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Remote Operation of CNC Milling Through Virtual Simulation and Remote Desktop Interface

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***Abstract*—**Increasing the demand for effectively use of the production facility requires the tools for sharing the manufacturing facility through remote operation of the machining process. This research introduces the methodology of machining technology for direct remote operation of networked milling machine. The integrated tools with virtual simulation, remote desktop protocol and Setup Free Attachment for remote operation of milling process are proposed. Accessing and monitoring of machining operation is performed by remote desktop interface and 3D virtual simulations. Capability of remote operation is supported by an auto setup attachment with a reconfigurable pin type setup free technology installed on the table of CNC milling machine to perform unattended machining process. The system is designed using a computer server and connected to a PC based controlled CNC machine for real time monitoring. A client will access the server through internet communication and virtually simulate the machine activity. The result has been presented that combination between real time virtual simulation and remote desktop tool is enabling to operate all machine tool functions and as well as workpiece setup..

***Keywords*—**Remote Desktop, PC Based CNC, Remote Machining.

I. Introduction

REMOTE control and remote access for many new CNC machines become a standard features. Over any network or the Internet is enables to Real-time remote control and monitoring of unattended CNC machines.

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This capability is convenience to control and monitor machines from anywhere with several benefit that increased productivity & profitability through decreased machine downtime, service and training costs. The device is used by seamlessly integrates into common network using a standard LAN, Switch hub and TCP/IP.

For current commercial system, Remote Machining melds two seemingly antithetical concepts control and freedom so that machining shops can do some reconnaissance work or tweak parameters on their own terms. The manufacturer's self-titled, all-hardware interface grants real-time access to all CNC functions via the Internet so that machine operator enable to manipulate the process, regardless of their distance to the actual machine.

II. Literature Review

Various activities utilizing the Internet communication for manufacturing systems have been also developed in the past decade for supporting life-cycle phases of product development. Many product development software tools, such as CAD systems, CAM systems, database management systems, knowledge-based intelligent systems, have also been integrated through web-based manufacturing [1]. Although many web-based manufacturing systems have been developed, most of these systems were implemented only for accessing the software and data [2]-[4].

Makino's Pro 5 is one of the example commercial CNC machine uses real-time access to all CNC functions via the Internet. Remote Machining, that is completely software-based, enables users to edit programs, check cut progression, and troubleshoot and more from any PC with Internet access. Remote Light Stack, which allows real-time, remote monitoring of milling machine status lights via e-mails, text messages or an integrated Web site [4]. Importance and usefulness of Internet communication of manufacturing systems for improving product of manufacturing industry by directly access shop facility have not been demonstrated. The weak of holding attachments is one of the problems need to solve for performing the automatic setup. The effective remote manufacturing systems are reasonable when no manual setup have to be conducted at shop floor site. This paper propose three integrated tools namely Process simulation using real-time position monitoring, remote desktop for fully access the

machine operation and setup free attachment for auto holding variety of workpiece.

III. Remote Desktop System

Remote operation and monitoring of the system is conducted by developing a client-server application running under PC based CNC controller. Task of server is to receive data from client, responds the client message to update the representation of virtual model. Depending on type of operation requested by client, the movement command will be sent to attachment controller through PCI 6251 data acquisition.

Remote Desktop Protocol (RDP) is a multi-channel protocol that allows a user to connect to a networked computer. Remote Desktop Protocol allows for carrying presentation data, serial device communication, and licensing information with encrypted data transmission. Multipoint data delivery allows data from an application to be delivered in "real-time" to multiple parties without having to send the same data to each session individually.

Remote Desktop Protocol is used to operate the controller by accessing the screen of Remote CNC panel. Remote Desktop Control displays the screen of remote CNC panel (via Internet or local area network) on client screen. The program allows user to use remote system mouse and keyboard to control the function of CNC machine remotely. It is similar to operate the remote machine like sitting in front of it, regardless of distance between user and machine.

