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# Application of the MODAPTS Method with Inovative Solutions in the Warping Process

**Abstract**
*The paper presents some general features of the MODAPTS (Modular Arrangement of Predetermined Time Standards) method and its application in the warping process during making fabrics. The labour of the worker in extra warping jobs was analysed by means of the movements and load and the MODAPTS method was used to analyse the efficiency of the operator's movements. This workplace was chosen for the analysis because it requires manual work where the body moves continuously and is subjected to exceptional loads; in most cases female workers perform these jobs. By use of the MODAPTS method every body movement and body part were analysed. The improvement was investigated by using a special transportation cart which can lift or lower bobbins to the height of the mounting of supply packages in a creel and carrying several bobbins at the same time. According to the results obtained and innovative solutions that can be applied as an additional tool, an easier, safer and more efficient work procedure for the same scope of work was obtained.*

**Key words:** *warping, manual work, body movements, body load, MODAPTS method, mounting supply packages, creel.*

## Introduction

The MODAPTS (**Modular Arrangement of Predetermined Time Standards)** system is used to analyse work performance by monitoring the operator's movements in the workplace. MODAPTS records the workplace or monitors the operator's movements in the workplace in order to [1 - 5]:

- simplify and facilitate work in the workplace,
- detect and eliminate idle motions,
- analyse the performance of the MODAPTS method.

The MODAPTS method allows more qualitative and efficient work as well as to achieve production quotas, and it assists in reducing risks of injuries, stresses and hard work. The worker becomes more satisfied with his work because work accomplishes his goal, which is the execution of the task in quantity and quality, achieving a higher personal income. The employer will be more satisfied and will have the production and profits planned [6 - 8].

## Analysis of body movements according to the MODAPTS method

The MODAPTS method of analysing the worker's movements is very simple to apply and provides very valuable and accurate results for each individual being recorded. Each body or body part movement is later multiplied with the factor of load mass to be carried or load factor (L). By increasing the load mass, efforts to perform a specific task are also increased. The modular ((MOD) for each movement (***Table 1***) increases (multiplies) with the load mass for the corresponding (L). The experimental part of the paper analyses the load of workers in assistant warping jobs using the MODAPTS method including the following tasks:

- The task will be studied and divided into operations or body movements or body part movements.
- Movements according to the MODAPTS method with corresponding symbols for each movement will be categorised.
- Load factors for each movement will be assessed.
- MODS will be calculated on the basis of the *number of movements and load factor.*
- MODS by category (cases) will be summed to obtain the total number for this action.
- The MODS before and after improving the work will be compared and the difference in work efficiency with and without innovative solutions will be observed.

***Table 1*** shows the evaluation of individual body movements by category and according to MODAPTS, which will be used in the experimental part.

## Experimental part

The experimental part deals with the MODAPTS method for analysing the load of workers during warping while creeling up bobbins. Work improvements were made by using a special cart for transporting cross-wound bobbins from the storage location of bobbins to the creel as opposed to the worker hand carrying and creeling up bobbins. This workplace represents one of the most difficult phases in fabric manufacturing performed manually even today. In order to facilitate this job, several solutions were offered by installing conveyer belts to transport bobbins to the point of creeling. However, this kind of creeling bobbins is not a permanent solution to be used under all conditions, which was the reason why transport carts were innovated with the possibility of lifting or lowering the load to the level of creeling cross-wound bobbins and exceptional handling in confined spaces. This kind of creeling up cross-wound bobbins reduced physical efforts and increased efficiency in performing the task.

Categories of movements *bend* or *straighten up* represent half of a rotation or half of an activity, while together they make one activity (***Table 2***).

