International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 09 | September - 2022 Impact Factor: 7.185 ISSN: 2582-3930

DESIGN AND IMPLIMENTATION OF A MECHATRONIC SYSTEM NAMELY SEAT CHECK MODULE WITH APPLICATION TO CNC SYSTEM: A REVIEW

Mr. Shubham Kumar[1], Mr. Sandeep Malik[2]

[1]*M.Tech. Scholar, University Institute of Engineering & Technology, Maharishi Dayanand University, Rohtak, Haryana, India*

[2] *Faculty Member, University Institute of Engineering & Technology, Maharishi Dayanand University, Rohtak, Haryana, India*

Abstract - In this study an effective method has been developed to automate a process implemented in manufacturing industry "CNC system", it details the research and development of a mechatronic system to overcome one of the most difficult tasks in today's manufacturing industry which is to reduce number of rejected parts of NG parts. This problem mainly occurs when the metal workpiece is disturbed or not properly attached to the fixture and due to that small change in location, it gets improperly machined, which leads to part getting rejected. A gap inspection sensor is included in the design to confirm that the workpiece is properly seated on the fixture and all the components needed for module assembly are designed and tested on a VMC machine. As the gap check sensor uses the principle of back pressure sensing to monitor the gap or distance, the sensor is supplied with pneumatic pressure through a regulator to ensure stabilized input, and outlet of sensor is connected to the orifices on the fixture plate under clamping points, so when the job is placed properly there is no air leakage and the change in pressure will respond to sensor. The developed module gets linked to PLC and needed changes were also made in ladder logic program to incorporate the new module in machine running cycle. This developed architecture is flexible and can be used on many other machines and applications. Doing so automates the machine and prevents potential tool damage and material wastage.

Keywords - **Mechatronic System, Sensor, Automation, Back pressure Sensing, CNC Programming, PLC program (Ladder Logic), Precision manufacturing**

I. Introduction

The projected system design aims to supply a universal platform, that each specialized and generic implementation is developed to tier appreciate the specialized systems. An electronic observation and management systems should be easy to deploy on a general, adaptable framework.

As Taskos, N. (2020) suggested “Industrial pressure sensors are strong, dependable, and built to withstand tough conditions. They are essential for monitoring industrial processes. Additionally, real-time data on ambient and flow conditions can be gathered via sensors employed in automation, and this information can serve as the foundation for optimization.” [1]

While parts are getting machined on a CNC machine or a VMC machine the rate at which material is removed is very high as the rpm of the tool is high and the workpiece is mounted on the fixture to ensure the workpiece is held still while getting machined to deliver safe and convenient working throughout

But the workpiece has to go under a lot of forces like cutting forces of tool vibrations internal resistances generated etc. They can lead to the workpiece to disorient while getting machined and this could lead in not the good part which is not up to the standard and will not go through to perform the work it is meant to do the assigned task or operation.

In general practice what happen when we put a workpiece in a machine for machining the forces acting on that it could disorient the work piece and result it in the deformation of that workpiece and after the deformation the machining would be completely abnormal and this will not sustain the task and applications it is supposed to perform or the purpose for which the product is designed for.

What we purpose for overcoming the problem there is a sensor-based method available to ensure there is no movement of the workpiece while getting machined and if there is any such play while job is under process the job operation running on CNC will be stopped automatically this is possible by using a seat check sensor which works on the principle of reverse pneumatic pressure look-up.

This will check that the sensor is placed and it will monitor the pressure of air which is being supplied and if there is no gap in between the fixture and the workpiece the return pressure will be uniform but in case if it get disorient or misalign than that return pressure will be variable i.e. it will change and that change will suddenly get reflected to the machine and in the programming on the CNC machining on the ladder we can ensure that the ongoing operation is stopped at that moment so that we can ensure there is no loss in the workpiece or there is no problem in the machine and less not good parts will be produced to make sure a day's reduce wastage of material and safe working operations could be performed with precision manufacturing this will result in the saving money saving time and increase production rate and this the best effective and efficient method.

II. Working Principle

The seat check or air gap sensor works on the principle of high accuracy back pressure sensing. An amount of 2 kg pressurized compressed air can be supplied or discharged to the fixture through an air hole, usually a 1.2-2 mm drilled hole.

A sensor measures the back pressure while the workpiece is held in a fixture. When everything is perfect, the back pressure is 2 kg. This indicates that there is no space between the fixture and the work surface. Air leakage and reduced back pressure might be caused by subpar manufacturing or contamination with foreign contaminants. The same is detected, and the PLC receives an output in response.

