A CONCEPTUAL DESIGN OF PATTERN TO REPLACE INVESTMENT CASTING

M.RAGHUNATHA REDDY
HT No: 14TT1D1603
Branch: M-Tech, Production Engineering
College: Ellenki Engineering College , Siddipet
E-Mail: mraghunathr@gmail.com

G. VINOD REDDY
Dept.: Mechanical Engineering
Designation: Assitant Professor
College: Ellenki Engineering College , Siddipet
E-Mail: vinod.reddy315@gmail.com

ABSTRACT

This project represents the loose-piece and piece-wise pattern manufacturing process as a new conceptual design of pattern to replace precision investment casting process. An object was prepared using the loose-piece pattern process and compared with the precision investment casting process. The analysis of results indicates that the investment casting process is a very slow and more expensive process due to the involvement of large manual labour and also due to the loss of wax in the process. The investment casting process is limited by the size and mass of the casting. While the loose-piece pattern is a low cost process and also a less time consuming process as compared to the precision investment casting process. The precision investment casting process attains better surface finish than the loose-piece pattern process. Although the loose piece pattern process does not attain a better surface finish than the precision investment casting process; nowadays good quality grinding machines is available, hence using good quality grinding machines a better surface finish can be achieved in the loose-piece pattern process.

Keywords: - *Precision Investment Casting, Loose-Piece Pattern*

INTRODUCTION

Pouring molten metal into hollow cavities of desired shape and then allowing it to solidify is a manufacturing process that can be traced back thousands of years. The product from traditional method is usually rough product with simpler design. With increased complexity of the designs, the lost wax process was introduced to handle casting of complex shapes. The lost wax process, also called investment casting process employ a wax mould around which the ceramic shell is built. The wax is removed by burning the ceramic mould to get a net shape cavity inside ceramic mould. The molten metal in then poured into cavity to get complex shapes and designs. The investment casting process has been an important method to produce components for aero-industry since 50's. It offers excellent tolerances and surface finish with freedom of design for complex geometries.

With increasing demands of more intricate and light weight engineering components, especially in aerospace industry, complexity of manufacturing process is also raised. The global requirements on lower fuel consumption and emissions are increasing the demands in lowering weight of cast components. Ability to produce components in lower wall thickness will not only help to reduce the cost of production but also help to improve the efficiency of engineering systems resulting in lower fuel consumption and lesser environmental hazardous emissions. In order to investigate castability of alloys in thin-walled geometries, it is important to understand the mechanism behind fluidity. Fluidity as an empirical concept used by foundry men is ability of molten metal to flow and fill the details in the mould. Fluidity measurements are not directly reciprocal of viscosity and are not presented as unique property of certain alloy composition but largely depends on the test-piece used to measure the fluidity length. The conventional test for fluidity measurement uses a spiral cavity in sand mould. The molten metal is then poured into spiral cavity which flows into spiral and stops at some length due to the solidification. The fluidity length is then measured from pouring point to the solidification stop point. The fluidity of molten metals depends upon number of materials properties. Some of the important properties are listed below.

- Temperature
- Solidification mode
- Viscosity of melt
- Composition
- Rate of flow
- Thermal conductivity
- Heat of fusion
- Surface tension

LITERATURE REVIEW

Throwing is an assembling process by which a fluid material is normally put into a mold, which holds an empty pit of the sought shape, and afterward permitted to cement. The set part is otherwise called a throwing, which is launched out or thought outside the box to finish the procedure. Throwing materials are typically metals or different cool setting materials that cure in the wake of combining two or more parts; samples are epoxy, concrete, plaster and dirt. Throwing is regularly utilized for making complex shapes that might be generally troublesome or uneconomical to make by different systems. Casting is a 6000 year old process. The oldest surviving casting is a copper frog from 3200 BC.

