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Intelligent Production Cost Allocation System

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Abstract

In the manufacture of machined products a large quantity of consumable tools are used. When simultaneously manufacturing a broad variety of products having different specifications, it is difficult to assign an accurate cost of tool usage to a specific product. What is often done is to assign a dollar value based on averages, however, this method does not meet a satisfactory level of accuracy. A system was developed by the University of Maine Instrumentation Research Laboratory comprised of a network of barcode scanners and decoders to solve this problem. Unique barcodes are assigned to operators, tools, operations, products etc. Information is gathered via a series of barcode scans as work is performed. This information is then translated, concatenated with a unique station ID, and transmitted to a PC via the network. We have designed a Visual Basic program designed to be a general-purpose data gathering application that runs on the PC. The application performs all the necessary data processing and, through the use of Open DataBase Connectivity (ODBC) drivers, is able to communicate with a variety of databases. Data queries can be run to determine all of the tools used on a specific product and a much more accurate dollar value can be placed on the manufacture of specific products. This system provides valuable information that can be used to reduce costs, improve productivity, and enhance competitiveness in a global economy.

Introduction: Statement of the Problem

In the manufacture of machined products, there are many contributors to cost of the final product. Figure 1 shows the major expenses and revenue associated with production. Arrows going into the machine shop represent expenses while the single arrow coming out represents the revenue generated by the finished product. Obviously, a company wants not only to maximize revenue, but also the ratio of revenue to expenses. In order to accurately control this ratio, a great deal of information must be examined. The more information used, the better the process can be understood. Monitoring monies spent on maintenance, energy, material, and labor in the production of a product is relatively straightforward. However, monitoring consumable tool expenses is surprisingly difficult. Since tooling cost may be a substantial expense, it would be beneficial to be able to accurately assign tooling costs to a specific product. Without this information it is impossible to know the true cost involved in producing a product.

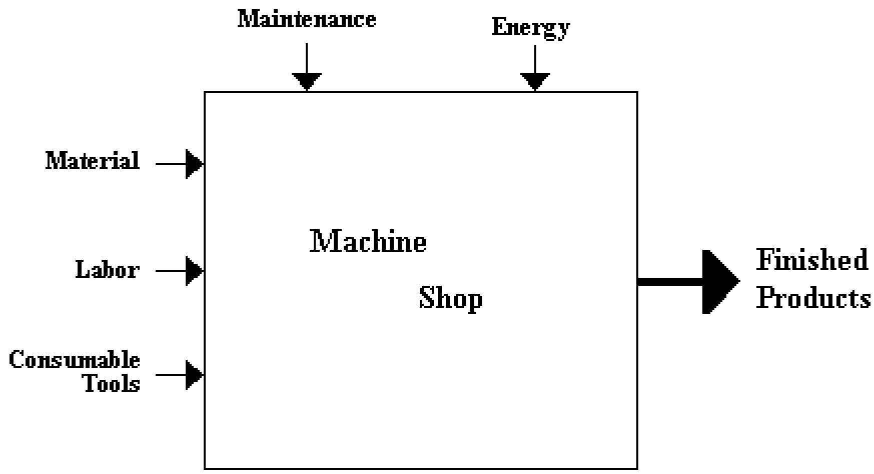

Figure 1: Factory Flow Chart

One way to quantify consumable tool expenses is to calculate yearly averages. This can be calculated, quite simply, as the year's tooling expenditures divided by the number of products produced. This yields an average tooling cost per product. When a variety of products are produced, this is not an effective way to estimate tooling costs. Machined products come in a variety of sizes and are composed of different materials. Therefore, it is very inaccurate to assume all products consume a similar amount of tools. Using averages, it is quite possible for a company to be selling a product for less than its manufacturing cost. It is obvious that a method for accurately monitoring tooling cost for machined products is greatly needed.

