3D SOLID MODELING OF SCREW AND SCROLL COMPRESSOR INCLUDING ANIMATION

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
in
Mechanical Engineering

By

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&
MANISH SONI

Department of Mechanical Engineering
National Institute of Technology
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Under the Guidance of

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2007

National Institute of Technology
Rourkela

CERTIFICATE

This is to certify that the thesis entitled, "3-D Solid Modeling of screw and scroll compressors including animation" submitted by Mr.Kishore Chandrasekhar Patnaik & Mr. Manish Soni in partial fulfillments for the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by them under my supervision and guidance.

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.

Date:

Prof. Sunil Kr. Sarangi
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Kishore Chandrasekhar Patnaik Manish Soni

30th April 2007

CONTENTS

ABSTRACT

The objective of the work is to do solid modeling of the screw and the scroll compressors using 3-D solid modeling software. Screw compressor rotors are available in various profiles out of which "N" profile with 3/5 configurations is taken for the modeling and fabrication purpose.

Scroll compressor consists of spiral vanes out of which one remains stationary and the other one wobbles around an axis so as to create a continuously decreasing volume between the two vanes. Solid modeling of screw and scroll compressors is achieved using the modeling software Autodesk Inventor Professional 11. The output of the software modeling is stored in various file formats out of which *.stl (STEREO LITHOGRAPHY) format is transferred to the Rapid Prototyping machine Z-Print 310 plus available at Department of Mechanical Engineering, NIT Rourkela . Then the rotors were fabricated using rapid prototyping technology which were afterwards planned to cast in metal. When conventional methods of preparing moulds did not work, rapid prototyping was again used to make moulds. Solid modeling of moulds was done to create a cavity of rotor's shape in a cylindrical mould of adequate wall thickness.

The material used in rapid prototyping was a starch based substrate, judging that molten metal would cause catastrophic damage to the mould, casting was first done in epoxy. The casting was strong as well as true to the intended shape. We then proceeded to test whether the material would resist the high temperature during pouring of molten aluminium. This was checked by casting in a test mould of only a tenth of the length of actual rotor with diameter and other aspects remaining the same.

One more dimension was added to the experimental work with the qualitative analysis of the powder being used for rapid prototyping. So we ran particle size tests of the rapid prototyping powder, followed by a similar test of two more starch containing powders i.e. Corn flour and Wheat flour. The crystalline additives in the rapid prototyping powder were analyzed to be anhydrous calcium sulphate and partially hydrated calcium sulphate.

List of Figures | Page No.

List of Tables Page No

Chapter 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Screw and Scroll compressors have found a wide range of applications in the modern day industrial scene. Rotary screw compressors are widely used today in industrial refrigeration for compression of ammonia and other refrigerating gases. Industrial applications include handling fuel/waste gases & petrochemical gases.

Scroll compressors have taken over as the next generation of compressors for air-conditioning systems. The volumetric efficiency of scroll compressors is very high as compared to other compressors. These devices have a huge advantage in terms of compactness, reliability and smoothness of operation.

1.2 SCREW COMPRESSORS

A screw compressor is a rotary type positive displacement mechanism. The mechanism for gas compression utilizes either a single screw element or two counter rotating intermeshed helical screw elements housed within a specially shaped chamber. As the mechanism rotates, the meshing and rotation of the two helical rotors produces a series of volume-reducing cavities. Gas is drawn in through an inlet port in the casing, captured in a cavity, compressed as the cavity reduces in volume, and then discharged through another port in the casing. They are mounted on bearings to fix their position in a rotor housing which holds the rotors in close tolerance.

Screw compressors are mainly of two types:-

1.2.1 OIL-FLOODED SCREW COMPRESSORS

In an oil-flooded rotary screw compressor, oil is injected into the compression cavities to aid sealing and provide cooling sink for the gas charge. The oil is separated from the discharge stream, then cooled, filtered and recycled. Standard oil-flooded compressors are capable of achieving output pressures over 200 psig, and output volumes of over 1500 cubic feet per minute (measured at 60 °C and atmospheric pressure)

1.2.2 OIL-FREE SCREW COMPRESSORS

In an oil-free compressor, the air is compressed entirely through the action of the screws, without the assistance of an oil seal. They usually have lower maximum discharge pressure capability as a result. However, multi-stage oil-free compressors, where the air is compressed by several sets of screws, can achieve pressures of over 150 psig, and output volume of over 2000 cubic feet per minute (measured at 60 °C and atmospheric pressure).Oil-free compressors are used in applications where entrained oil carry-over is not acceptable, such as medicial research and semiconductor manufacturing.

1.3 SCROLL COMPRESSORS

A scroll compressor, also known as scroll pump and scroll vacuum pump, uses two spiral-like vanes to pump or compress fluids such as liquids and gases. The vane geometry may be involute, Archimedean spiral, or hybrid curves. Often, one of the scrolls is fixed, while the other orbits eccentrically without rotating, thereby trapping and pumping or compressing pockets of fluid between the scrolls. These devices are known for operating more smoothly, quietly, and reliably than conventional compressors in some applications. The scroll's gas processes are more continuous. The more steady flow yields lower gas pulsations, lower sound, lower vibration, and more efficient flow. And the air-conditioning scroll does not have dynamic valves, gaining flow efficiency and reduced sound versus other compressors.

1.4 SOLID MODELING

Solid Modeling has emerged as a superb tool for component design, especially when there is added value in linking geometry to various forms of structure, thermal, kinematic, dynamic and ergonomic analysis, etc. It is more important that Solid Modeling can be used as a powerful tool to bridge the gap between the designer and the manufacturing engineers.

The first step in solid modeling is to collect information regarding the design requirements of the part. In the second stage a Constructive Solid Geometry (CSG) solid model is to be created. For this purpose we used Autodesk Inventor Professional 11.

1.5 COURSE OF THE PROJECT WORK

1. Tracing of screw compressor rotor profile

   The solid modeling of the screw compressors involves an examination of the profiles. The profile chosen by us is the rack-generated N-profile, with male rotor having 3 lobes and the female rotor having 5 lobes.

2. 3D solid modeling using Autodesk Inventor Professional 11

   The traced profile was then extruded along a helical path with a specified wrap angle over a given length. The flute thus obtained was copied to cover the entire circumference in order to achieve the desired no. of lobes.

3. Assembly of the rotors was done in the assembly work bench of Autodesk Inventor to ensure that the two rotors meshed properly.

4. Preparing a prototype by Rapid Prototyping

   Rapid prototyping was used to obtain prototypes of the modeled rotors. The completed rotors gave us an idea of the shape of the moulds we would prepare in the next step
5. Preparing the mould for casting

6. Rapid prototyping of the mould

   Rapid prototyping of the moulds was done with provision to place a shaft as core, while casting. The mould and mould cap were designed to allow easy pouring, during casting.

7. Casting of the rotors

   The rotors were cast in epoxy resin, and later a test mould was prepared to check viability of casting with aluminium.

8. Analysis of Rapid prototyping powder

9. Solid Modeling and Animation of Scroll Compressor rotors.

Chapter 2

LITERATURE REVIEW

2.1 SCREW COMPRESSOR CONSTRUCTION AND WORKING

2.2 PROFILE OF SCREW COMPRESSOR ROTOR

2.3 WORKING OF A SCROLL COMPRESSOR

2.4 SCROLL COMPRESSOR VANE PROFILE

2.1 SCREW COMPRESSOR CONSTRUCTION AND WORKING

2.1.1 CONSTRUCTION

A typical oil flooded twin screw compressor consists of male and female rotors mounted on bearings to fix their position in a rotor housing which holds the rotors in closely toleranced intersecting cylindrical bores. The rotors basic shape is a screw thread, with varying numbers of lobes on the male and female rotors. In refrigeration, four or five lobed male rotors generally drive six or seven lobe female rotors to give a female rotor speed that is somewhat less than the male speed.

2.1.2 FUNDAMENTALS OF OPERATION

A screw compressor is best described as a positive displacement volume reduction device. Its action is analogous to a reciprocating compressor more than any of the other common compressor types. Gas is compressed by pure rotary motion of the two intermeshing helical rotors. Gas travels around the outside of the rotors, starting at the top and traveling to the bottom while it is transferred axially from the suction end to the discharge end of the rotor area.

Suction process

Suction gas is drawn into the compressor to fill the void where the male rotor rotates out of the female flute on the suction end of the compressor. Suction charge fills the entire volume of each screw thread as the unmeshing thread proceeds down the length of the rotor. This is analogous to the suction stroke in a reciprocating compressor as the piston is drawn down the cylinder.
The suction charge becomes trapped in two helically shaped cylinders formed by
the screw threads and the housing as the threads rotate out of the open suction port. The volume trapped in both screw threads over their entire length is defined as the volume at suction, (Vs).

Compression

The male rotor lobe will begin to enter the trapped female flute on the bottom of the compressor at the suction end, forming the back edge of the trapped gas pocket. The two separate gas chambers in each rotor are joined to form a "V" shaped wedge of gas with the point of the "V" at the intersection of the threads on the suction end. Further rotation begins to reduce the trapped volume in the "V" and compress the trapped gas.