DIFFERENT TYPES OF CASTING PROCESS:

1) Investment casting
2) Permanent mold casting
3) Centrifugal casting
4) Continuous casting
5) Sand casting

METHODOLOGY

Real world problems very often use traditional way for casting turbine blades i.e. by investment casting process. Which involve alots of issues like labour cost, working skill etc. So being the people of the modern era of science & technology we must always aim towards a economic way for designing the same. Eventually now a days we have a lots of computer operated machine & machine tools like CNC, DNC etc are available which we can use for the finishing, machining operation of the sand casting product. Taking all those issues in to consideration one should opt for designing the turbine blade in an alternative way which may leads to better accuracy and optimality.

Metal casting & its historical background

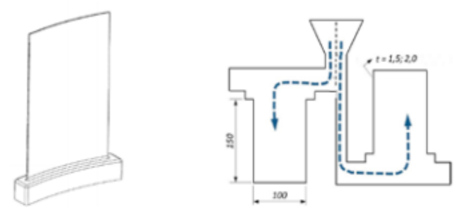
Metal Throwing is an assembling process by which a fluid material is typically put into a mold, which holds an empty depression of the sought shape, and after that permitted to set. The cemented part is otherwise called a throwing, which is catapulted or thought outside the box to finish the procedure.

Throwing materials are typically metals or different cool setting materials that cure in the wake of combining two or more segments; cases are epoxy, solid, mortar and dirt. Throwing is regularly utilized for making complex shapes that might be generally troublesome or uneconomical to make by different strategies.

Procedure for cast-ability study

To study the effects of casting parameters on cast-ability and quality of castings, geometries with two different thicknesses, i.e. 1.5 mm and 2 mm were assembled on both conventional top-gated and bottom-gated runner system. The test geometry used was a curved blade of 100 x 150 mm with a base of 120 x 20 x 20 mm. In order to establish a relationship between casting parameters and fluidity, a set of experiments was designed. The alloy used in this study was a aero-space grade of steel, 17-4PH. The reason to choose the 17-4PH was it's potential application in aero-space industry as a suitable alloy for many structural applications. The parameters studied were superheat, shell preheat temperature, thickness of test geometry and mode of filling. The selections of parameters were based on their significance on fillability and flowability as found in literature. To produce data for simulation work, the thermal properties of the ceramic shell and thermodynamic data for 17-4PH were also collected. Shell properties were measured in lab-scale experiments. For the alloy properties, however, commercial software JMatPro was used.

Geometry and gating system



(a) Casting geometry (b) Gating principle, top and bottom-gated runner system

Figure Illustrating sample test geometry and filling modes

The method used in the casting trials was a top-down pouring (top-gated filling), and bottom-up pouring (bottom-gated filling). The principle for the set-up is shown schematically in fig. The sprue used in tree design was 300 mm high with a diameter of 40 mm. The pouring cup attached to sprue was 125 mm high and 125/60 mm in diameter. The runners were 40x40 mm in cross-section. The gating was designed such that the entire cross-section of the base of blade was attached to the runners. No additional feeders were used. Test geometries were mounted on runner systems (trees) both in top-gated and bottom-gated configurations.

