Design manufacturing and analysis of Turbine Blades by using digital Technologies

Mr. Akshay Sakhpara [1], Prof. Arvindsinh G Rana [2], Mr. Mohit Sakhpara [3]
1(BE Student – Department of Manufacturing Engineering, CIPET Ahmedabad, India)
2(Head of Department - Department of Manufacturing Engineering, CIPET Ahmedabad, India)
3(Company – Inventive3D, Rajkot, India)

Abstract: **Digital Technologies in Engineering is playing a game changer role in the data driven Industrial revolution 4.0. Digital technologies in Engineering is inclining towards collecting data from the existing manufacturing infrastructure and analyzing it for creating new methods for production. Digital engineering uses data ranging from technical drawings to simulations and 3D Models to craft designs in a digitized environment. The aim is to study various methods of modern-day engineering and learning onto how these technologies help in making better products and solving real time challenges in the engineering. Here we take an example of a turbine blade and learn about the digital technologies which were involved in manufacturing and analysis both at the same time.**

***Index Terms* - : Scanning, Designing, analysis, Turbine blade, Advantages and disadvantages of digital technologies.**

I. INTRODUCTION

Digital Technologies in Engineering is playing a game changer role in the data driven Industrial revolution 4.0. Digital technologies in Engineering is inclining towards collecting data from the existing manufacturing infrastructure and analysing it for creating new methods for production. Digital engineering uses data ranging from technical drawings to simulations and 3D Models to craft designs in a digitized environment. Through progressive applications, the art of digital engineering enables designers to explore possibilities and develop innovative solutions in a virtual environment. 3D Models are the most important form of digital engineering but actually the computable data behind it plays the big role which opens vast possibilities and opportunities. The data can be analysed, sorted and utilized in constructive methods to gain fast, accurate and economic operations in the modern methods of manufacturing engineering.

Key factors for Digital Technologies in engineering.

1) Evolution of Digital Data: The process and methods of acquiring digital data from the existing technologies is evolving rapidly. Actuators, sensors, switches etc. provide with a lot of real time digital data which can be analysed and sorted according to the floor requirements to enhance productivity saving a lot of time and economy. The newest technologies might soon become absolute and will be replaced by faster and more efficient tools that will change the method we create and deliver projects.
2) Cracking data: Capturing accurate data is essential in developing precise digital models that can self-test the performance of the digital design. Understanding the digital data, the various methods on how it functions will unleash the power of the modern digital engineering systems.
3) Basic Engineering principles will still exist: The fundamental principles in engineering will never get out dated rather they will be enhanced with the digital engineering methods. The education system will always be around the traditional engineering principals and more on how to integrate the digital tools with them. The best result can be delivered by enhancing human and machine interactions.
4) Working in Collaboration: The traditional work process for the engineers is now being broken down to a more real time collaborative real time interaction with data and designs. Paperless ecosystems have taken over the manufacturing shop floors in the industry.
5) Improved R&D: So far predicting the performance of a design was very tough analysing a single option to derive a result. Digital engineering era allows engineers to harness the power of cloud computing to derive multiple results for a single design and also test them on the go in a virtual environment.

II. LITERATURE REVIEW

Our Aim is to analyze the dimensional accuracy of a turbine blade using digital technologies in Engineering. A blade of a turbine plays a very critical role in the flow of fluids through it. The blade profile keeps changing at various cross sections for which inspection needs to be performed.

Basically, there is an engineering drawing or a 3D CAD model for the blade which is designed keeping in mind the turbine needs and mechanical parameters. This CAD Model is the simulated using simulation software's. Once the basic tests are performed the blade goes in the casting process for which initially a wooden pattern is made using a CNC router. This pattern was then used to green sand cast the blade.

Figure 1: - Original blade of turbine

The raw casting then undergoes basic machining operations to acquire the desired dimensions. The blade further needs to be inspected to validate if the desired dimensions are acquired or not.

The inspection process begins with NON-CONTACT Laser 3D Scanning. Here we have used a Creaform 3D Laser Scanner to acquire the dimensional data of the blade profile. The 3D Scanner gives output in the form of facets also known as the mess output. The raw scanned data is processed and prepared for 3D Modeling.

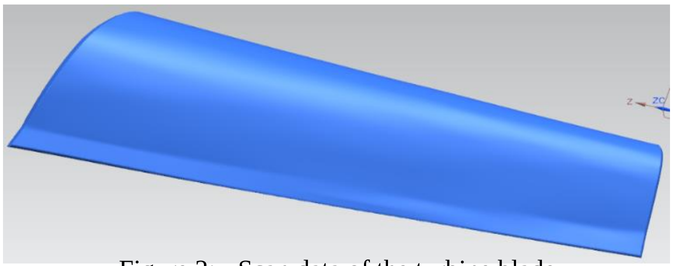


Figure 2: - Scan data of the turbine blade

This scanned data is further aligned and prepared for 3D Modeling. Using Design X software a 3D CAD Model is generated. The CAD Model will be further used for inspection purpose.

