattern produced for the investment. Hence in the present work an attempt is made to produce the good quality wax pattern by using the different form of wax like Paraffin wax, Bee wax, Montan wax, Carnauba wax, China wax. We will vary the proportion of these waxes and make the different samples. In each sample we will find out the volumetric shrinkage, linear shrinkage, cracks formation etc.

Sr. No	Name of wax	Density (gm/cc)	Melting point (°C)	Volumetric shrinkage (%)
1	Bees wax	0.97	65	7.25
2	Paraffin wax	0.78	64	6.20
3	Carnauba wax	0.99	87	4.20
4	Montan wax	1.02	82	2.45

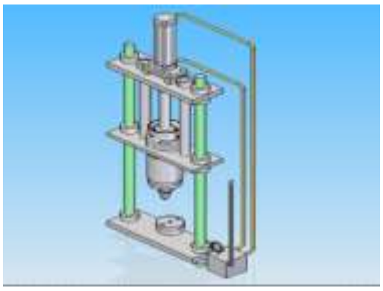
Timothy M.Wolff found that the way pattern wax is handled during the melting and injection stage of pre pattern production will directly reflect the quality of the wax pattern produced in the wax room. Proper handling method can eliminate a multitude of the wax pattern defects for the investment casting foundries. It is important to recognize that all the material used to produce the casting are part of the system and must work together to make a quality cast. Therefore, the final casting can only be as good as wax pattern produced.

J.-C. Gebelin, M.R. Jolly, A. M. Cendrowicz, J. Cirre and S. Blackburn used the three different Experiments. The first was to characterize the flow of the wax during the filling and the capacity of the models developed to describe it accurately, in the liquid state. The second experiment was to test the capacity of the models to predict the apparition of filling defects. The third was to compare the predictions in liquid and paste or semi-solid state. A good agreement between experiments and simulations has been found, showing that the models are able to represent the behaviour of the wax used.

Gebelin and Jolly explained that the accuracy of the wax patterns used has a direct effect on the accuracy of the final cast part. They also concluded that, it is usual for the investment caster to use precision-machined full – metal dies for producing wax patterns when large numbers of highly accurate components are required.

Dr. K. D. Desai Mr. Raghav Ramdas a new innovation in **lost wax investment casting process.** The new innovative technology gives enhanced quality of **gold** and **platinum jewelry** at reduced cost. The innovation potentially reduces the process timing and at the same time improves the quality. The concept is based on the quick and efficient removal of carbonized wax and gases generated during casting from the investment mold. From the above literature review it has been found that lot of work is carried out on the investment casting some of them used rapid freezing prototype for the ice pattern some of them used Silicon, Plastic, Paraffin wax, Bee wax etc mostly paraffin wax is used for making the wax pattern due to its property of produce the better finish but it does not gives the dimensional accuracy. At some foundry it uses a Carnauba wax because it gives the better dimensional accuracy but poor surface finish similarly with the Bee wax, Montan wax etc. ice pattern gives the better accuracy at the corner points but temperature maintenance is very difficult, plastic and silicon produces the cracks in the pattern. All of these the wax is good for making the pattern because it is easy to shape, cheap and can give the high degree of accuracy. Now we are going to use the different form of waxes to produce good wax pattern.

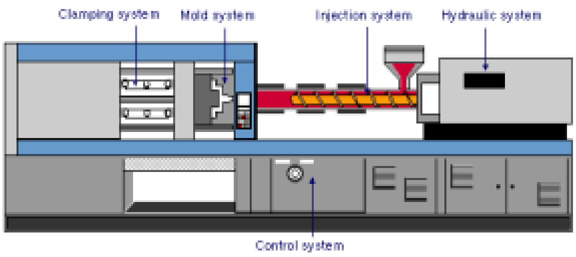
Mohammed Waseem H.S says Injection molding machine is the only technique for producing many ideal products in large volume and the most common method in part manufacturing. There are two main parameters which effect the operation of injection moldings are pressure and temperature. The basic principle of injection molding machine is to inject molten wax in to a closed die cavity, where it solidifies to give the product. The cylinders are usually heated by a heater band, but viscous heating also occurs, because at this point a channel is narrow and thus the shear rate is high. The viscosity therefore decreases and this in turn helps easy injection. The die is held by a clamping unit which holds the die while the molten plastic or wax is forced through the die. The die is removed after sometime to get the final product.



