OPERATION BASED COST ASSESSMENT OF MACHINED PARTS IN THE EARLY DESIGN STAGES

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ABSTRACT: Cost is the driving factor of current manufacturing industry. The market is willing to accept products that come at a lower cost. In order to cater such a market, manufacturer has to look to make the product at a lower cost while recovering the expenses. Therefore, the design stage is critical when it comes to achieve this optimum cost. One of the most difficult tasks undertaken by the designer is to evaluate the cost of a design. The designer must develop a design in order to fulfill the required performance characteristics as well as provide the appropriate quality at minimal cost. Substantial research effort has been expanded in exploring design implications, new techniques, and methods for producing accurate and consistent cost estimates not only to generate optimum design solutions but also to achieve the maximum customer satisfaction in terms of low cost, high quality and in time product delivery. This paper focuses on a system developed to estimate the machining cost of a component by analyzing it in the early design phases. The developed system allows the user to consider the part machining operations as well as the manufacturing resources on hand during the analysis stages. A hybrid method, which uses qualitative and quantitative cost estimation techniques, is used in developing the system. The proposed system will be demonstrated and finally, further improvements on the system and its limitation are also discussed.

KEYWORDS: *Cost Estimation, Qualitative, Quantitative.*

1.0 INTRODUCTION

Research results showed that over 70% of the manufacturing cost of a product is determined during the conceptual design stage [1]. Therefore, it is worth to give more attention to cost estimation during the early phases of the design process. Cost estimating approaches found in the literature can be broadly classified as quantitative and qualitative techniques [2-7]. As presented in [7], an extensive hierarchical classification of these techniques is based on grouping the techniques with similar features into various categories. Some of the researchers

who use qualitative techniques are as follows. The knowledge-based cost models for the machined parts and injection moulded parts are initially designed by [1] whereas [8] implemented the cost estimating architecture for sedans in the Chinese market using neural networks. The quantitative cost model developed by [9] estimated the manufacturing costs considering three different times. While the requirements to setup a tool that supports manufacturing feature-based costing are explained by [10] and a system with the minimum cost to manufacture of die-cast parts and the cost calculation formulation is proposed by [11]. However, [12] developed the hybrid cost estimation system that has the features of qualitative and quantitative techniques. But this system is only for machining the rotational parts.

Based on this issue, this paper focuses on a system developed with its related methodology to estimate the machining cost of a component by analyzing it in the early design phases. The developed system allows the user to consider the part machining operations as well as the manufacturing resources on hand during the analysis stages. A hybrid method consists of qualitative and quantitative cost estimation techniques that will be extensively used in developing the system.

2.0 METHODOLOGY

Machining cost calculation is an ultimate objective of this software. A typical product would have more than one machining steps. The program is developed to find cost of each machining step and summation of costs of every machining step would give the total machining cost of the product. Since a part may be processed on several machines before it is finished it is advantageous to have this kind of approach. Figure 1 shows the overall methodology for the proposed cost estimation method.

3.0 MACHINING COST ESTIMATION SYSTEM METHODOLOGY

The system is developed using Microsoft visual C# 2005 and Microsoft SQL Server 2005 is used as the driver for the database connections. Common and uncommon variables are identified and database connections are created. The developed cost estimation system considers three types of machines, namely lathe machine, milling and drilling machines.

The system can be expandable to any other type of machine by executing the database script on the relevant machine. So it will automatically generate the database table, database diagrams and all other relevant data. The system is given the ability to store information of available machinery. This information includes technical details as well as financial details. Information of machines is necessary, since those are retrieved at different stages of the software program. Technical or operational details of a machine generally include type, spindle speeds and feed ranges. This information is utilized when calculating the machining time.

