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DESIGN AND STRUCTURAL ANALYSIS OF 3D PRINTED HYDRAULIC VANES

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ABSTRACT

Three Dimensional (3D) Printing or Additive manufacturing is a novel method of manufacturing parts directly from digital model by using layer by layer material build- up approach. This tool-less manufacturing method can produce fully dense parts in short time, with high precision. Features of additive manufacturing like freedom of part design, part complexity, light weighting, part consolidation and design for function are garnering particular interests in additive manufacturing for aerospace, oil & gas, marine and automobile applications, mechanical components. It is the most promising additive manufacturing technology that can be used for manufacturing small, low volume, complex parts. This project work is based on 3D printed hydraulic vanes and their structural analysis using Ansys. The 3D printed model of hydraulic vanes are initially designed using catia and further analyzed their stress and deformation at different velocities of the turbine rotor and 3D printed by using Raise 3D pro2 equipment.

CHAPTER – 1

INTRODUCTION

EARLY HISTORY:

Three Dimensional (3D) printing or additive manufacturing (AM) is a process for making a 3D object of any shape from a 3D model or other electronic data sources through additive processes in which successive layers of material are laid down

Under computer controls. Hideo Kodama of Nayoga Municipal Industrial Research Institute is generally regarded to have printed the first solid object from a digital design.

Charles a Hull was a pioneer of the solid imaging process known as stereo lithography and the STL (stereo lithographic) file format which is still the most widely used format used today in 3D printing. He is also regarded to have started commercial rapid prototyping that was concurrent with his development of 3D printing. He initially used photopolymers heated by ultraviolet light to achieve the melting and solidification effect. [2]Since 1984, when the first 3D printer was designed and realized by Charles W. Hull from 3D Systems Corp., the technology has evolved. These machines have become more and more useful, while their price points lowered, thus becoming more affordable. Nowadays, rapid prototyping has a wide range of applications in various fields of human activity .

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Fig shows 3D printers

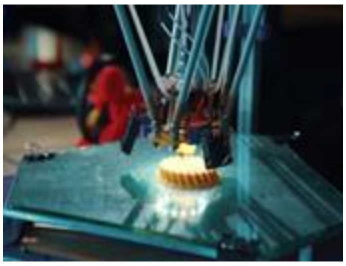

Fig 1.1 3D PRINTER

Fig 1.2 3D PRINTED COMPONENT

research, engineering, medical industry, military, construction, architecture, fashion, education, the computer industry and many others. In 1990, the plastic extrusion technology most widely associated with the term "3D printing" was invented By Stratasys by name fused deposition modeling (FDM). After the start of the 21st century, there has been a large growth in the sales of 3D printing machines and their price has been dropped gradually. By the early 2010s, the terms 3D printing and additive manufacturing evolved senses in which they were alternate umbrella terms for AM technologies, one being used in popular vernacular by consumer - maker communities and the media, and the other used officially by industrial AM end use part producers, AM machine manufacturers, and global technical standards organizations. Both terms reflect the simple fact that the technologies all share the common theme of sequential-layer material addition/joining throughout a 3D work envelope under automated control. Other terms that had been used as AM synonyms included desktop manufacturing, rapid manufacturing, and agile tooling on- demand manufacturing. The 2010s were the first decade in which metal end use parts such as engine brackets and large nuts would be grown (either before or instead of machining) in job production rather than obligatory being machined from bar stock or plate.

CHAPTER -2

LITERATURE REVIEW

- **Dr. D. N. Raut** has carried research on 3D printing and the various materials used in 3D printing and their properties which become a notable topic in technological aspects. First, define what is meant by 3D printing and what is significant of 3D printing. We will go into the history of 3D printing and study about the process of 3D printing and what materials used in the manufacture of 3D printed objects and select the best materials among them which are suitable for our 3D printing machine. Also, see the advantages of 3D printing as compared to additive manufacturing.

