VIETNAM NATIONAL UNIVERSITY
HO CHI MINH CITY
UNIVERSITY OF TECHNOLOGY

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INFORMATION OF THE DISSERTATION

Dissertation's title: Structural design research of woodworking CNC machine based on criteria of working ability.

Major: Mechanical Engineering

Major code: 62.52.01.03

PhD candidate: Tran Van Thuy

Science advisor : Assoc. Prof. Nguyen Huu Loc

Institution: Ho Chi Minh City University of Technology, Vietnam National University - Ho Chi Minh City

Objective of dissertation

The dissertation focuses on conducting research with two main objectives. The first is to study the basis of structural design of the gantry-type CNC router body structure according to the criteria of working ability: Durability, stiffness to ensure reliability. This result will improve the strength and stiffness of the CNC router body structure. The second is research to improve the vibration stability of the CNC machine body structure (Theory, simulation and experiment) to ensure the amplitude of spindle vibration and the natural frequency of the body structure. To solve the above objectives, the dissertation has carried out five research contents: Overview research, research on theoretical basis, study on durability and stiffness of CNC router body, research and simulation vibration stability and experimental studies to determine vibration stability.

Contribution of dissertation

With the above research objectives and content, the dissertation has some new points and contributions as follows:

1 - *Research on the application of geometric-kinematic structure (G-KS) in the design of wood processing CNC machine:* Presenting the conceptual design for structural options for CNC router milling machines based on the Geometry - Kinetics Structural method. Then apply Boolean algebra to combine constraints and use CAD/CAE software to analyze and evaluate the technical characteristics of the machine structure. A model of the wood milling machine according to the most suitable plan was fabricated and tested and the results

obtained during the processing met the requirements. Thus, the G-KS method is a new method that was first applied to milling machines of gantry CNC router and gave good results. Thus, the research of dissertation has contributed to building a process for designing ideas for structural options for CNC router milling machines based on the G-KS method. Based on this process, it is possible to design and manufacture a variety of gantry-type wood working machines with different capacities.

2- *Research using second-order reliability method (SORM) to analyze the reliability of CNC machine body structure:* Building process and design algorithm to analyze the reliability of body structure according to second-order reliability method (SORM) according to strength and stiffness. With the analysis results obtained from SORM, it is important data to calculate and design to ensure the durability, stiffness according to the reliability, safety and working efficiency of the body structure. Thus, the research dissertation has contributed to building a scientific basis for the design of the gantry-type CNC router body structure according to the probabilistic (reliability) design method. Based on the gantry CNC router design process, it is possible to design and manufacture many types of gantry woodworking machines with different capacities.

3- *Research on the influence of bolt joints on the body structure according to stiffness criteria:* The existence of different joints destroys the continuity of the machine structure, making the dynamic characteristics of the machine structure is affected not only by the machine components, but also by the dynamic characteristics of these joints. Studies show that about 60% of the total dynamic stiffness of machine structures originates from joints. Therefore, it is necessary to study on the influence of bolt joints, specifically the tightening force value on the structural stiffness of the machine body. The simulation results show that when increasing the tightening force of the bolt joint, the vibration amplitude of the spindle head decreases, meaning the stiffness of the body structure increases. Thus, choosing an appropriate tightening force value will contribute to improving the stiffness of the body structure.

4- *Studying and analyzing the natural frequency of the body structure to determine the reasonable value of the number of spindle revolutions:* Usually the first natural frequency of the gantry-type structure is rarely higher than 100 Hz. Machines with a natural frequency below 150 Hz cannot process high-quality products because they are in the frequency resonant domain of the number of spindle revolutions generated. To avoid encountering resonance, the body construction must be adjusted so that the value of the forced frequency applied to the body does not coincide with any value of the natural frequency of the CNC machine body. That is, it is necessary to evaluate and correct the design to raise the fundamental natural frequency out of the frequency domain generated by the spindle rotation speed in order to improve the resistance to vibration when the machine is working

at high speed. and avoid resonance to achieve the best machined surface quality. The research dissertation has also built a process of analysis, simulation and experiment to determine the frequency and amplitude of vibration of the body structure in order to choose the frequency, amplitude of vibration and reasonable value of the number of spindle revolutions. This procedure can be applied to machine structures of similar function and shape.

5- *Research on optimization of body structure by method of genetic algorithm with the following objectives*: *Natural frequency of vibration, mass and displacement*: The gantry-type body structure is optimized using the method of multi-objective genetic algorithm (MOGA) to improve the natural frequency, mass and displacement. With the results achieved, it will improve the stiffness, improve the natural frequency to improve the machining accuracy and achieve the best machined surface quality.

6- *Experimental study on the influence of factors on the vibration amplitude of CNC machine spindle and determine the reasonable machining parameters*: Self- vibration is the vibration generated by the cutting process and it is maintained by the cutting force. When cutting process is stopped, the self-vibration also ends. Self- vibration is a great obstacle to improving machining quality and productivity. There are many factors affecting the self-vibration, including the cutting parameters. Therefore, it is necessary to study the effect of cutting parameters such as cutting speed, feed rate and cutting depth on self-vibration, specifically the amplitude of vibration of the spindle when machining on CNC wood milling machines according to the experimental design method (DOE) aims to choose the most reasonable cutting parameterse so that the vibration amplitude is minimal to improve the quality of the work piece.

7- *In terms of practice:* With the transfer of research structure to CNC router manufacturing companies to improve existing models and manufacture domestically to improve quality, increase productivity and reduce prices into processed products, helping VietNam's wood industry in general and businesses in the wood industry to participate more deeply in the global value chain. Contributing to VietNam becoming one of the leading countries in the world in terms of manufacturing, processing and exporting wood products with prestigious brands in the world market.

Science advisors	**PhD Candidate**
Assoc. Prof. Nguyen Huu Loc	**Tran Van Thuy**