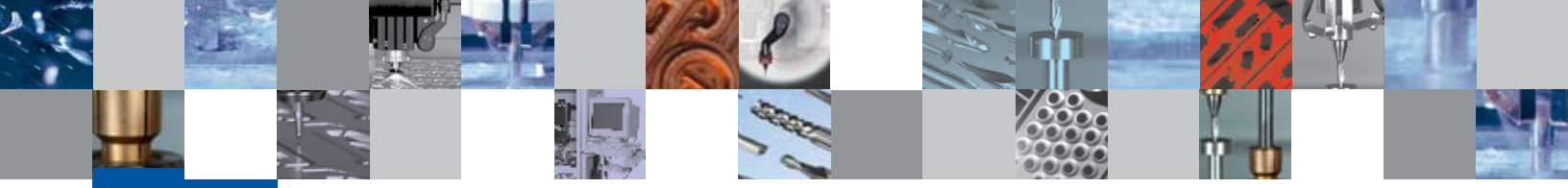

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Batch Machining With Micro-Tooling

This paper focuses on batch machining as it applies specifically to high-speed machining with micro-tooling. Topics covered include definitions, challenges, available technology and solutions. The paper's purpose is to prove the direct correlation that batch machining (as an alternative to one-up production) has with a manufacturer's profitability. Further, the ability to effectively implement batch machining relies on the presence of CNC machining systems featuring larger beds that facilitate "lights-out" production.

Defining batch machining, micro-tooling, and high-speed machining

Batch machining is defined as manufacturing a minimum of two parts on the machining table at any given time. This paper uses the terms "batch machining" and "batch processing" interchangeably. There is no limit to the number of parts that define a batch, but ideally the manufacturer achieves efficiencies by maximizing the space available on the machine bed and producing as many parts in one run as possible.

Micro-tooling involves mills and drills with a diameter of 0.250" or less. Higher RPM rates are required to run these small-diameter tools in an efficient and economical manner. The use of high-speed micro CNC machining systems that utilize high-frequency spindles with speed ranges from 6,000 to 60,000 RPM results in feed rates that produce significantly faster manufacturing times in intricate work-pieces, as well as superior edges and surface finishes.

High-speed machining has no set definition or absolute parameters, but one workable definition is machining with spindle speeds of 25,000 RPM or more.

The challenges of batch machining

When companies produce a batch of parts, they usually have an operator in front of the machine for an entire shift, producing work-pieces one at a time. The operator takes raw stock, puts it on the machine bed, machines the part and then removes it — repeating the entire process for eight hours. Therefore, the operator is dedicated or "tied" to a single machine. This procedure is known as "one-up" production.

Based on an 8-hour day, labor costs about $0.40 a minute and a machine costs about $0.20 a minute to operate. Therefore, if you tie an operator to the machine with one-up production, your total cost will be $0.60 a minute. If you were to run two shifts, the machine would cost only $0.10 a minute, while the labor cost remains the same at $0.40 a minute. Although it's a savings, it falls short of maximizing the impact on a manufacturer's bottom line ... and more can actually be saved. By empowering the machine do the work without operator intervention during the

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second shift, the reduction in the labor cost brings the machine cost as low as $0.05 a minute.

Meeting the challenge

Batch machining on large beds reduces operator intervention since it accommodates sizable "blanks" and a full batch can have a cycle time that coincides with the length of an operator's shift. That way, the operator can place a batch on the machine in the morning and attend to other duties during the day. The automated machine works all day producing the needed pieces. Near the end of the shift, the operator then removes the completed batch, sweeps down the machine, and sets up another batch to run unattended all night.

When the operator returns to work the next morning, he removes the batch that the machine produced overnight and starts up another one. This gets two shifts' worth of work out of one operator. This is the principle of "lights out" production — so named because the machine is left running overnight when everyone has gone home. Bear in mind that the above example reflects the "ideal", since it keeps the machine operating unattended for most of the workday and at night. This may not fit your exact application but, the closer you can get to that ideal, the more efficient and cost-effective your operation will become.