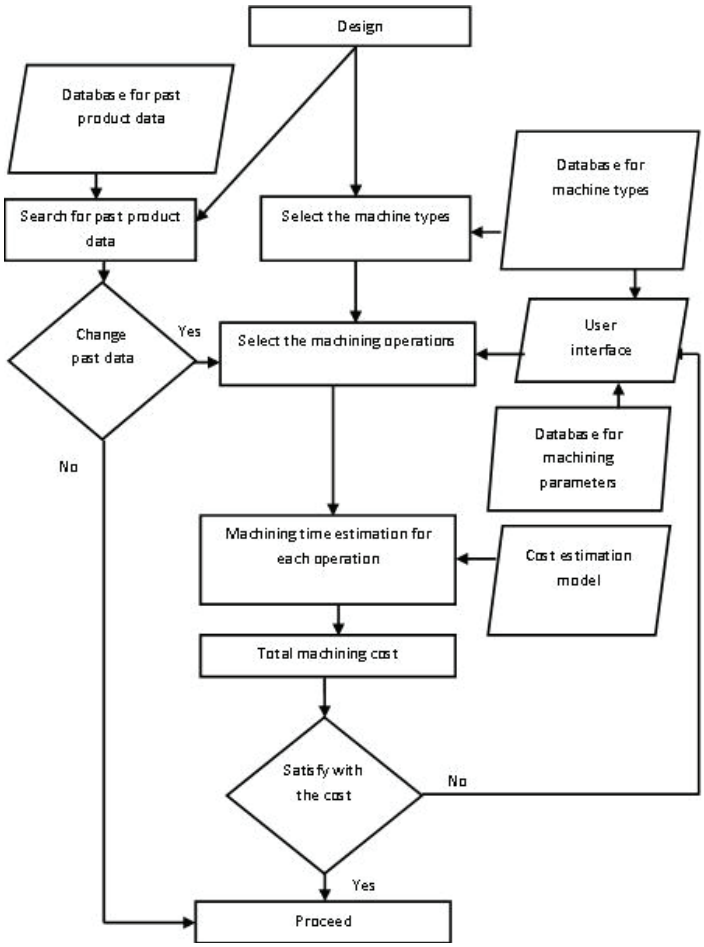

Figure 1: System approach for cost estimation

Financial details include initial and salvage values, lifetime as well as an interest rate selected by the firm. Calculation of annual cost of capital recovery is performed with these details. A predicted value for annual operating hours is also added to this record. These details

are generally kept as confidential information at business firms. The records of machines are kept under password protection in the program. Therefore only authorized personnel will have the access to view, add and change those details.

New machines can be added to the system by "AddNew" button in the opening interface as shown in Figure 3. Further, the user is given the chance of editing and deleting records. When deleting existing records user is prompted for confirmation by a message box and when the user confirms, the respective record will permanently deleted from the database.

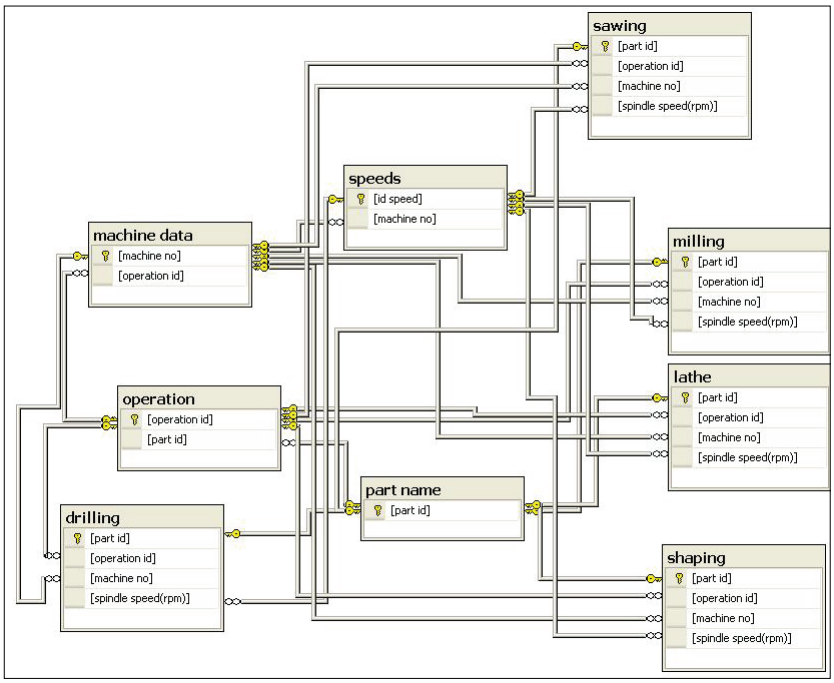

Figure 2: Database diagram

The system is designed for user friendliness from giving visual aids in the form of detailed pictures and buttons. Where ever necessary automatic display of important parameters is also an advantage to the user. User Help is provided which is a detailed documentation of the operating details of the system in a simple and understandable form. Figure 4 shows a picture for user help for manual machining. Further the system maintains a library of parts which were previously designed. This is useful for the user, if in case user has to design a part which has almost similar features of a previously designed part in which the cost is already calculated.

