Have You Updated Your Manufacturing Process Course?

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Abstract

Like most sectors of the goods-producing industry, discrete manufacturing is undergoing evolutionary advances--primarily due to the innovations in microelectronics, computers, and communications. It is up to the manufacturing faculty at institutions of higher learning to incorporate these advances in the curricula. Manufacturing curricula invariably require several credit hours in the areas of production processes and machine tools. This article summarizes the major advances in these areas for the benefit of manufacturing faculty. Both machining and forming processes are covered along with tools, workholding, factory automation, and quality assurance.

Introduction

Prior to the advent of computers and communications, advances in manufacturing processes and machine tools used to be fewer and far in between. The same is not true today. Global competition and developments in information technology, fueled by powerful, inexpensive microchips, are impacting manufacturing at an unprecedented rate. We in the academia have the sole responsibility to incorporate the developments in the curricula. In this article, recent advances[1] in processes and associated machine tools are presented along with those in tools, workholding, factory automation, and quality assurance. The article is aimed at manufacturing instructors who often update course contents to reflect what is happening on the shop floors. The presented overview is divided into three major sections: metalcutting, metalforming, and ancillaries. The former two also include advances in the respective machine tools.

Metalcutting

PC Rules. To use a personal computer (PC) to communicate with the computer numerical control (CNC) system of the machine is now standard practice in most new machine tools. The PC-CNC interface is effective even with older CNC machines. The newer machines are more intelligent and capable of self-diagnosis. They incorporate 64-bit processors to boost programming and information transfers to and from the machine. For example, newer CNCs can compensate for thermal elongations, due to heat generated by processing, of the machine, tool, spindle, and the guide ways.

High-Speed Machining. Another trend is high-speed machining, in which cutting speeds are five-toto-ten times higher than conventionally practiced. Some machines have spindle speeds as high as 40,000 rpm. High speeds are being sought in operations such as milling, drilling, and boring. Tool change time has been shrinking. It is as short as 0.7 second, with an expectation of 0.5 second in the near future.

High-Precision Chucking. Operating at 8000 rpm and 0.03 mm/revolution feed, newer high-precision chuckers can produce roundness of 0.2 micron and size accuracy of 1.4 micron.

Hard Turning. There is a lot of interest in hard turning that can cope with materials as hard as R_c 68. If hard turning can achieve four-to-six microns of finish, grinding will become unnecessary.

Structure. There is a trend to shift to unconventional materials for the structure of the machine tool. More modular designs and polymer concrete beds are being used.

Horizontals are Winning. Though more expensive, horizontal machines are replacing vertical ones. The reasons are: feasibility of being able to use standardized pallets, easier chip disposal, longer tool life, and faster machine loading.

No Lube. Some of the machines need no oil or grease lube. They contain packs of phenolic material impregnated with lubricating oil; the packs' rubbing on the ways provides the lubrication.

Who Trains the Operator? Manufacturers of cells and machining centers are generally conservative, preferring to incorporate existing technologies rather than try unproven ones. With the existence of a buyers market customers of machine tools are asking for lot of support from the suppliers, especially in the area of operator training. Established manufacturers such as Cincinnati Milacron have their own training centers, usually in association with local community colleges, to meet customer needs.

Miscellaneous. Efforts are continually being made to reduce the setup time. All-electronic servo control that will do away with hydraulics, pneumatics, belts, or microswitches, are under development. The goal is less maintenance, resulting in higher utilization.

Another important technology under development is linear drive, which will eliminate servodrives and motors. The resulting elimination of ballscrews will substantially speed up processing.

Some other areas of process enhancements are: one-step cutting of hardened steel rather than usual roughing-hardening-finishing approach, high-pressure water at 5,000 psi for deburring a wide variety of materials, dry cutting, and use of virtual reality in process simulation.

Metalforming

Laser Diodes. An exciting area of development is laser processing using laser diodes. The high-power diode modules are used to pump solid-state lasers, resulting in maintenance-free compact lasers. This increases operating efficiency by 40% over that with conventional CO_2 or Nd:YAG laser.

EDM.. In the area of electric discharge machining (EDM), the trend is to broaden its use for complex parts. Also affected by EDM are special materials, applications, and customization.

Miscellaneous. In the area of metalforming, most recent developments have occurred in the automation of material handling and in machine controls. PC-based controls are the trend here too.

Another goal is to be able to process a lot of one as efficiently as a batch size of fifty.

Ancillaries

PC-PLC Controversy. The PC-PLC (programmable logic controllers) controversy seems to continue. Though some industry experts are predicting the demise of PLC, some think that it will continue to fulfil its role in the near future. A PC control for PLCs offers the best of both the worlds.

Mix-and-Match. Our offices are already surrounded by PCs; the same is expected on the shop floors. Standard CNC screens allow limited customizing, which is enormously enhanced by a front-end PC operating in the windows environment as an intuitive and flexible interface. More and more manufacturers are able to pick up the best product from any supplier to build the best overall system.

Connectivity. To achieve computer-integrated manufacturing[2], connectivity is the basic ingredient, which is now offered free by all machine tool builders. The connectivity must be available at all the three levels: PC to CNC, serial or parallel port, Ethernet connectors as a low-cost option, and public interface. The availability of microprocessors as powerful, low-cost computational device is helping develop new algorithms to solve problems due to backlash and resonance.

CAM. Modern CAM technologies such as feature recognition, automatic NC, and knowledge-based machining are offering complete automation of the manufacturing process. In modern shop floor systems, the operator edits the drawing, not the conventional G-codes.

Quality Assurance. In the area of quality and inspection, there exists a lack of software to automate video inspection. Modern coordinate measuring machines (CMM) are based on off-the-shelf technologies, rendering them affordable. Icon-based software result in user-friendly CMM programming on or off-line. Though the prices of quality assurance equipment have remained constant over the years, their performance has been improving exponentially. In general, the trend in quality assurance is focused on the shop floor, rather than in the lab.

Tools and Workholding. Tools are one area of manufacturing where the user gets the most *bang for the buck*. Newer tools offer more cutting edges for the same tool cost. Tool designers aim at balancing hardness with toughness to maximize the positive rake possible. Though smart cutting tools are futuristic at this time, tools will in the next 5-10 years be able to ask the machine and the control system to adjust the cutting speed and compensate for thermal expansion.

Toolholders[3] and inserts are undergoing an evolutionary change. Tool manufacturers are developing better microstructural control to improve the adherence of the coating to its substrate. One emerging development that improves the toughness of inserts as well as their hardness is called multilayer technology. It is possible to deposit as many as 200 layers in a 4-

micron thickness, with the layer-to-layer thickness being as small as 40 nanometers. Uncoated tools are being replaced by the coated ones.

Concluding remarks

Manufacturing is undergoing significant changes due to the unabated developments in computers and communications in the name of information technology. Recent advances in machining processes and the associated machine tools have been summarized in this article. It is hoped that manufacturing faculty will incorporate some of the material presented here in their courses.

Bibliography

1. *Manufacturing Engineering*, Society of Manufacturing Engineers, August 1998.
2.Vajpayee, S. Kant. *Principles of Computer-Integrated Manufacturing.* Prentice-Hall, 1995.
3. Cartier, Dan. Four Toolholder Quality Factors. *Modern Machine Shop.* November 1998, pp. 96-103.

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