Screen resolution for RDP a supported by 8, 15, 16, and 24 and 32-bit color. Reduction of data transfer rate can be done by reduction of color bit. Encryption with 128-bit using the RC4 encryption algorithm is provided for secure data communication using Transport Layer Security support. Transport Layer Security (TLS) and its predecessor, Secure Sockets Layer (SSL), are cryptographic protocols that provide security and data integrity for communications over TCP/IP networks.

File System Redirection is a facility that allows users to use their local files on a remote desktop within the terminal session. File transfer facility is necessary for transferring NC program and part model to remote machine. RDP is also serves as a user-friendly graphical interface, can be connected to a network, used to store motion programs, and run main NC program and other applications like database software, spreadsheet programs, or statistical process control applications.

IV. Setup Free Pin Type Fixture

An auto setup of CNC milling machine which is equipped with specially developed Setup Free Attachment is a tool for remote machining process [5]. A specially designed attachment with setup free machining methodology has been developed for hold a workpiece to be machined completely in one process for all surfaces without resetting the workpiece setup.

Pin-type reconfigurable fixture as shown in Fig. 1 is attached at sub clamp for clamping irregular surfaces. A pin type fixture consists of a main body or base that contains a two-dimensional array of orthogonal to the base roads or pins. Each pin is protruded downward independently, and therefore all the tips of the pins form a cradle conforming to the shape of the workpiece which is fixed during manufacturing operation.

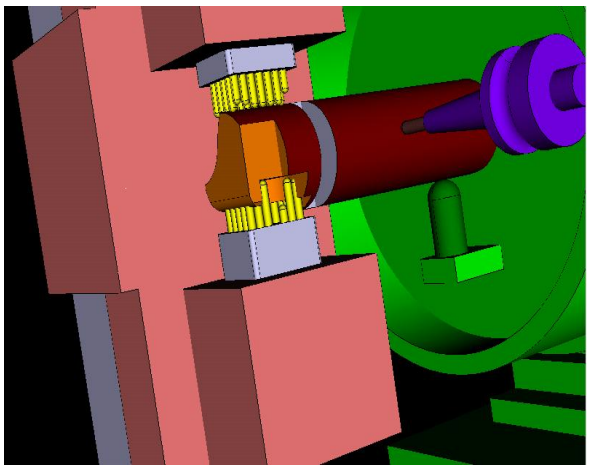

Fig. 1 Virtual Model of Pin Type Reconfigurable Setup Free Attachment

Finite Element modeling is used for evaluation clamp ability in order to perform automatic clamping process. Determination of pins configuration is initiated by selecting usable pins by interfere contact analysis. Variety of Contact analysis for workpiece holding using Finite Element can be found from several literatures[6]-[8]. Result of this analysis has been improved for Setup Free Attachment to obtain the optimum configuration. Hybrid optimization, Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) is used for obtaining the best clamping configuration [10].

V. System Architecture

PC Based CNC Controller running under Linux Operating system connected to a server using a Data acquisition system is utilized. Server is a system to control data between remote user and machine with window as shown in Fig. 2. PCI Interface card with programmed using LabView software formates the transmission data received from machine tool before sends using TCP connection to client. Server also process the data received from client translated it to activate the mechanical elements of machine tools. Composition of formatted data includes the x,y,z table or tool coordinate and pins clamping status.

Fig. 2 Server for intermediate communicating between client and NC machine

Java 3D based virtual simulation is constructed to simulate the machine mechanical activity through real-time position monitoring. Structure of Machine and Setup Free 3D model is defined with scene graph relation as shown in Fig. 3. Scene graph is arrangement of model representation refers to mechanical relationship of the equipment that contains complete description of model properties. It includes the geometrical data, information of attributes viewing information. Connection between machine table, tool spindle and pin elements organized by branch group nodes. Behavior of all machine elements in simulated by element accordingly when positioning signal is introduced through transformation group node to the elements inside the scene.