The details of the parts in the history can be retrieved, edited and saved as a new part. With this feature the user does not have to start from scratch every time a part cost is to be calculated. A hard copy of the details of designed part can be printed. This is important since by this, design and planned manufacturing information at the design stage can be transferred to the machine shop. By providing specifications for production, part fabrication will be done accordingly.

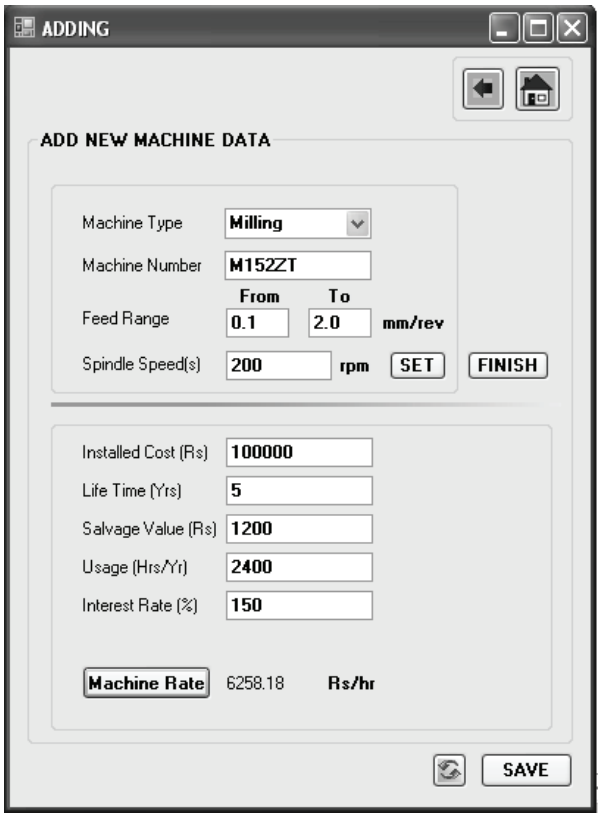

Figure 3: Interface to add new

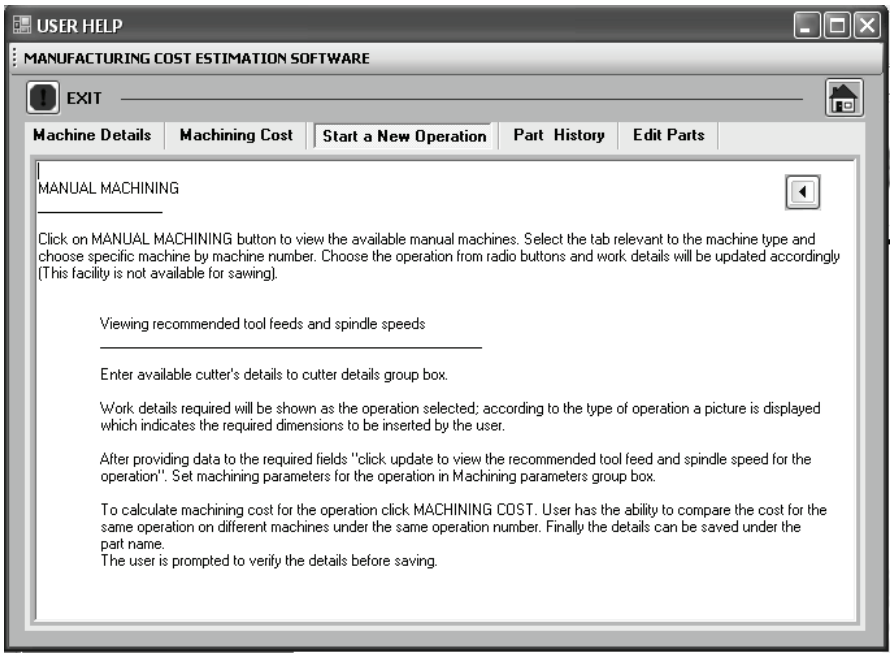

Figure 4: User help

Cost calculation procedure starts by naming a new part and saving it. Figure 5 shows the interface for this purpose. When a part is given a name and saved, all the details are stored under that name. The saved information can be recalled by that name whenever necessary. Figure 6 displays the screen after the initiation of a part. The operations that build up the machining sequence of a part are listed here. Also the final total machining cost of the part is displayed at this window. At the start the screen is blank, since no operation details are given. Clicking "NEW" button starts to add details of a new operation. Details have to be added operation by operation. This screen provides a chance for the user to add a remark to the part containing any special information of the part.