- **Fernando Gasi** did analysis and classification about 3D printing. Through the CAPES Sucupira platform, 124 articles with a high degree of relevance published between the years 2014 and 2018 were selected. Each of these articles was classified by means of 9 categories: study types, affiliation, approach, origin of the study, geographic scope, unit of analysis, scope, benefits and negative points. Through the results obtained, it was verified thatthe number of articles on 3D printing is increasing every year, which indicates its importance and popularity. Most of the time, scientific research is conducted and led by people connected to universities in Europe, Asia and the Americas. And finally, the number of citations related to the benefits of 3D printing are greater than the number of citations on the negative points of the process.

- **Adam Nulty** according to his review the first part in a 3D Printing series that looks at thehistory of 3D Printing, the technologies available and reviews the literature relating to the accuracy of these technologies. Conclusions: The recent advancement in digital dentistry to incorporate these tools has modernised dental practices by paving the way for computer-aided design (CAD) technology and rapid prototyping.
  3D printing has led to 3D digital models produced with intraoral scanners (IOS), which can be manipulated easily for diagnosis, treatment planning, mockups, and a multitude of other uses. Combining 3D Printing with a 3D intraoral scan eliminates the need for physical storage but makes it toretrieve a 3D models for use within all dental modalities.

- **Paul Gemmel** performed anlysis and has gained much interest in the medical world. The constantly improving quality of 3D-printing applications has contributed to their increased use on patients. This paper summarizes the literature on surgical 3D-printing applications used on patients, with a focus on reported clinical and economic outcomes

- **Simon Ford** provided a review of literature concerning the application of 3Dprinting in the education system. It considers two questions: where and how is 3DP being used in the educational system? The review identifies that3DP is being applied across the K-12 spectrum and in universities, as well as in libraries, make spaces, and special education settings, although adoption is isolated in pockets of excellence and faces integration challenges. University libraries in particular are a rich source of insight into their adoption. The review also finds that 3DP is being used to teach both students and educators about 3DP and to develop 3DP skills; to develop design skills and methodologies for creativity; and to create are facts that can be used as learning aids or as assistive technologies in special learning settings.

CHAPTER 3

1. INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixelated) environments.

The main modules are

Part Design
Assembly
Drawing

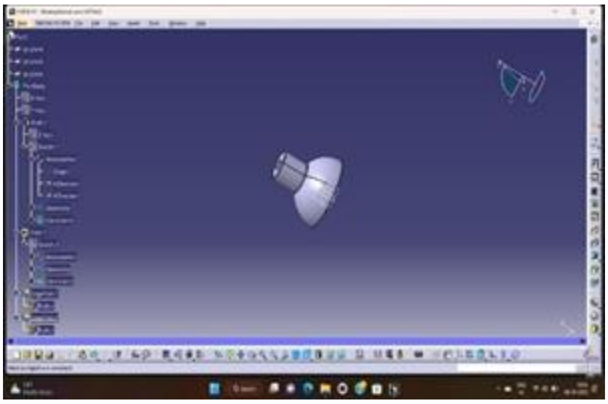

Fig 3.1 HEMISHPEHICAL VANE

Fig 3.2 INCLINED VANE

2D DRAWINS:

