

start datum: [0108]		LIC		End datum [0512]
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Proper area: **Product and Process Integration**

Main Project title:

Static and dynamic behaviour study of Parallel Kinematics machine

2002-02-14

Static and dynamic behaviour study of Parallel Kinematics Machine

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1 Summary

In today's manufacturing industry, machine tools play a very important rule; in order to increase company's competitiveness many companies are searching for machine tools, which should be flexible, high accuracy, productive and cost efficiently. The tradition machine tool cannot fulfil such demand. They lack either high flexibility or high accuracy. Although Parallel Kinematics machines (PKM) appeared in 50's, due to the capability of the control system it was not used in the real production until in the middle of 90's. PKM have many advantages comparing to the conventional machine tools and serial kinematics robots, such as high flexibility, high stiffness, and high accuracy. It is very suitable for High-Speed-Machining (HSM), light machining and has received a wide interesting in manufacture industry. Parallel Kinematics Machines development is considered as a key technology of robot applications in manufacturing industries in the future.

To achieve a higher accuracy and stability the static and dynamic behaviour must be better understood. The main object of the research is to model the static and dynamic model of PKM machine and improve the quality of the machine. The research will be mainly focused on Tricept. The research result will be integrated into Siemens Sinumerik 840D controller for Tricept.

The application experience of PKM is very important factor to a successful application. Make the PKM machine easier and quicker to set-up, easier to operate are another aim of the project.

2 Background and the state-of-the-art

It is shown in modern manufacture industry that there are two issues that have come in focus in recent years: (1) short life cycles of products and (2) sustainable manufacturing systems which are able to cope with different products over time. The combination of these two issues have made it almost impossible to build systems as in the old days where a shop-floor, in many cases, could be designed specifically for a specific product. Instead, a system of today may need to be interlinked with the production of many products that change from time to time. This shows importance of flexibility of the machine tools.

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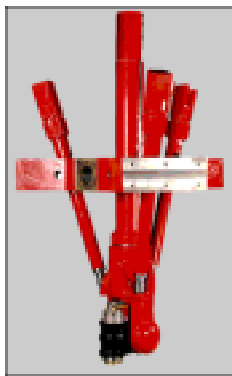
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Many PKM systems have been developed for this purposes. Theoretically the PKM can be used in the areas wherever conventional machine can do. However many types of PKM can only perform very limited tasks due to the very limited tilt angle, work space or high cost.

Among the PKM for machine tools Tricept by SMT Tricept AB (former Neos Robotics AB) in Sweden is considered as the most successful PKM application in manufacture industry. The competitive edge for the Tricept against other PKM's and conventional serial machines are:

- High dynamic for high machining productivity
- Full 5-axis (even 6-axis) machining capability for high flexibility
- Big working space, 2400X 2400 X 800 (max) in XYZ C(-360 + 360) A(-10 +180)
- Good static stiffness and high dynamic stiffness due to the Direct Measuring System (DMS) technology
- Very good price/performance ratio.
- Capability of wide range of applications
- Scalability
- Complete machine versions by SMT Tricept AB and also OEM-modules delivered other machine tool builders who can build their own machine products



Currently the Tricept applications can be fit into light machining very well (cutting aluminum, plastic, wood, composites). It can be also fit into the robotic applications whenever conventional robots cannot handle the required path accuracy and/or high process force, like friction welding. Application examples of Tricept can be found in Volov, Scania, Saab Gripen in Sweden; Boeing, British airspace, Ford, Peugeot, GM, Hrdro, Metabo...

3 Objective

To get better accuracy and dynamic performance for both light machining and heavy machining and can reconfigure the machine quickly due to the change of task the static and dynamic performance must be better understood.


The objectives of the research are:

- Study the static and dynamic behavior of the Tricept
- Establish the model for static and dynamic properties, which can provide the tool for mechanic designer and the controller designer to evaluate the machine

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- Optimize the control parameters and get the best performance for the specific mechanic configuration.
- Develop a software which can make the compensation of the mechanic errors
- Develop application utilities, which can make the setup processing easier and quicker.

4 Industrial and academic relevance

The researcher as an industry PhD student is also an employee at SMT Tricept AB. The research work is related to the industry application directly. The problem occurs in the machine end user will be considered in the research. The research result will benefit the machine end user in the industry. The study of PKM in production environment is a new topic in PKM research area. The result will be valuable to the academia.

