

## CASE STUDY AND PART ANALYSIS FOR CNC MACHINES

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**Abstract:** *Computer numerical control setups have begun to pop up in the manufacturing industries across the world due to their high efficiency and minimal dependance on human labor. In this research paper, we aim to understand the in depth functioning of CNC machines, perform different analysis and finally suggest a vast no. of ways in which these manufacturing marvels can be implemented into different industries. Under the analysis aspect of this research paper, we have performed the analysis of miller beds with the basematerials as Cast Iron, Stainless Steel and Carbon reinforced polymer using state of the art analysis software like Ansys and we have tried to understand the differences between these materials using their Stress and Strain analysis on Ansys.*

### INTRODUCTION

CNC machining is a manufacturing process in which pre-programmed computer software dictates the movement of factory tools and machinery. The process can be used to control a range of complex machinery, from grinders and lathes to mills and routers. With CNC machining, three-dimensional cutting tasks can be accomplished in a single set of prompts. When a CNC system is activated, the desired cuts are programmed into the software and dictated to corresponding tools and machinery, which carry out the dimensional tasks as specified, much like a robot. The programs for CNC machines are fed to computers through small keyboards instead of heavy-duty systems. CNC programming is retained in a computer's memory. The code itself is written and edited by programmers. Therefore, CNC systems offer far more expansive computational capacity. Best of all, CNC systems are by no means static, since newer prompts can be added to pre-existing programs through revised code. Abbreviated as CNC, the Computer

MODELING AND  
ANALYSIS

A simulative analysis on Material Selection of a CNC Milling machine's Bed

The transfer of high speed as well as the high cutting speed of machine tools is very essential for the improvement of productivity. It ensures not only faster cutting rates but also lesser cutting force. Faster cutting speeds can be acquired only by structure which has high stiffness and good damping characteristics. Clear the life of a machine is inversely proportional to the levels of vibration that the machine is subjected.

A 3D model of the CNC machine bed was created in the SOLIDWORKS 2019 software and saved in the images format and imported into Ansys workbench. The analysis was carried out on three materials cast iron, stainless steel and carbon fiber polymer. The forces in the front are the weight of the machine bed and cutting forces that are applied to the guideways. The forced at the back of the bed are mainly due to the motors that are present in the machine.

There are two types of analysis that this machine bed undergoes:

1. Statical Analysis - A static analysis calculates the effects of steady loading on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads.
2. Normal Stress Strain analysis - A normal strain results from tensile stress and is a strain computed from relative displacements that are measured perpendicular to two reference planes.

Machine Bed supports all elements like column, work table and servo motors. Whatever the cutting force induced in the machining process is simply transformed to machine bed, and machine beds absorb the vibrations induced in the machining process. Machine bed contains hole for accommodating the lead screw which drives the work table. So that workpiece can be moved as per the user programming code. It also supports the column on the rear end of it with the help of lead screws. Machine beds withstand the various forces generated during the cutting.

#### OBSERVATIONS AND INFERENCES

Total deformation of carbon polymer composite machine bed is less than the deformation due to both Steel and Cast Iron due to its high Young's Modulus than both Steel and Cast Iron.

Since stress is independent of Material Property, hence stress induced all the machine beds is approximately same because there is no design modification.

Normal Strain of carbon polymer composite machine bed is less than the both Steel and Cast Iron due to its high Young's Modulus than both Steel and Cast Iron.

Condition	Cast Iron	Steel	Carbon Fibre Polymer
Total deformation	$3.9567 \times 10^{-5}$	$2.887 \times 10^{-5}$	$2.0543 \times 10^{-5}$
Normal Stress(mpa)	0.040325	0.036949	0.040325
Normal Strain (mpa)	$2.5335 \times 10^{-7}$	$1.4113 \times 10^{-7}$	$1.3193 \times 10^{-7}$

Table 1: Comparison of Different Materials

This composite material offers high accuracy and precision of the component manufactured in such machine tools made of composite materials. By considering all the results, the induced deformation and strain in carbon polymer machine bed is less than conventional cast iron machine beds because specific strength and specific rigidity of carbon polymer machine bed is more than cast iron. The work suggests that carbon polymer material is best suited for CNC milling machine bed.

#### Finite element analysis of CNC Lathe: The Spindle

Machine tool industry is the key industry of machinery manufacturing industry, to provide equipment for the manufacturing industry. The machine tool spindle is the key components of the machine tool spindle, a chuck mounting the front end of the workpiece or tool directly involved in cutting performance, especially the low order natural frequency has a great influence on the performance of the machine tool. Especially for CNC machining it requires both high precision and high efficiency requirements, it is necessary to carry out and finish machining process, but also some rough machining, therefore, put forward higher

requirements on the static and dynamic characteristics of the spindle. In this paper, the finite element machine spindle based on ANSYS analysis, provide a reference for the design of the spindle.

#### OBSERVATIONS AND INFERENCES

The harmonic motion is observed in the spindle of the lathe as the frequency of a normal turning operation is increased at stated intervals of time.

Every increase in the frequency is referred to as order and each order changes with an increase in the rotation frequency. The spindle here undergoes 4 orders Starting from 1 to 4.

The vibration of the structure can be expressed as a linear superposition, including low order modes than the effect of higher modes of vibration on the structure. The dynamic characteristics of low order modes of structure play a decisive role, it analyzes the vibration characteristics of structure. The natural frequency of the spindle is high enough, the spindle static stiffness can meet the design requirements of high stiffness. The first critical speed calculation of  $60 \times 338.52 = 20311.2 \text{ r/min}$  according to the natural frequency of spindle. Modal analysis was done far greater than the working speed of spindle (less than  $1600 \text{ r/min}$ ), indicating that the work spindle speed can effectively avoid to ensure the machining precision of the spindle resonance. The spindle should be stiff enough to carry operations without any bending and with increasing speed of the CNC lathe the job was done more precise and accurately than a manual one.