Figure 5: Interface for the beginning of cost calculation

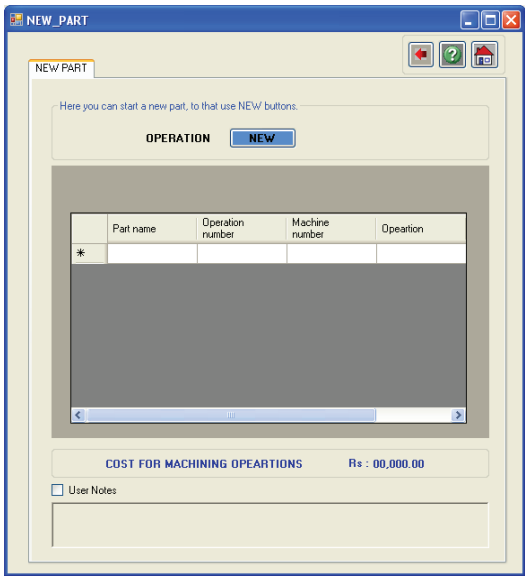

Figure 6: New part window

Figure 7 displays the new operation window. Available machine types and various machining operations that can be performed on those machine types are shown here. The user has to select the type of machine appropriate for the machining operation. Then operation type that should be performed on the respective machine is selected by the radio button. The data will be verified before saving. A screen containing all the information of the operation will appear for verification.

For a typical machining operation the operator has to provide three parameters. Those are spindle speed, feed and the depth of cut. Here user has the ability to see most appropriate spindle rpm and tool/work feed. These are set by program automatically, choosing the most suitable metal cutting speed. Data of metal cutting are stored in the program. According to the cutter material and work material the parameters are selected from the stored information. But user is given the option of manually selecting the spindle speed and feed. The cost of each machining step and summation of costs of every machining step would give the total machining cost of the product.

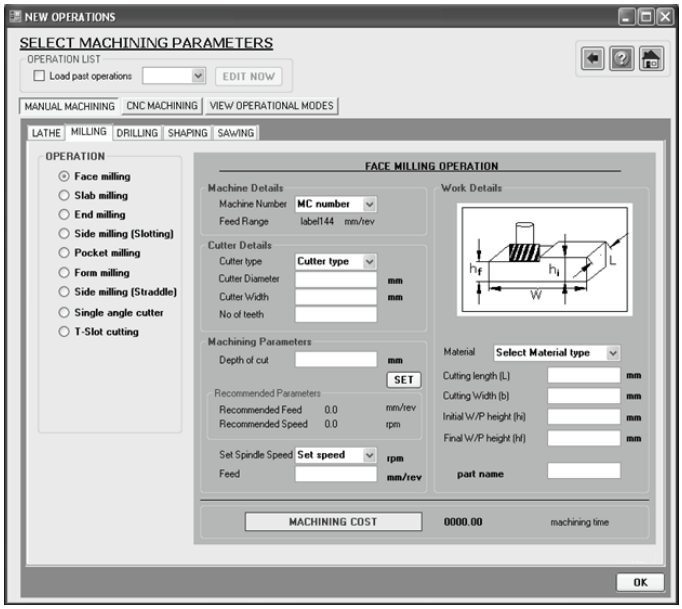

Figure 7: Machining operations

4.0 CONCLUSION

A system for machining cost estimation during the design stage is developed. The proposed method uses equations to calculate machining operation time and productive hour cost to obtain machining cost as in quantitative cost estimation techniques. Also it uses the previous data of past designs and making necessary changes to them, allowing the user not to begin the estimation from scratch as in qualitative cost estimation techniques. Therefore the system developed can be named as a hybrid method for cost estimation. The system considers the available resources such as different types of machineries available. This gives an opportunity to compare the costs of machining in different kind of machineries. In the software only manufacturing cost is considered. A Totally Integrated Manufacturing Cost Estimating System (TIMCES) is preferable. In the current system, no attempt was made to allow on-line interaction with networked databases. It may be desirable in future to provide this capability.

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