Discharge Process

The screw compressor has no valves to determine when compression is over. The location of the discharge ports determine when compression is over. The volume of gas remaining in the "V" shaped trapped pocket at discharge port opening is defined as the volume at discharge, (Vd).
A radial discharge port is used on the outlet end of the slide valve and an axial port is used on the discharge end wall. These two ports provide relief of the internal compressed gas and allow it to be pushed into the discharge housing. Positioning of the discharge ports is very important as this controls the amount of internal compression The end of the discharge process in the screw occurs as the trapped pocket is filled by the male lobe at the outlet end wall of the compressor.
At the end of the discharge process in the screw, no clearance volume remains. All compressed gas is pushed out the discharge ports. This is a significant factor that helps the screw compressor to be able to run at much higher compression ratios than a reciprocating compressor

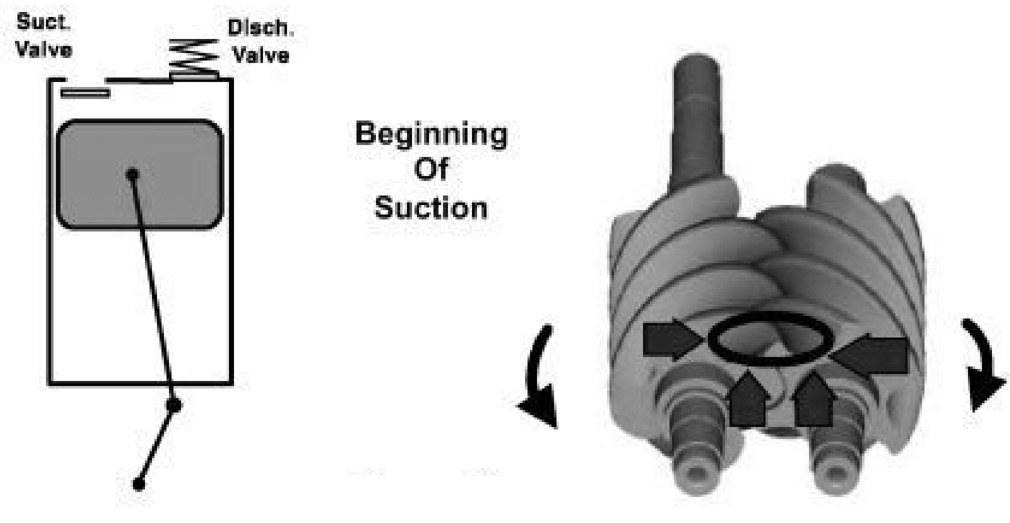

Figure 2.1 Suction process in screw compressor

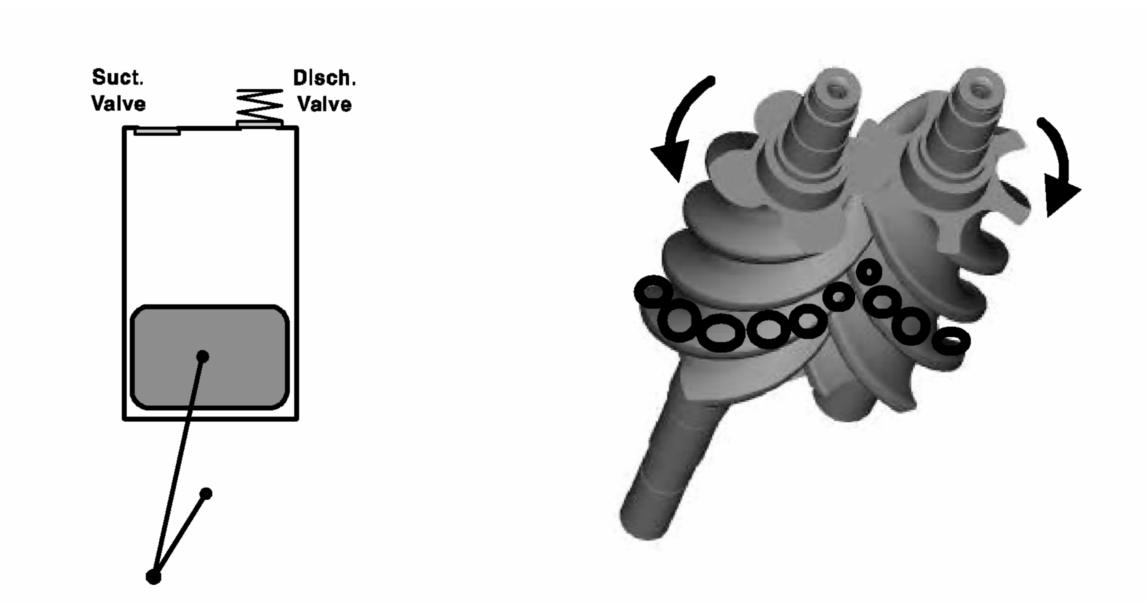

Figure 2.2 Compression process in a screw compressor

Volume Ratio

In a reciprocating compressor, the discharge valves open when the pressure in the cylinder exceeds the pressure in the discharge manifold. Because a screw compressor does not have valves, the location of the discharge ports determine the maximum discharge pressure level that will be achieved in the screw threads before the compressed gas is pushed into the discharge pipe. Volume ratio is a fundamental design characteristic of all screw compressors. The compressor is a volume reduction device. The comparison of the volume of trapped gas at suction, (Vs) to the volume of trapped gas remaining in the compression chamber when it opens to discharge, (Vd) defines the internal volume reduction ratio of the compressor.

This volume index or "Vi" determines the internal pressure ratio of the compressor and the relationship between them can be approximated as follows.

$$Vi = Vs/Vd$$

where;

Vi=Volume ratio or index

Vs= Volume at suction

Vd= Volume at discharge

$Pi = Vi^{k}$

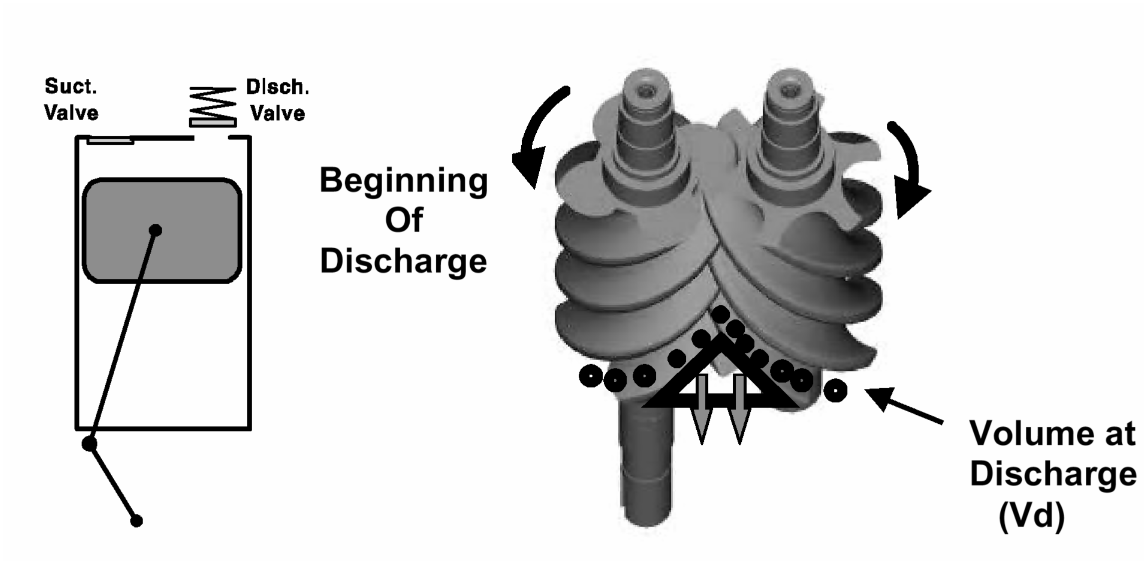

Figure2.3 Discharge process

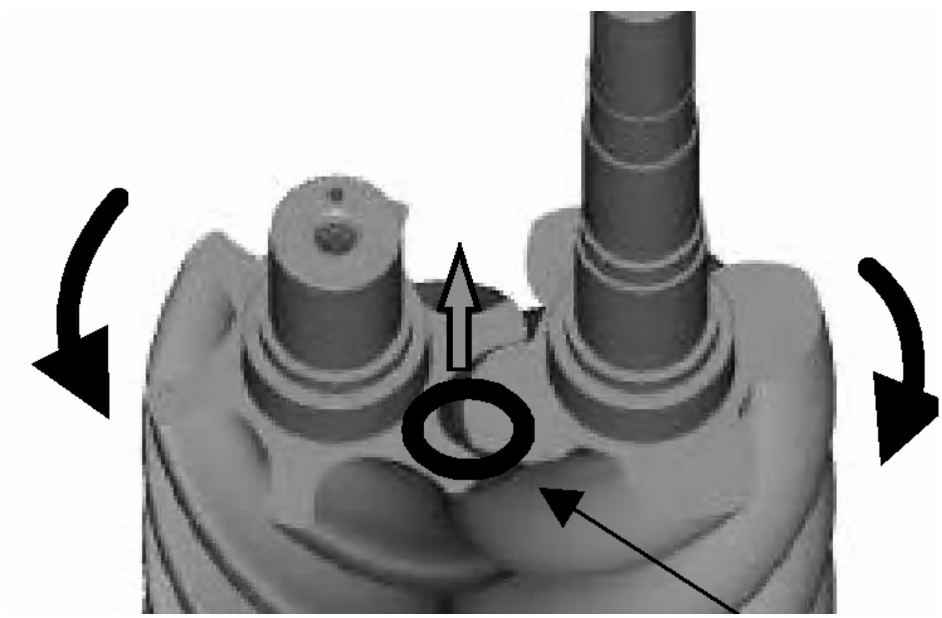

Figure 2.4 Close up view rotor tolerance

2.2 PROFILE OF SCREW COMPRESSOR ROTOR

'N' rotor profiles for screw compressors, based on a patented rack generation procedure, offer greater flow area, less leakage, smaller internal friction and greater lobe strength than any other known rotor profile.