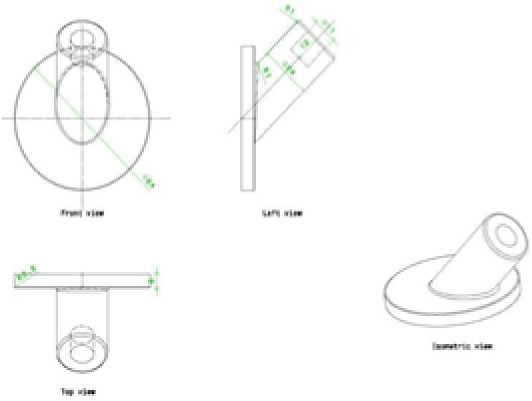

Fig 3.3 INCLINED VANE DRAFTED VIEW

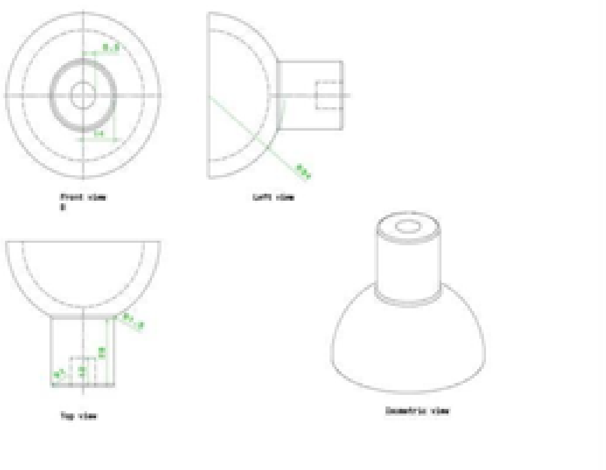

Fig 3.4 HEMISPHERICAL VANE DRAFTED VIEW

2.ANALYSIS USING ANSYS

INTRODUCTION TO ANSYS

Finite element analysis (FEA) is a fairly recent discipline crossing the boundaries of mathematics, physics, engineering and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. The finite element method is comprised of three major phases: (1) **pre-processing**, in which the analyst develops a finite element mesh to divide the subject geometry into subdomains for mathematical analysis, and applies material properties and boundary conditions, (2) **solution**, during which the program derives the governing matrix equations from the model and solves for the primary quantities, and (3) **post-processing**, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacements and stresses), and derives and examines additional quantities (such as specialized stresses and error indicators).

MODEL:

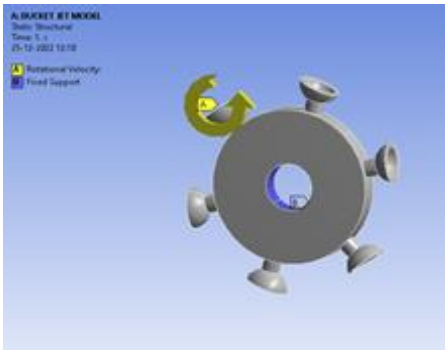

Fig 3.5 Importing Geometry into ansys

RESLUTS FOR 500 RPM

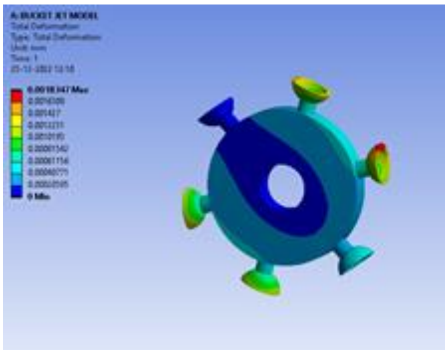

Fig 3.6 DISPLACMENT :0.0018MM

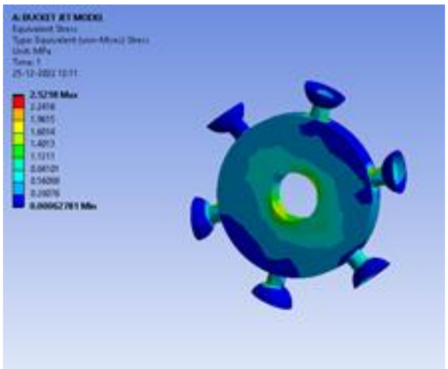

Fig 3.7 VON MISES STRESS :2.52MPA

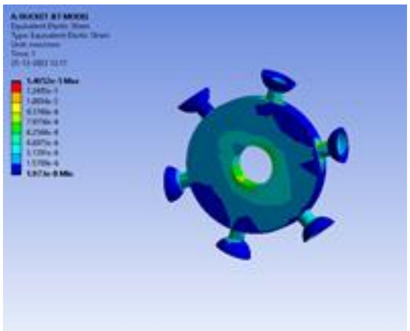

Fig 3.8 VONMISES STARIN:1.4E-5mm/mm

RESLUTS FOR 750 RPM

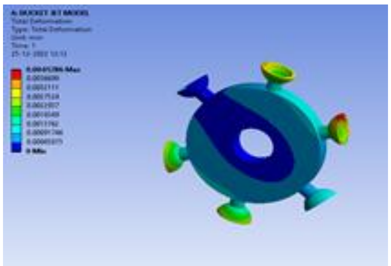

Fig 3.9 DISPLACMENT :0.032MM

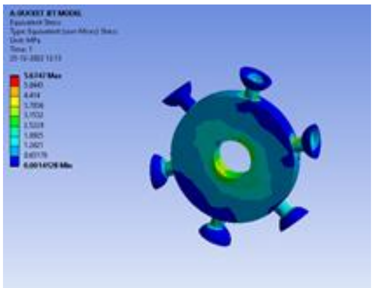

Fig 3.10 VON MISES STRESS :5.67MPA

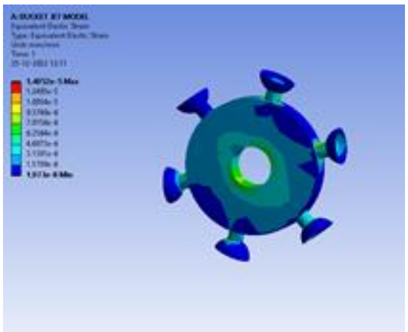

Fig 3.11 VONMISES STARIN:3.16E-5mm/mm

Post processing:

further processing and viewing of the results; in this stage one maywish to see:

- Lists of nodal displacements
- Element forces and moments
- Deflection plots

Fig 3.7 VANES IN ANSYS

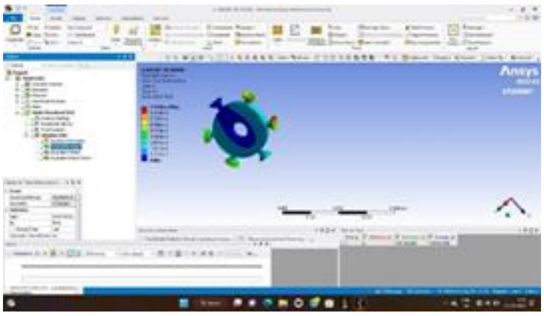

Fig 3.12 TRADITIONALLY USED NICKEL

A.Nickel 200 at 1000 rpm

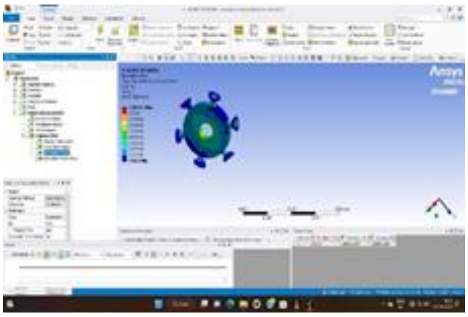

Fig 3.13 NICKEL VANES STRESS AT 1000RPM

B.Nickel 200 at 500 rpm

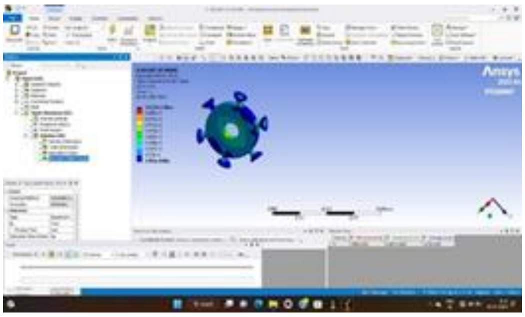

Fig 3.14 NICKEL VANES STRESS AT 1000RPM

CHAPTER -4
3D PRINTING OF HYDRAULIC VANES

❖ IDEA MAKER

What is ideaMaker from Raise3D?

The Raise3D ideal Maker software is a slicing program that converts 3D files into printable designs.

A 3D model does not have the data needed to operate the machine, so processing the model through a slicing software will create a set of instructions for your printer to make the design.

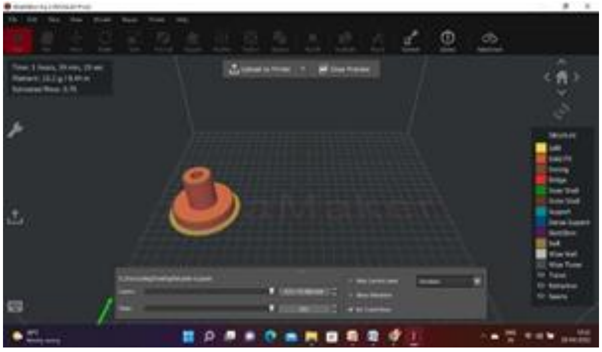

Fig 4.1 IDEA MAKER FLAT VANE

When using ideaMaker you can import 3D models files (.stl, .obj, .3mf file formats), and specify specific printing settings through the software's interface.