Note: Achieving the highest degree of efficiency or the "ideal", requires increasing the machine's role in the process while decreasing the need for operator supervision. So, manufacturers striving to reach this ideal must employ the right machines and also identify alternative labor functions to fill the void left by the operator's diminished role in production.

The right tools for the job

Thanks to today's technology there are many tools available for facilitating batch machining. Often, these tools are most effective when used in conjunction with one another. For the purpose of this paper these batch-machine tools have been divided into the categories "limited" and "optimal."

Limited Tools

The following tools are useful but cannot fully support batch machining and are therefore defined as "limited".

- Pallet changers. Economy-minded manufacturers try to increase efficiency by augmenting machining centers with the addition of a pallet changer. Pallet Changers allow the operator to exchange freshly made parts with a new blank — facilitating continuous machine operation and cutting down on machine idle time. Pallet changers usually run in the range of $10,000-20,000. Unfortunately, automatic pallets usually involve tying the operator to the

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machine making this accessory an inefficient solution that yields no significant savings. In the end, a company trying to save money has, in fact, just spent money on a pallet changer to make the operator's job easier without further automating their process, facilitating "lights-out" production or significantly impacting their bottom-line.

- Robots. Robots demand an investment in both time and money. On average, a machining center costs about $80,000. The addition of a robot to the machining process requires another $30,000-40,000 — making the machine-robot combination a $100,000+ investment.

  Robots replace workers, which certainly cuts labor costs but rather than simply programming them, they must be taught their tasks. So conducting batch-processing operations using robots requires significant set-up and preparation time. Additionally, robots usually don't fit in the machine envelope due to their size and shape. Finally, robots need to be presented with the parts to be machined — often placing the burden on the manufacturer to develop a custom magazine design to ensure a continuous feed of parts to the robot.

Optimal Tools

These tools are far more suitable for batch-machining operations and are therefore defined as "optimal". They are listed in descending order based on significance.

- CNC machine with large bed. In short, a large bed size accommodates a big enough sheet of stock to let the machine work all day long to yielding a significant amount of parts. Machines can be purchased with large bed sizes as an integrated feature as opposed to a more costly accessory.

  Large bed sizes also allow machining of larger parts and the ability to handle unexpected emergency machining tasks without disrupting regular workflow.

- Quick-Pallets™. These low-cost manual pallet changers are light and easily handled. Pallets enable a manufacturer to completely change their workholding setup in a few seconds. Pallets are mounted securely onto the machining bed via vacuum and keyed to a fixed position. This setup allows smooth batch machining operations with a rapid turnover. When the batch is completed, changing a pallet involves removing the old pallet, sweeping down the surface, and installing a new pallet, a process that takes seconds.

  Light-weight pallets are available for different workholding solutions, including pneumatic short stroke clamps, vacuum plates, and blank panels for custom workholding solutions. Pallets are easily lifted by hand and provide a cost-effective solution to an old problem.

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- Pick & Place Systems. For parts that need to be machined either along their circumference or on their face, machines can be fitted with a gripper, creating a "pick and place" system. Grippers can pick up a part from a pallet and secure it in a 4th (and 5th) axis in such a way that it can be machined from any and all sides.

Conclusions

While the cost of labor is something that the manufacturer cannot control, companies can still achieve substantial savings through batch machining that gets twice the work out of an operator with no increase in labor cost. This method can be expanded into "lights-out" production (one shift of unattended machining) to further reduce machine costs. Any form of batch machining is superior to one-up production and represents a "set it and forget it" method to achieve cost-effective, efficiency with machines that were designed to be automated in the first place.

A machine center featuring a large machine bed, Quick-Pallets and possibly a pick and place system, offers a complete solution for batch machining that will directly and positively impact a manufacturer's bottom line.