ISSN No:-2456-216

Using Work Factor Method with the MOST System for Accurate Disassembly Time Evaluation

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Abstract:- Rapid disassembly of components is required in various contexts such as repair, remanufacturing, and recycling. Work Factor Method illustrates a good sequence of disassembly activities which is very heavy to implement. That is why it is intended to interpret this sequence with the MOST system. Therefore by applying a globally known work evaluation system MOST (Maynard's Operation Sequence Technique) in a Work Factor Disassembly Sequence, we obtain a standard pattern of evaluating Disassembly sequences time based on MOST principles. The implementation of the Work factor Sequence with the MOST system gives more accurate disassembly time than using the Work Factor Methodonly. The combination of these two techniques helps with time accuracy definition and therefore can increase product life-cycle quality.

Keywords:- *MOST system, Work Factor Method Sequence, Disassembly, Modelling.*

I. INTRODUCTION

The needs for Disassembly include different stages such as maintenance, repairing, remanufacturing, recycling and disposal. In designing for Disassembly, improvements can be achieved by considering future Disassembly of product elements at the planning stage of new products [1] [2] [5]. Several investigations have demonstrated through case studies the cost-effectiveness and the environmental impact reduction from the application of Design for Disassembly in designing processes. Disassembly can be defined as the systematic separation of a product into its components, sub-assemblies, materials, and other groupings**[3].** Fasteners are a type of relationship that can significantly impact the Disassembly time of a Product. That is due to introducing additional system elements in nuts, bolts, rivets, and screws and the interaction of these fastening elements with Bolting. Based on those parameters, quantitative disassembly analysis is summarized.Disassembly planning consists of finding an optimal and feasible path for disassembly under given constraints[6].Then comes this study which has as objective to propose a Standard, Adequate Disassembly Sequence Planning for Industries with the Application of MOSTWork Measurement System. This study presents a way of Evaluating the Disassembly Sequence, which permits the technician to estimate the easinessof disassembled Productsusing the Motion of Time and other Factors.[4]. MOST is a predetermined motion time system used primarily in industrial settings to set the standard Time in which a worker performs a task. A task is broken down into individual motion elements, and each is assigned a numerical time value in units known as time measurement units, or TMUs [7].Time and motion study is a process efficiency technique, combining the Time Study work and the Motion Study work. There are many types of MOST: **Maxi, Basic, and Mini MOST.**

Basic MOST: At the intermediate level, operations that are likely to be performed more than 150 but less than 1500 times per week should be analyzed with Basic MOST. An operation in this category may range from a few seconds to 10 minutes in length (Operations longer than 10 minutes may be analyzed with Basic MOST, with 0.5-3 minutes being typical cycle time for Basic MOST). The majority of operations in most industries fall into this category. Basic MOST index ranges readily accommodate the cycle-to-cycle variations typical at this level. The method descriptions that result from Basic MOST analyses are sufficiently detailed for use as operator instructions[7].

Work Factor method aims to obtain approximate disassembly time for a product to be disassembled by using the formula derived from the information on the Product's connecting parts and working environment disassembling the Product directly. This method was developed by **[8].** Most products are composed of various components and different shapes and sizes by joint elements. Computing disassembly time, the standard Time is calculated using the Work Factor method in the selected influence factor and disassembly work.

Effective time is computed by using predetermined values of Time according to characteristics and conditions of each basic movement after analyzing the operation by humans as a basic movement. This operation time is divided into four (04) Factors as shown in the results section.

This short presentation of the MOST technique and the Work Factor method should permit us to deduct the disassembly sequence operation time.

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II. METHODOLOGY

A. Principles of MOST

Accordingly, for effective and economical Disassembly, we must consider Disassembly when developing and designing a product, even though the product designer considers the Disassembly of the Product that he has developed [9]. A Tool is necessary to judge how much the disassembly process is easy objectively. In these studies, we will apply the MOST system as a tool to get the best, shortest way for Disassembly using the Work Factor sequence. The MOST worksheet represents the different Data card that provides the index value for each Sub-Activity and Sequence.

In general, objects call to be moved in only two ways, either they are picked and moved freely through space, or they are moved while maintaining contact with another surface. For each type of Move, a different sequence of events occurs. Therefore, a separate MOST activity model applies. The use of tools is analyzed through a separate activity sequence model. Consequently, only three basic MOST activity sequences are needed for describing manual Work:

- The General Move Sequence (for the movements of objects free1y through the air)
- The controlled Move Sequence (for the movements of objects when it remains in contact with a surface or it is attached to another object during the movement)
- The Tool Use Sequence (for the use of common hand tools)

General Move Sequence: General Move is defined as moving objects manually from one location to another freely through the air. Four sub-activities make up the activity sequence by considering the various ways in which a General Move can occur. The parameters are the series of letters representing various activity elements. The parameters of the Basic MOST General Move Sequence consist of 5 step pattern as below: ABG ABP A

Control Moves Sequence: Used when an object is moved through a path that is somehow constrained.