## Discussion

The introduction of the MODAPTS method in workplace creeling of cross-wound bobbins (mounting cross-wound bobbins in a creel) has proved itself in

***Table 1.*** *Evaluation of movements according to MODAPTS; a) Category of movements groups and shows each movement, b) Symbol or sign of each movement whereby the letter signifies the corresponding movement, while the numbers are equal to the number of MODS, c) MOD, i.e. the number of necessary MODS for a movement, d) Description of each movement, ○ - Natural body movement which does not require much effort, ◎ -Movements requiring little effort. They should be reduced at the workplace, ● - Movements which impede work performance; they should be completely eliminated.*

| Categories of movements a) | | | | Symbol b) | MOD /seconds c) | | | | | | | | Description d) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0/0 | 1/0.129 | 2/0.258 | 3/0.387 | 4/0.516 | 5/0.645 | 17/2.193 | 30/3.870 | |
| BASIC MOVEMENTS | SHIFTING MOVEMENTS | SHIFTING |  | M1 | | ○ | | | | | | | Fingers to the knuckle |
| | | | | M2 | | | ○ | | | | | | Fingers and hand to the wrist |
| | | | | M3 | | | | ○ | | | | | Finger movement using the forearm |
| | | | | M4 | | | | | ● | | | | Arm movement using mostly the upper part of the arm |
| | | | | M5 | | | | | | ● | | | Movement of the outstretched arm |
| | FINAL MOVEMENTS | GRASP |  | G0 | ○ | | | | | | | | Touching with the tips of the fingers |
| | | |  | G1 | | ○ | | | | | | | Grasping an object |
| | | |  | G3 | | | | ● | | | | | Grasping an object which is not easily grasped |
| | | PLACING |  | P0 | ○ | | | | | | | | Placing using a usual movement |
| | | |  | P2 | | | ○ | | | | | | Placing movement with tracking view |
| | | |  | P5 | | | | | | ● | | | Placing with increased attention |
| OTHER MOVEMENTS | Sitting and standing | |  | S30 | | | | | | | | ● | Sitting and standing |
| | Bending | |  | B17 | | | | | | | ● | | Bending and straightening up |
| | Walking | |  | W5 | | | | | | ◎ | | | Walking and body rotating |
| | Turning | |  | C4 | | | | | ○ | | | | Hand or arm rotation |
| | Pressing | |  | A4 | | | | | ○ | | | | Pressing button, switch or placing pins, needles |
| | Assessment | |  | D3 | | | | ● | | | | | Momentary confusions (good or bad) |
| | Foot | |  | F3 | | | | ○ | | | | | Ankle movement with heels on the floor |
| | Grasp again | |  | R2 | | | ● | | | | | | Putting aside and grasp the pen again |
| | Eye | |  | E2 | | | ◎ | | | | | | Eye movement, focusing |
| | Balance | |  | L1 | | ◎ | | | | | | | $L_1$ (m≤2kg); $L_2$ (2kg<m≤6kg) etc. (tab. 2) |

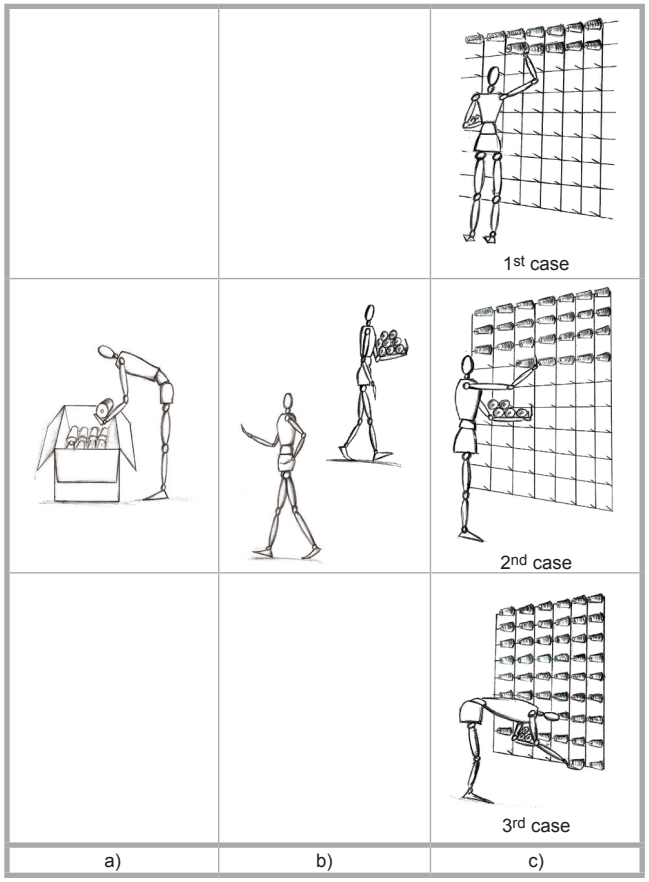


***Figure 1.*** *Manual creeling cross-wound bobbins: a) taking cross-wound bobbins from the box, b) walking from the storage location of bobbins to the creel, c) creeling up at higher, normal and lower height (1st, 2nd & 3rd case).*