Our system's primary goal is to ensure that the component is perfectly seated or butted on the machining fixture, which will have an impact on other elements like high output and cost-cutting due to less metal waste. Additionally, it encourages avoiding tool breakage due to improper loading and lowering the likelihood of improper machining, which results in rejection of jobs

Control systems have been reviewed to address various elements of precision manufacturing, from cost control to process management and location analysis. This system offers user friendliness as an improved package for CNC machines. System requirements for modern machining and control systems in manufacturing provide appropriate guidelines for developing universal systems. These devices use input from multiple sources (pneumatics pressure sensor, PLC ladders, I/O commands, and operators' input) to perform control tasks and improve performance. It has a user-friendly interface, supports dynamic situations.

The application of this system is specific to the manufacturing industry. The majority of sensor and actuation control systems created for particular purposes are in this situation. This is a complex solution that aims to outperform general-purpose systems in terms of performance. A flexible platform is what the suggested industrial automation control system module attempts to offer. This platform enables the development of custom systems and generic layout which can be improved for many other applications

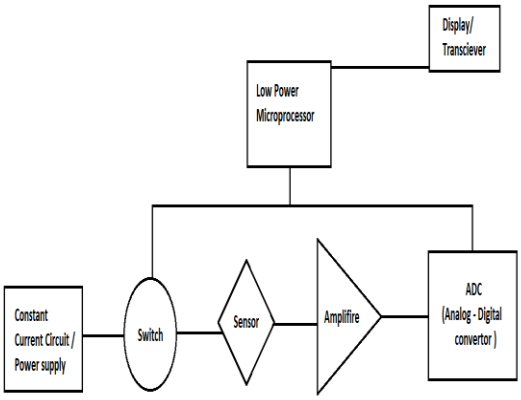

Fig.1. - Block Diagram of gap check sensor module

Here ADC is Analog to Digital Convertor and Transceiver is also called Display unit, Microprocessor is a low power type. The relevant control unit additionally gets incoming signals, processes and controls automatically (or may be manipulated manually)

III. Proposed Structure

The first phase focused mainly on the development of the software framework, not the hardware. The system is designed to be developed to meet all system requirements. Many of these needs had not yet been implemented by the time the original frameworks were finished. These aspects involve: sampling of sensors and actuators, driving circuits, housings, interconnection and environmental conservation.

Fig. 2. - 4 point - Gap Check Module installed on VMC with SMC ISA-3 GAP Check Sensor and Inlet Pneumatic Pressure Regulator [13]

The main purpose is not only to monitor the seat check but also if in any ongoing operation there is any change in set parameters for sensor gets changed it will result in generation of an error and display message on operator screen is seat check error and without clearing or resetting the error cycle will not start again.

To make this feature in effect we not only made change in plc programming of machine we edit the VMC cycle with a new M code for seat check assign the required functions in the MDI mode so the master program gets the parameters and by any possibility if there is any fault in sensor or module, we made an alternative m code to run the machine without using seat check also

ON is for job placed and OFF is for job Not placed

Green color displayed value – Job is in the allowable range and red color displayed value – Job is beyond the allowable range

Although this framework demonstrates a high degree of originality and adaptability, some aspects still need improvement. Control system applications currently account for the majority of development. The platform will thereafter be improved for commercial use, and a common framework will be used for new applications, which are the two key categories of future development.

IV. Literature Review

Related Work

Lanzolla, et al. (2022) “To characterize either movement or force profiles during autonomous characterization testing utilizing a high repeatable industrial robot, a suitable measuring setup was created. An approach was created to account for the impact of temperature by evaluating the relationship between the applied stimulation and the change of the resistance value of the 3D-printed sensor.”.[2]

Author says that “In a variety of industrial applications as well as in our daily lives, sensors are frequently utilized as the "ears," "noses," or "eyes" for information processing systems. Real-time information is often provided by sensors, which has advanced the electronic industry by simplifying contemporary technical systems and making many systems analysis and design more affordable, dependable, and safe.”.[3]

Dornfeld et al. Says that “Due to recent advancements and trends in machining technology and machine tool design, monitoring systems in the production environment are facing new challenges (high speed machining and hard turning, for example). The use of in-process sensors helps manufacturing systems produce goods at a price that is affordable to the mass consumer market. Manufacturing systems are controlled and produced more effectively by using control signals produced by in-process sensors.” [4]

N. Kyura and H. Oho (1996) highlights “To give a framework for technological and practical considerations, the term "mechatronics" is defined. The significance of "intimate and organic" integration is emphasized within this framework for mechatronics product designs. There are several obstacles in the way of mechatronics product designs achieving this ideal blend of mechanical, electrical controls, and system engineering.” [5]

Ntemi, et al. (2022) "Computer numerical controlled (CNC) tools are the most basic systems in the manufacturing sector. The entire machining operations are governed by complicated dynamics and non-linear interactions, making it extremely difficult to automate and optimize their functionality. Recent technological developments in machining incorporate intelligence into CNC equipment to increase the accuracy and productivity of real-time cutting operations while lowering waste and expense." [6]

