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Design and Analysis of Gantry Automation System for Crankcase Machining in VMC

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***Abstract*: Industrial automation deals mainly with automation of manufacturing, quality control and material handling processes. Gantry system is one of the pioneer stages in industrial material handling systems. The aim of this work is to design and develop the part-handling units of a gantry automation system. Different part handling units like End-of-arm, Input Conveyor, shuttle and swing arm unit and output Conveyor have been designed, manufactured and deployed in the gantry automation system that facilitates automatic loading and unloading of crankcase component during CNC operation. These part handling units are custom designed to meet the customer requirements for production line that consists of one Vertical Machining Centers that performs drilling operation in upright condition of the crankcase component .In this gantry automation system, first design is carried out as per customer requirements then assembly process is carried out with electrical wiring as per design, then gantry is made to automatically pick and place the crankcase component using controlling unit and PLC software from one station to other and the machined component is placed on top of the output conveyor as the end operation in gantry system. The main objective behind this work is to reduce the material handling time of the crankcase component during the machining operations and to increase productivity.**

***Keywords*: Industrial Automation, Gantry system, Vertical Machining Centre (VMC), Productivity, Crankcase.**

1. Introduction

Automation is a technology makes use of self-regulating equipment, electronic equipment, etc. to make a manufacturing process or systems operate at higher speed and with little or no human intervention. Automation is “The formation and application of technology to monitor and control the production and delivery of products and services”. Though automation can be applied in a wide variety of areas, it is most closely associated with the manufacturing industries.

The word ‘Automation’ is derivative of Greek words “Auto” (self) and “Matos” (moving). Automation therefore is the mechanism for systems that “move by itself”. However, apart from this original sense of the word, automated systems also reach significantly superior performance than what is possible with manual systems, in terms of power, precision and speed of operation.

Automation have been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices the gantry system are column, beam, Carriage with Loader, End-of-Arm Tool (EOA).This gantry system is placed between VMC in the layout and all other automated stations are positioned in- line with this gantry system thereby making the gantry to automatically pick the crankcase component from machine and place it on other machine. The different part handling systems to be designed in order to handle the crankcase component are End-of-Arm, Input shuttle, Rotary Orientation with swing arm loader unit.

2. Related Work

There are number of technologies proposed for Gantry Automation System, some of the related literatures reviewed for this work is as follows.

The part needs to be handled in this work is a crankcase. The size and shape of this component is unaltered throughout the operation; hence the gripper system is designed for a component that is having a same size and shape all the time. Whereas the author A. Chesoh et.al [1] has proposed a gripper suitable for different size and shape of the component. Hence, only the basic gripping technology is considered from the paper that helps in building the gripper system for a crankcase component that is having a definite size and shape throughout the process. Sandeep S et.al [2] has proposed the automatic loading and unloading of components to the CNC machine. It makes use of gravity chute for the part flow which is fixed to the machine itself and a swing arm is deployed for picking and placing the component automatically. The complete system is designed for the front loading of the CNC machine. Whereas the requirement in this present work is to develop a system that is capable of loading and unloading the component from top of the machine. Thereby utilizing the overhead space and decreasing the overall layout space. Hence, an overhead gantry system needs to be designed.

The crankcase component needs to store on the buffer conveyor when the other crankcase is in machining operation. Hence, mechanical conveyors need to be designed for part storing. S. Gualtiero Fantoni et.al [4] has discussed the grasping devices build with the help of different sensors for detection of part.

3. Design of Part Handling System of Automated Gantry System

The design of various handling system of automated gantry system used for crankcase machining in VMC are discussed in this section.