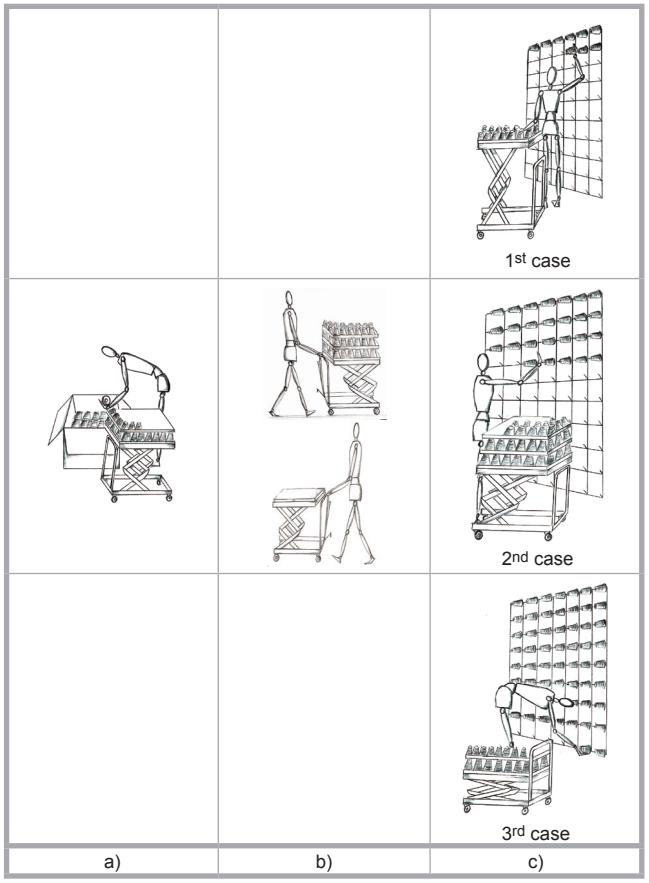


***Figure 2.*** *Process of creeling cross-wound bobbins with the innovative transport cart: a) placing cross-wound bobbins in the transport cart, b) walking from the storage location of bobbins to the creel and from the creel to cross-wound bobbins, c) creeling up bobbins at higher, normal and lower height (1st, 2nd & 3rd case) with the adjusted cart height.*

***Table 2****. MODAPTS worksheet for calculating the total number of MODS by hand mounting cross-wound bobbins in a creel; L - load factor with corresponding mass: L1 = 0 to 2 kg, L2 = 2 to 6 kg, L3 = 6 to 10 kg, L4 = 10 to 14 kg, L5 = 14 to 18 kg, L6 = 18 do 22 kg, L7 = 22 to 26 kg. L8 = 26 to 30 kg etc.*