3D model of Wax injection molding machine

OYETUNJI, A. Says that Development of small injection moulding machine for forming small plastic articles in small-scale industries was studied. This work which entailed design, construction and test small injection moulding machine that was capable of forming small plastic articles by injecting molten resins into a closed, cooled mould, where it solidifies to give the desired products was developed. The machine was designed and constructed to work as a prototype for producing very small plastic components. Design concept, operation, and assembly of components parts were made. Also, working drawings and materials selection were made based on calculations of the diameter of injection plunger, number of teeth required for the plunger rack and spur gear, the angular velocity, number of revolution, torque and power obtained from the electric motor selected and the leverage on the handle of the machine. The machine parts/components were then assembled in line with the designed made, thereafter the constructed machine was tested using high density polyethylene and master batch. The results obtained from the test were satisfactory.

SHARIFAH RAFIDAH BINTI SYED HAMID Have studied Plastic has, quite literally, become the cornerstone of our society. We make so many things from plastic that it is hard to imagine what our lives would be like if it was never invented. The value of parameters should be correct and exact so that the good and quality of product can be produced. The objective for this project is to study the effects of injection parameters which are temperature, pressure and volume to the mechanical properties of the injected parts. Besides that, it also to determine the optimum amount of pressure, temperature and volume at the injection machine in producing document tray. In order to achieve the objectives, the scopes of studies are performed which is the study will be using a polymer material which is Samsung Starex® SD-0150GP High Impact Grade ABS. Besides that, only pressure, temperature and volume will be varied in this study while other parameter for instant clamping unit is fixed constant. The project can be divided into 4 stages. Firstly, is the preparation of the material. Then, injection moulding machine is used to produce document tray with the parameter that control the process which is temperature (220° C, 230° C, 240° C), pressure (1675 bar, 1700 bar, 1725 bar) and volume (340 cm^3 , 350 cm^3 , 360 cm^3). There are 27 samples produced by using full factorial method. After the samples are produced, there will be some testing for the samples such as mechanical testing such as tensile test and hardness test and physical testing such as density test. Lastly, analysis to determine the best and high quality of the samples was done. All the data obtained can be analyze and evaluate to produce the best optimum parameter for the injected part produce. As a result, the best injected part produced is sample number 10 which has good properties and optimum parameter is temperature at 230 oC, pressure at 1675 bar and volume at 340 cm3. It gives the low value of mass, low value of density, high of strength-to-weight ratio, high value of maximum strength and high value of hardness.



Injection moulding machine for thermoplastics

C.A. Hieber, S.F. Shen had made a detailed formulation is presented for simulating the injection-molding filling of thin cavities of arbitrary planar geometry. The modelling is in terms of generalized Hele-Shaw flow for an inelastic, non-Newtonian fluid under non-isothermal conditions. A hybrid numerical scheme is employed in which the planar coordinates are described in terms of finite elements and the gapwise and time derivatives are expressed in terms of finite differences. The simulation is applied to the filling of a two-gated plate mold having an intentionally unbalanced runner system. Good agreement is obtained with experimental results in terms of short-shot sequences, weldline formation and pressure traces at prescribed points in the cavity.

Hasan Oktem, Tuncay Erzurumlu, Ibrahim Uzman has said that application of Taguchi optimization technique to reduce warpage problem related to the shrinkage variation depended on process parameters during production of thin-shell plastic components for or those part. For this purpose, a number of Mold Flow analyses are carried out by utilizing the combination of process parameters based on three-level of L_{27} and L_9 Taguchi orthogonal design. The signal-to-noise (S/N) and the analysis of variance (ANOVA) are used to find the optimum levels and to indicate the impact of the process parameters on warpage and shrinkage. The results show that warpage and shrinkage are improved by about 2.17% and 0.7%. A verification test is also performed to prove the effectiveness of Taguchi technique after the optimum levels of process parameters are determined. It can be clearly inferred from this conclusion that Taguchi optimization is sufficient to solve the warpage problem with shrinkage for thin-shell plastic components of or those parts.