A. *Design of End-of-Arm Tool*

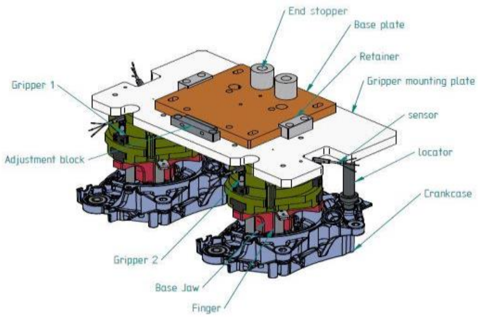

Fig. 1. End- of-arm for gantry

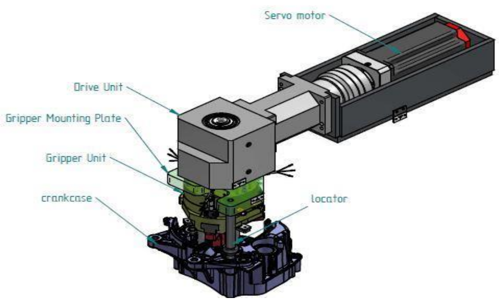

Fig. 2. End-of-arm for swing arm loader

End-of-Arm tool is an end effector used to grasp and change orientation of the component during the machining work cycle. The End-of-arm tool used on the gantry and loader is undistinguishable. The schematic representation of the proposed End-of-arm for gantry operation and swing loader operation is as shown in the Fig 1 and Fig 2 respectively. The function of End- of-arm on swing loader is to grip the inner diameter of the component, which is of 30.5 in diameter in Upright condition of crankcase, and to load the same to gantry pick station. End-of-arm on gantry is to grip the inner diameter of the component, which is of 30.5 mm in diameter in upright condition, and to load the same to output conveyor.

Working Mechanism: The pneumatic functioned three jaw concentric gripper, grasp the component firmly using the fingers provided. Once the component is grasped in upright or down condition, a feedback is taken using the sensors mounted to know the gripper condition (open or close). Using this feedback, the EOA will be moved to the intended position to unload the component. The gripper is made open condition to unload the component to the chuck, then the pressure start provided will be actuated having a stroke of 8 mm, it will push the component away from the chuck during unloading.

Analysis of Base Plate: The base plate is made of mild steel with yield strength of 296 MPa and modulus of elasticity of 2x105 MPa. In this analysis, it is made confirmed that the load on the base plate is 150 N. Base plate is constrained in all of its degree of freedom by fixing it to the Z-axis beam. The static displacement plot of base plate is as shown in Fig 3 and the static stress plot of the base plate shown in the Fig 4 the maximum displacement is 0.000714mm; the maximum stress induced is $1.48*10^3$ kPa Hence base plate safe.

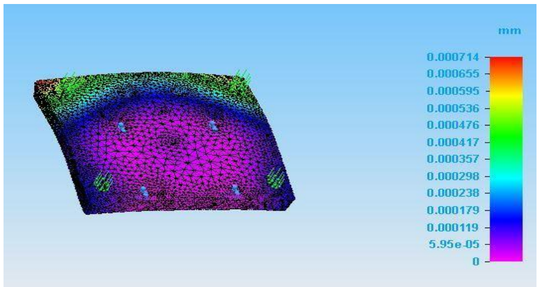

Fig. 3. Maximum displacement

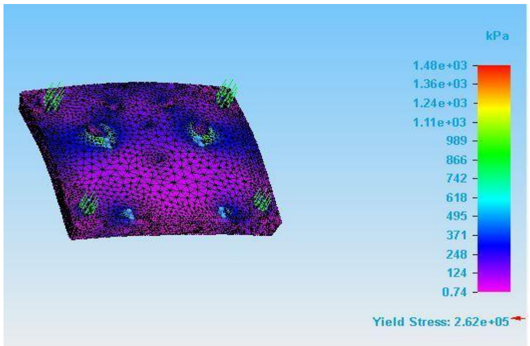

Fig. 4. Maximum stress

4. Design of Input Shuttle with Swing Arm

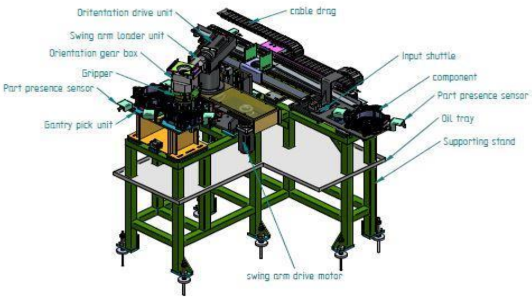

Fig. 5. Swing arm loader with input shuttle

A. *Swing Arm Orientation Unit*

The First machine (VMC) loads crankcase in Upright condition on input shuttle to start the workflow operation. However, the component is loaded in Upright condition on to the rest pad, which intend to rest component firmly over the input shuttle. Thus, moves the component toward swing arm pickup position. In order change the orientation of component by 90 degrees from input shuttle to gantry pick up station. The below Fig 5. Shows the input shuttle and Swing arm loader arrangement and change in orientation of component from input shuttle to gantry pick area.