Once you commit these selections, the software will automatically begin „slicing‟ the model into the printable layers based on those settings. The resulting G-code file type will be the set of instructions that your printer will use to print your design. The resulting G-code file type will be the set of instructions that your printer will use to print your design. The resulting G-code file type will be the set of instructions that your printer will use to print your design. The resulting G-code file type will be the set of instructions that your printer will use to print your design.

Features of ideaMaker

IdeaMaker is a powerful, but easy to use slicing software that was specifically designed for the Raise3D line of 3D printers. Its high level of customization allows it to be compatible with several different 3rd party machines and materials – making it a very popular choice for many 3D printing users.

Presets

Most notably, the automatic presets in ideaMaker allow you to select a pre- made profile for your material and press print. This effortless process can get you to your final print in only 2 clicks.

Filament Network

ideaMaker is supported by several specialty filament manufacturers. A large range of high-quality materials has tested and approved ideaMaker templateson the Raise3D OFP (Open Filament Program).Custom Supports When it comes to 3D printing, the machine will need a platform to place the material on. For designs that have overhanging features, there will need to be support structures added to support the model from below. In ideaMaker, supports can be added to the model directly in the program, and are highly customizable.

Fig 4.2 IDEA MAKER HEMISPHERICAL VANE

RaiseCloud

IdeaMaker is directly compatible with the RaiseCloud software, allowing you to create a custom workflow for streamlined printing and on- the-go monitoring. Free and most impressively, ideaMaker is completely free. Download ideaMaker today at raise3d.com/ideamaker.

Initiate Print

To run your print file, insert the USB through one of the available USB ports on the touch screen. Select the "Print" tab and open the "USB" icon to open the available file.

If the files were uploaded via a local network, navigate to the "local storage" folder for the file instead. Select your file, and verify the information. When you're ready to start, press "Print".

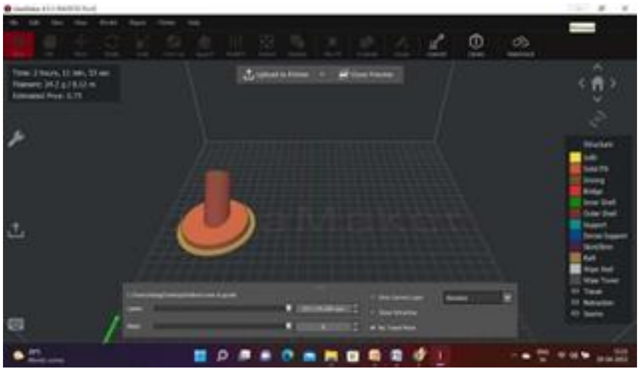

Fig4.3 IDEA MAKER INCLINED VANE

Advanced Features

Once you succeed with your first single extrusion print, you can begin to explore several advanced features for your machine.

CHAPTER-5

RESULTS & GRAPHS

5.1 GRAPH RESULTS: MAT 01- NICKEL 200

S.NO.	RPM	DISPLACEMENT (MM)	STRESS (MPA)	STRAIN (MM/MM)
1	500	0.0018	2.52	1.4E-5
2	750	0.0041	5.67	3.16E-5
3	1000	0.057	1.347	4.222E-5

