CONCEPTUAL DESIGN OF CASTING PATTERN

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF

Bachelor of Technology

In

Mechanical Engineering

By

RAJAT KUMAR NAHAK

Department of Mechanical Engineering

National Institute of Technology,Rourkela-769008

2014

CONCEPTUAL DESIGN OF CASTING PATTEREN

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF

Bachelor of Technology

In

Mechanical Engineering

By

RAJAT KUMAR NAHAK

Under the Supervision of

PROF. S. K. SAHOO

Department of Mechanical Engineering

National Institute of Technology, Rourkela-769008

National Institute of Technology

Rourkela

CERTIFICATE

This is to certify that the thesis entitled **" Conceptual design of casting patter"** Submitted by **Rajat Kumar Nahak, Roll No: 110ME0313** in the partial fulfillment of the requirement for the award of degree of **Bachelor of Technology** in **Mechanical Engineering**, National Institute of Technology, Rourkela , is being carried out under my supervision.

To the best of my knowledge the matter embodied in the thesis has not been submitted to any other university/institute for the award of any degree or diploma.

Prof. S. K. Sahoo

Date: Department of Mechanical Engineering

National Institute of Technology

Rourkela-769008

ACKNOWLEDGEMENTS

I take the opportunity to express my reverence to my supervisors **Prof. S.K. Sahoo**for his guidance, inspiration and innovative technical discussions all during the course of this work.

I find words inadequate to thank him for enabling me to complete this work in spite of obstacles.

I am also thankful to all faculty members and research students of Mechanical Department, **NIT Rourkela**. Special thanks goes to **Dr. S.K. Patel**,**Dr. S.K.Behera** and **Dr. S.K. Panda** for their constructive criticism and motivation during the course of my work.

We also express our sincere gratitude to **Dr. K.P. Maity**, Head of the Department,Mechanical Engineering, for providing valuable departmental facilities.

I find words inadequate to express any form of acknowledgement to my grandmother who has been an emblem of blessings in all my steps of life.

Submitted by:

Rajat Kumar Nahak

Roll No: 110ME0313

Department Of Mechanical Engineering

National Institute of Technology,

Rourkela-8

INDIA

Dedicated to my Grand Parents “BENU & MADHI”

TABLE OF CONTENTS

LIST OF TABLES & FIGURES

ABSTRACT

The present trend of design for turbine blade is basically done by investment casting process, which incurs a lots of disadvantages like labour cost, Working skill, machining cost etc. Hence in order to overcome these problems our main objective is to cast the same blade with an conceptuallyalternative valid design. So this may reduce all the problem associated with the ongoing process.

Moreover since now a days we people have a lots of advanced and modernized machine tools like CNC, DNC, Automated lathe etc which can take care for all the machining process after the job has been casted by say sand casting process and hence reduce surface roughness etc.

So overall we can design a number of conceptually alternate ways for casting process of the turbine blade. But after having all those alternatives we need to select the best suitable alternative among them. Then we go for casting of the blade.

KEYWORDS: Design; Analysis; Gas Turbine Blade; CNC

Chapter 1. INTRODUCTION

1.1 Motivation

Real world problems very often uses traditional way for casting turbine blades i.e. by investment casting process. Which involve a lots 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.

1.2 Scope of the thesis

This thesis was born out of the need to design and fabricate a turbine blade in a different way to meet the need of present era.

1. To decide the shortcoming associated with the various method of casting
2. To find out the proper dimension of the pattern material
3. To decide various alternative ways for designing the same
4. Finally design and fabricating the blade with the best suited alternative

1.3 Metal casting & its historical background[Ref.1]

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.

Chapter 2. Literature survey

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]

1)Investment casting

2)Permanent mold casting

3)Centrifugal casting

4)Continuous casting

5)Sand casting

Investment casting

Venture giving (referred to a role as lost-wax throwing in craft) is a process that has been polished for many years, with lost wax procedure being one of the most seasoned known metal framing strategies. From 5000 years prior, when bumblebees wax shaped the example, to today's high innovation waxes, unmanageable materials and pro combinations, the castings guarantee top notch segments are handled with the key profits of precision, repeatability, adaptability and uprightness.