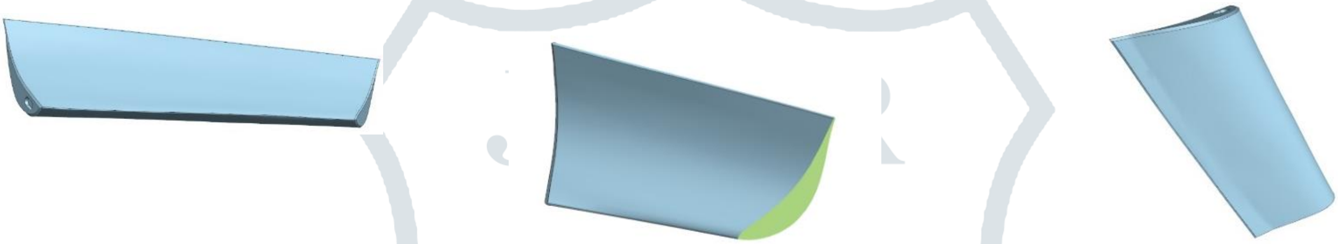


Figure 3: - CAD Model from Scan Data and Cross Section of turbine blade

The CAD model generated from the scan data is superimposed on the original CAD model and a visual deviation report is generated.

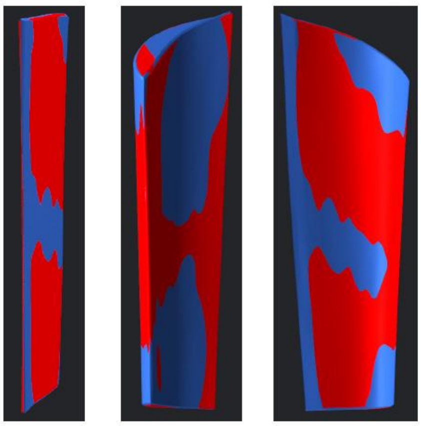
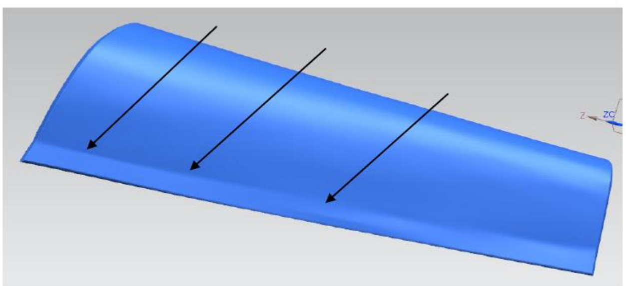


Figure 4: - Visual Deviation Report [Blue: Scan Model and Red is Original Model]

Further basic inspection from the visual CAD model is provided.



NOTE:
THE ARROW'S INDICATE MAJOR DEVIATION ON THE OUTER FACE OF THE BLADE. ORIGINAL BLADE HAS A SINGLE SURFACE ON THE OUTER FACE WHEREAS THE CASTING MODEL HAS TWO SURFACES ON THE OUTER FACE.

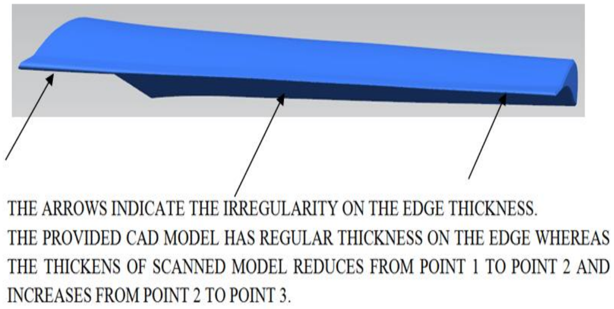


Figure 5: - The visual CAD model

The CAD Model needs to be checked at various cross sections for which a 2D Drafting is done and all the necessary values are drawn from it.