Schöner, Hans-Peter et al. (2004) proposes that "In mechanical systems, adding actuators to boost actuation forces or actuation speed is frequently the first step toward automation. This action introduces external power into the system. Many seat positioning or window actuation systems in cars are actually in this state." [7]

Yalcin M. Ertekin et al. (2003) "That Cutting speed (CS), feed rate (F), and depth of cut (DOC) are the three main machining factors that can be adjusted in order to manage the surface roughness and dimensional accuracy when cutting metal. The factors can be easily changed, have a clear impact on the quality features, and there is a wealth of machining and empirical data obtained from the cutting operations, making the control practicable." [8]

Nuaimi et al. (2012) given "a review of this area highlighting its main ideas and difficulties. Flexibility, ease of extendable development, and centralized high-level decision making are among the fundamental design elements mentioned. The efficiency and efficacy of data management, interoperability and extensibility, data integrity, computational cost, multiuser support, real-time information processing, and security are among the major issues. Web-based sensor networks are offered by a number of systems for a range of purposes, with data collection and processing being the main priorities." [9]

While "On the other hand, according to McKeown, quality control is most effective when measurements are made as close as possible to the manufacturing process, such as with on-machine and in-process surface metrology.".[10]

Bradley David, et al. (2015) "that the growth of the Internet of Things is requiring mechatronics engineers, designers, practitioners, and educators to investigate how mechatronic systems and components are viewed, created, and manufactured. By doing so, they may tackle new problems including data security, machine ethics, and the human-machine interface.".[11]

Mali et al.,2022 says "Actuators and sensors continued to advance alongside the created designs in order to achieve precise placement. A great number of XY stage actuators are used in micro-positioning, however these days, actuators with stage XYZ and stage XY (3 - DOF) are more common, especially in robotics applications. Additionally, the sensors improved in sensitivity and dependability. The present compliance system has an incorporated sensing element and integrated actuator." [12]

V. Conclusion

The development of a modular, adaptable platform for mechatronic sensor monitoring and control. Hardware management and optimization are made possible by the platform's configuration and modularity.

By using a mature system design, flexibility, innovation, and extensibility have all been effectively demonstrated. The three main elements of the CNC logical interface are the spacing inspection sensor, controller, and programme. They are all well integrated and provide a strong framework for complex monitoring and control.

The present setup enables system customization for a variety of applications. This platform's design and implementation in the VMC production system, which controlled the speed of the machine in space, were successful.

Due to the effectiveness and efficiency of our module, less material is wasted, and more productive productions are obtained, ultimately saving time.

VI. References

[1] Taskos, N. (2020, September 16). Sensor applications in Industrial Automation & Control. ES Systems. Retrieved September 5, 2022

[2] Lanzolla, Anna Maria Lucia, et al. "Additive Manufacturing for Sensors: Piezoresistive Strain Gauge with Temperature Compensation." Applied Sciences 12.17 (2022): 8607.

[3] Maddipatla, Dinesh, Binu B. Narakathu, and Massood Atashbar. "Recent progress in manufacturing techniques of

printed and flexible sensors: a review." Biosensors 10.12 (2020): 199.

[4] Dornfeld, David, and Dae-Eun Lee. Sensors for precision manufacturing. Springer US, 2008.

[5] N. Kyura and H. Oho, "Mechatronics-an industrial perspective," in IEEE/ASME Transactions on Mechatronics, vol. 1, no. 1, pp. 10-15, March 1996, doi: 10.1109/3516.491405.

[6] Ntemi, Myrsini, et al. "Infrastructure monitoring and quality diagnosis in CNC machining: A review." CIRP Journal of Manufacturing Science and Technology 38 (2022): 631-649.

[7] Schöner, Hans-Peter. "Automotive mechatronics." Control engineering practice 12.11 (2004): 1343-1351.

[8] Yalcin M. Ertekin, Yongjin Kwon, Tzu-Liang (Bill) Tseng, "Identification of common sensory features for the control of CNC milling operations under varying cutting conditions", International Journal of Machine Tools and Manufacture, Volume 43, Issue 9,2003, Pages 897-904.

[9] K. Al Nuaimi, M. Al Nuaimi, N. Mohamed, I. Jawhar and K. Shuaib, "Web-based wireless sensor networks: a survey of architectures and applications," in Proceedings of the 6th International Conference on Ubiquitous Information Management and Communication, 2012.

[10] McKeown PA, Wills-Moren WJ, Read RF (1987) “In-situ metrology and machine-based interferometry for shape determination. Proceedings of SPIE”: 802: 42-47.

[11] Bradley, David, et al. "The Internet of Things–The future or the end of mechatronics." Mechatronics 27 (2015): 57-74.

[12] Mali, Arun B., and G. Arun Kumar. "Design and development of compliant mechanisms using various sensors and actuators: A review." AIP Conference Proceedings. Vol. 2460. No. 1. AIP Publishing LLC, 2022.

[13] Images clicked from ASR engineers Gurugram