The benefits of accurately logging tool usage and cost are numerous:

- Discovering true profit margins
- Learning which products are most profitable
- Accurately predicting tooling budget for upcoming year
- Improved control of inventory
- The ability to compare different tools from different vendors
- Accurate information to make intelligent money saving decisions

Requirements for the Solution

The solution to this problem must accurately assign tool usage to each product as it is machined and must save this data in an easy to use format. Also, the system must be able to handle simultaneous, factory-wide data collection. It is imperative that the solution be easily scalable to accommodate a growing enterprise. Another requirement of the solution is that it must not impede normal production procedures. Implementing the solution must not require hours of training and must not add a considerable amount of time to production. Of course, the solution must also be cost effective.

The Solution: Overview

To achieve the above goals, a factory wide network of barcode scanners and decoders has been employed. Figure 2 illustrates the hardware network. Each production station has a barcode-decoding terminal. The first station is a master terminal with the identification number 01. This master terminal communicates with a local PC via RS-232 [Welch-Allyn, 1999]. All other workstations have slave terminals with unique station identification numbers that communicate with the master terminal via an RS-485 differential pair. When a barcode is scanned using the hand-held scan gun (Figure 2), the barcode is sent to the decoding terminal [ADC, 1999]. The terminal buffers the new data and holds it until polled by the master. The master terminal polls each slave terminal in turn. If a slave terminal is polled and has new information it transmits this data to the master along with its unique station ID on the RS-485 network. The data is then received by the master terminal and is buffered. Once the data has been buffered in the master terminal, the master replies to the slave with a receive acknowledgment. Only after the slave terminal receives this acknowledgment will data be removed form its buffer. Because data is buffered in the slave terminals as well as the master terminal, it is possible to have numerous simultaneous scans throughout the system. The PC accesses the data in the master terminal's buffer serially and may read and delete buffered data.

