World Academy of Science, Engineering and Technology
International Journal of Information and Communication Engineering
Vol:6, No:3, 2012

Methodology of Estimating Assembly Cost by MODAPTS

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Open Science Index, Information and Communication Engineering Vol:6, No:3, 2012 publications.waset.org/4140.pdf

***Abstract*—**This paper presents the development of an MODAPTS based cost estimating system to help designers in estimating the manufacturing cost of a assembly products which is belonged from the workers in working fields. Competitiveness of manufacturing cost is getting harder because of the development of Information and telecommunication, but also globalization. Therefore, the accuracy of the assembly cost estimation is getting important. DFA and MODAPTS is useful method for measuring the working hour. But these two methods are used just as a timetable. Therefore, in this paper, we suggest the process of measuring the working hours by MODAPTS which includes the working field's accurate information. In addition, we adduce the estimation method of accuracy assembly cost with the real information. This research could be useful for designers that can estimate the assembly cost more accurately, and also effective for the companies that which are concerned to reduce the product cost.

***Keywords*—**Cost estimation, DFA, MODAPTS, Assembly cost

I. Introduction

IN Management decision making, depending on how to estimate the cost of production, the strategy of company could be changed. Especially, in manufacturing, product cost estimation directly affect product price. In some cases, competitiveness of products could be reduced, or could be increased. Such cost estimation methods are developing from one piece estimation to assembly estimation. The purpose of cost estimation in manufacturing is to reflect the cost information, which is from the exact cost deduction, accordingly to the pricing policy of company. [1], [2]

In estimating the cost of the product, the difficulty of deriving the assembly time and estimating the costs has become a problem. Because of this, the method to draw the assembly line by the output per hour has been introduced. This method is hard to affirm the exact time in each process, because the working time of the bottle neck is just reflected. Therefore, the distortion of direct working hour occurs in each process. In other method, DFA techniques are used to deduct the working hours. DFA analysis is used to improve the 'assemblability' in considering the number of separate parts or change the shape of the parts. Assemblability means how easy enough to assembly the parts to manufacture product. DFA also uses the sign from PTS method, but the estimated time are less accurate than real field, because DFA cannot reflect the real information of real field.

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Because of this, the PTS method has been used to estimate the working hour which is based on real job site. This method is able to set the standard time objectively, so the effectiveness is empirically validated. [13]

Out of the studies that reported the method of cost estimation which used DFA technique, we used MODAPTS to estimate the assembly cost in this paper. MODAPTS uses a coding technique that consists of a letter and an integer number (all but 1 code), where the integer numbers each represent MODS that can be easily added to determine a coded task's time and it is convenient for users. In reality, the newly developed products do not vary dramatically. The majority case, existing parts are added, deleted or the shape gets changed. Because of these reason, after the completion of MODAPTS analysis of total process, the users only need to consider the changed part which is changed by the working analysis. This is effective for the users to reduce the deduction time to reset the assembly time. Because of these reasons, the studies of cost estimation method which is using MODAPTS will be researched actively.

The significance of this paper is as following. Even though, the research of cost estimation is developed so far, the target of existing studies are for part and artifacts from machines. There for regardless of domestic and foreign studies, the studies for assembly are extremely short. Also, many existing studies are based on DFAA so the accuracy of exact assembly time is lacked. Therefore, the model which is easy and effective to estimate the cost with real motion and real information from the real field should be offered. In this study, we offered the method of assembly cost estimation using the MODAPTS to deduct the assembly by stages, and this is the significance of this paper.

In this paper, we suggested the cost estimation method using MODAPTS to deduct the assembly time. Also, we suggested the general method of calculating labor cost rate. With these elements, we offered the method to estimate the assembly cost. New method of estimating assembly cost by MODAPTS will contribute for cultivating cost controlling system. In addition, this method will contribute for development of market price of product.

II. Theoretical Study

A. Literature review

Majority of cost estimation research is base on DFA technique. Chan, Lewis (2000) estimated the cost of machine parts and developed DFM-C, the cost estimation program, to assist product designers in small to medium size enterprises make early evaluation of manufacturing costs and achieve cost

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effective designs. The range of this research was just in small, simple shaped parts which are produced from only by machines.[3] Wei, Egbelu(2000) a framework for the estimation of product manufacturing cost is proposed. The aim is to improve the product de sign function to realize lower manufacturing cost. In this research, the method of estimating the process cost, but does not reflects the real assembly time.[4]