The standard Sequence in Controlled Move: ABG MXI A

The table below lists the parameters and possible action circumstances and the corresponding values of the index numbers.

Example: A worker takes two steps, grabs the waist-level feed lever on the lathe, pulls up the lever approximately 15 cm to engage the feed. The processing time to turn the part is 25 sec. Solution: 25 sec.s = 69.5 indices A3B0G1M1X70I0A0 where A3=walk 2 steps; B0=no body motion; G1=gain control of lever; M1=pull the lever up 15 cm: X70=process time of; I0=no alignment; A0=no motion. The sum of index values: 75. Normal time: 10*75=750 TMUs = 27 seconds.

Tool use sequence:The Tool use sequence is composed of sub-activities for the General move sequence, along with specially designed parameters describing the actions performed with hand tools or, in some cases, the use of certain mental processes. We have five main activity phases: Get Object or Tool; Place object or Tool in working position; Use Tool; Put aside Tool; Return to the workplace. These are the particular parameters, which describe the tools use sequence like – F: fasten, – L: loosen, etc.

Only one is used in a sequence: ABG ABP * ABP A

B. *The procedure of basic MOST method*

Here is the process of applying basic MOST methods:

- Selection of Job and the Operator for study;
- Record details of activity and conditions of Work;
- Observation of each parameter Phases;
- Parameter Indexing;
- Addition of all the parameter Index values of activity;
- Convert the total of Index values into TMU;
- Convert the TMU value in corresponding Time (Hours);
- Convert the Time from an hour into Minutes.

III. APPLICATIONOF MOST METHOD INTO THE ABOVE DISASSEMBLY SEQUENCE BY IMPLEMENTING WORK FACTOR SEQUENCE

To facilitate the disassembly process in product designing by the use of Maynard's Operation Sequence Technique to evaluate Disassembly time and make an objective judge which disassembly process to choose based on the level of ease, we came up with the following:

A. *Preparation Time*

The preparation time is acquired by Adding the Time getting from the below influence factors.

a) Identifying the joint elements

Here the task consists of using our mental processes, particularly those involving visual perception. We need to determine the Tools we will need to accomplish the task by looking at the different joint elements and what type of Bond holds them together hence determining the required tools to disassemble them. Example It may be **Screw and nut**; we will need to identify what type of **wrench** can be used to disassemble that Screw or nut. The most appropriate parameter to determine this is the *Think* parameter in the tool Use Sequence of MOST. In this parameter, we can find indexing on *Inspection*, which is the task for identifying joint elements. Inspection index values refer to the inspection number points examined on the Product, such as the number and the size of the nuts on the Product. Objects displacement is not considered here.

The Sequence Model is **ABG - ABP - T - ABP – A**

Where:

A: Action distance, the displacement made if necessary to identify the joint elements.

B: Body Motion, Bending, Seating, Arising if require for the identification.

G: Gain Control, if the identification task can be completed without griping the object to turn or displace it.

P: Reposition the Object if it was held to identify the joint elements.

T: Think (Inspection), the special parameter in the sequence Model, determines the Time required for identification.

Those parameters and their indexes are depicted in appendices 1 and 3.

b) Searching and Identifier tools

After identifying the tools required for Disassembly, we need to search and identify our Tool Box or storehouse tools. Generally, workers already know the size and shapes of tools. This still falls under the same category as the above staff since it consists of observing and also displacing some objects.

On the observation side, we shall still use the *Inspection* operator to evaluate the Time of this task. The Sequence Model remains **ABG - ABP - T - ABP - A**

A: Action distance, the displacement made if necessary to identify the Tools.

B: Body Motion, Bending, Seating, Arising if require for the identification of the tools.

G: Gain Control, if the identification task can't be completed without griping objects to turn or displace them to see hidden tools.

P: Reposition the Object if it was held to identify the tools required.

T: Think (Inspection), the special parameter in the sequence Model, determines the Time required for identification. Its index value can be obtained from **annex 3.**

c) Griping Tools

Getting the tools we need requires us to complete the following Sub-activities: Body Motions that are bending to take the tools if required and Griping the tools required.

To do that, we use the Sequence Model below: **ABG**

Where:

A: Action distance, the displacement made if necessary to get the Tools.

B: Body Motion, Bending, Seating, Arising if require to get the tools.