Curves at ‘N’ profile are given as a "general arc" form of the type: axp+byq=1. Straight lines, circles, parabola, ellipses and hyperbolae are all easily described by selecting appropriate values for parameters a, b, p and q.

Segment DE is a straight line on the rack, EF is a circular arc of radius r4, segment FG is a straight line for the upper involute, p=q=1, while segment GH on the rack is a meshing curve generated by the circular arc G2H2 on the gate rotor. Segment HJ on the rack is a meshing curve generated by the circular arc H1J1 of the radius r2 on the main rotor. Segment JA is a circular arc of radius r on the rack, AB is an arc which can be either circle, or parabola or hyperbola or ellipse, segment BC is a straight line on the rack matching the involute on the rotor round lobe and CD is a circular arc on the rack, radius r3.

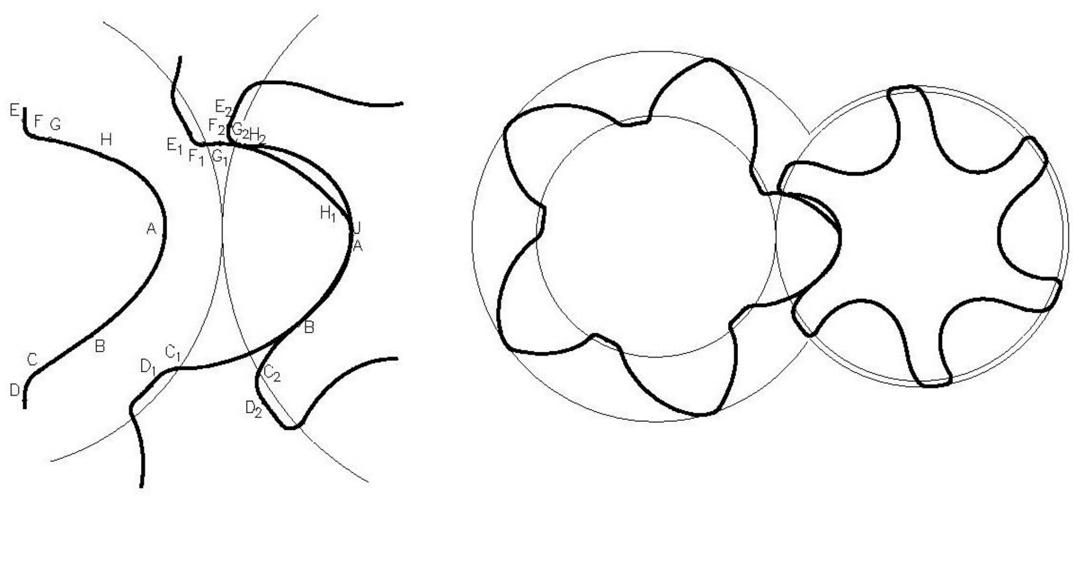

Figure 2.5 Profile of screw rotors

2.3 SCROLL COMPRESSOR

2.3.1 Construction

A typical scroll compressor is shown schematically. Its principal components include a fixed scroll, an orbiting scroll, a drive shaft, frames, an electric motor. The motor is placed at the top and the compressor at the bottom. The orbiting scroll is driven directly by the driving shaft connected with the motor rotor.

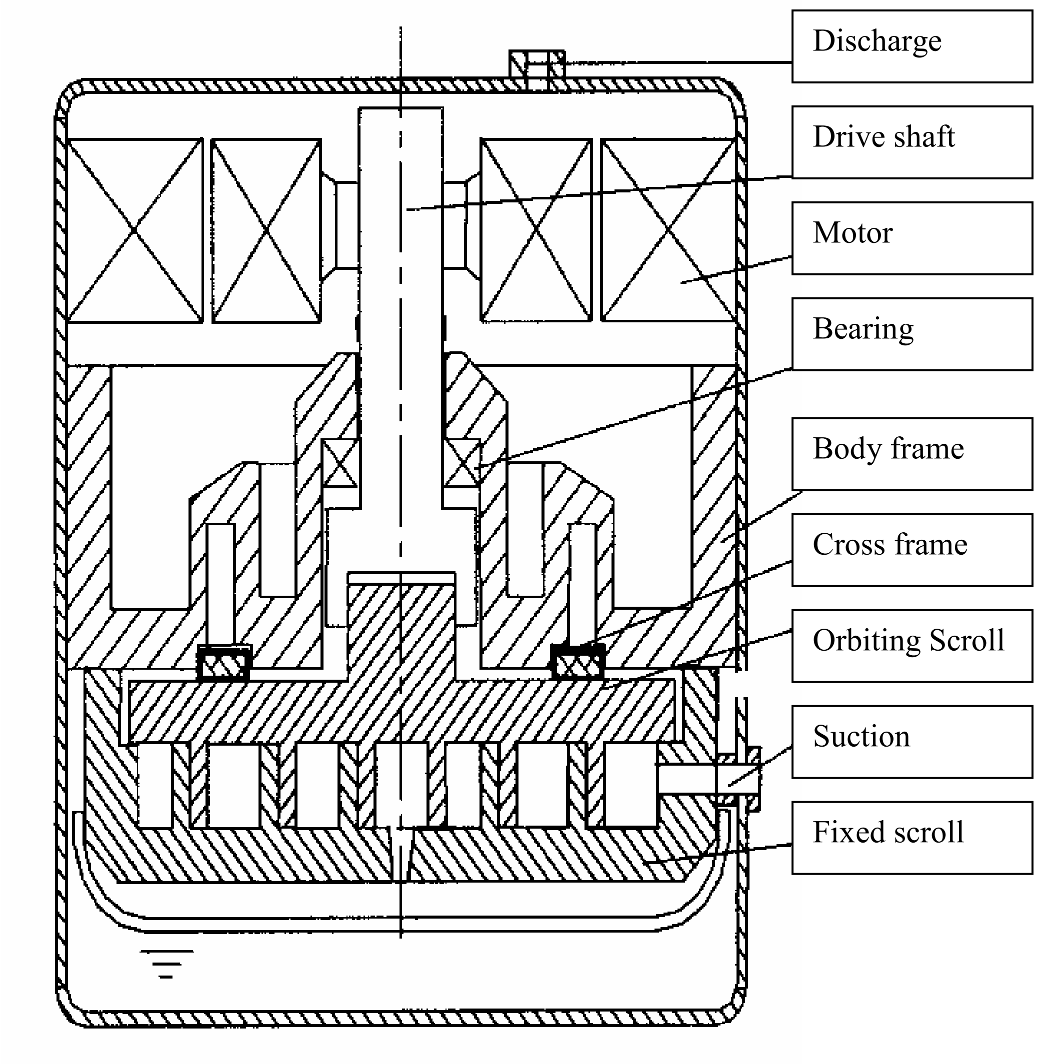

Figure 2.6 Construction of scroll compressors

2.3.2 Working

Two identical scrolls, i.e. the fixed and orbiting ones, whose axes of rotation do not meet each other and are assembled at a relative angle of 180° contact each other at several touch lines and form a series of crescent-shaped chambers. The orbiting scroll rotates around its own axis in a plane motion. In Fig. 2.7a the gas suction process is just finished, the centre of the orbiting scroll is at 0°. At this position, the gas is trapped within the outer chamber. As the orbiting scroll rotates, the outer chamber becomes smaller and smaller. Fig. 2.7b shows the centre of the orbiting scroll being at 90°. At this position, the outer chamber is in the suction process, the middle chamber in the compression process and the inner chamber in the discharging process. Fig. 2.7c and d shows the suction and compression process in progress simultaneously. This working cycle appears periodically.

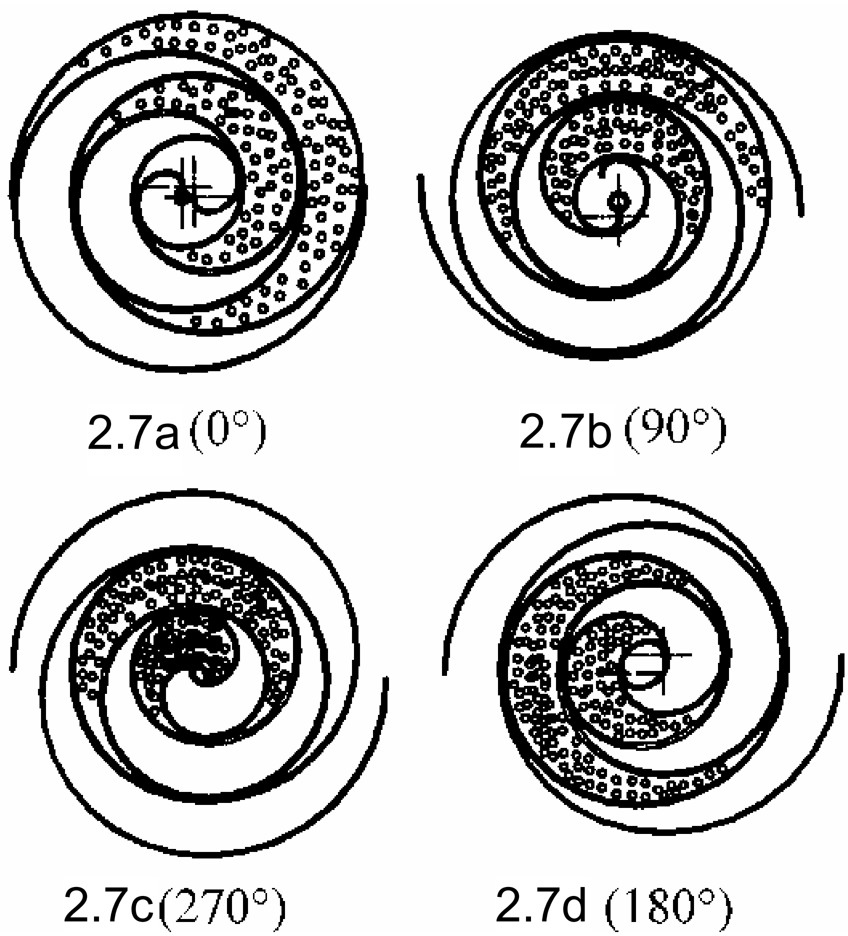

Figure 2.7 Various processes in a scroll compressor

2.4 SCROLL VANE PROFILE

For the ease of manufacturing, the circle involute curve is often used. Because the scroll curve has a wall thickness, the outer surface involute and inner surface involute of a scroll can be represented as