The cost estimation of machine processed parts are studied, also. Shehab, Abdalla (2001) focused on the unit product cost estimation according to the material, process, and processing machine selection for the machine parts, but they did not focused on cost estimation function for assembled parts, and has a characteristic of expressing the knowledge from fuzzy logic and CAD model.[5] N. A. M Boons (1998) tried to join the benefits of ABC with a more realistic model of complex manufacturing processes in order to create a managerial support system which enables to monitor manufacturing performance more closely.[7] C.Bloch & R.Ranganathan (1992) presents a method of performing the cost analysis by taking into account the process yield at each step of the process sequence and how the yield at different steps impacts the overall cost of the module. Above studies are based on simple parts and machine parts. The information used in the research is limited. Therefore, the design factors and process factors are not used in right way. Because of this, the cost estimation could not be correct. Especially, the accuracy of assembly time information is low, because of the lack of information from real field. In this study, we supplemented existing study's weakness, and developed to estimate the assembly cost not only for the parts but also for the process assembly goods. In addition, suggested to deduct the exact assembly time by information from work field. Also, with these factors, we suggest the method to estimate the assembly cost with higher accuracy.[8]

B. Cost estimation method

In this paper, estimated cost of product occurs as total cost. The total cost includes three sectors, material cost, labor cost and other expenses. Material cost means the purchase cost of material which is involved in the product. Labor cost means the cost of labor who is involved in manufacturing the product. Also, the machine cost is involved in labor cost. Other expenses mean every cost except the material cost and labor cost. (Fig. 1)[9], [10]. Material cost includes direct cost and indirect cost. Direct cost is the cost of material which is used directly to the product, so the cost could be estimate by the quantity and unit cost of the material. Indirect cost means the cost of consumables. These consumables are difficult to figure the real quantity. In this simulation, the indirect material cost is measured of the rate against the direct material cost. Labor cost includes worker's labor cost and machine labor cost. Nowadays, many machines are operating in assembly line. To calculate the right process cost, the machine labor cost is also necessary. To estimate the workers labor cost, the factor ST and labor cost rate are essential.

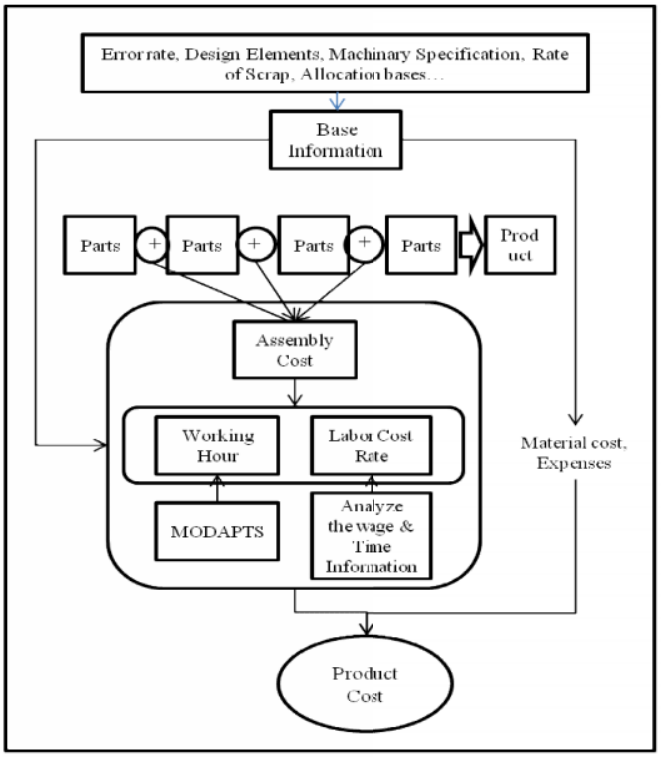

Fig. 1 Cost estimation Process

MODAPTS method is used to deduct the ST. The process of checking ST is as following.

① Film the process

② Operate the motion analysis with the taken picture

③ Check ST of every contributed motion by the time watch

④ Make the Database of ST

In this study, ST is checked by each process, not by the output per hour, because one of the purposes of this simulator is to show the cost reduction point. If ST were measured by the output per hour, then only the ST of bottle neck process could be confirmed. Then, the real direct time could be hidden, and also, the operators are not able to find the cost reduction point. Therefore, the higher accuracy assembly time of each process could be supplied by the MODAPTS method.Estimating the workers labor cost rate, it could be calculated by the total salary ledger and the absenteeism and tardiness records, which is the workers information. To estimate the machine labor cost rate, at least the information of the machine investment cost, the economic life time of the machine, power consumption and the unit electric charge. Each labor cost rate could be calculated by dividing the charge to the time information. It is important to decide the exact time reference, because of the change of labor cost rate. Generally time reference includes the total hour for reporting and direct labor hour, so the labor cost rate could be change by choosing each of one.In this paper, we considered only the labor cost, because assembly time and labor cost rate are able to control in-house, but material cost and other expenses are related to other companies also.