Speculation throwing determines its name from the way that the example is contributed, or encompassed, with a hard-headed material. The wax examples oblige amazing administer to they are not solid enough to withstand powers experienced throughout the mold making. One playing point of venture throwing it that the wax could be reused.

The methodology is suitable for repeatable generation of net shape parts, from an assortment of diverse metals and superior amalgams. Despite the fact that for the most part utilized for little castings, this procedure has been utilized to generate complete airplane entryway outlines, with steel castings of up to 300 kg and aluminum castings of up to 30 kg. Contrasted with other giving courses of action such a role as pass on throwing or sand throwing it could be an exorbitant procedure, however the parts that might be transformed utilizing financing throwing can consolidate multifaceted forms, and much of the time the segments are thrown close net shape, so obliging practically no revamp once cast.

Permanent mold casting

Changeless mold throwing (regularly for non-ferrous metals) obliges a set-up time on the request of weeks to set up a steel instrument, after which processing rates of 5-50 pieces/hr-mold are attained with an upper mass point of confinement of 9 kg for every iron amalgam thing (cf., up to 135 kg for some nonferrous metal parts) and a more level cutoff of about 0.1 kg. Steel pits are covered with an obstinate wash of acetylene residue before transforming to permit simple evacuation of the workpiece and advertise longer instrument life. Changeless molds have a

constrained life before wearing out. Worn molds oblige either revamping or replacement.cast parts from a perpetual form by and large show 20% expansion in rigidity and 30% increment in lengthening as contrasted with the results of sand throwing.

The main vital info is the covering connected normally. Normally, perpetual mold throwing is utilized within framing iron, aluminum, magnesium, and copper based amalgams. The procedure is exceptionally robotized.

Sub-types of permanent mold casting

1.Gravity Die Casting.

2.Low pressure die casting.(LPDC)

3.High pressure die casting.(PDC)

Centrifugal casting

Diffusive throwing is both gravity- and weight-free since it makes its constrain food utilizing a makeshift sand mold held in a turning chamber at up to 900 N (90 g). Lead time changes with the requisition. Semi- and genuine-diffusive transforming allow 30-50 pieces/hr-mold to be generated, with a useful point of confinement for clump preparing of roughly 9000 kg aggregate mass with an average for every-thing utmost of 2.3-4.5 kg.

Mechanically, the radial throwing of track wheels was an early provision of the strategy created by German mechanical organization Krupp and this capacity empowered the quick development of the undertaking.

Continuous casting

Consistent throwing is a refinement of the throwing procedure for the nonstop, high-volume handling of metal segments with a steady cross-area. Liquid metal is put into an open-finished, water-cooled copper mold, which permits a "skin" of strong metal to structure over the still-fluid focus. The strand, as it is presently called, is withdrawn from the mold and passed into achamber of rollers and water splashes; the rollers help the slim skin of the strand while the showers uproot heat from the strand, progressively hardening the strand from the outside in. After cementing, decided beforehand lengths of the strand are cut off by either mechanical shears or voyaging oxyacetylene lights and exchanged to further framing techniques, or to a stockpile. Cast sizes can extend from strip (a couple of millimeters thick by something like five meters wide) to billets (90 to 160 mm square) to sections (1.25 m wide by 230 mm thick). Once in a while, the strand may experience an introductory hot moving process before being cut.

Constant throwing is utilized because of the easier expenses connected with consistent generation of a standard item, and likewise builds the nature of the last item. Metals, for example, steel, copper and aluminum are ceaselessly thrown, with steel being the metal with the best tonnages cast utilizing this technique.

Sand casting

Sand throwing is a standout amongst the most mainstream and easiest sorts of throwing that has been utilized for a long time. Sand throwing takes into consideration more modest clusters to be made contrasted with lasting mold throwing and an extremely sensible expense. Not just does this strategy consider producers to make items for a great cost there are different profits to sand giving such a role as there are next to no size operations. From castings that fit in the palm of your hand to prepare cots (one throwing can make the whole couch for one rail auto) it is possible with sand throwing. Sand throwing additionally takes into consideration most metals to be thrown depending in the kind of sand utilized for the molds.