B. Working Mechanism

Crankcase component is loaded on to the input shuttle unit in upright condition, before orienting the component should rest firmly on rest pad. Once the component is placed the drive assembly and driven assembly together swing or rotate by 180 degrees, so that the component is placed from input shuttle to gantry pick area in upright condition. As well as orientation of the component is changed by 90 degrees Once the required position is achieved the complete cross weldment is lowered with the help of cylinder, LM Rail and block assembly, so that the component is placed on top of the gantry pick area.

C. Analysis of Input Shuttle Stand

The Input shuttle and swing arm unit stand is made up of mild steel with yield strength of 296MPa and modulus of elasticity of 2x105 MPa. In this analysis, it is made sure that the load on the stand is 1500 N where the top assembly is fixed and 1000 N where orientations unit is fixed. Stand is constrained by fixing it to the floor. The static displacement plot is as shown in Fig 6 and the static stress plot is as shown in Fig 7. The maximum displacement is $1.2*10^{-5}$mm; maximum stress induced is 6.45*10-09. Hence, the input conveyor stand is safe for the given loads.

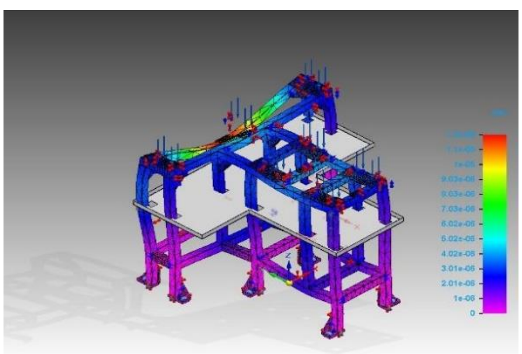

Fig. 6. Maximum displacement

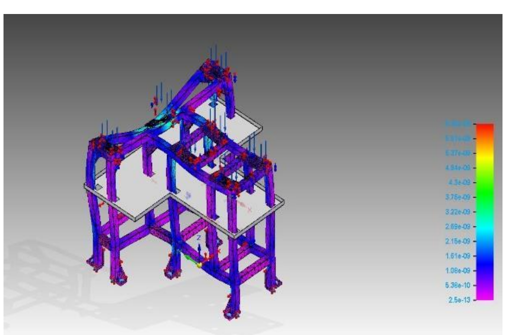

Fig. 7. Maximum stress

5. Design of Overall Layout

The overall layout of Gantry Automation System is designed as shown in fig. 8 to perform the intended operations automatically in sequence. The component after finishing machining operation in first machine it loads the component on input shuttle, thus after retraction of shuttle. Swing arm loader will pick the part from input shuttle and places it on to the gantry pick station, thus by shifting component and changing its orientation of component by 90-degree, gantry picks two components from pick up station to second machine (VMC). Once machining is done, End-of-arm on gantry picks the two crankcase and drops it on the output conveyor. Output conveyor has holding capacity of six components which could be used for next.

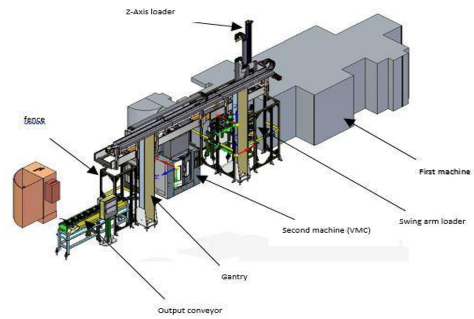

Fig. 8. Overall layout of gantry automation

6. Conclusion

The production industries continuously look for a greater productivity and high quality of its finished components. This can be attained by integrating a custom designed automated gantry system which suits the particular component and helps in automatic part handling which results in decreasing the total cycle time and helps in eliminating the hurdles that affect the quality of the finished components. The Gantry automation system for automatic loading and unloading of crankcase component to the VMC machine is designed and fabricated as per the. Requirements of customer considering the specifications provided by them. The Gantry automation system manufactured is capable of performing the planned tasks automatically in a pre-determined sequence and orientation.

The automated gantry system is tested and the results states that system meets the customer needs successfully and runs without intervention of human being thereby results in increased Productivity, higher quality and decrease in overall cycle time during crankcase machining in VMC.

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