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C. MODAPTS

MODAPTS, the predetermined time system authored by Chris Heyde in 1966, provided a system that is easy to learn and easy apply. MODAPTS is similar to other predetermined time systems such as MTM or MOST. MODAPTS is a system for measuring work, without the use of a stopwatch. It is based on analyzing the body motions required in a work task or work process. It is an accurate and quick work analysis system that can be applied to production activities, non-cycle work environments and safety management. It is currently being utilized by automotive manufacturers and suppliers, government organizations, not-for-profit workshops, shipping and transportation industries, as well as office and data processing organizations..

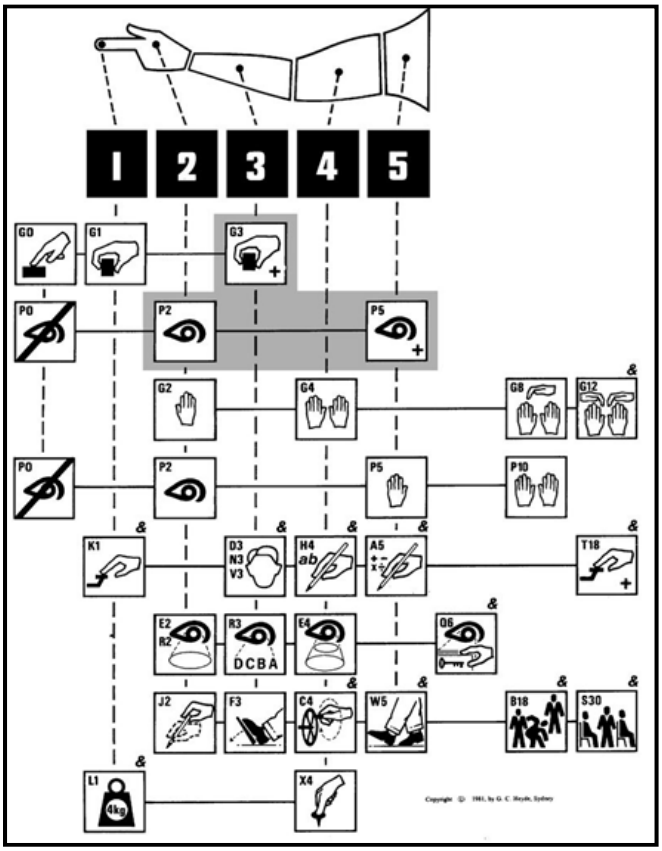

Fig. 2 MODAPTS Signature

This system can be used for contract bidding, direct labor cost estimating, quality control, safety analysis and establishing productivity standards for work stations and manufacturing processes.

MODAPTS is easy to explain and employs a small number of values, a review of standards by interested parties is simple and the possibility of controversy is reduced. MODAPTS analyses motion patterns and subjective operator ratings. Its MOD based system is accurate and easy to interpret.Nowadays, trend of developing the new products are changing the shapes or adding and deleting the parts. Therefore, if the product developers have the analyzed MODAPTS library, it is easy to re-estimate the assembly cost by changing the assembly time of changed process because of the developed part by MODAPTS signatures. MODAPTS library is a Database that is contributed with work elements and their working hours, so the product designer can use to estimate the working hour if the product is developed, easily. Because of this, the developers do not need to change the whole assembly time, and they can reduce the re-estimation time. Also, signatures of MODAPTS are related to hands, arms, and shoulders. In addition, numbers are related to the distance of movement of each parts of the body. These signatures and numbers could be related to the complexity of assembly and shape of the products. Namely, the according to this complexity, the movement and operation gets more difficulty, so the relation between the design specification and operation activity could be desired. In this paper, we use these theoretical reviews to make the automatic logic of working time estimation of each process and offer the cost estimation method.

III. Estimation Process of Assembly Cost

Labor cost rate and Standard time is necessary to estimate the assembly cost. In this paper, we used MODAPTS to deduct the working time of each process. We supply the general method of calculating the labor cost rate, also. These elements are used for estimation.

A. Process to deduct labor cost rate

Generally, labor cost rate includes direct labor cost per hour and indirect labor cost per hour. Indirect labor cost means the labor cost that the workers who does not work in the process line. However, in this study, the indirect labor cost is classed as other expenses to confirm the direct labor cost in assembly line. Because of this, the line manager is able to check the exact manufacturing cost of each process. To estimate the machine labor cost rate, the depreciation cost of each machine should be calculated. And also the electric cost per hour is necessary.
The process to estimate the labor cost rate is as following. (Fig. 3)

First, collect the materials for labor cost rate. The materials are the direct workers salary books, reference time, also, the investment cost of machine, description of the machine to confirm the power consumption of the machine.