Sand throwing obliges a lead time of days for processing at high yield rates (1-20 pieces/hr-mold), and is unsurpassed for expansive-part creation. Green (soggy) sand has very nearly no part weight limit, while dry sand has a down to earth part mass utmost of 2300-2700 kg. Least part weight ranges from 0.075-0.1 kg. The sand is fortified together utilizing muds (as within green sand) or synthetic folios, or polymerized oils, (for example, engine oil.) Sand in most operations might be reused ordinarily and obliges minimal extra include.

Sand throwing, otherwise called sand formed throwing, is a metal throwing methodology portrayed by utilizing sand as the mold material. The expression "sand throwing" can likewise allude to an article handled through the sand throwing procedure. Sand castings are handled in particular processing plants called foundries. In excess of 70% of all metal castings are prepared through a sand throwing methodology.

Sand throwing is moderately shoddy and sufficiently unmanageable actually for steel foundry utilization. Notwithstanding the sand, a suitable holding operator (generally dirt) is blended or happens with the sand. The mixture is saturated, ordinarily with water, however frequently with different substances, to create quality and versatility of the mud and to make the total suitable for embellishment. The sand is commonly held in an arrangement of edges or mold boxes known as a cup. The mold pits and door framework are made by compacting the sand around models, or designs, or cut specifically into the sand.

Sand throwing obliges a lead time of days for processing at high yield rates (1-20 pieces/hr-mold), and is unsurpassed for substantial-part creation. Green (wet) sand has just about no part weight limit, while dry sand has a handy part mass breaking point of 2300-2700 kg. Least part weight ranges from 0.075-0.1 kg. The sand is reinforced together utilizing dirts (as within green sand) or concoction fasteners, or polymerized oils, (for example, engine oil.) Sand in most operations might be reused ordinarily and obliges minimal extra enter.

Sand throwing, otherwise called sand shaped throwing, is a metal throwing procedure described by utilizing sand as the mold material. The expression "sand throwing" can likewise allude to an item transformed by means of the sand throwing methodology. Sand castings are transformed in specific industrial facilities called foundries. In excess of 70% of all metal castings are processed by means of a sand throwing procedure.

Sand throwing is moderately modest and sufficiently hard-headed actually for steel foundry utilization. Notwithstanding the sand, a suitable holding operator (generally dirt) is blended or happens with the sand. The mixture is saturated, commonly with water, however some of the

time with different substances, to create quality and versatility of the earth and to make the total suitable for trim. The sand is normally held in an arrangement of casings or mold boxes known as a cup. The mold depressions and door framework are made by compacting the sand around models, or designs, or cut specifically into the sand.

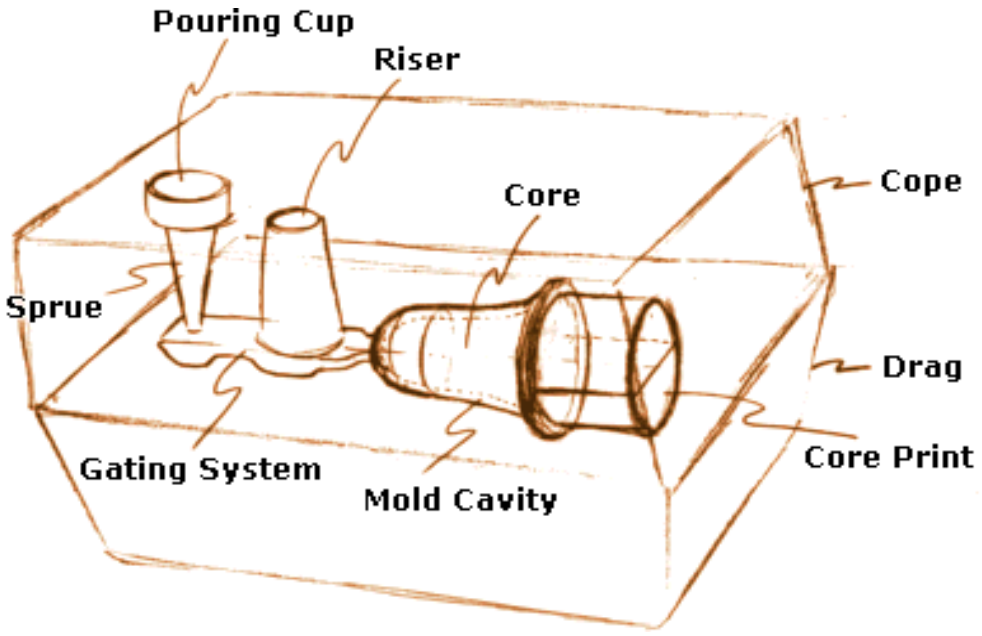


Fig-1 Typical Components of a Two-part Sand Casting Mold.Refer[1]