Fig 5.1 RESULT TABLE FOR MAT 01- NICKEL 200

5.2 GRAPHS:

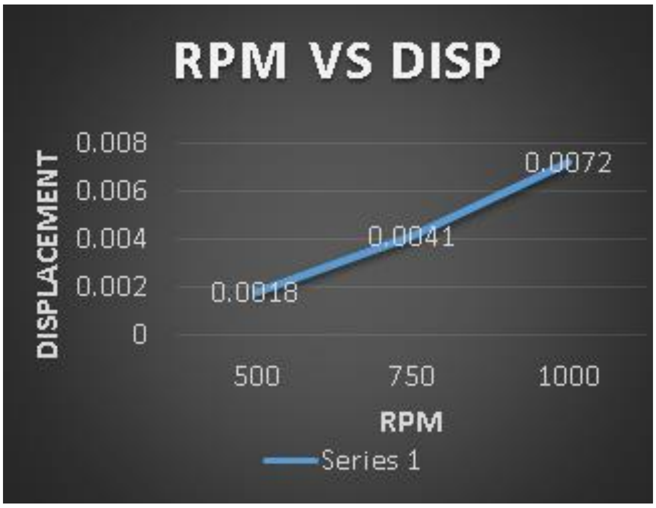

FIG 5.2 RPM vs DIPS

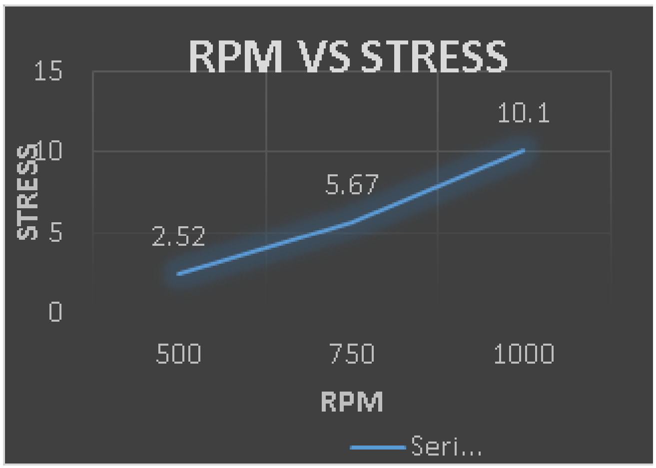

FIG 5.3 RPM vs STRESS

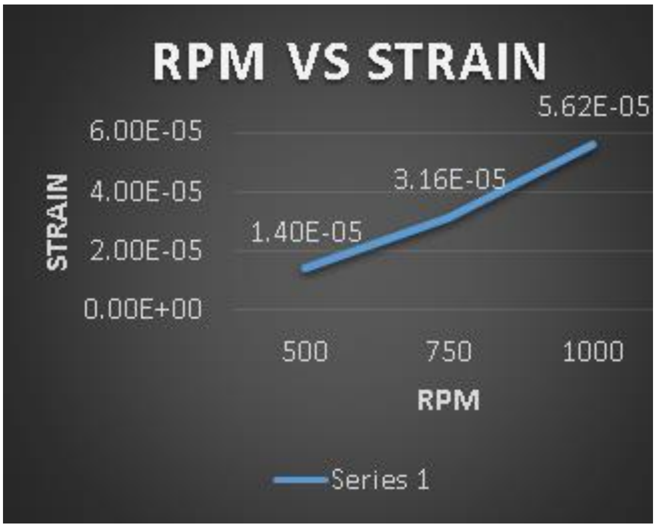

FIG 5.4 RPM vs STRINE

5.3 GRAPH RESULTS: MAT 02-POLYLACTIC ACID

S.NO.	RPM	DISPLACEMENT (MM)	STRESS (MPA)	STRAIN (MM/MM)
1	500	0.014	0.33	1.05E-4
2	750	0.032	0.75	2.37E-4
3	1000	0.057	1.34	5.76E-4