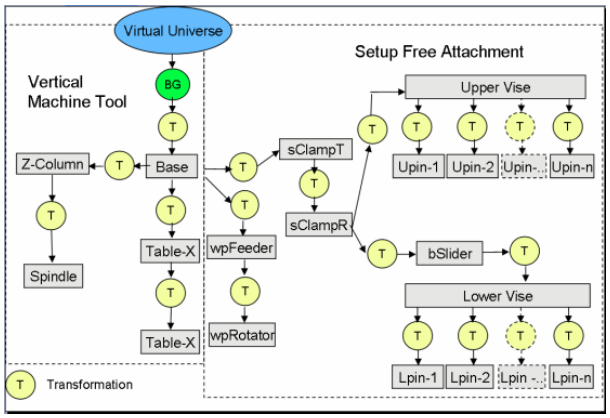

Fig. 3 Scene graph structure of CNC Milling with reconfigurable Pin Fixture

Client is enabling to operate the machine such as uploading NC program, clamping the workpiece or execute NC program. Machine ability of a part is prior evaluated by Clamping Evaluation application located at a Server. Using equipment tested in the laboratory it takes fifteen seconds to open and closed all pins commanded by remote client.

During monitoring and running of machine, client will monitor the process based on block NC program executed and Real position of cutting tool. Simulation of executed NC program is monitored using Remote Desktop data transfer while real position of cutting tool is exhibit by 3D virtual model. Through 3D virtual model, user can evaluate the actual position of cutting tool from variation view directions and moving closed or far by changing the view without degrading resolution with low bandwidth consumption.

Fig. 5 shows the monitor screen short that simulate remote machine at client site. Wire frame mode (right) is screen 3D simulation performed by Remote Desktop while 3D model (left) is real-time position presentation. In this case study Remote Desktop tool of Linux operating system has been used for simulating the machining process of a blade geometry. Remote machine is operated in the client computer for operating the machine tool, while 3D virtual window exhibit the machine position after receiving the positioning signal from machine tool. There is no lagging between two presentations. Comparison between speed of Wire frame simulation captured by Remote desktop and 3D Virtual simulation is presented with almost the same time.

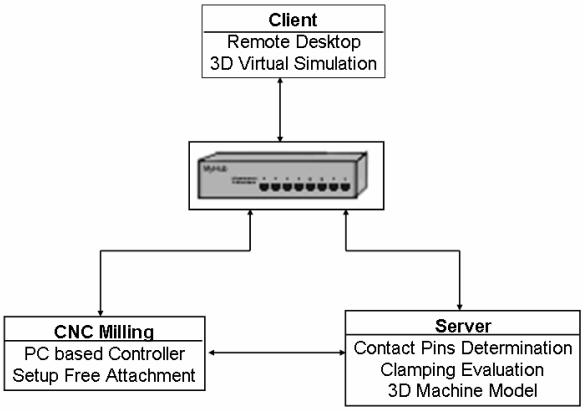

Fig. 4 Flow Process of Remote CNC

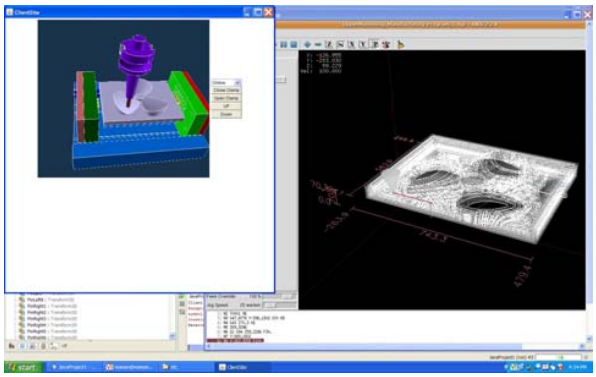

Fig. 5 Client Screen shot for operating and monitoring a remote machine

VI. Conclusion

Hybrid remote machining simulation has been developed with a virtual monitoring system and remote desktop for enabling the remote operation of CNC milling. Quick respond

of Machine tool behavior enable to monitored by sending status updates of the according to real time transmission of machine axis. Implementation of Remote Desktop tool for easy access of machine control panel from a PC based CNC controller is demonstrated.

Improving the capability of Setup Free Technology and Integrated with remote desktop system is suitable for fully operated the CNC Milling from remote side.

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