| Case | Steps | Movements | Category of movement (Table 1) | Load factor, L/kg | Calculation MOD × number of movements × load factor | MOD |
|---|---|---|---|---|---|---|
| 1 - 3 | 1 | Bend to grasp cross-wound bobbins in the box (Figure 3.a) | B17 | 1 | 17/2 (½ movement) × 1 | 8.5 |
| | 2 | Take the load | G1 | 4 | 1 × 2 (hands) × 4 | 8 |
| | 3 | Straighten up and lift the load (Figure 3.a) | B17 | 4 | 17/2 (½ movement) × 4 | 34 |
| | 4 | Walk 5 steps (Figure 3.b) | W5 | 4 | 5 × 5 (steps) × 4 | 100 |
| 1 | 5 | Extend the arm to reach the highest positions of the creel (Figure 3.c) | M5 | 4 | 5 × 4 | 20 |
| | 6 | Mount a cross-wound bobbin (precise mounting, Figure 3.c) | P5 | 4 | 5 × 4 | 20 |
| | 7 | Return to the box with bobbins (Figure 3.f) | W5 | 1 | 5 × 5 (steps) × 1 | 25 |
| | **Total number of MODS for case 1** | | | | | **215.5** |
| 2 | 5 | Mount a cross-wound bobbin (precise placing, Figure 3.d) | P5 | 4 | 5 × 4 | 20 |
| | 6 | Return to the box with bobbins (Figure 3.f) | W5 | 1 | 5 × 5 (steps) × 1 | 25 |
| | **Total number of MODS for case 2** | | | | | **195.5** |
| 3 | 5 | Bend to the place at the bottom of the creel (Figure 3.e) | B17 | 4 | 17/2 (½ movement) × 4 | 34 |
| | 6 | Mount a cross-wound bobbin (precise mounting, Figure 3.e) | P5 | 4 | 5 × 4 | 20 |
| | 7 | Straighten up | B17 | 1 | 17/2 (½ movement) × 1 | 8.5 |
| | 8 | Return to the box with bobbins (Figure 3.f) | W5 | 1 | 5 × 5 (steps) × 1 | 25 |
| | **Total number of MODS for case 3** | | | | | **238.0** |

*Table 3. MODAPTS worksheet for calculation of the total number of MODS after improvement.*

| Case | Steps | Movements | Category of movements | Load factor | Calculation MOD × number of movements × load factor | MOD |
|---|---|---|---|---|---|---|
| 1 - 3 | 1 | Take the trolley | G1 | 1 | 1 × 2 (hands) × 1 | 2 |
| | 2 | Walk five steps to the creel | W5 | 1 | 5 × 5 (steps) × 1 | 25 |
| | 3 | Leave the trolley | P0 | 1 | 0 × 1 | 0 |
| | 4 | Take the load | G1 | 2 | 1 × 2 (hands) × 2 | 4 |
| 1 | 5 | Extend the arm to reach the highest positions of the creel | M5 | 2 | 5 × 2 | 10 |
| | 6 | Mount a cross-wound bobbin (precise mounting) | P5 | 2 | 5 × 2 | 10 |
| | **Total number of MODS for case 1** | | | | | **51** |
| 2 | 5 | Mount a cross-wound bobbin (precise mounting) | P5 | 2 | 5 × 2 | 10 |
| | **Total number of MODS for case 2** | | | | | **41** |
| 3 | 5 | Bend to the place at the bottom of the creel | B17 | 2 | 17 × 0.5 (½ movement) × 2 | 17 |
| | 6 | Mount a cross-wound bobbin (precise mounting) | P5 | 2 | 5 × 2 | 10 |
| | 7 | Straighten up | B17 | 1 | 17 × 0.5 (½ movement) × 1 | 8.5 |
| | **Total number of MODS for case 3** | | | | | **66.5** |

practice. An innovative transport cart was proposed for this task because they can lift and lower cross-wound bobbins to the level of mounting bobbins in a creel, facilitating and speeding up the worker's job. ***Figure 1*** shows the inappropriate posture of a worker bending in order to take 8 cross-wound bobbins with a weight of approximately 8 kg from a box. Then he walks with this load to the creel and mounts cross-wound bobbins in appropriate positions. There are three positions: In the first position, ***Figure 1*****, 1st case,** the worker must lift an approx. 2 kg heavy cross-wound bobbin and mount it in the highest position of the creel. The worker suffers the lowest load when mounting the bobbin at normal height (***Figure 1*****, 2nd case**), while he suffers the highest load when the bobbins are mounted in the lowest position of the creel (***Figure 1*****, 3rd case**). In this case the worker must bend carrying an approx. 2 kg heavy cross-wound bobbin and mount it in an empty position and then straighten up.