Second, estimate the labor cost rate by gathered information. To check the validity of estimated labor cost rate, the manager can confirm the national material, in national statistical office. The average wage of each age group in each company group is offered in there. Also, the time reference is given. Therefore the manager can calculate the average labor cost rate. After this, the manager can find the problem or appropriateness of labor cost rate.

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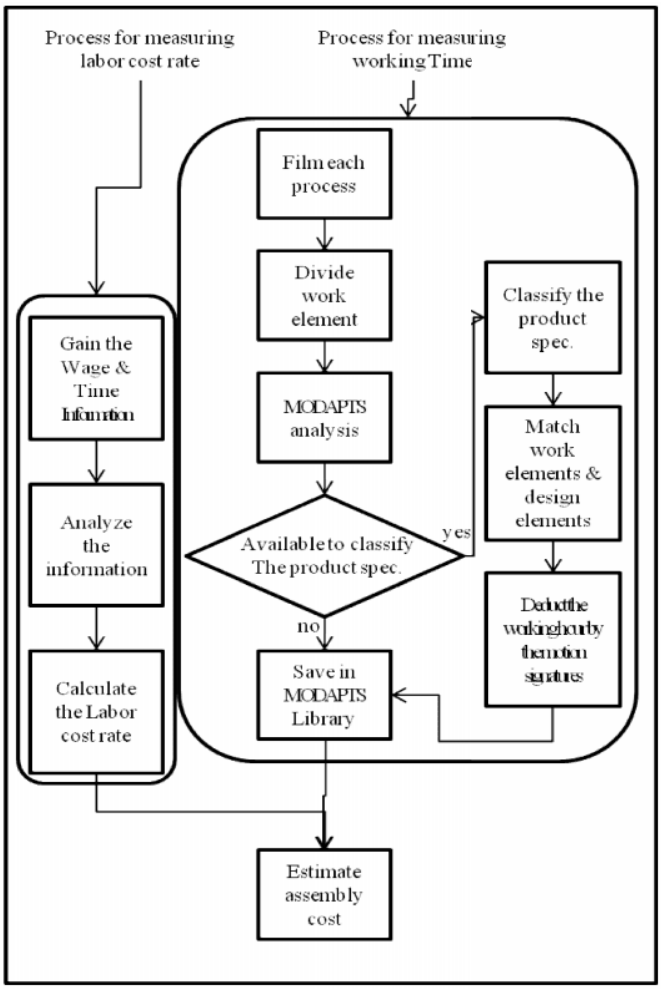

Fig. 3 Assembly cost estimation process

B. Process to deduct the standard time

Generally, to deduct the standard time, the PTS method, MTM method, MODAPTS method is used. In assembly line, sum of standard time of each process could be the total standard time. In machine line, sum of the Cycle time of each machine could be the total standard time. MODAPTS method was used to check the standard time of the assembly line, and stop watch for cycle time of the machines, in this paper.

The process to estimate the standard time is as following

① Film the pertinent process

The video of the process is necessary to divide the operation activities and to check the activities repeatedly. The video filming has been operated continually from the insert of material to finish of complete product. The skill level of workers also reflects the assembly time, so asked to work in average speed. For the accuracy of the action and assembly time, we filmed at least 5 times for each process.

② Division of work elements

From the video that we filmed, the work elements could be divided. Dividing the work elements

③ Operate MODAPTS analysis and save in MODAPTS library

Each process, which is contributed by many work elements, is analyzed by MODAPTS. Every work elements are converted to MOD. MOD is the time unit of MODAPTS. 1MOD is 0.129 second, so every work elements could be converted to working time. For the user interface, every analyzed MODAPTS table should be saved in MODAPTS library, for easy using to calculate the assembly cost.

④ Classification of product design elements

Every product has own design elements. Each product has different working times. However, the similar shape of the products has similar design elements, and it could be made as a table.

⑤ Match the work elements and design elements

Each work elements has working hour, because of MODAPTS. Also every product has design elements. Because of the MODAPTS, every analyzed element work is based on the design elements of the products. For example, The size of product is related to the MODAPTS signature M and its length number. If the size is small then the signature M will have small number like M1 or M2, but if the size is bigger than 30cm, then the signature M will have big number like M3 or M4, because the worker's arm has to move not only the wrist but also the elbow.