Chapter 3 .Casting technique

3.1 Sand casting process[1]

Sand throwing is a standout amongst the most prominent and easiest sorts of throwing that has been utilized for a long time. Sand throwing considers more modest groups to be made contrasted with lasting mold throwing and an exceptionally sensible expense. Not just does this strategy take into consideration makers to make items for a great cost there are different profits to sand giving such a role as there are next to no size operations. From castings that fit in the palm of your hand to prepare cots (one throwing can make the whole couch for one rail auto) it is possible with sand throwing. Sand throwing additionally considers most metals to be thrown depending in the kind of sand utilized for the molds.[2]

Sand throwing obliges a lead time of days for preparation at high yield rates (1-20 pieces/hr-mold), and is unsurpassed for extensive-part handling. Green (wet) sand has just about no part weight limit, though dry sand has a handy part mass cutoff of 2300-2700 kg. Least part weight ranges from 0.075-0.1 kg. The sand is reinforced together

utilizing dirts (as within green sand) or substance fasteners, or polymerized oils, (for example, engine oil.) Sand in most operations could be reused commonly and obliges minimal extra enter.

Sand throwing, otherwise called sand shaped throwing, is a metal throwing methodology portrayed by utilizing sand as the mold material. The expression "sand throwing" can additionally allude to an article generated through the sand throwing procedure. Sand castings are transformed in particular plants called foundries. In excess of 70% of all metal castings are processed through a sand throwing methodology.