$Xo = R[\cos(\omega_o - \acute{\alpha}) + \omega_o \sin(\omega_o - \acute{\alpha})]$

$Yo = R[\sin(\omega_o - \acute{\alpha}) - \omega_o \cos(\omega_o - \acute{\alpha})]$

$Yi = R[\sin(\omega_i + \acute{\alpha}) - \omega_i \cos(\omega_i + \acute{\alpha})]$

$Xi = R[\cos(\omega_i + \acute{\alpha}) + \omega_i \sin(\omega_i + \acute{\alpha})]$

where R is the radius of the base circle, X the co-ordinate of the scroll curve, Y the co-ordinate of the scroll curve, ά the initial angle of the scroll curve, and ω the changeable angle of the scroll curve. Subscripts o and i correspond to outer and inner curves, respectively.

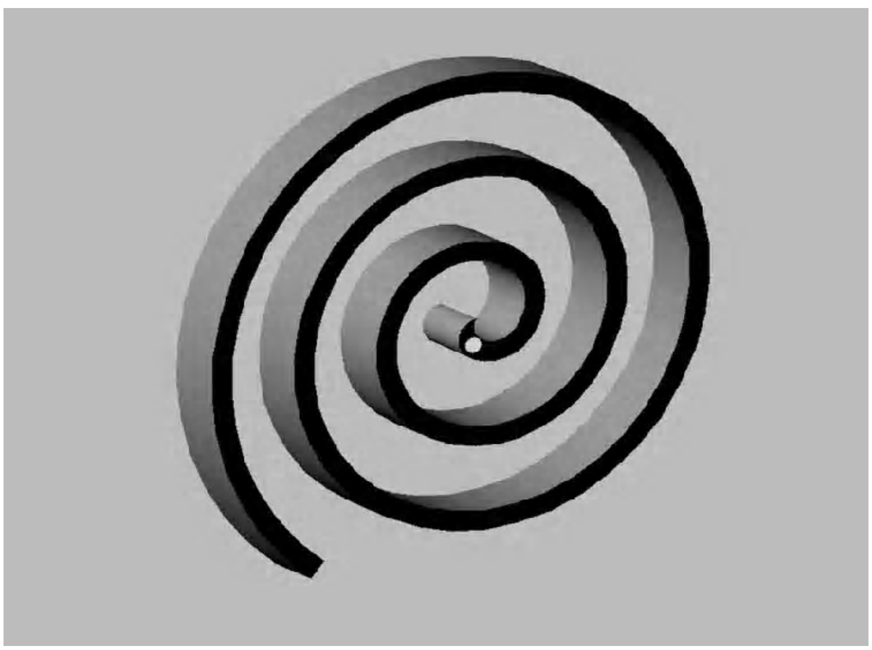

Figure 2.8 Profile of Vane of scroll compressor

Chapter 3

FABRICATION OF THE MODEL & EXPERIMENTAL WORK

3.1 SOLID MODELING AND FABRICATION OF SCREW COMPRESSOR ROTORS

The complete procedure adopted by us for solid modeling of compressor rotors can be broadly classified into following sections and subsections:

1. Solid modeling of individual rotors using Autodesk Inventor.
2. Making rotor moulds and assembly views of the rotors.
3. Fabricating the rotors and their moulds by rapid prototyping.
4. Epoxy Casting in the prepared moulds.
5. Metal Casting in a test mould.

These steps are further explained below:

3.1.6 <u>Solid modeling of individual rotors using Autodesk Inventor.</u>

I. Generation of profile :

The image file containing the N-rotor profile was imported in to the Inventor. Using the zoom and the spline type line features, the profile was successfully traced in the sketch panel. After completing the sketch, the sketch was updated to the modeling panel by clicking *UPDATE.*

II. Extrusion :

The base cylinders of the rotors were then extruded. The inner circle of the rotor profiles was chosen as the sketch and then extruded by activating EXTRUDE button on the part feature panel. After providing parameters like direction of extrusion and length of extrusion, the circle got extruded in to the cylinder.

Diameter of rotors	= 65 mm
Taking l/d ratio	= 2.1
Length of rotors	= 140 mm

Table 3.1 Dimensions of boss cylinder

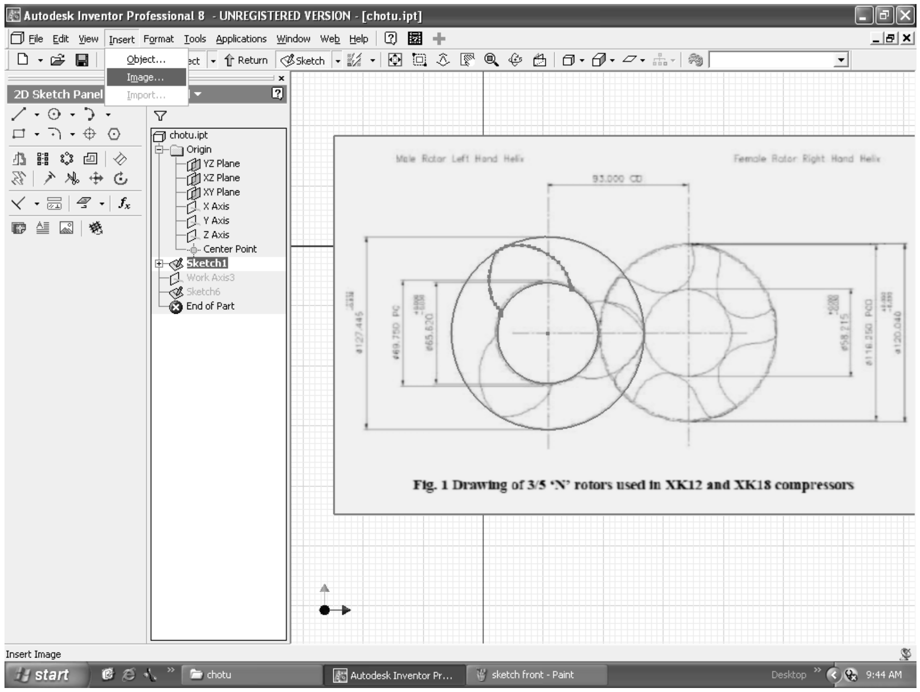

Fig 3.1: Tracing of profile

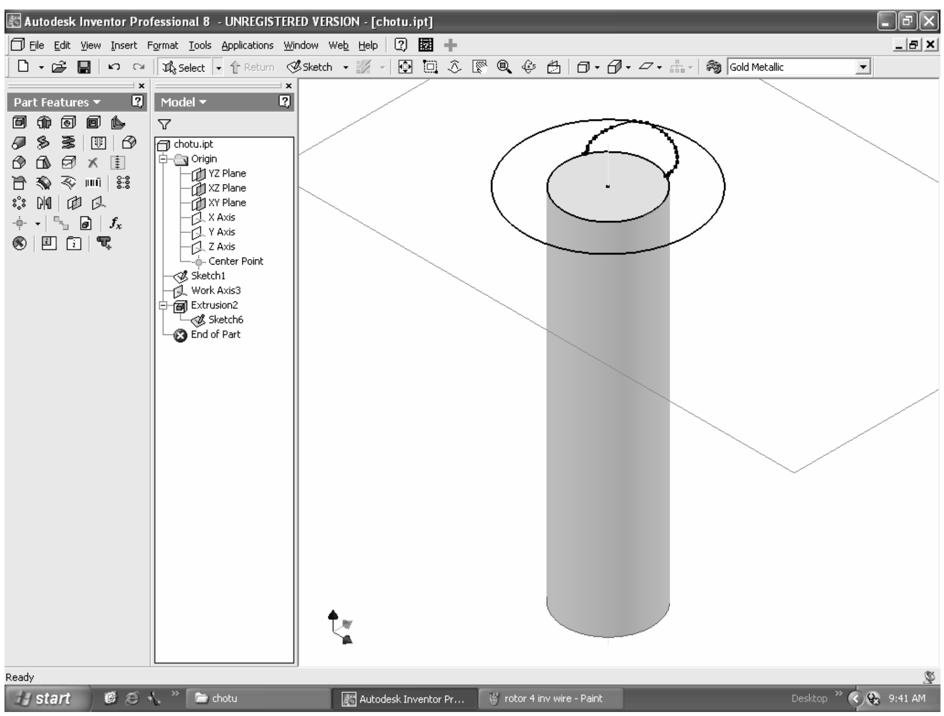

Fig 3.2: Extrusion of cylinder

III. Coil :

Coil is a very helpful tool for creating helical shaped objects. To create the flutes on the female rotor and the lobes on the male one, the *COIL* button on the sketch panel was activated. Suitable parameters were given as input, like,

Direction of rotation :	clockwise for female, anticlockwise for male.
Number of turns	1 turn for female rotor and 5/3 turns for male rotor.
Angle to be turned	360 deg. for female and 500 deg for male.
Type of coil ends	Natural.
Length for coil	140mm

Table 3.2 Coil geometry data

The type of extrusion was union for male while subtract for female. The work axis was chosen as the axis of the cylinder.