R.D.Saraiya had found that to realize best result from a pattern wax blend for investment casting, carefully study of wax quality summarized in the form of supplier’s data sheet is advised. Relevance of this data sheet information to operating as well as performance indicator is explained. Three types of wax formulations viz. straight resins filled or water emulsified waxes are described under broad classification to explain how differently they performed. Concept of wax conditioning is dealt with in detail mentioning what it may signify with a perfectly conditioned wax , cash individual job may demand specific consideration of die design factors like mould opening and realize mechanism , die cooling system, locatioin and size of grating etc. to optimize the wax pattern quality.

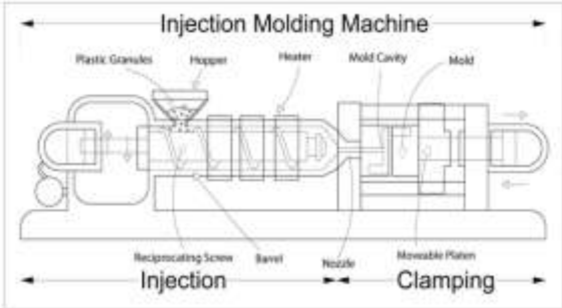
Balwinder Singh, Pradeep Kuma, B.K. Mishra had shown that The present investigation is aimed to determine the effects of injection parameters on the dimensional accuracy of the wax patterns, produced by wax injection machine, to be used in ceramic shell investment casting process. The injection parameters viz. time, temperature, die temperature and holding time were considered. Experiments were performed and optimal parameters were determined. Linear and volumetric contractions of wax patterns were measured and dimensional variations were evaluated. Results reveal that an increase in injection temperature increases wax shrinkage, whereas increase in die temperature reduces the wax shrinkage. Slow injection and short holding time reduces dimensional variation in castings.

Michelle M. Gauthier Injection Molding refers to a variety of processes that generally involve forcing or injecting a fluid plastic material into a closed mold (Ref 1, 2). It is differentiated from compression molding, in which plastic materials in a soft but not fluid condition are formed by transferring them into an open mold, which is then forcibly closed. This latter process is fully discussed in the article "Compression Molding and Stamping" in this

Volume. The injection molding process generally has the advantages, first, of being more readily automated and, second, of permitting finer part detail, in contrast to compression molding. The part and mold often can be designed so that no subsequent trimming or machining operations are required. However, not all plastic materials can be injection molded successfully; for example, there is a limit to the amount and types of fibrous reinforcement that can be incorporated in an injection molded part. There are two basic categories of plastic injection molding: thermoplastic and thermoset. In the former, a thermoplastic material is melted and forced through an orifice, or "gate," into a relatively cool mold in which the material solidifies and from which it can then be removed. In thermoset injection molding, a reacting material is forced into a generally warm mold in which the material further polymerizes or cross-links into a solid part.

Ng Chuan Huat, Lim Bam Soon and Sulaiman Hassan have discussed about Today, the time to market for metal casting products is becoming shorter, thus the lead time available for making the wax injection mould is decreasing. There is potential for timesaving in the mould design stage. This paper presents the basic structure of an interactive knowledge based wax injection mould design system. The basic of this system arises from an analysis of the wax injection mould design process for mould design companies. This wax injection mould design system covers both the mould design process and mould base standardization. In this system, the graphic module and the knowledge based module for generating mould features are integrated within an interactive Mold Wizard platform, Unigraphics system. This ensures that both speeds up the wax injection mould design process, without the need to redesign the mould base layout. With this capability, metal casting product could be designed quickly, cheaply with quality and competitively.

MURALIDHAR LAKKANNA, RAVIKIRAN KADOLI , G C MOHAN KUMAR has defined that Plastic injection mould design methodology and criteria to configure sprue bush for augmenting functionality are briefly compiled. Hereto prevalent sprue conduit design criteria is systematically consolidated and its sensitivity to machine, moulding and material influences are quantitatively ghettoised as expansion ratio on the basis of ubiquitous empirical relationships. This generic, simple, inexpensive preventive criterion exemplifies sprue bush conduit geometry design to inject melt specifically for a particular combination. Further for design meticulousness its sensitivity is also briefly deliberated over a feasible range to achieve best performance.



Schematic Diagram of Plastic Injection molding

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