CMM Training to Fill the Skills Gap in the Advanced Manufacturing Industry

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Abstract

Coordinate Measuring Machines (CMM) are the back bones of coordinate metrology and the related inspection process. These high precision machines demand technical skills in metrology and computer programming that enable the metrologist or engineer to successfully complete the programming for quick and automated inspection processes in industries. There are not enough highly trained engineering personnel available to meet the industry demand in this advanced manufacturing sector. At the University Of Texas Rio Grande Valley, an initiative has been undertaken to address the skills gap in this very important area of manufacturing. The paper presents the details on the industry university partnership in bridging the skills gap in metrology and advanced manufacturing. Also, the pedagogical aspects of CMM training, the related challenges and the future growth of the program are presented.

Introduction

Quality assurance and the related technology are vital for the functioning of multifarious products, including cars and computers that govern the daily aspects of human life. Manufacturing ensures the creation of these products through the production of hundreds or thousands of parts each week. In modern manufacturing, all these parts are produced to high precision to ensure the quality of finished products. A quality assurance engineer or a metrologist ensures that the specifications required for the finished parts meet the stringent tolerance requirements. This is an ongoing process in advanced manufacturing. Coordinate Measuring Machines (CMM) are the back bones of coordinate metrology and the related inspection process. These high precision machines demand technical skills in metrology and computer programming that enable the metrologist or engineer to successfully complete the programming for quick and automated inspection processes in industries. There are not enough highly trained engineering personnel available to meet the industry demand in this advanced manufacturing sector. At the University of Texas Rio Grande Valley, an initiative has been undertaken to address the skills gap in this very important area of manufacturing. The paper presents the details on the industry university partnership in bridging the skills gap in metrology and advanced manufacturing. Also, the pedagogical aspects of CMM training, the related challenges and the future growth of the program are presented in the subsequent sections.

What is Coordinate Metrology & Why is it Important in Manufacturing?

Metrology is the science of measurement.

As quality demands continued to increase, one of the challenges has been that the human eye is incapable of measuring with the precision necessary to produce the highest quality of parts that the modern industry needs.

In industries where precision is of utmost important, like automotive, aerospace, instrumentation, machine tools etc.; the latest metrology technology like Coordinate Measuring Machines is needed to make measurements to within a millionth of an inch.

The widespread adoption of precision metrology in the automotive industry is one reason the modern cars last longer than they used to.

At one time, owning a car that lasted 100,000 miles was an accomplishment. Now, it's pretty common for cars to last 200,000, and even 300,000 miles and still be going strong.

This huge increase in quality is due to automotive manufacturers paying close attention to every part that goes into the car, and making sure those products fit together exactly right, every time one comes off the assembly line.

These advances have been made possible by coordinate metrology technology.

Skills Gap in Metrology Technology

Technology has transformed many of the methods of manufacturing and product development in the industry. Nowadays, more complex products are manufactured and the requirements of quality and efficiency are in turn higher. The industry is interested not only in producing more, but also in reducing its waste through the reduction of variability. A technology that supports the process improvements and the evolution of quality inspection plans is the Coordinate Measuring Machine (CMM). Many companies are adopting such technology due to the high precision and repeatability of these machines. However, they require specialists for their operation with a new set of skills that combine Metrology, Computer Aided Design (CAD), Geometric Dimensioning and Tolerancing (GD&T), Computer Programming and Problem Solving.

The Engineering Technology Department at the University of Texas Rio Grande Valley (UTRGV) has created a curriculum that includes the development of such skills and has equipped its metrology laboratory with a last generation CMM, with characteristics identical to those existing in the industry, where the student can develop the set of skills that the industry demands and that can help them to integrate faster into this specific field of the industry. The first generation of students has graduated recently; and has been able to quickly and successfully enter the local industry.

Detailed Design of Coordinate Measuring Machine Training

The modern industries have high demand for engineers and technologists with good quality control skills and knowledge in manufacturing. The CMM manufacturing companies, such as the Hexagon Manufacturing Intelligence [1], have put together comprehensive training needs with the help of major worldwide manufacturers, educational institutions and training specialists.

These training needs are translated into programs that are designed to fill the skills-gap in dimensional measurement and coordinate metrology.

Two of the Engineering Technology instructors (authors) are trained by the Applications Engineers and PC-DMIS Trainers who are all factory trained to the very latest standard to take advantage of all the software and hardware advancements made. These trainers are using, testing and being trained in the software before it is released to market; this means they have more experience than third party suppliers which will reduce costly mistakes due to inexperience. Therefore, the faculty engaged in training students in the latest CMM machine and PC-DMS software are fully trained and possess the skills required to handle this advanced training. This aspect of the training program is very much appreciated by the partnering industries.