#### Applications of CNC Machines

##### APPLICATION

CNC machines are used to create various complex parts for a large number of industries. Although mass production can also be used in some fields, others require custom-made parts for certain purposes. Industries tend to use CNC machines since it provides the ability to create precise parts with the help of a computer. From medical to military fields, all rely on machining parts. Since the technology has vastly improved over the years in both machines and computers, using CNC machines makes it easier to produce complex and intricate parts as compared to the conventional methods.

##### Medical Industry

This is an industry involving life and death and hence precision is of utmost importance. High precision and high rate of production are needed to meet the demands in this field. The CNC machines are easily able to cope up with stipulations due to a variety of materials and techniques. They can easily create intricate and custom parts in large volumes. The approval of the Central Drugs Standard Control (CDSCO) is also required in this industry. Since a computer is used for manufacturing, it enables the engineer to check the part prior to machining and the margin of error. There may be some parts which combine to form a device and, in such cases, high accuracy is needed to prevent device failure and incorrect results.

##### Transportation Industry

The need and use of CNC Machines is very similar to the aerospace industry. The testing and analysis during the prototyping stage requires parts and any changes needed can be quickly implemented through the computer and new modified parts can be obtained. The

properties required in this field are slightly different to those in the aviation industry. There we require highspeed strength and stability but here we need and durable parts. Since a CNC Machine can work with a variety of materials, it can be used to create almost every part, from engine to brakes.

#### Oil and Gas Industry

The machinery required in this industry is built up of a large number of parts that need to be accurate so that they can properly fit together. In case of a mismatch, there could occur a leak or some functions may not work as intended. Hence, a CNC machine is needed for high accuracy. Generally, oil and gas plants are set up at locations far away from major towns and cities and hence the parts of the machinery should be robust and have high they should be able resist various natural forces because if they fail, production will stop for a long time.

#### Military Industry

Much like the oil and gas industry, the military requires parts that are tough and sturdy and there can be no compromise in accuracy. The government sets strict regulations on military products that need to be followed and these are conveniently complied with while using a CNC Machine since it can easily make intricate parts with high precision. Although the working and operation of all procedures related to the military are kept private, the CNC Machines are an entity that cannot be ignored for manufacturing processes given its quick and accurate production.

#### FUTURE SCOPE

The development of CNC Machines transformed the design and manufacturing industry. Their attributes of providing complex parts with great accuracy and precision at high production rates made their importance unprecedented. However, the question of whether there is room for improvement or if production should continue as it is, still persists. One opinion was that the human programmers operating on this machine would soon be replaced by Artificial Intelligence and Machine Learning, which have taken massive strides in recent years. This could be possible since it is believed that machining through CNC Machines is highly adaptive and a closed-loop and computers these days have the ability to study and learn from the past operations and quickly implement them through Artificial Intelligence and Machine Learning.

#### CNC and Robotics

The idea here is to create an environment of machines that requires minimal human influence and continues the process in an efficient manner. Projects are being carried out to incorporate CNC Machines and robots to work together. The CNC Machines will make the parts as they currently do but robots will be used for packing and moving of these parts. The plan will be to create such a software that allows the CNC operator to easily control this system of machines to achieve maximum efficiency with minimum effort. With the growing advancement of Artificial Intelligence and Machine Learning, this collaboration of CNC Machines and robots could happen in the near future.

#### Digitalization

This involves simulating an object or a process in a virtual environment to get a better insight on the situation. It basically involves collection of data and processing it to help in analysis and simulation. It is a trend that is being adopted by various industries and shall soon make its way into the machining world. This will increase productivity and help new ideas come to life. The idea is to collect as data as possible because it would make the “virtual twin” more accurate and hence its simulation will also be more precise. The design engineers can use the findings of the simulation to great effect to plan and the machining process.

#### Personalization of CNC Machines

Over the years, CNC Machines have become cheaper, smaller and easier to use. Companies that manufacture them are trying to make them more to increase not only industrial but personal use as well. Just like 3D printing has become very popular these days, CNC Machines can have similar demands if the machines are made compact and easy to use and are made available for an affordable price. People can keep them in their personal workshops. No one thought that computers would be so widely used and could even fit in our pockets when they were invented. A similar situation with CNC Machines is likely on the cards with growing efforts to these machines. This will birth new ideas and innovations.

#### CONCLUSION

Computer numerical control (CNC) is a strategy for robotizing control of machine instruments using programming installed in a microcomputer connected to the apparatus. CNC machines are utilized to make an assortment of items utilizing various cycles. With appropriate preparing, a human administrator can utilize CNC machines to make exact parts with diminished danger of mistake. Subsequent to taking this class clients ought to have the option to depict regular parts of CNC machine instruments and controls. CNC machining assumes a fundamental part in the advancing universe of current assembling. On account of ongoing headways in innovation, gone are the times of abrasive plant life. Laborers today utilize their machining abilities in a perfect, proficient setting with cutting edge and forefront innovation. Laid out above are the essentials of the CNC machining measure, different CNC machining activities and their necessary

hardware, and a portion of the contemplations that might be considered by makers and machine shops when choosing whether CNC machining is the most ideal answer for their specific assembling application. In this existence where there is no time at all to squander, CNC machining is the most ideal approach to be productive and on schedule with substantially less mistake than a human worked machine. With developing age and innovation, the necessities of utilizing such machines have been prime and acknowledged around the world. This guarantees less work exertion with more prominent exactness.

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