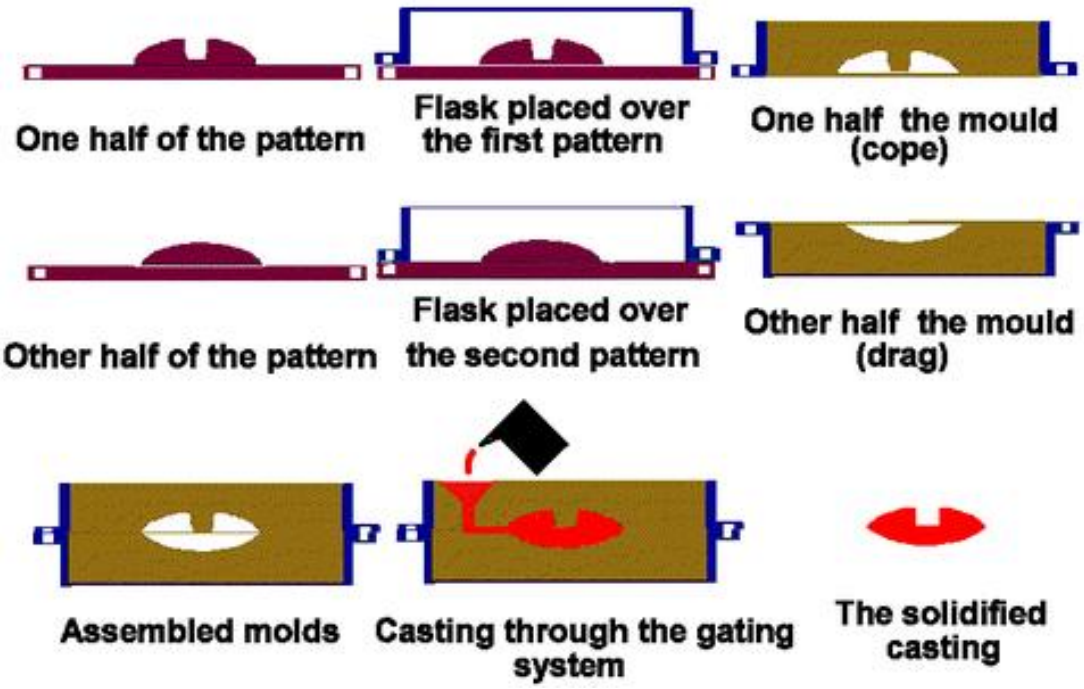
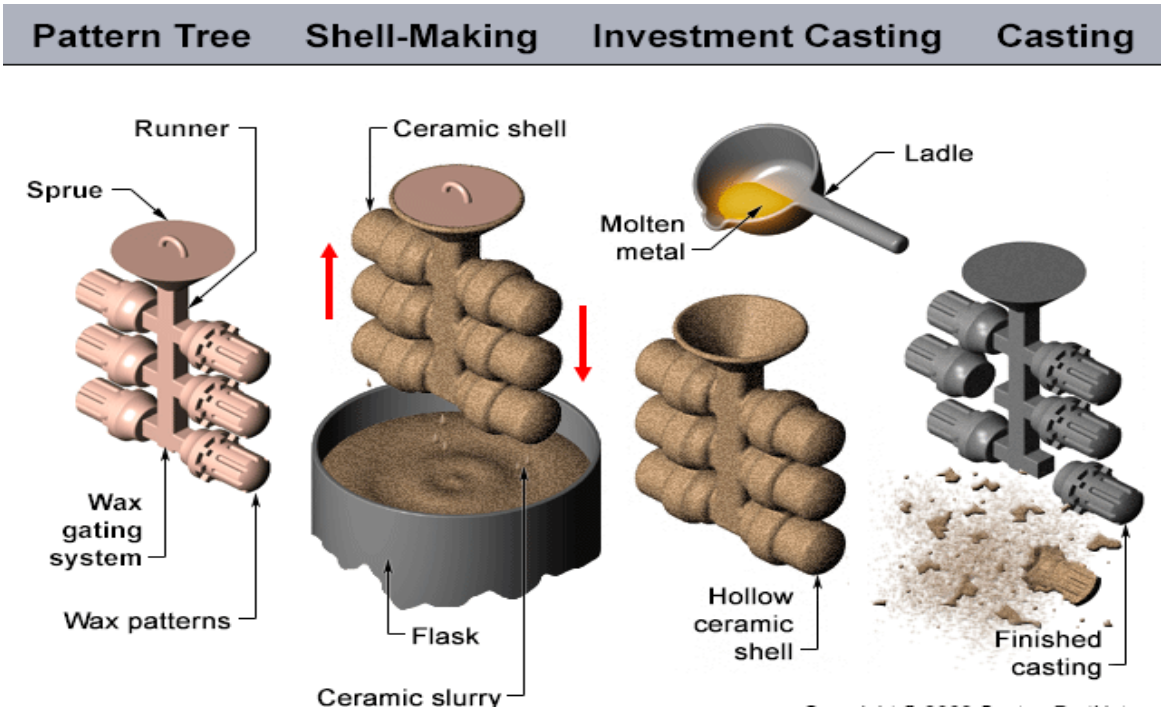


Fig-2 Sand casting process flow chart Refer [1]

3.2 Investment casting process[5]

Venture throwing is a modern procedure focused around and likewise called lost-wax throwing, one of the most established known metal-framing systems from 5,000 years back, when beeswax shaped the example, to today's high-engineering waxes, hard-headed materials and master composites, the castings permit the creation of parts with precision repeatability, flexibility and uprightness in a mixture of metals and superior-amalgams.

The methodology is by and large utilized for little castings, yet has been utilized to generate complete flying machine entryway casings, steel castings of up to 300 kg (660 lbs) and aluminum castings of up to 30 kg (66 lbs). It is by and large more exorbitant for every unit than pass on throwing or sand throwing, however has easier gear costs. It can handle convoluted shapes that might be troublesome or unimaginable with bite the dust throwing, yet like that process, it obliges minimal surface completing and just minor machining. The itemized work stream in venture throwing is indicated underneath in the fig-3 appended beneath.



(Fig-3 Investment casting process flow chart)

3.3 Advantages & disadvantages of casting methods

The following tables-1show the advantages & disadvantage of sand casting process.