Fig 5.5 RESULT TABLE FOR MAT 02-POLYLACTIC ACID

5.4 GRAPHS:

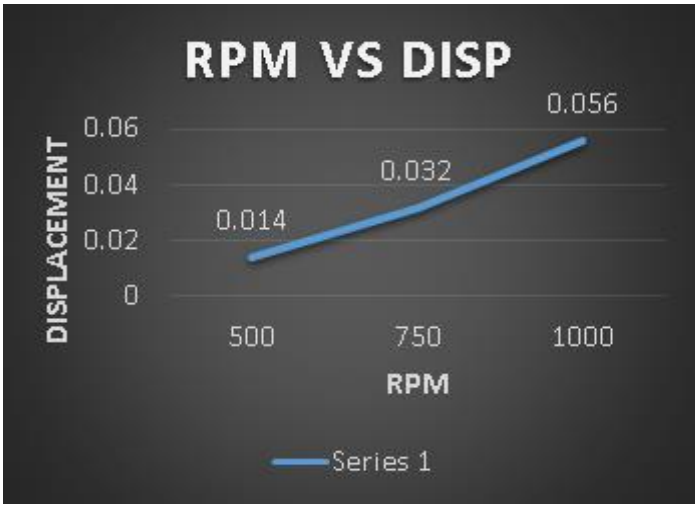

FIG 5.6 RPM vs DIPS

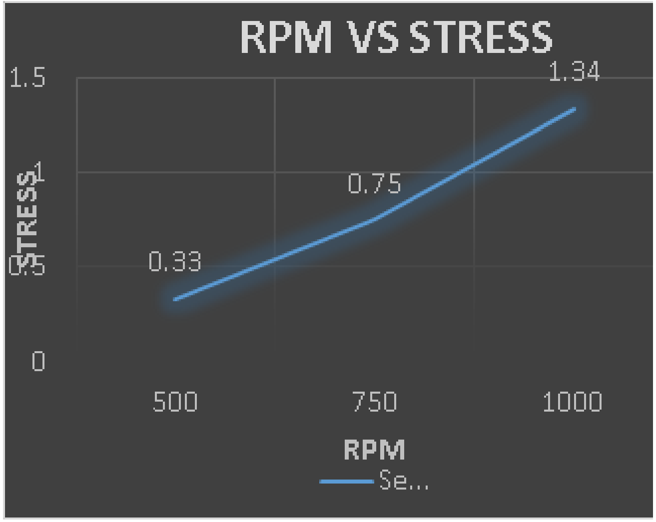

FIG 5.7 RPM vs STRESSZ

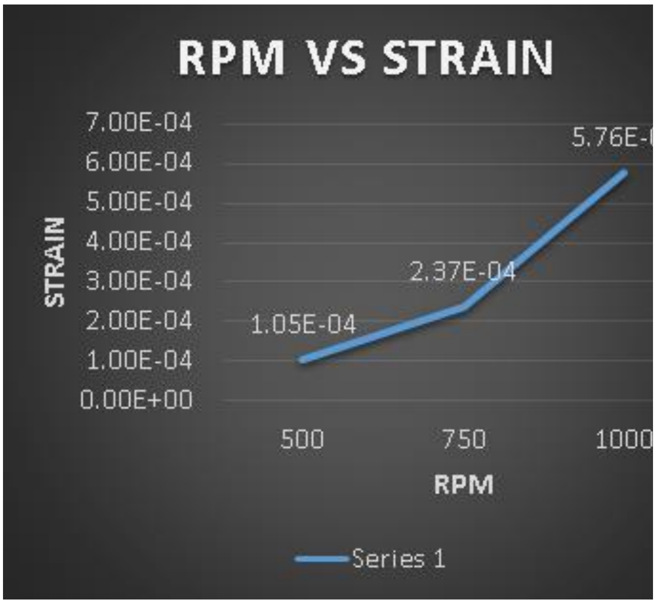

FIG 5.8 RPM vs STRINE

CHAPTER - 6
CONCLUSION

Here in this these is we have designed and 3D printed different types of vanes and performed impact of jets experiment by considering traditional vanes and 3D printed vanes.

In this project we have designed and printed 3 vanes: flat, inclined, hemispherical, in catia and saved them in stl format, then after using the ideamaker software the component is sliced and further printed on the printing bed by using the Raise 3D Pro2 equipment. From the tabular form the vane coefficient of vane corresponding to the Pla material is observed to have better value when compared to that of the traditional vanes, And the major factor to be noted is that the weight of vane can reduce to a great extent, and the pla material don't corrode when compared to the traditionally printed vanes.

Similarly analysis in ansys is performed at different Rpms comparing the PLA vanes with NICKEL vanes and found the stress and deformation values and graphs. Hence we can use 3D printed jet vanes since any complex shape can be easily obtained and there won't be any corrosion since vanes are made of PLA material and the overall weight is reduced to a great extent, this 3D printed vanes can be used for small scale power generation also.

FOR INCLINED PLATE : the vane coefficient of 3d printed vane increased by
0.04 (FROM RESULT TABLES)

FOR HEMISPHERICAL VANE : the vane coefficient of 3d printed vane increased by 0.04 (FROM RESULT TABLES)

CHAPTER - 7
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