MOULD MANUFACTURING

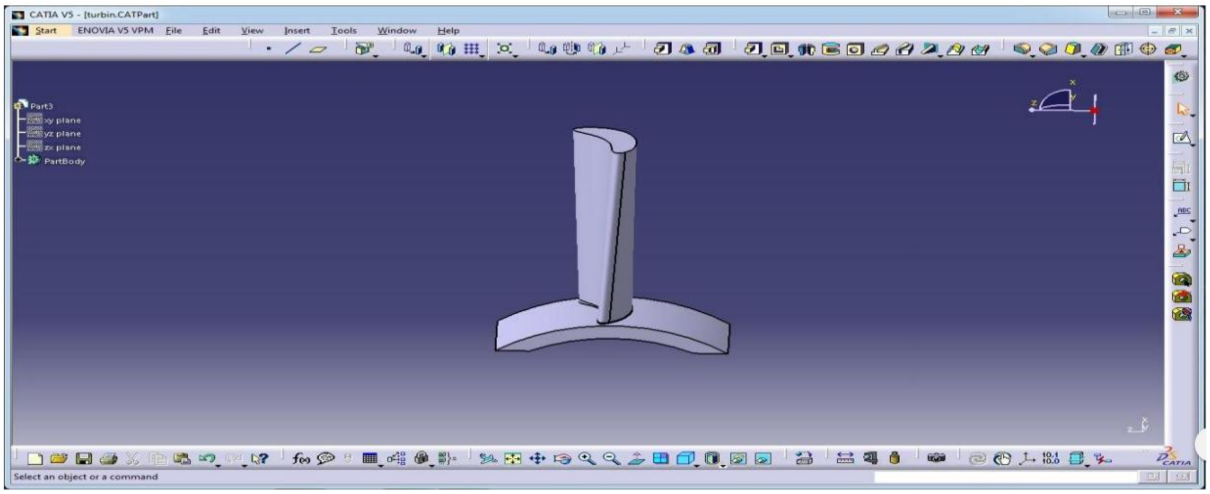
Ceramic moulds were produced, following standard foundry procedures, by continuously dipping and stuccoing the wax assemblies until the desired 6-8 mm thickness of the shell was achieved. For prime layers colloidal silica slurry was used with a 325-200 mesh zircon flour. Aluminum oxide, with a mesh size ranging from 90-54 was used to coat the slurry. For back up layers colloidal silica with a 200 mesh aluminum silicate slurry was used. Aluminum silicate with a 16-30 mesh was used for stuccoing the backup layers. After drying, shell were placed autoclave for de-waxing. In order to harden the shells, sintering was performed. The shells were preheated in a push through furnace for a minimum of two hours before castings.

EXPERIMENTAL PROCEDURE

Design of pattern

In order to design the specific shape of the product for this study several issues were considered. Some of these issues are as follows. First of all a preliminary issue is considered in CATIA software.

Though our prime job is to design the turbine blade, first I have analyzed the proper dimensions of a steam turbine blade using CATIA design software**.**



Conceptual alternative

As we have seen that the present technology for the casting of turbine blade i.e. Investment casting process has got lots of disadvantages so our objective is to minimize the obstacle by casting the same by the sand casting process. Though sand casting has also demerits like surface finish, but now a day due to the availability of CNC machine one can be able to further machine the component and provide proper shape and size. Hence we can think of some conceptually alternative way to cast the blade by sand casting, for which a fuse able pattern is required. We here in this project are going to find out those alternative pattern which can replace the problem with investment casting**.**

LOOSE-PIECE PATTERN:-

Loose piece pattern is the type of pattern used when the contour of the part is such that with-drawing the pattern from the mould is not possible. Hence during moulding, the obstructing part of the contour is held as a loose piece by a wire. After the moulding is over, first the main pattern is removed and then the loose pieces are recovered through the gap generated by the main pattern. In most of the cases, small projections or overhanging portions are found in this type of casting. These portions or projections make it difficult in withdrawing the pattern. Hence these portions or projections are made as the loose pieces. The loose pieces i.e, the portions or the projections are attached loosely to main part of pattern. A pattern is different from the casting; even though the pattern resembles the casting to be produced. A pattern is different from casting in regarding to the terms of the certain allowances which are required in producing correct dimensions and the correct shapes and also in eliminating the minor details that are too small or complicated in order to be produced. Complexity of the casting along with the shape of the casting, casting material, the pattern, etc depends on the design of the pattern . Some of the castings requiring patterns that have parts with the back draft in a way such that it cannot be produced into the split patterns. In these kind of patterns parts containing the back draft are produced into loose pieces which can be removed separately from mould after main pattern has been removed. Loose pieces are held initially , during moulding ,in a place with the help of the slides or with the help of the pins . When the main body is withdrawn in vertical direction, loose pieces are left inside the mould . Then the loose pieces are withdrawn sideways and then pulled up through the cavity which the main piece makes up. The loose piece patterns are of a low pattern cost and hence have the advantage over other patterns. But normally the loose piece pattern takes longer time in moulding as compared with other patterns.