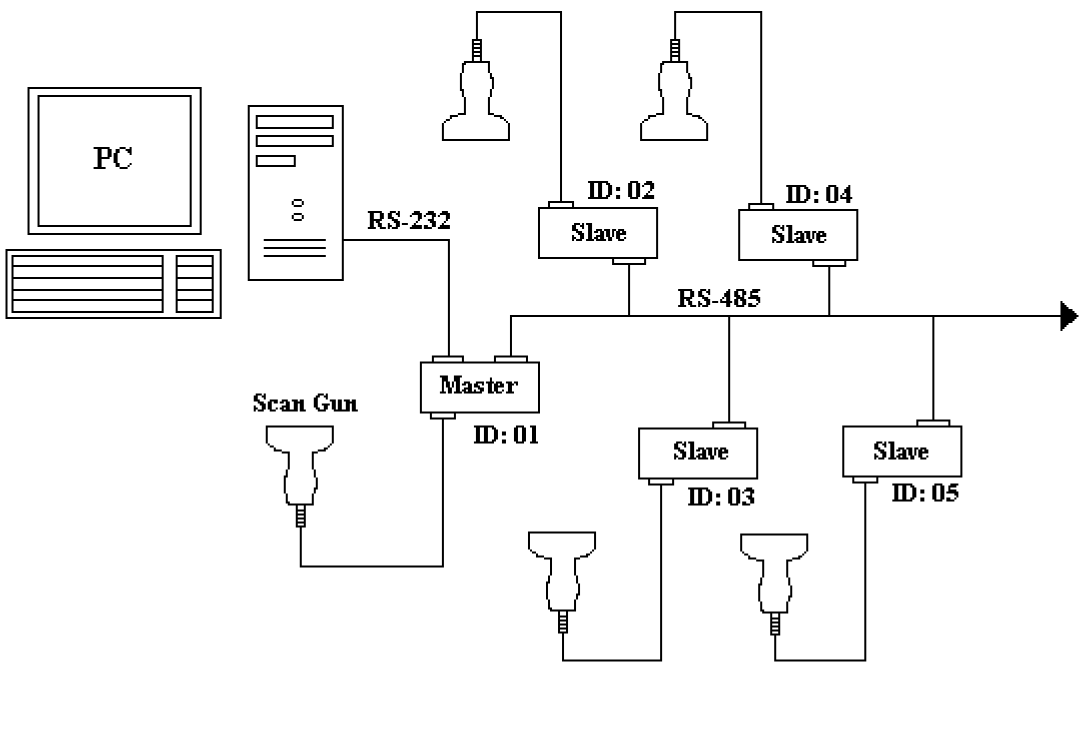

Figure 2: Layout of barcode network

The general concept of the solution is to label all consumable tools with unique barcodes and to have barcodes for all operations to be done on a batch of product. When scanned by the operator, these barcodes are decoded by the barcode decoders, collected by the PC via the RS-232 network, and stored in a local database. The information in this database thus associates all of the tools with the products on which they were used.

To implement the solution, a method for producing barcode labels was first developed. A Visual Basic [Appleman, 1997] application was written to make appropriate sized labels for individual tools. This application is given a tool ID and searches a database to locate the next available serial number for that type of tool. The program then creates labels starting with that serial number and makes as many labels as were specified. The label making application also allows for virtually any sized label; both height and width can be optimized for a particular tool case surface. Once all of the options have been set to the desired values, the application is ready to print. Upon printing, the label has the desired data printed in plain English and in 3 of 9 Barcode in the proper configuration. At the time of printing, the label printing application also enters these new tool labels in the database as new tools. The label and the tool identification number stay with the tool throughout its entire service life. This identification number is used to track each specific tool's usage. Figure 3 gives an example of how a typical tool label might look.

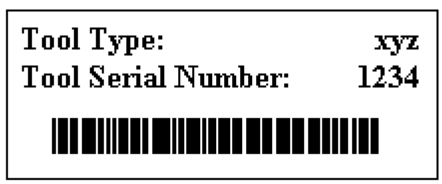

Figure 3: Sample Tool Label

It is also necessary to have an identification barcode linked to each operation to be done on a batch of product. These identification barcodes travel with a product from start of production to finish. These barcodes are alphanumeric strings and contain both the batch number as well as the operation number.

In the development of this system, it was also determined that an employee could be associated with the work done with relative ease. Each operator is given an identification badge with a unique employee number bar-coded on the front. Although it was not originally part of the system, this feature adds a great deal of information at almost no cost. All of the information about tool usage is linked to a specific operator, in addition to a particular workstation and date and time.

The barcode decoder network is configured to communicate with the PC via an RS-232. The PC runs a Visual Basic data gathering application that is customizable to meet specific needs. This program is designed to run constantly; as long as the PC has power, the application will not terminate. This allows constant, and precise error checking to ensure the network of decoders is operating properly. If an error should occur in the network, the application displays the error and records the error in a special error database table. The application is also configured to allow for easy scaling. Adding more workstations is as simple as running wires, connecting new decoders, and programming them with unique station IDs. The program also performs all the necessary error checking on the incoming data. Only predetermined data formats are processed as useful information. All other data will be stored in the error database for debugging purposes. Once the VB application receives valid data, it then processes the data and stores it in a database through the use of ODBC drivers [Microsoft, 1999]. The data gathering application does not delete buffered data from the master terminal until it has been successfully stored in the proper database.

Standard Order of Procedure: A start to finish run through of the system

Assuming that all of the required barcodes are in place and in the correct format, an example of the Intelligent Production Cost Allocation System process is as follows:

As the operator begins the procedure, he or she scans their personal identification barcode. This data is decoded, and sent to the PC by way of the network. The Visual Basic application reads in this data and performs error checking on the data and determines that it is an employee ID and also determines from which station it was received. This information is stored in a 'Log' table and will remain until the employee logs out of this station. Figure 4a shows an example 'Log' table. An employee scan is stored in the 'Employee ID' field. Next, the operator scans in the batch's unique identification barcode for the operation being performed. This information goes through the standard error checking and processing. The 'Log' table now contains an operator ID, a station ID, and a batch number. Now, when the operator loads a tool into the machine to operate on a batch he or she scans in the barcode that is attached to that tool. This data is then transferred to the PC via the network where the data gathering application performs the usual error checking, and determines that it is a tool identification number. The application then determines the station from which the data came. The application then uses this terminal ID to retrieve information form the 'Log' table.   All of this information is then transferred to a 'Tool Usage' table.   An example 'Tool Usage' table is given in Figure 4b. The entries in this table contain all of the information pertinent to tool usage.