The students that go through the CMM training program are educated in the best programming practices and techniques which will help to speed up programming time and reduce cost to the industries that they will be serving. The students that are graduated from the program are fully competent at using PC-DMIS to the required standard.

Rationale behind the selection of CMM and PC-DMIS training

The following criteria were used in the selection of the OEM PC-DMS trainer to train the instructors that has provided the industrial acceptance to the CMM training program.

- As the OEM (Hexagon) can certify that the instructors achieve the level of understanding required for PC-DMIS using the latest versions.
- Trainers have over 30 year’s metrology experience in the industry
- New state of the art dedicated PC-DMIS Training center
- Regular classroom based and online training schedules with access to software and CMM’s to include practical and theoretical exercises.

Emphasis on Hands-on Metrological Activities on CMM

A typical CMM is composed of three orthogonal axes, X, Y and Z operate a three dimensional coordinate system. Each axis has a scale system that indicates the position of the axis. The machine will read the input from the touch probe, as directed by the operator or a computer program.

The Hexagon Global Performance Bridge CMM (Figure 1) has been used in the training program. The reason for selecting this machine for the training is that this machine is the most common types of CMMs used in the industries. Many of the industries in the region use these types of CMMs for their metrology and inspection applications. In a moving bridge CMM, the measuring head determines values for the X-axis by moving back and forth across the bridge. Values on the Y-axis are determined by moving the entire bridge over the granite base. A fixed bridge CMM determines values on the Y-axis by moving the table rather than the bridge. The added rigidity that comes from keeping the bridge immobile reduces measuring uncertainty, but because the table need to be mobile its maximum load are more restricted.

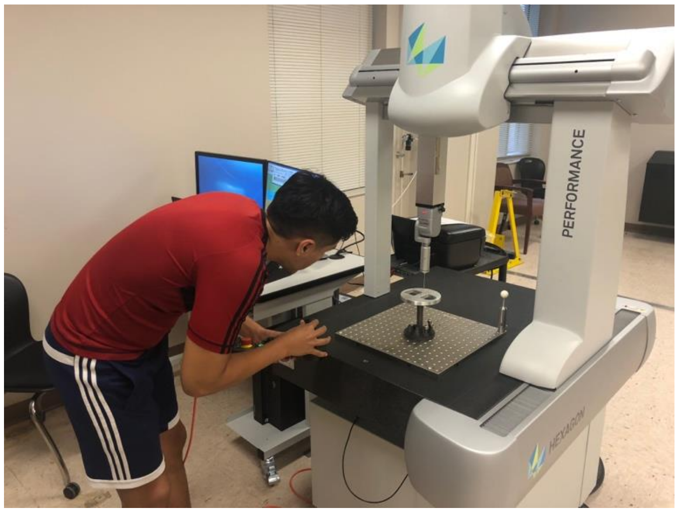

Fig. 1 Hexagon Global Performance Coordinate Measuring Machine

The training program covers the fundamentals of coordinate metrology and CMM operation. Also, the programming aspect of CMM using the PC-DMS software is thoroughly covered. The outcome of the training program is to enable the students to fully operate the CMM with adherence to safety standards. Also, students should able to program the CMM using the PC-DMS software for inspecting a range of moderately complex industrial components.

The students who have successfully completed the CMM training has the option to choose their senior design projects in the field of coordinate metrology and CMM.

Senior Design Project on CMM

The senior design projects that surrounds the use of CMM reinforces the training that they have received on CMM and PC-DMS programming. One of the recent senior projects on CMM is presented in the following sections.

Development of precision inspection procedures using CMM takes time and money in terms of equipment and training. The investment made on CMM saves money on inspection tasks in a long run; however, it takes a considerable time and effort in developing inspection programs. This means that the inspection personnel must be trained in different areas of manufacturing; such as, interpretation of engineering drawings, GD&T, and inspection procedures. An inspection plan generated from the CAD drawing will greatly help the CMM programmer/inspector in developing the PC-DMS programs quickly with more accuracy.

Hence, the goal of the senior project is to automatically generate an inspection plan for the CMM based on the CAD data of the component. Students have successfully developed a user-friendly program that automatically generates an inspection plan for the CMM.

Integrated CAD and Computer Aided Inspection Planning.