G: Gain Control, The vital parameter to grasp the tools.

B. Movement Time

Movement time is calculated by adding the Time getting from the following influence factors:

a) Movement between joint elements.

Movement between joint elements involves the different displacements made to access some part/side of a product. We can use the sequence model below derived from the General Move Sequence: **ABG**

Where:

A: Action distance, the displacement made if necessary to go through the joints.

B: Body Motion, Bending, Seating, Arising if require.

G: Gain Control, not necessarily important here; hence it shall have an index value of 0.

b) Redirecting towards the side of joint Elements

This influencing factor involves the different displacements made to access some part/side of a product. This may involve:

A: Action distance is our displacement around the Product.

B: Our body Motions such as bending to have a better view.

G: Griping the object to turn it or access a different part or have a different view of the object

P: And placing it back if it was lifted.

We can use this sequencing model: **ABG – P**

C. Working Time

The working Time or operation time depends on the condition of joint elements and the work environment. Its total Time can be calculated by adding the Time getting from the following Influence Factors:

a) Basic separation of joint Elements:

This process purely involves the Tool use Sequence of Maynard's Technique where we are involved after some of the following Operations: Loosening. Cutting, etc.

It is applied in the sequence model below: **ABG - ABP**

A: Action distance, the displacement made if necessary to separate the joint elements.

B: Body Motion, Bending, Seating, Arising if required for the separation of joint elements.

G: Gain Control to grasp the elements and make an easy separation.

P: Reposition the Object if it was held to separate the joint elements.

b) Time for aligning between Tool and Joint elements

The Time taken to complete this task can be evaluated by the following sequence model: **A B P**

Where:

A: Action distance, the displacement made if necessary to align the Tool to the joints.

B: Body Motion, Bending, Seating, Arising if required to align the Tool and the joints.

G: Gain Control; one will need to grasp the Joint Element for better Control.

P: Position, the most important parameter of this task, since we need to position accurately with precision if necessary, the Tool to the joints.

c) Tool operation Area

The tool operation area is the active operation in disassembling a product. Because this is the area where we disassemble the Product by some of the following disassembly parameters:

- Loosening bolts, nuts, and other elements.
- Cutting if required.
- Surface Treat

It is applied in the sequence model below: **ABG - ABP - X - ABP - A**

A: Action distance, the displacement made if necessary to effectively complete our task.

B: Body Motion, Bending, Seating, Arising if required to complete our task effectively.

G: Gain Control to grasp the elements.

P: Reposition the Object if it was held to complete the operation.

X: where X can be any of the special parameters mentioned above needed to complete the task. Its index value can be gotten from appendix 2.

D. Post-Processing Time:

This is the Time taken to collect position the disassembled parts to the box or any other save location. In order words, it is the Time taken to move the different parts to the proper location after separating the disassembled part. The Time is also taken to move disassembled parts due to weight and size or due to hazard. The Time required to complete this task can be evaluated by applying the General Move sequence of MOST as shown below.

ABG - ABP - X - ABP – A

Where:

A: Action distance, the displacement made to get or place the parts.

B: Body Motion, Bending, Seating, Arising made to keep the part.

G: Gain Control, The important parameter to grasp the part to displace it.

P: Positioning the part displaced at the desired location.

X: where X can be any of the special parameters due to hazard, weight, and size needed to complete the task.

In sum, to calculate the total Disassembly time, we need to add up all the indexes gotten from the different Sequences seen above, Multiple them by 10 and 0.036s, to get the Time in Seconds, as shown in Fig. 1.

Work Factor Sequence		Derived MOST Sequence	Equations
Preparation Time (Tp)	Time for identifying joint elements (Tpb)	ABG - ABP - T - ABP - A	(1)
	Time for searching and identifying tools (Tps)	ABG - ABP - T - ABP - A	(2)
	Time for gripping tools (Tpg)	ABG	(3)
Movement Time (Tm)	Time for moving between joint elements (Tmd)	ABG	(4)
	Time for redirecting toward the side of joint elements (Td)	ABG - P	(5)
Operation Time/ Disassembly Time (Td)	Time for aligning between Tool and joint Element (Tdal)	A B P	(6)
	Time for basic separation of joint Element (Tdb)	ABG - ABP	(7)
	Time for tool operation area (Tda)	ABG - ABP - X - ABP - A	(8)
	Time for the intensity of Work (Tw)		
Post-processing Time (Tpr)	-Time for post-processing due to weight and size of the disassembled parts (Tprsw)	ABG - ABP - X - ABP - A	(9)
	-Time for post-processing due to movement of disassembled parts (Tprdt) -Time for post-processing due to hazard (Tprd)		

$$\textbf{Total disassembly time} = \left[\sum \begin{matrix} ((1)+(2) \\ +(3)+(4) \\ +(5)+(6) \\ +(7)+(8)+(9)) \end{matrix}\right] \cdot 10 \cdot 0.0036s$$