The improvement reduced the operator's physical effort while mounting cross-wound bobbins in the lowest position because the body remains longer in a bent position without holding cross-wound bobbins in the hands, as he takes one at a time from the transport cart and mounts them on the creel at the same level (***Figure 2*****, 3rd case**). Likewise, at greater heights cross-wound bobbins are on the creel at a height which is the most appropriate for the worker using the smallest physical effort when carrying bobbins from the cart to the creel (***Figure 2*****, 1st case & 2nd case**). The frequency of walking of the worker from the location of the bobbins to the creel and vice versa is lower because the transport cart carries more cross-wound bobbins (about 60 bobbins) than the worker can do in manual handling (8 bobbins). This increases work efficiency and reduces the time of assistant jobs or increases the efficiency of the warper. Comparing the number of MODS before and after improving the mounting of cross-wound bobbins, a great difference is observable as the number of MODS was considerably reduced after improvement; in the first case from 215.5 to 51.0, in the second from 195.5 to 41.0 and in the third from 238.0 to 66.5 (***Table 2*** and ***3***). The improvement and simplification of work with the innovative transport cart can be shown by means of the relative sizes of reductions reduce MODS The improvement and simplification of work with an innovative transport cart can be displayed and the relative sizes reduce MODS

$$(\frac{215.5 - \bar{52}}{215.5} \times 100 = 67.3\%)$$

in the first case by 76.33%, in the second by 79.03%, and in the third by 72.06% (***Tables 2 & 3, Figure 3***). The lowest MODS were achieved by mounting cross-wound bobbins in the middle of the creel (2nd case) before and after improving because in this case the operator's efforts are the smallest. The greatest MODS are found in the 3rd case when the worker bends to mount cross-wound bobbins before and after improving, at the moment of which the worker is exposed to the greatest physical effort.

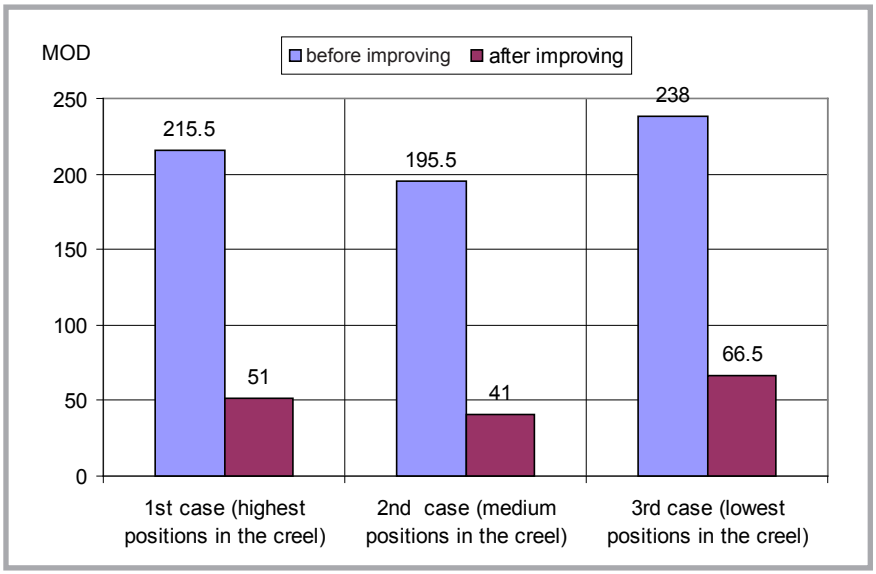


*Figure 3. MODS before and after improving according to the position of mounting cross-wound bobbins in the creel.*

## Conclusions

Despite automation and improvements in many workplaces, in the manufacture of fabrics there are still jobs to be done manually. One of them is the mounting of cross bobbins on a creel, which is a preparatory operation in warping.

The MODAPTS method redesigns workplaces with the aim of safer, better and easier work. Finding new solutions such as the reduction of manual labour through the elimination of idle motions as well as harmful and cyclical movements of the body provides a breakthrough in improving working conditions, labour efficiency and product quality, which ultimately contributes to the satisfaction of workers and employers.

Situation analysis and improvement of the process of creeling cross-wound bobbins will reduce the risk of injuries caused by muscular stresses and efforts which are present in this phase because of much manual work and numerous different movements. The improvements achieved will increase productivity and work quality will rise and operator sick leave will be reduced.


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