The following feature based design approach was used to develop an inspection plan for the CMM.

1. Generation of data based on Initial Graphics Exchange Specifications (IGES) [2] & Standard for the Exchange of Product (STEP) of the CAD file.
2. Retrieve inspection information such as dimensions, and tolerances from the IGES and STEP data.
3. Generate Computer Aided Inspection Plan (CAIP) for the CMM [3].
4. Transfer the CAIP information to the PC-DMS software for part Inspection [4].

The senior design students have successfully integrated the CMM into the CAD/CAM environment through this project. The above feature based inspection planning is developed during the design stage itself. This plan saves time and effort in the inspection and mistake proofing process.

The Figure 2 shows a student engaged in the development of PC-DMS program for the component that needs inspection using the inspection plan generated from the CAD data. A total Time of 20 min was taken to develop the PC-DMS program while working with the inspection plan. On the other hand, a total time of 50 minutes was taken while working directly with the PC-DMIS software. A substantial amount of time saving was noticed through this approach of developing PC-DMS programming with the help of the inspection plan generated from the CAD data.

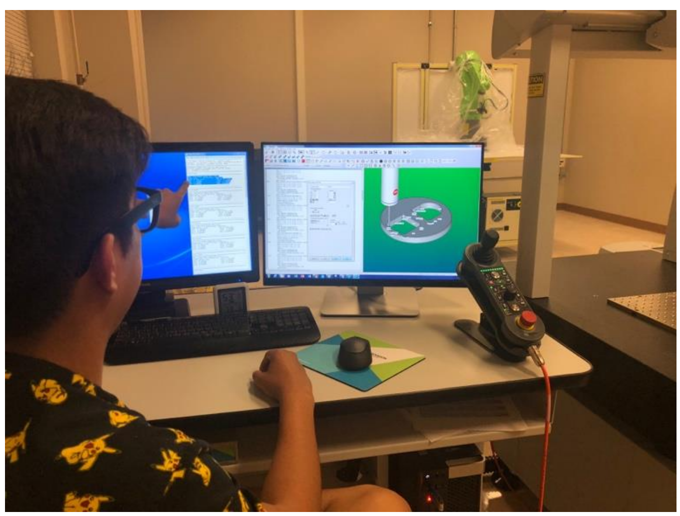

Fig. 2 Student developing a PC-DMIS program using the inspection plan

Results of the CMM based Senior Design Project:

A total of 60 % of time was reduced by using the Inspection Plan along with PC-DIMS compared to only using PC-DMIS. This was possible due to the flexibility of the inspection plan. Having the exact coordinates alongside of the PC-DMIS enables the CMM programmer to quickly develop the inspection program for the component. Inspection time is reduced due to the inspection plan, since the reference data is provided before the machine setup. Cost of CMM visual guidance is also reduced since operators/technicians will be provided with a data that will not be cluttered with information like an engineering drawing/blueprint in order to start the inspection process.

Industry-University Partnership

Industries are experiencing labor shortages in highly skilled manufacturing areas like robotics, automation, CNC, CMM operation and PC-DMS programming [5, 6, and 7]. The solution to bridge the skills-gap in these areas is through work with industry as a partner and stakeholder [8, 9, and 10]. At the University of Texas Rio Grande Valley, the department of Engineering Technology has established partnerships with local industries to develop a CMM training program. The successful graduates from the training program are hired by these industries to work as CMM programmers and quality control engineers. The engineers from these industries are also helpful in testing the research projects associated with the coordinate metrology and CMM, as presented in the previous section.

Conclusion

The UTRGV's department of engineering technology has enduring partnerships and collaborations with several companies in the region and across the border in Mexico for many years. These collaborations were developed through faculty taking initiatives in bringing the senior personnel of the companies to laboratories and forging relationships by helping them with testing and small projects through senior design projects. These personnel are part of the industry advisory board and help the program grow through their valuable suggestions. These companies also provide internships to the students and help them join their workforce. In the present case, the industry that partners with the university in the CMM training is tremendously benefitted by the supply of much needed workforce for their inspection process. Since, the qualified PC-DMS programmer and CMM operator is very difficult to hire and retain in the Rio Grande Valley. Hence, the home grown talent in this technology is of immense help to the industry in recruiting highly skilled manpower in advanced manufacturing and also with retention; as most of the students prefer to stay close to home after graduation. The engineering technology department is taking initiatives to train students in collaborative robotics, CNC etc., and also provide certifications in these areas. Through industry-university partnership students, faculty and all stake holders win!

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