The collected information includes:

- Station identification
- Employee identification
- Batch and operation number
- Tool identification
- Tool serial number
- Time and date of tool usage

As the employee performs more operations with different tools, the 'Tool Usage' table records all of the tools used on that batch. When it comes time to machine a new product, the operator scans in the new batch identification barcode. This automatically updates the 'Log' table and will now associate tool usage with this new batch of products.

Similarly, when a new operator takes over a job, he or she simply scans their personal identification barcode. This updates the 'Log' table and subsequent tool scans will be associated with this new employee. When the manufacturing process of a product is complete, the 'Tool Usage' table will have record of every tool used on every batch of products.

Log : Table

ID	Station ID	Operator ID	Batch ID	Time
1	01	1234	785-9686a	12/2/99 4:51:40 PM
2	02	4562	h764-8456	12/2/99 4:52:12 PM
3	03	5784	hu5-9033	12/2/99 4:52:42 PM
(AutoNumber)				12/2/99 4:53:01 PM

(a)

Tool Usage : Table

ID	Station ID	Operator ID	Batch ID	Tool ID	Tool Serial #	Time
1	01	1234	785-9686a	htop2	760	12/2/99 6:45:30 PM
2	01	1234	785-9686	lwd76	322	12/2/99 6:49:39 PM
3	03	5784	hu5-9033	htop2	799	12/2/99 6:53:58 PM
4	02	4562	h764-8456	mrkfa	1	12/2/99 6:55:09 PM
5	01	1234	785-9686a	kfrag	910	12/2/99 6:57:30 PM
(AutoNumber)						12/2/99 6:58:41 PM

(b)

Figure 4: Sample Database Entries.

Outcome

The physical product of the Intelligent Production Cost Allocation System is a database containing a wealth of information. This database, similar to the example shown in Figure 4b, associates every tool used in production with an operator, a station, and a specific product. Using this database, queries can be run to enumerate the precise tooling cost for each product. With this information, a company can realize the true profit each product brings forth. It is also possible, given the company's projected production plan, to keep only the tools necessary for upcoming production runs in inventory. This controls overhead and allows for a very accurate estimate of the tooling budget.

The operation of the Intelligent Production Cost Allocation System is trivial. An operator can be trained in minutes and must only get used to scanning barcodes whenever an attribute in production is changed. The system only adds the time to make a few barcode scans to the overall production time. Realistically, this time should be less than a minute for an entire shift.

Cost effectiveness is another very important attribute of the Intelligent Production Cost Allocation System. The worth of the system is based on the value of the data retrieved by the system. Since tooling costs are such a large part of the overall cost of a machined products, any information that can lead to a cost saving has great value. That is exactly what the Intelligent Production Cost Allocation System provides; A great wealth of information that can be used to make educated decisions that could potentially save the company millions of dollars of the course of the years. Also the initial outlay of the system is financially diminutive when compared to the potential savings. The Intelligent Production Cost Allocation System builds on existing network infrastructure in conjunction with a dedicated PC. The barcode network consists of several modestly priced terminals and a minimal amount of wiring.

Conclusion

In any manufacturing process, it is imperative that profits be maximized. This can only be done with accurate knowledge of expenses versus revenue. The more a company knows about the origins of their expenses will allow it to make better financial decisions. In the manufacture of machined products, a large source of expenses is attributed to consumable tools. The Intelligent Production Cost Allocation System gives the manufacturing company a great deal of information on exactly how much money is spent on the machining of a product. This valuable information can be used to reduce costs, improve productivity, and enhance competitiveness in a global economy.

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