IV. Circular pattern:

After the completion of one of the lobes in each rotor, there was a need to replicate the same for the required number of times i.e. to get three lobes on the male rotor and 5 flutes on the female one.

To achieve this, the *CIRCULAR PATTERN* button on the part feature panel is activated. Input parameters were the part to be replicated and the number of such replications.

The work axis was again chosen as the cylinder axis.

This was the final step in creating the 3-d solid models of individual rotors.

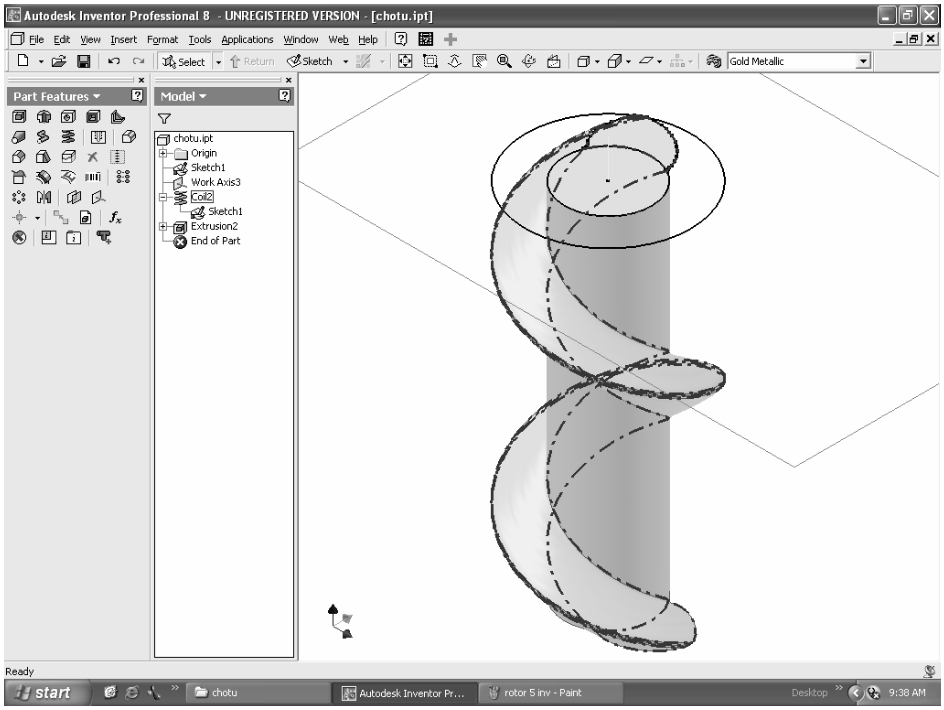

Fig 3.3: Making a coil

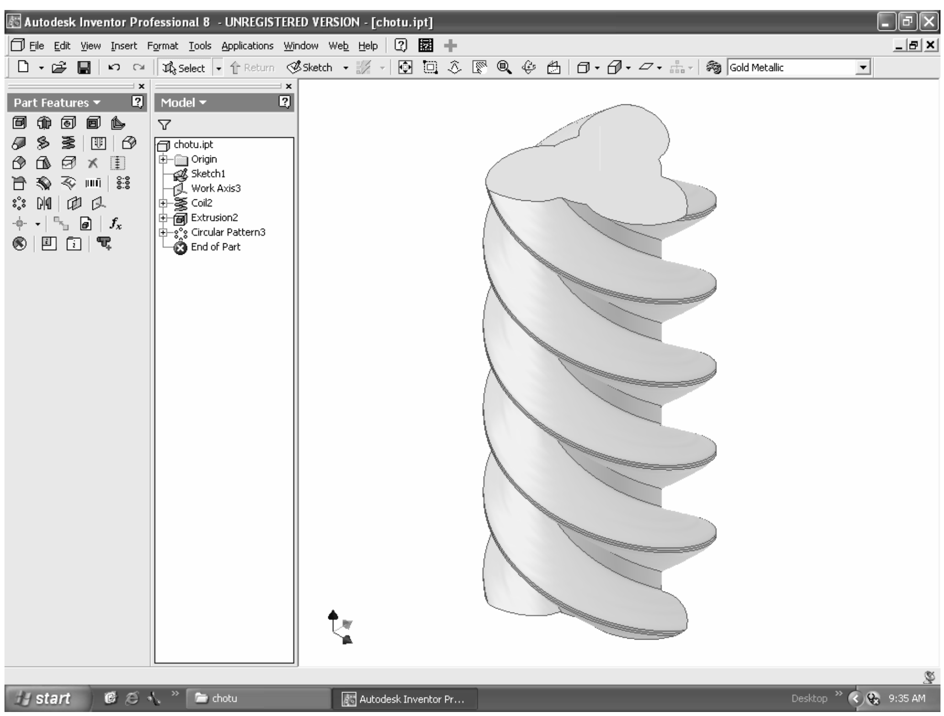

Fig 3.4: Circular pattern of coil

3.1.7 Making rotor moulds and assembly views of the rotors:

I. Making rotor moulds:

To make rotor moulds for the future need of casting operation, two solid cylinders were modeled in Inventor. Then individual rotors were subtracted from either cylinder to create a cavity of the shape of rotors inside the cylinder.

The diameter of cylinder is greater than the diameter of rotors so as to provide sufficient wall strength to the mould.

II. Making assembly view of rotors:

New template *.iam was selected for the purpose. The two rotors' ipt files are opened in the template to bring the rotors in the *ASSEMBLY* environment. Thereafter, using *MOVE* command, the rotors are placed together at appropriate positions.

It was found that the two rotors are satisfactorily meshing.

The entire work till now was saved in various file formats for achieving particular goals. The formats that were used are:

- *.ipt
- *.sat
- *.dwg
- *.stl
- *.bmp

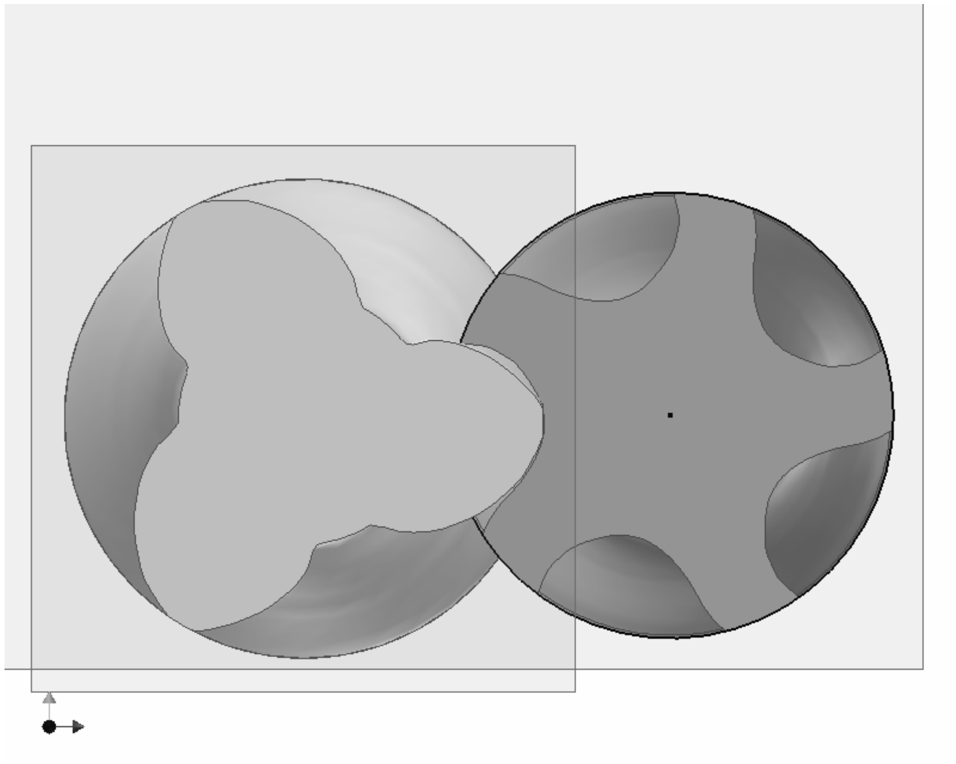

Fig 3.5 : Rotors assembly-front view

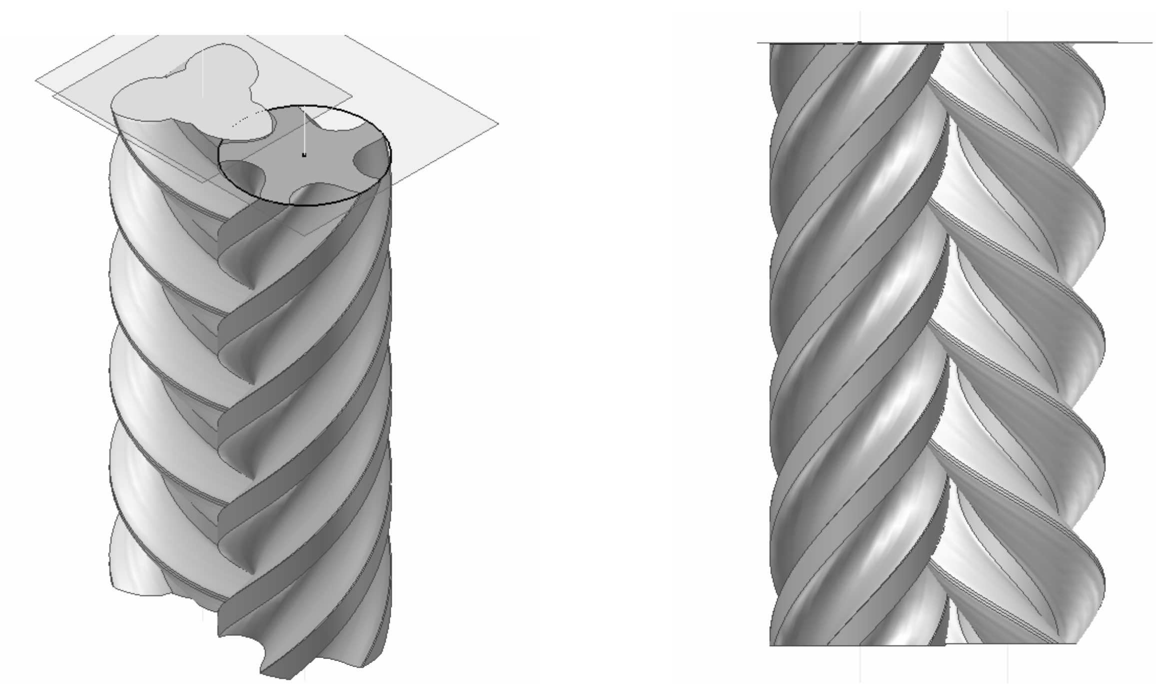

Fig 3.6: Rotors assembly- isometric and side views

3.1.3. Fabrication of rotors and moulds by rapid prototyping:

The rapid prototyping machine Z-Printer 310 Plus available in the CAD lad was used for the purpose. The machine's specifications are as follows:

Machine's dimensions	74 x 86 x 109 (all in cm)
Build Speed	2-4 layers per minute
Build Size(maximum)	8" x 10" x 8"
Layer Thickness	0.089 - 0.203 mm (user selectable)

Table 3.3 Specifications of ZPrint 310M Plus rapid prototyping machine

(Source: http://www.zcorp.com/products - the Z Corporation's website)

The machine uses Z-print software as the human-machine interface. The Z-print software accepts *.stl and *.vrml file formats.

Once the files were opened in the software, various parameters like build time, amount of binder required, total volume of parts were calculated and displayed. Then it proceeded to build the model in a layer by layer sequence. The status of build is kept updated on the computer screen.

Once the rotors were formed, they were left inside the machine itself for final curing process. It took sixty minutes for each rotor for curing, while the approximate time taken for build was 2 hr 40 min. The cured rotors were then taken out of Z-Printer and then moved to another machine called Powder Recycling Machine to remove the extra powder that was coated on the rotors. This completed the rapid prototyping process for the rotors. Similar steps were taken for the preparation of moulds for rotors.

Once the rotors were prototyped, another adhesive *cyanoacrylate* was applied on their surface to make them stronger, as they are brittle otherwise. Cyanoacrylate is commercially available as *ANABOND-202* at major hardware stores.

Preparation of mould for casting

For casting of the rotors a mould was prepared. The steps are as follows:

I. Extrude circle of diameter 80mm to generate a cylinder of length 170mm.
II. Subtract the rotor from this cylinder keeping 15mm wall on top and bottom, to generate a cavity of rotor's volume.
III. On the top side of rotor, a cap as shown in figure and on the bottom a thorough hole of 15mm dia is made.

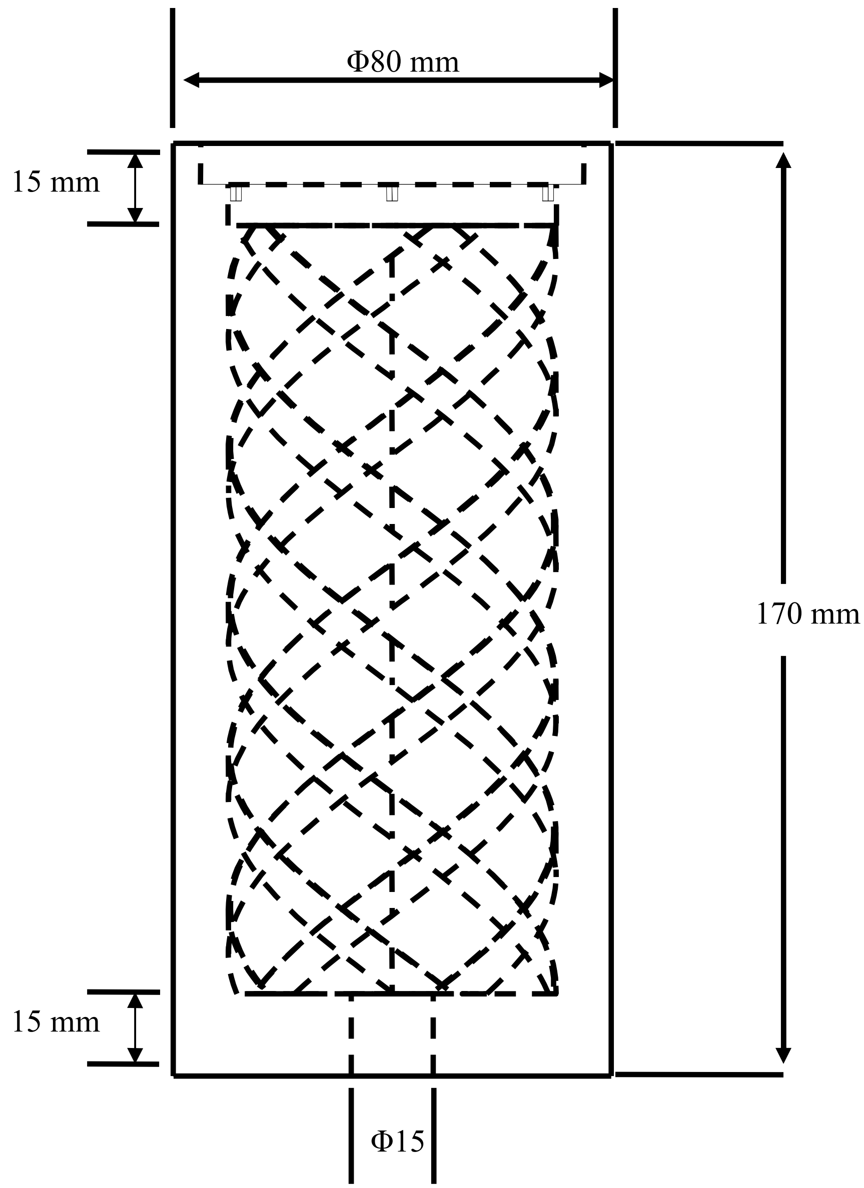

Figure 3.7 Front View of Mould for casting of female rotor

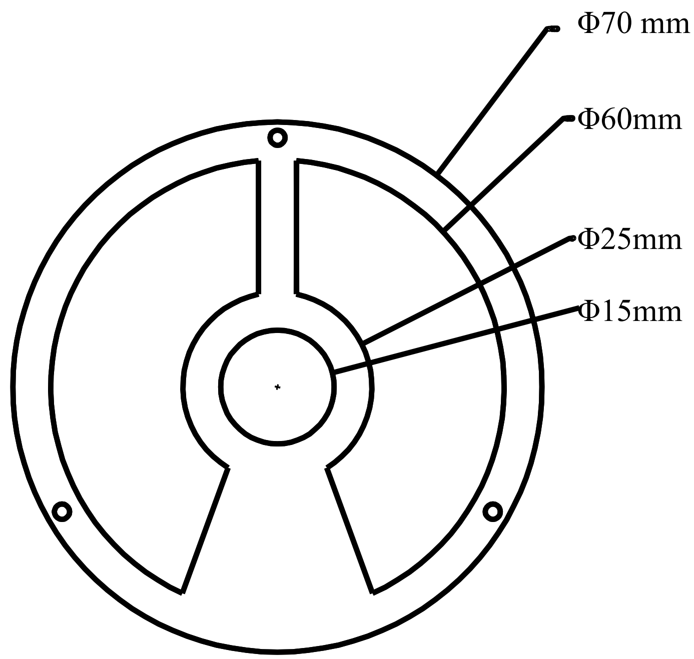

Figure 3.8 Top view of mould cap

3.1.4 Epoxy Casting in the prepared moulds

After the moulds were prepared in the rapid prototyping machine, it was time for casting. The material of the mould was a starch based substrate, whose heat resistance was not known, for this reason we didn't opt for a metal casting. Casting was thus done using epoxy mixed with hardener.

The epoxy was first heated in a plastic container, to increase its fluidity and then about 10% (by weight) of hardener was added. The mixture was stirred slowly till it became homogenous. Care was taken to see that there were no bubbles. After mixing it was poured slowly and uniformly so as to reach all the intricate parts of the mould. The mould was then left for about 4 days to set and harden.

Due to the hard nature of the mould it had be wetted to break it. The casting was then carefully dug out using a hammer and a chisel.

3.1.5 Metal Casting in a test mould

Prior to actual casting, the mould material had to be tested to see if it could withstand the heat of molten aluminium. Thus a test mould was prepared with only 1.5cm of the rotor length. The casting was removed by simply breaking the mould.

3.2 ANIMATION OF SCREW COMPRESSOR ROTORS

3.2.1 Placing the assembly

The assembly of the rotors was imported form the *.iam file. Using the "look at" command the rotors were brought to a proper view.

3.2.2 Tweaking the components

Using the "Tweak Components" command the rotors were given the axis, orientation and degree of rotation.

Rotation of female rotor= 360° CCW

Rotation of male rotor = 600° CW

3.2.3 Animation

The animation dialog box contains commands for interval (seconds), repetitions and Sequence of animation,

Values used:

Interval 25

Repetitions 1

Sequence – Grouped (since both rotors rotate simultaneously)

3.3 MODELING AND ASSEMBLY OF SCROLL COMPRESSOR VANES

The scroll compressor was modeled using Autodesk Inventor Professional.