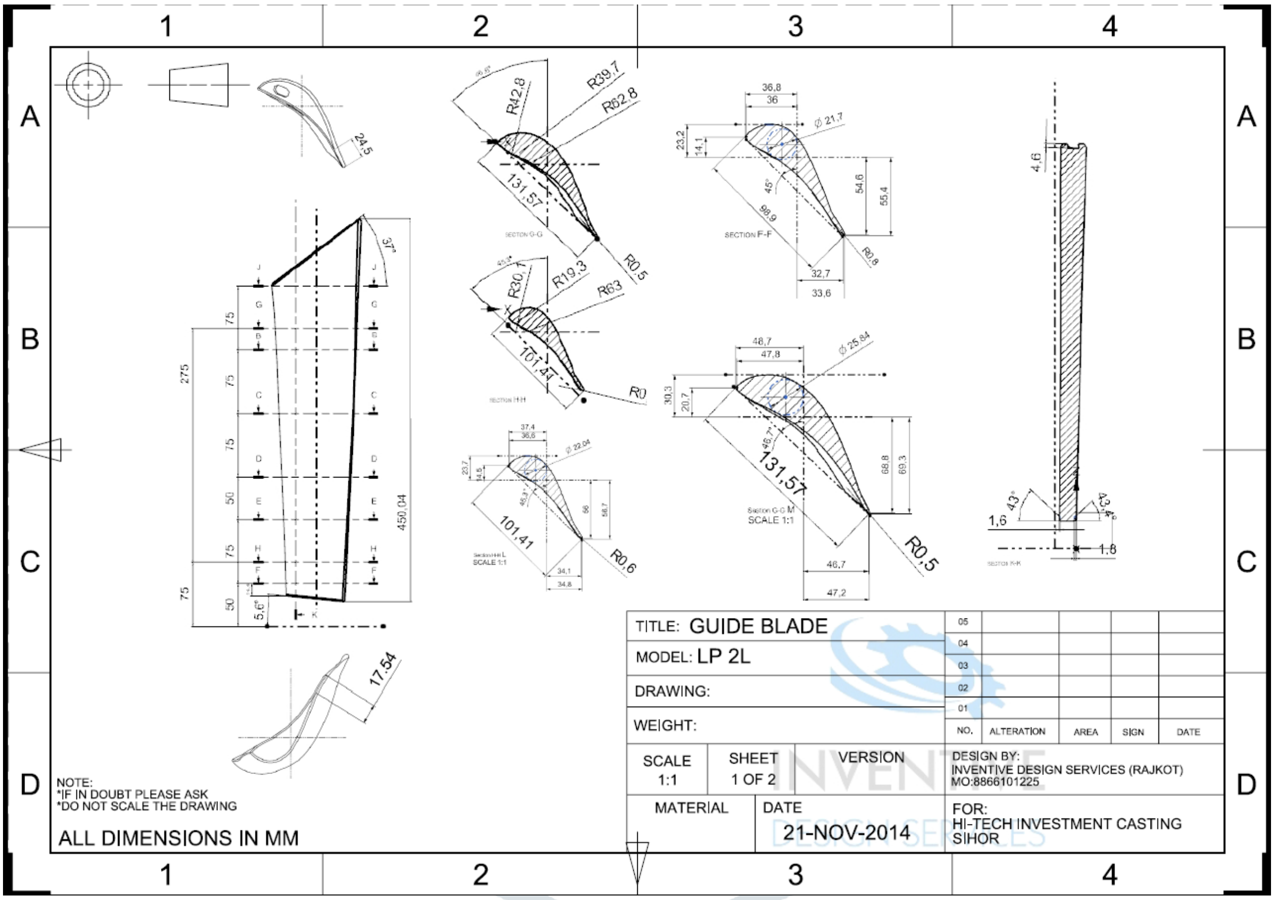


Figure 6: - 2D Drawing of the turbine blade

These values from the 2D Drawing are compared with the original values and the values for deviation are acquired. Here we take section E-E to understand the comparison. Likewise, all the cross sections and studied and analyzed.

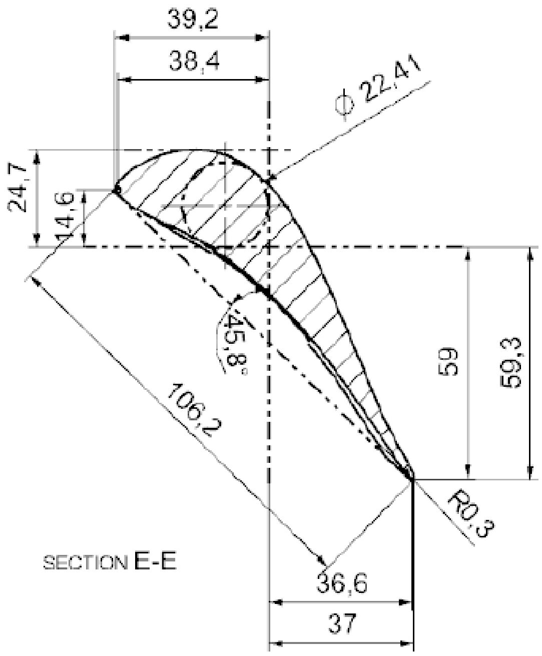


Figure 7: - Cross section area of the turbine blade

SECTION A6-A6 (E-E)

	ORIGNAL CAD	SCAN CAD
AMI	-35.09	-39.17
AMO	-34.12	-38.40
UMA	25.83	24.74
UMO	16.79	14.56
BETA B1	43.26°	45.8°
LP	106.84	106.18
R1	0.29	0.28
UM1	-60.79	-59.00
UMI	-61.07	-59.29
AM1	37.06	36.64
AMA	37.35	37.03
D	22.45	22.41

Figure 8: - Analysis results of the original and scan data

This comparative study provides details of all the dimensions and its variation from the actual values required. This helps to make necessary changes in the DIE/Pattern for casting and also necessary changes to made in the machining the raw casting and achieving the component to its desired dimensions within the tolerance limits.