OBJECTIVE: - The objective is to manufacture the compressor blade by sand casting i.e., by loose piece pattern.

PROCEDURE:-A wooden piece of 90*60*30 mm was taken and using the carpentry tools , the shape of the compressor blade was made that is of :- main or middle part (50*40*30) mm Blades (20*10*15) mm Now the compressor blade was manufactured by sand casting method i.e., by loose piece pattern process . The blades were held by a loose piece by a wire and were connected using cope and drag.

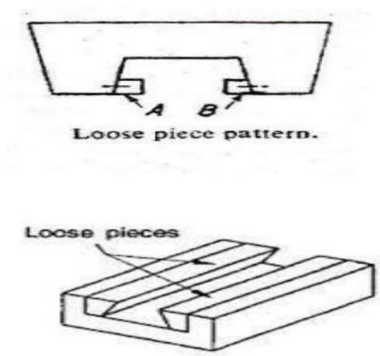
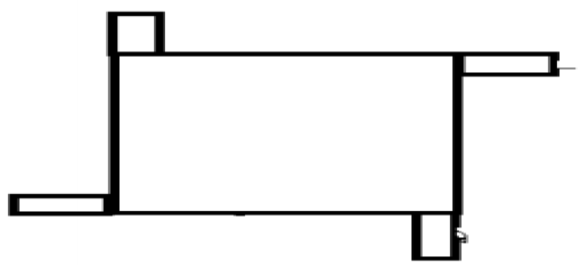


FIG :- loose pieces of pattern



2D VIEW OF AN COMPRESSOR BLADE
Whose main part is of 50*40*30 mm and the blades are of 20*10*15 mm

After moulding was over first the main pattern was removed and then the blade part was recovered through the gap generated by the main pattern. 17 Thus the mould was prepared and was ready for pouring of molten metal into it. Thus the compressor blade was prepared by sand casting method i.e., by loose piece pattern method.

RESULT

1. Loose piece Pattern method is not an Expensive process

2. Investment casting is limited by the mass of the casting
3. Investment casting is a slow process .
4. Also the investment casting is limited by size of casting .

CONCLUSION:-

The analysis of results indicates that the investment casting process is a very slow and more expensive process due to the involvement of large manual labour and also due to the wax lost in the process . The investment casting process is also limited by the size and mass of the casting . While the loose-piece pattern is a low cost process and also a less time consuming process as compared to the precision investment casting process . The precision investment casting process attains better surface finish than the loose-piece pattern process . Although the loose-piece pattern process does not attain a better surface finish than the precision investment casting process ; nowadays good quality grinding machines are available , hence using good quality grinding machines a better surface finish can be achieved in the loose-piece pattern process. Also the work i.e. to conceptually design the casting patteren has been completed by taking all those issue into consideration. Also choosing the best alternative among all those concept. Finally the lost foam type casting method has been given the highest priority. The pattern material used is foam so there is no need for the arrangement of avoiding the mould breakage during pattern withdrawal. Since foam melts under that temperature of moten metal so no need to withdraw it from the mould flask. Advantages of foam casting:-

i) High surface finish
ii) Low labour cost i
iii) Complex jobs can be easily manufactured
iv) No problem for withdrawal of patteren
v) Cheaply available

REFERENCES

BOOKS

1. "Production technology", HMT publication.
2. "Elements of workshop technology", S K Hajra Choudhury, S K Bose, A K Hajrachoudhury, Niranjan Roy, Vol-II, Media promoters and media publications.
4. Production technology by P.C. Sharma' S. Chand publication
5."Manufacturing technology", by RAJIESH
6. "Manufacturing technology advanced", by Gesch

WEBSITES

[1]http://en.wikipedia.org/wiki/sand casting
[2] http:// sciencedirect.com/casting/pattern design
[3] http:// www.scopus.com
[4]http://en.wikipedia.org/wiki/lostfoamcasting
[5] http://en.wikipedia.org/wiki/investment casting
http://cdn.intechopen.com/pdfs-wm/39309.pdf