Spirals are generated using predefined commands(Coil>spiral) and then placed at 180 degrees wrt each other.

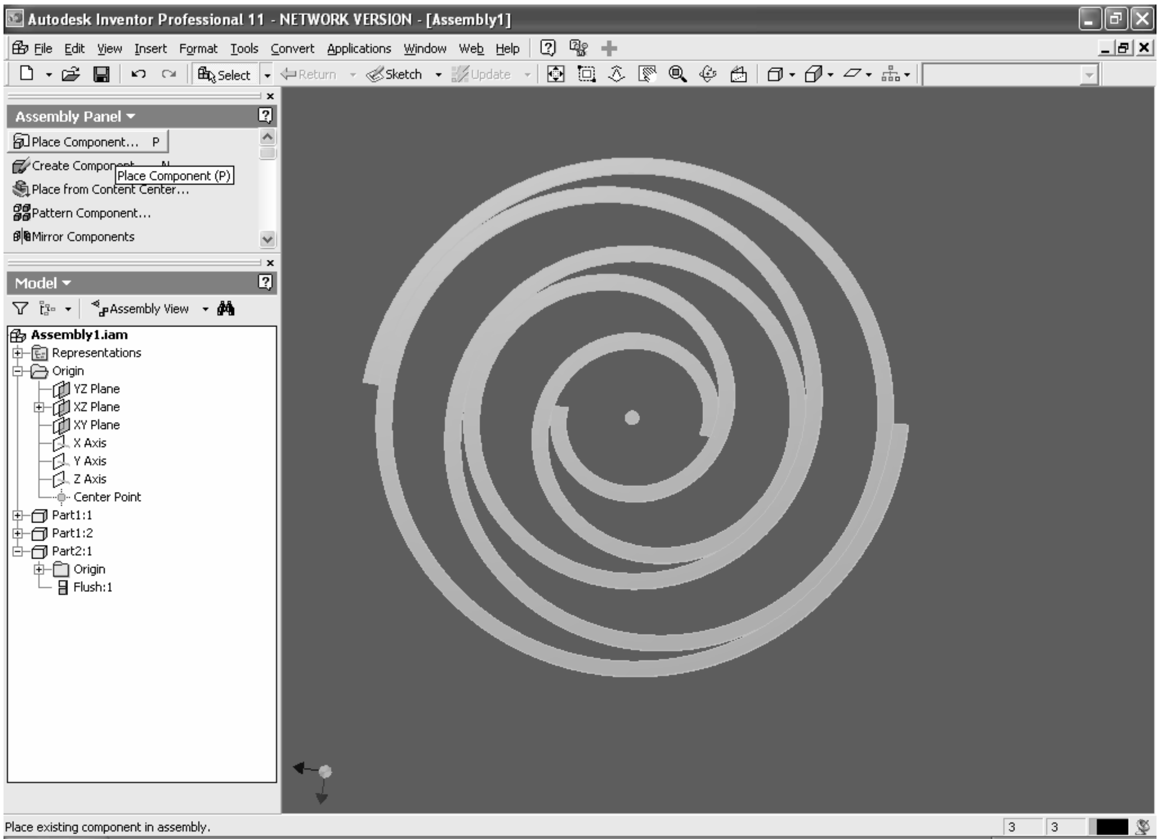

Figure 3.9 Solid modeling of scroll compresor

3.4 ANIMATION OF SCROLL COMPRESSOR

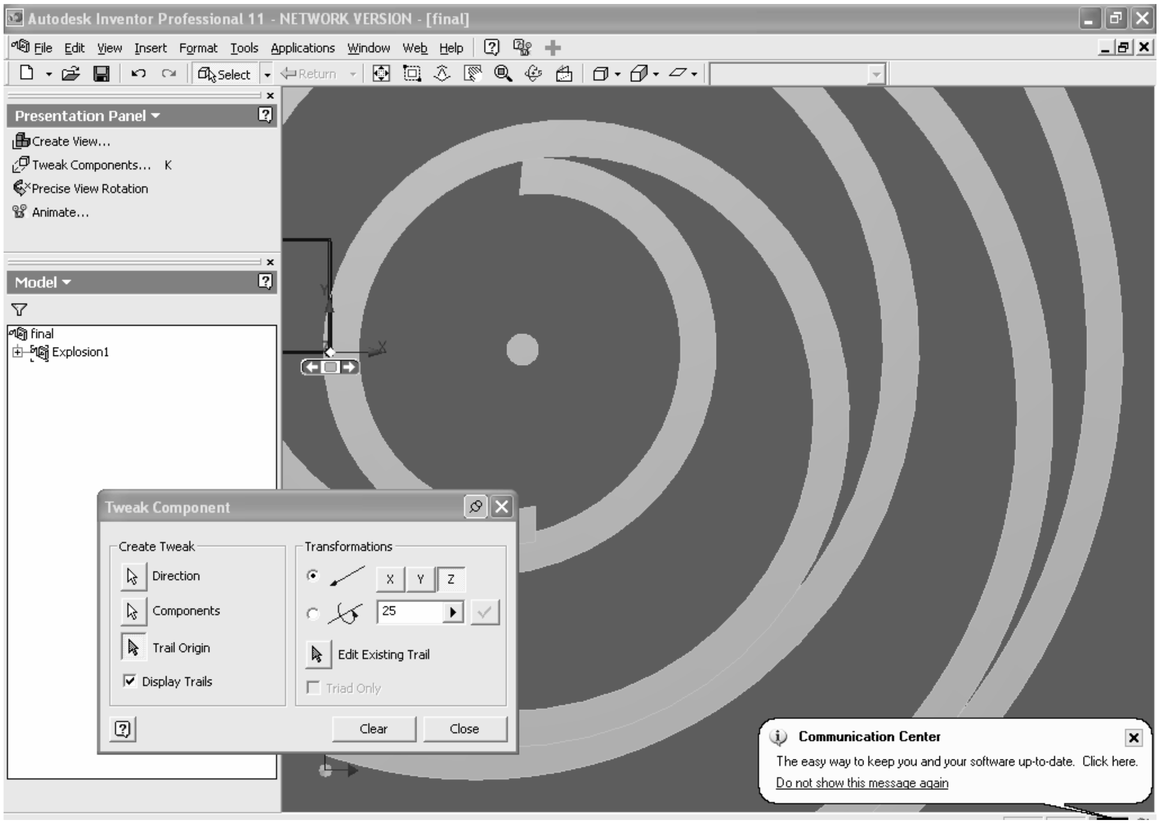

Figure 3.10 Animation of screw compressor

3.4.1. Placing the assembly

The assembly of the vanes was imported form the *.iam file. Using the “look at” command the vanes were brought to a proper view.

3.4.2. Tweaking the components

Using the “Tweak Components” command, the vane given the direction and magnitude of translation of the moving vane.

Translation along X = 25 units

Translation along Y = 50 units

3.4.3. Animation

The animation dialog box contains commands for interval (seconds), repetitions and Sequence of animation,

Values used:

Interval 2.5

Repetitions 10

Sequence – -X +Y +X -Y

3.5 ANALYSIS OF RAPID PROTOTYPING POWDER

The need to synthesize rapid prototyping powder arose when there was a shortage of the same. The first step was to analyze the powder to know its various properties such as

1 Chemical composition

2 Particle size

3 Crystalline phase (which is responsible for setting of the RP products)

The tests were carried out at X-Ray Diffraction machine and particle size testing machine Mastersizer at Dept of MME to know the crystalline components and the mean particle size of the RP powder.

Two more samples of Corn flour and Wheat flour which are predominantly starch powders were subjected to particle size test.

Chapter 4

RESULTS AND DISCUSSION

4.1 RESULTS

4.2 DISCUSSION

4.1 RESULTS

After each part of the experimental procedure, following components related to the project are fabricated.