⑥ Deduction of working hour based on active signature

Because of number ⑤, the movement signatures could be matched with design elements. MODAPTS analysis includes the movement signature and numbers also, and it also reports the working time. Therefore the design signature could be matched with working time also. Finally, the timetable which is based on the design elements could be occurred and this is also saved in MODAPTS library.

C. Process to estimate assembly cost with MODAPTS library

Estimating the assembly cost could be operated by the labor cost rate and working hour, which is quoted. This operation has higher accuracy than DFMA. The proposed MODAPTS method reflects the real field work. We use MODAPTS Library to check the working time for each product. MODAPTS library includes the product name, product specification, working elements, MODAPTS signature and also the working time.

Usage of this library is as following. (Fig. 4) First, check the product information. Size, specification, description is the example of product information. This information is a base to search the MODAPTS analyzed process of similar product. Second, by the product information, the similar process should be searched in MODAPTS library.

The user can see the whole process of similar product. Third, the developer can check the difference of process or work elements because of the assembly drawing and floor plan of the product.

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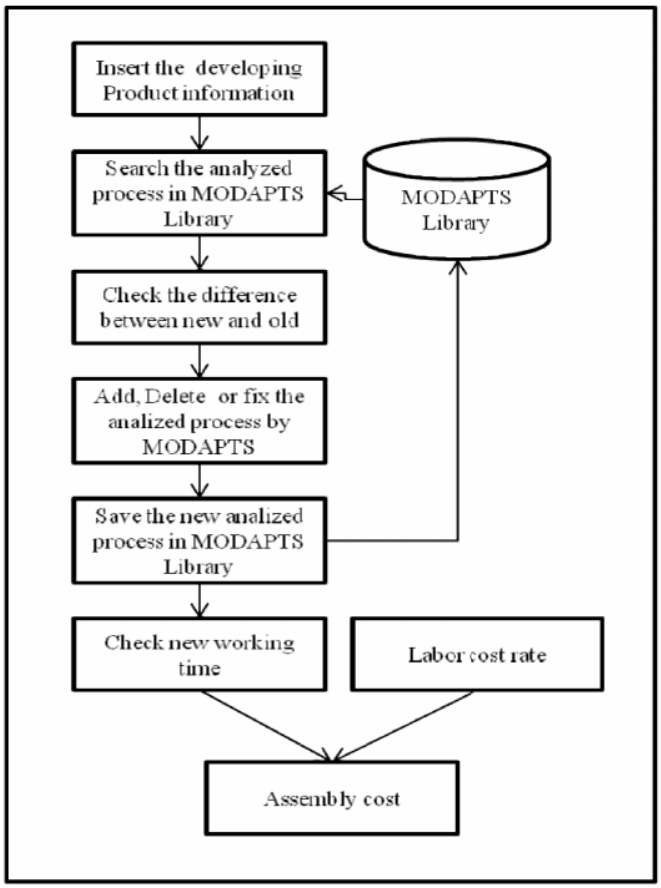

Fig. 4 Process for user to estimate the assembly cost

Therefore, the designer can create the new analyzed process. Fourth, after checking the difference between old product and developed product, the designer can add or delete the work element and also change the work elements. Fifth, if the fixing process is done, then the new process should be saved in MODAPTS library for re-use at next time. Finally, the designer can recalculate the working hour of new analyzed process.

With the labor cost rate and working hour, the designer can check not only the accuracy assembly cost of each process, but also the assembly cost of total process.

IV. Conclusion

In this paper, we suggested the method for estimating the assembly cost using the MODAPTS. The purpose of this paper is to increase the reality and accuracy of assembly cost estimation. For this reason, we made the working time deduction process of using MODAPTS. First, for the reality, we filmed the video of real field process. Second, analyzed by MODAPTS and struggled to check the relation with product specification. Third, we made the MODAPTS library to check the work elements and each working hours. Because of the MODAPTS library, designers can easily check the working hour of each developed product and fix the process and recheck the assembly time. Also, in this paper, the method for calculating the labor cost rate is suggested. Therefore, designers can easily estimate the assembly cost.

The effectiveness of this research is as following

First, assembly cost could become realized. The suggested method of measuring the working hour by MODAPTS supplies the real working field's working hour.

Second, the rapidity of determining the product cost could be prompt. Because of the existence of MODAPTS library, the occurred working hour could not be different in the company. This is also same to the cooperative firm.

Research in this paper will be affective for cost estimation by real information. Actually, just a few analyzed processes could be classified by the specification. Therefore, for the convenient usage of MODAPTS library, the researches for finding the design elements which is affective to the working hour, are necessity.

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