Sand casting[1]

Table-1

Advantages	Disadvantages
1) Low capital investment means that short production runs are viable; 2) Use of sand cores allows fairly complex shapes to be cast; 3) Large components can be produced; 4) Suitable for small batch production(small production rates 5) The method of casting is quite simple so an unskilled worker can also perform the job.	1) Bad surface finish, due to sand indentation and oxidizing medium etc. 2) Not suitable for mass production, often used to produce few number of products compared with other casting proccesses which produce thousands and millions

Investment casting[5]

The following tables-2 show the advantages & disadvantage of Investment casting

Table-2

Advantages	Disadvantages
• Many Intricate forms with undercuts can be cast. • A very smooth surface is obtained with no parting line. • Dimensional accuracy is good. • Certain unmachinable parts can be cast to preplanned shape. • It may be used to replace die-casting where short runs are involved.	❖ This process is expensive, is usually limited to small casting, and presents some difficulties where cores are involved. ❖ Holes cannot be smaller than 1/16 in. (1.6mm) and should be no deeper than about 1.5 times the diameter ❖ Investment castings require very long production-cycle times versus other casting processes. ❖ This process is practically infeasible for high-volume manufacturing, due to its high cost and long cycle times. ❖ Many of the advantages of the investment casting process can be achieved through other casting techniques if principles of thermal design and control are applied appropriately to existing processes that do not involve the shortcomings of investment cast.

Chapter 4 .Objective of present work

The objective of the project is to design the blades of a single stage high pressure & high temperature steam turbine in a very conceptual way which may not look like as the actual prototype but it should be designed in such a way that it will satisfy all the necessary mechanical strength, surface finish & defect free criterions.

Hence now work objective is to design the same by sand casting process, though it can't provide that level of surface finish but we can go for further machining of the casting by CNC machining which can give most accurate dimension.

Now the design of the blade pattern can be thought of conceptually as a number of methods like

1) Lost foam casting

2) Brick piece pattern casting

3) Loose piece pattern casting

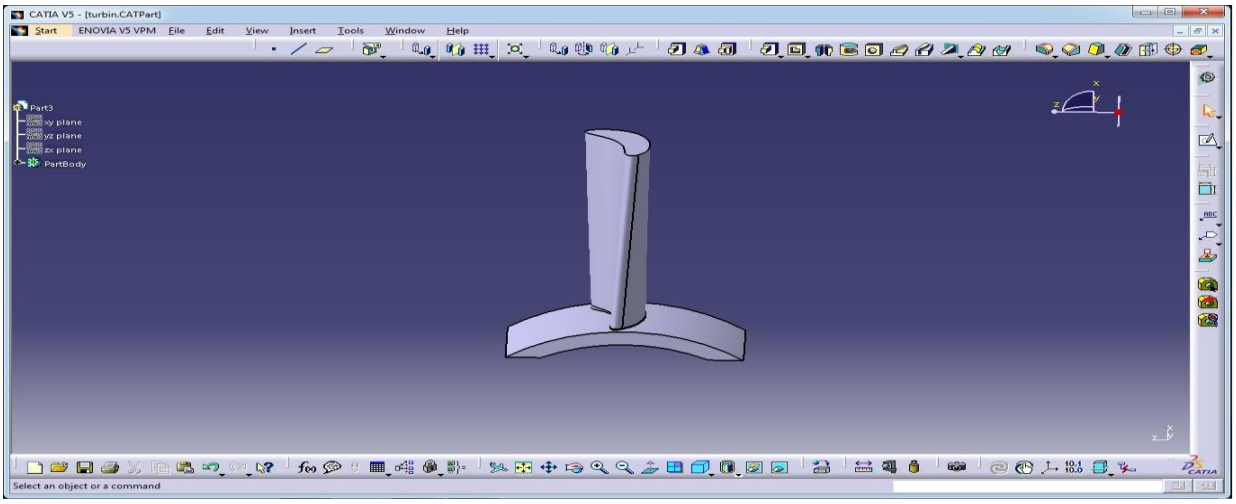
4) Rubber bladder type pattern casting

Chapter 5 .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.

Design:[2]

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.



Chapter 6 .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.

- These alternative design are fully conceptual.

CONCEPT-1……. Lost-foam pattern

CONCEPT-2……. Loose piece pattern

CONCEPT-3……. Rubber bladder pattern

CONCEPT-4……. Brick piece pattern

Chapter 7. Comparative study

Table- 3 comparative analysis

CONCEPTS	Strength	Cost	Surface finish	Rigidity	Feasibility
Lost-foam pattern	High	Low	High	High	Yes
Loose piece pattern	Medium	High	Medium	Medium	No
Rubber bladder pattern	Low	Medium	High	Low	No
Brick piece pattern	Medium	High	Low	Low	No

Weighted average method for prioritization:

Lets consider the following weights given to the various parameter in the determination of suitability. This has been explained below and shown in table-3.