Technologies behind Digital Engineering: Manufacturing industry has changed very rapidly in the last decade. The manufactures have now inclined themselves onto the technologies of industry 4.0. Manufacturers are very much aware about the shear speed of developments powered by industry 4.0.

This transformation is helping to develop more innovative solutions and products for the growing need of the consumers. The production processes have also now been integrated with data to improvise on time and speed. Technologies like IoT, robotics, atomization, 3D Printing, machine to machine talking, cloud computing, machine learning, artificial intelligence, data analytics are changing the face of industry.

For many of the manufacturers these days utilizing IoT, robotics and 3D Printing isn't a long-term goal. They have developed the capabilities and the infrastructure to adopt and utilize these data driven methods. These new technologies help them develop their product manufacturing life cycles. These technologies have already been started to be accepted in day-to-day operations of many industries in all segments.

Efficient Working and Production: With the adoption of data driven digital methods, manufacturers now have the complete set of data for their product life cycle. This gives them insights on various parameters like raw material consumption, raw material wastage, utility consumptions, packaging details and much more. This helps them eliminate wastage of material, cutting down the costs of production and organizing flexible production to meet their customer requirements faster.

Customer Focus and Servitization: Digital engineering also helps you to gather customer data, their needs, after sales and service data. This helps the manufacturer provide more support to their customers from the point where they place their buying request till the sales and after sales. Digital engineering also helps them gather customer feedback and analyze it for enhancing their product and services. Client expectations are molded by their experiences as consumers.

Innovate Easily: A digital platform is a more efficient innovative workplace. Rather than using the traditional methods like depending on the drawings for manufacturing machines, digitalization makes it possible to develop and plan the processes more efficiently. Exciting new technologies like 3D modelling systems and data connectivity enable factories to be configured and reconfigured faster and more easily than ever before – for less money.

Share specialist knowledge: There's a lot of ingenious, well-engineered machinery out there. However, the original designs – and the reasons for creating them – are often locked inside the heads of only a few people. As time passes and personnel changes, those vital insights and secrets are lost. Ultimately, no one in your organization might know why a particular machine is configured a certain way – making upgrades and replacements more complex to carry out. In a digital world, these designs are created collaboratively and stored centrally, so they can be shared with anyone. This vital knowledge therefore stays inside your company, for as long as it's needed.

2.1 Challenges in Digital technologies in Engineering:

Apart from all the benefits there are also certain challenges involved in complete implementation of Digital technologies in Engineering:

1) Adaption of Business models.
2) Investment to returns ratios.
3) High Initial Investments.
4) Concerns about data privacy.
5) Data security and surveillance.
6) Threat of IT- corporates to control the data driven markets.
7) Loss of jobs for under skilled personals.
8) Regulatory policies and standards are still not well defined.
9) Legal issues.
10) Securing data from existing and future threats.
11) Reliability on machine to machine talking and interaction.
12) Less skilled manpower available to implement digital engineering methods.

III. RESULTS AND DISCUSSION

We have improved the design of the turbine blade to reduce the following factors:

- Custom Manufacturing
- Complex Manufacturing
- Planning supply chain
- Low inventory and low volume production
- Integration into existing manufacturing methods
- Predictive and Preventive maintenance

REFERENCES

[1] Wind Turbine Blade Design Energies **2012**, *5*, 3425-3449; doi:10.3390/en5093425
[2] Fuglsang, P.; Madsen, H.A. Optimization method for wind turbine rotors. *J. Wind Eng. Ind. Aerodyn.* **1999**, *80*, 191–206.
[3] Oerlemans, S.; Sijtsma, P.; Lopez, B.M. Location and quantification of noise sources on a wind turbine. *J. Sound Vib.* **2006**, *299*, 869–883.
[4] Brown, R. G. Driving digital manufacturing to reality. In Proceedings of the 2000 Winter Simulation Conference, Orlando,Florida, USA, 10–13 December 2000, vol. 1, pp. 224–228 (IEEE, New York).
[5] Cagliano, R. and Spina, G. Advanced manufacturing technologies and strategically flexible production. J. Ops Mgmt, 2003, 18, 169–190.