Fig. 1. Derived MOST system from Work Factor Method

IV. CONCLUSION AND PERSPECTIVES

The aim here was to implement the Work Factor disassembly sequence to the MOST system to derive the standard operation time based on the appropriate disassembly sequence as Work Factor Method. The present Work is also regarding the method on disassembly time calculation, which does not just consider the product Side, Shape, and Influence factors but also the Body Motion of the Worker. When calculating the disassembly Time, we just need to follow the MOST Sequence given above; from there, the disassembly time can be calculated, determining the best Disassembly Sequence to implement on the designer's Product.

If we assume for example the case of recycling activities, practically, it is not easy to precisely estimate the Time taken for Disassembly in the Recycling process because the Product's condition would not be constant. It is anticipated that workers' expertise, assignment of the workplace, characteristics of the Product, and hazards during operation have a more significant influence on the Time and may change; hence, it may be necessary to make some adjustments on standard Time suitable for the feature of each category.

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APPENDICES

APPENDIXI. GENERAL MOVE SEQUENCE DATA CARD [7]

General Move Activity Sequence Model = ABG - ABP - A				
Index	A=Action Distance	B= Body Motion	G = Grasp	P = Placement
0	< 2 IN < 5 CM			**HOLD TOSS**
1	**WITHIN REACH**		**LIGHT OBJECTS LIGHT OBJECTS SIMO**	**LAY ASIDE LOOSE FIT**
3	1-2 STEPS	**BEND AND ARISE 50% OCC**	**NON-SIMO HEAVY OR BULKY BLIND AND OBSTRUCTED DISENGAGE INTERLOCKED COLLECT**	**ADJUSTMENT LIGHT PRESSURE DOUBLE**
6	3-4 STEPS	**BEND AND ARISE**		**CARE OR PRECISION HEAVY PRESSURE BLIND OR OBSTRUCTED INTERMEDIATE MOVES**
10	5-7 STEPS	**SIT OR STAND**		
16	8-10 STEPS	**THROUGH DOOR CLIMB ON OR OFF**		

ISSN No:-2456-216

APPENDIX II. TOOL USE DATA CART [7]

Tool use sequence Model for Fastening and Loosening = ABG - ABP * ABP - A										
INDEX	FINGER ACTION	WRIST ACTION				ARM ACTION				TOOL ACTION
	SPINS	TURNS	STROKES (REPOSITION)	CRANKS	TAPS	TURNS	STROKES (REPOSITION)	CRANKS	STRIKES	SCREW DIAMETER
	FINGER SCREW-DRIVER	HAND SCREW-DRIVER RATCHET T-WRENCH	WRENCH ALLEN KEY	WRENCH ALLEN KEY RATCHET	HAND HAMMER	RATCHET T-WRENCH	WRENCH ALLEN KEY	WRENCH ALLEN KEY RATCHET	HAND HAMMER	POWER WRENCH
1	1				1					
3		1	1	1	3		1		1	1/4IN (6MM)
6	3	3	2	3	6	2		1	3	1IN (25MM)
10	8	5	3	5	10	4	2	2	5	
16	16	9	5	8	16	6	3	3	8	

APPENDIX III. TOOL USE DATA CART [7]

Tool use sequence Model = ABG - ABP * ABP - A														
INDEX	C				S			M	R			T		
	GRIP	CUTOFF	CUT	SLICE	AIR CLEAN	BRUSH-CLEAN	WIPE	MEASURE	WRITE		MARK	INSPECT	READ	
	PLIERS		SCISSORS	KNIFE	NOZZLE	BRUSH	CLOTH	MEASURING DEVICE	PENCIL		MARKER	EYES FINGERS	EYES	
		(WIRE)	CUTS	STROKES	SQ. FT. (DM)	SQ. FT. (DM)	SQ. FT. (DM)	IN. (CM)	DIGITS	WORDS	DIGITS	POINTS	DIGITS SINGLE WORDS	TEXT OF WORDS
1	GRIP		1						1		CHECK MARK	1	1	3
3		SOFT	2	1			½		2		1 SCRIBE LINE	3	3	8
6	TWIST BEND LOOP	MEDIUM	4		1 POINT OR CAVITY	1 SMALL OBJECT			4	1	2	5 TOUCH FOR HEAT	6	15
10		HARD	7					PROFILE-GAUGE	6		3	9 FEEL FOR DEFECT	12	24