W_1 = Weight given to strength — X1= Importance of strength in overall design

W_2= Weight given to cost — X2 = Importance of cost in overall design

W_3= Weight given to surface finish — X3= Importance of surface finish in overall design

W_4= Weight given to rigidity — X4 = Importance of rigidity in overall design

Weighted average = $\frac{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}{}$

Analytical study:

Analytical study reveals that the concept 1 will be the best alternatives among these four concepts. Hence our objective is to manufacture the turbine blade according to the **"Lost foam casting method".**

Concept-1 (LOST-FOAM PATTERN)[4]

Lost foam casting (LFC) is a type of investment casting process that uses foam patterns as a mold. The method takes advantage of the properties of foam to simply and inexpensively create castings that would be difficult to achieve using other casting techniques.

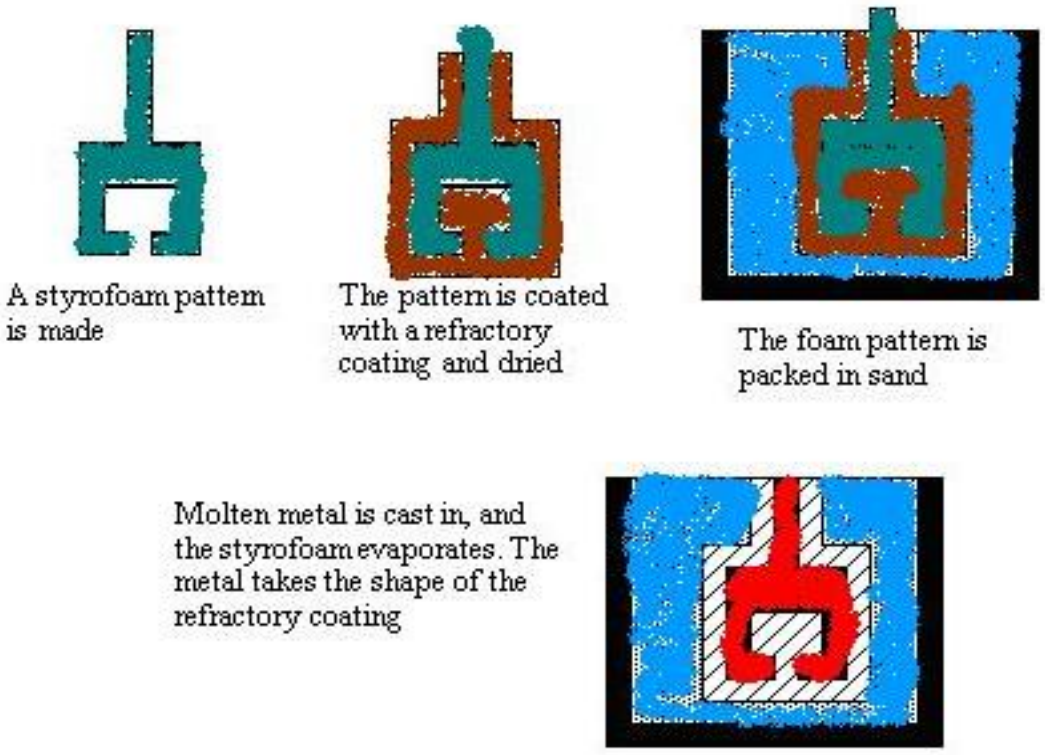


Fig-4Lost foam pattern casting flow chat

Lost foam casting:

In this method of casting the main advantage is that all kind of complex and intricate shapes can be easily casted without any problem of mould breakage during the withdrawal of the patteren from the mould flask.

In the fig 4 the various steps that involved in lost foam casting are shown. Here the patteren is not removed from the mould and it also provide better surface finish.