4.1.1 Rotors Fabricated by Rapid Prototyping.

Fig 4.1 Rotors Fabricated by Rapid Prototyping

4.1.2 Rotor Fabricated by Epoxy Casting.

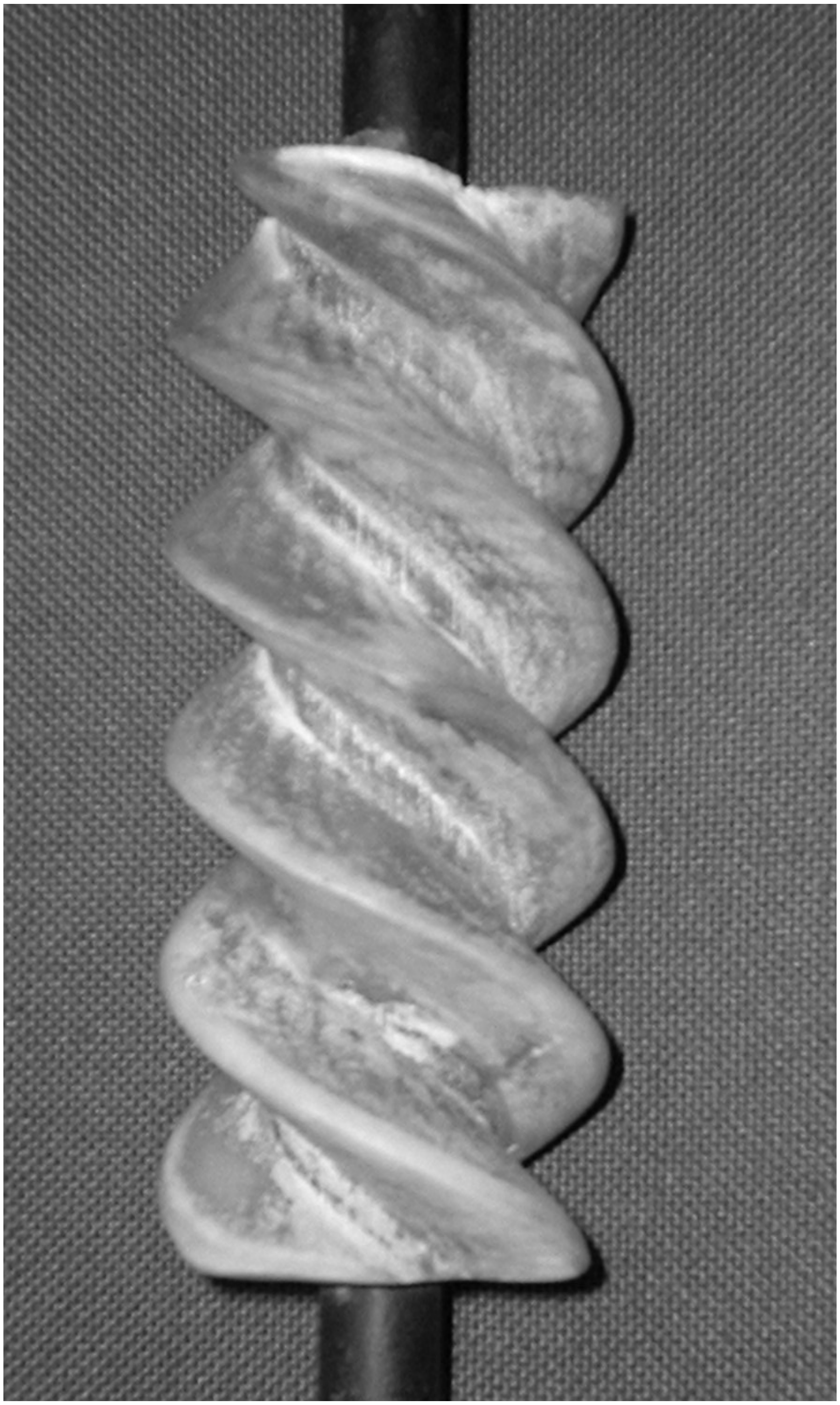

Fig 4.2 Rotors Fabricated by Epoxy Casting

4.1.3 Test part by metal casting with burnt out mould

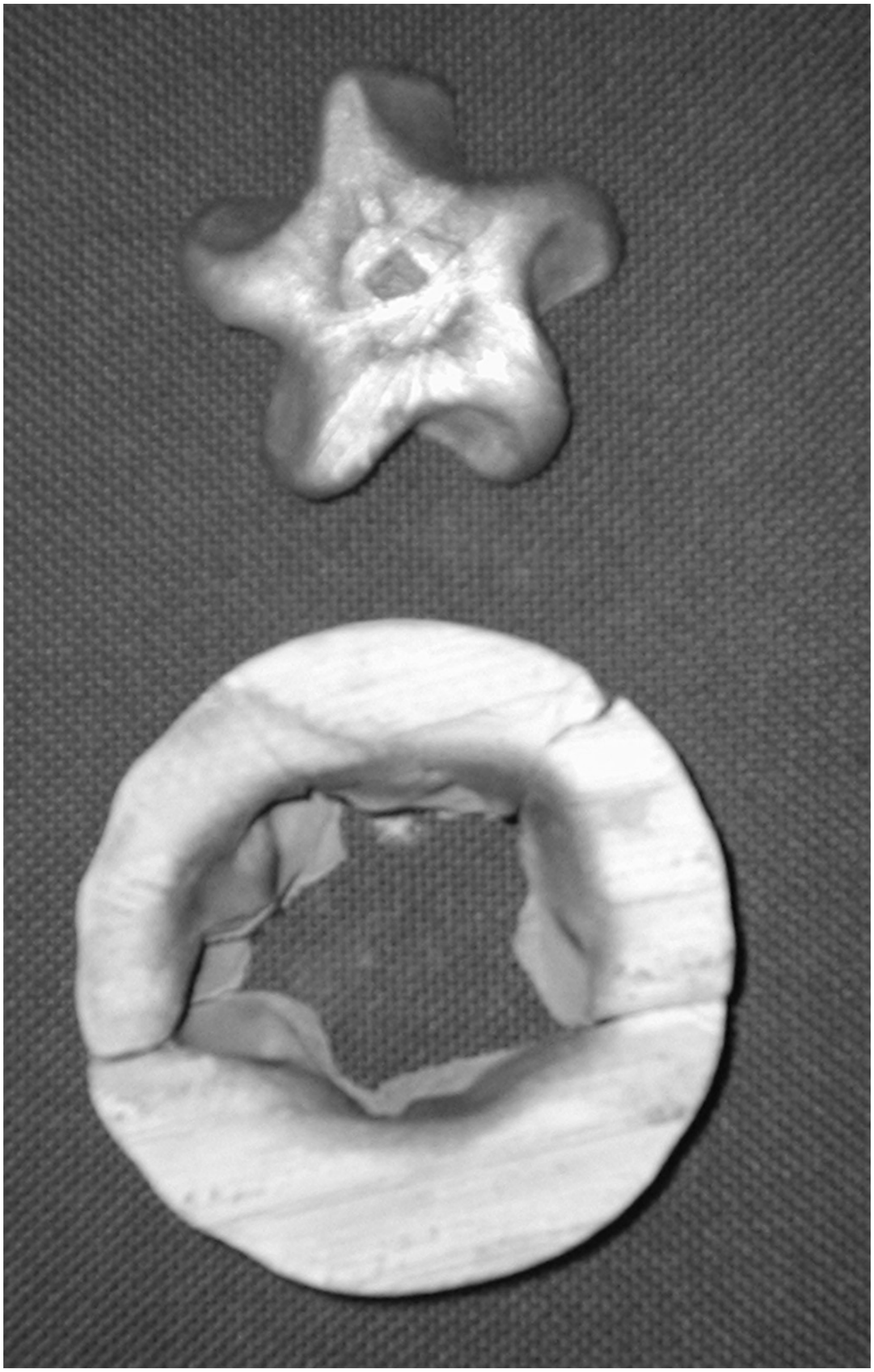

Fig 4.3 Test part by metal casting with burnt out mould

4.1.4 Analysis on X-Ray Diffraction machine and particle size testing machine

The following results were obtained after the experiment:

I. The crystalline components of the RP powder are $CaSO_4$ anhydrate and CaSO4.0.5 H_2O.
II. The powder predominantly contains a starch base with a particle size of 54.41µm.
III. Other components are present in traces such as lycopodium.
IV. The other powders have a particle size of
    a. Wheat Flour = 67.51 µm
    b. Corn Flour = 31.79 µm

4.2 DISCUSSION

4.2.1 Epoxy Casting

The most critical part of casting in epoxy is the mould release agent. In the first experiment, we used a spray type mould release. This led to insufficient mould release and a lot of material left on the finished casting which had to be removed by tediously filing the surface. In the second experiment liquid silica gel was used. This test did not come off successfully. It was observed that the silica gel caused non-uniform spreading of the liquid epoxy. The casting was filled with blow holes and none of the flutes were properly formed. In our view silica is not recommendable for preparing closely- toleranced castings, a thin coat of spray works best to produce intricate shapes

4.2.2 Aluminium Casting

The test mould for metal casting had no vent holes due to this the sharp contours could not be reproduced (air prevented entry of metal). For final casting in aluminium proper vent holes should be provided along with provision for support of the mould. Moreover, increasing volume of molten metal brings the risk of cracking and deforming the mould.

4.2.3 Suitability of using mixture of Wheat flour and corn flour as a substrate for RP powder.

It was seen that mean diameter of the two samples mixed in equal proportions is close to 50 µm is close to RP powder. In addition to the organic substrate the inorganic constituents i.e. $CaSO_4$ (anhydrous) and $CaSO_40.5H_2O$.

Chapter 5

CONCLUSIONS

5.1 CONCLUSION

During the course we accomplished solid modeling of screw and scroll compressors using Autodesk Inventor Professional 11. The files of the rotors were then exported to *.stl (STEREO LITHOGRAPHY) format to be sent to the Rapid Prototyping machine. Thus the rotors were produced by rapid prototyping. We then planned to produce the same rotors in metal. When conventional methods of preparing moulds did not work, rapid prototyping was again used to make moulds.

The material used in rapid prototyping was a starch based substrate, judging that molten metal would cause catastrophic damage to the mould, casting was done in epoxy. The casting was strong as well true to the intended shape. We then proceeded to test whether the material would resist the heat of pouring molten aluminium. This was checked by using a mould of only $1/10^{th}$ length of the actual size, diameter and other aspects remaining same.

Finally we ran particle size tests on the rapid prototyping powder, Followed by two more starch containing powders i.e. Corn flour and Wheat flour.

5.2 FUTURE SCOPE OF THE PROJECT

5.2.1 Manufacture and Assembly of Screw compressor

The moulds designed in the modeling software can be used to cast Aluminium rotors. This can be assembled to motors, bearings, ports and other components to manufacture a working model of a screw compressor.

5.2.2 CFD Study of Screw Compressor

Solid modeling of the flutes etc can be used for CFD analysis. This would yield several results relating to the pressure, temperature, velocity and other parameters at different points during compression.

5.2.3 A Simulator of Screw Compressor

Combining the data of solid modeling and CFD of the obtained soft versions of the compressor, we can produce a database. This then can be used to make a simulator where inputing say the no. of lobes, diameter and length a rotor is created automatically and flow data corresponding to it is displayed along side.

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