5 Expected results

The expected result of the research is

- Software will be developed and implemented or integrated in Siemens Simumerik 840D controller.
- Machine performance will be improved.
- Application utilities will be developed and be implemented in the production.

6 Current status and results of the Project

During the past period, some suggestions were proposed both by the end user and the company. Some application utilities need to be developed. These utilities focused on the application, set-up of the Tricept.

- Error sensitive analysis model

In the PKM, the TCP error in x direction does not mean the X-axis has the same error mechanically. The TCP moves in X direction linearly in Cartesian coordinate system involved all of the 5 axes movement nonlinearly. The error patterns due to different kinematics parameters are different and ever for the same error source at different location. In order to identify the different error sources an error sensitive analysis model has been developed. This tool can also be used to analysis the effect of different geometry parameters error on TCP. To identify the error source the measured error pattern should be compared with the calculated pattern.

- PKM kinematics parameters optimisation

Calibration is a very important task in the machine set-up procedure and is often time consumed. In order to get a precise machine all of the kinematics parameters must be measured precisely. Some of the parameters are 3D parameters and the measurement needs expensive equipment especially for big parts. Usually the error of the part is within

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the tolerance. The actual values after the assembly are difficult to determine and these errors will affect the accuracy of the TCP.

A kinematics parameter optimisation prototype model has been proposed and the software has been coded. The program will generate an optimised kinematics parameter set and minimum the total error on the points for calibration.

- Fixture set-up application

When a fixture is placed on the machine table the position and orientation of the fixture related to the machine basic coordinate system must be measured.

A utility program for machine set-up and fixture set-up for production has been developed. By probing some points on the fixture the program can calculate the frame for the fixture hence G54 can be decided and the machine data can be updated automatically, both in NC program and Windows application version are available.

- Fixture parameter optimisation

Depends on the complexity and accuracy of the fixture and other factor of the machining processing the accuracy of the machined part can be improved by adjust the fixture frame parameters. By checking the error of the machined part the fixture parameters are adjusted automatically so that the total error on these check points are minimal i.e. a part of better quality can be achieved.

- Emulation software development


Simulation and emulation play an important rule in the application of PKM. Without the simulation it is difficult to make a production plan. A improper set-up of the production (fixture parameters, feedrate, tool path plan, etc.) will lead to problems such as axis move out of soft-limit problem, singularity problem, cycle time limit. To solve this problem, commercial simulation programs (such as Igrip) are intensively used before the production plan. Most of them are initially designed for robot simulation and lack the real CNC machine interface and the estimated cycle time is based on the simulation program configuration not on the real CNC control. The other factor is these commercial are rather expensive to invest.

An emulation software prototype has been developed. This software can link the real 840D controller and display the main information such as current alarm status, NC block, operation mode and be able to link to a 3D simulation software (Igrip, EasyRob) via Local Network (even Internet) in real time. This will also provide a tool to test a NC program and estimate the cycle time for the NC program without the necessary to run the real machine. The tool can also be used to train the NC operator and make the PKM machine be better understood. The operator can jog the machine (Transformation ON or OFF), run NC program in auto mode on the real control and visually see the movement of the machine. Another application is as a production monitor for production line. It can link several machines and display information and visualize these machines in 3D on a remote computer.

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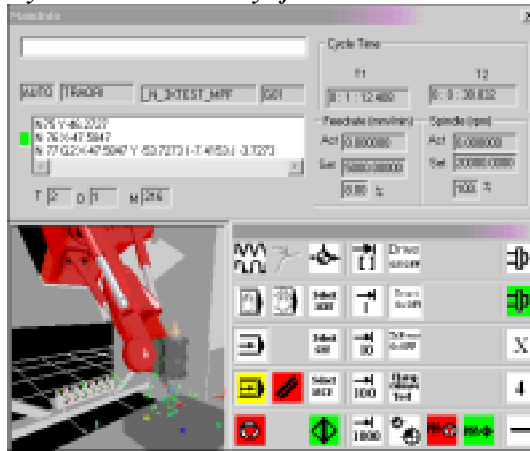
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7 Preliminary project work-plan

The next step will be focused on the preliminary machine propriety test. and machine property analysis.

- Tricept static modelling
- Tricept dynamic modelling

8 Partners

SMT Tricept AB (former Neos Robotics AB).
Royal Institute of Technology, KTH

9 Graduate student plans

Preliminary dissertation dates: Licentiate theses May 2003.

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