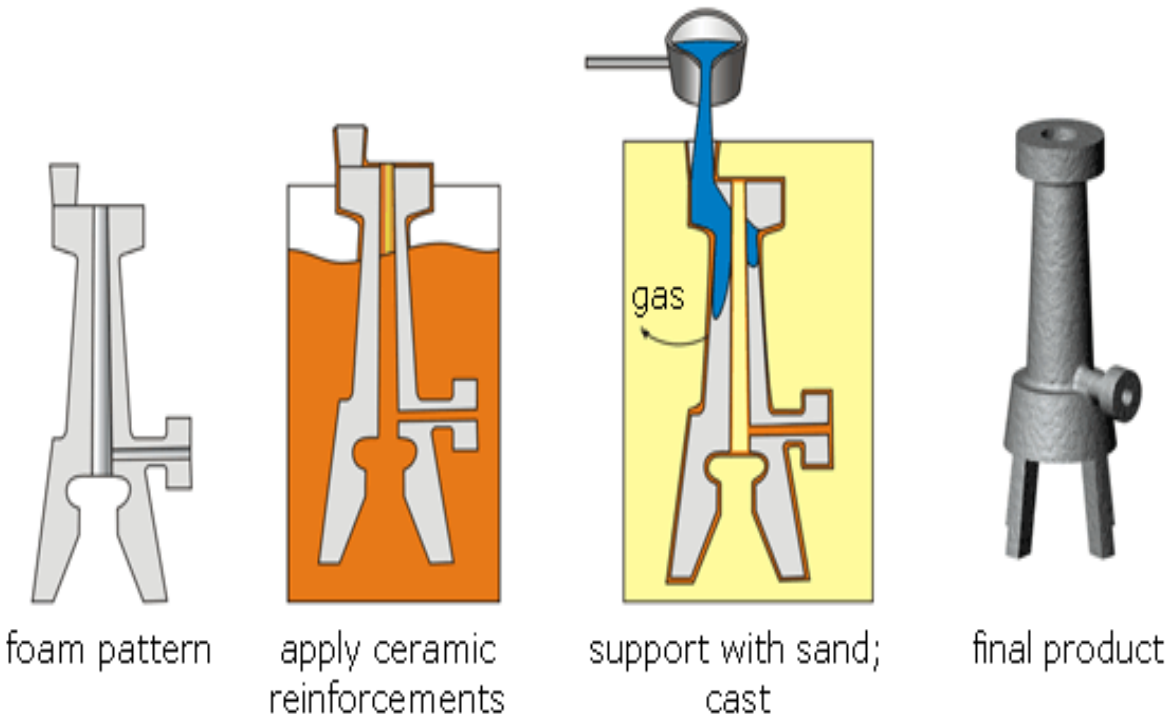


Fig-4Lost foam pattern casting flow chat contd.

- Lost foam, is similar to Investment or Lost wax, in that the medium, or pattern device, is Expendable, they melt or evaporate away, leaving the cast part.
- They both have advantages, for the type of function they were designed. One Process's advantage, could be the other Process's weak area.

Chapter 8. Design & Fabrication

In order to design the specific shape of the product for this study several types of concepts were considered. Some of the key concepts considered for the design of shape of the product are as follows: (a) complexity of the shape for the easy removal of the wax pattern from the mould; (b) complexity of features, which can distort the shape easily; (c) should have both constrained and unconstrained dimensions so that the variation between soft and hard tooling can be compared. (e) The mehod of casting. By considering all these issues an shape as shown in Fig.5is selected, since it satisfies most of the criterion discussed earlier. Investment casting is classified as a precision casting process.

Including that also the method of casting that we select is the “Lost foam casting”. So the design of such casing has been prepared as shown in fig-6

Fig-5Lost foam casting pattern, top view

Fig-6Lost foam casting pattern, side view

Chapter 9. CONCLUSIONS

Hence the objective of 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

iii) Complex jobs can be easily manufactured

iv) No problem for withdrawal of patteren

v) Cheaply available

Chapter 10. Reference

LIST OF 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.

3. THE DESIGN AND ANALYSIS OF GAS TURBINE BLADE.John.V 1, T. Ramakrishna

Research paper

4. Production technology by P.C. Sharma’ S. Chand publication

WEBSITES

[1] http://en.wikipedia.org/wiki/sand casting

[2] http:// sciencedirect.com/casting/patteren design

[3] http:// www.scopus.com

[4] http://en.wikipedia.org/wiki/lost foam casting

[5] http://en.wikipedia.org/wiki/investment casting