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# Process Rationalisation with MTM and 3-D-motion Analysis in Horticulture

*Continuously increasing machine capacities with a remaining part of manual work in the horticultural harvest and postharvest sector demand the optimisation of the man/machine interfaces. Within the mass production the rationalisation of movements is of special interest. For this, Methods Time Measurement (MTM) is regarded as an appropriate method. Placing spears of asparagus on a conveyor belt serves as a practical example to compare the calculation of time needed for the process based on MTM and the results obtained by a 3-D-motion analysis.*

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**Keywords**

MTM, motion analysis, process rationalisation

## Literature

[1] *Jakob, M. und M. Geyer*: Zur Gestaltung von Fließbandarbeitsplätzen. Landtechnik 58 (2003), H. 3, S.138-139
[2] -: REFA-Methodenlehre des Arbeitsstudiums, Teil 2. Datenermittlung. 7. Auflage, 1992
[3] -:DIN ISO 11226, Ergonomics - Evaluation of static working postures. 2000 (E)

Monotonous, boring and repetitive tasks within the horticultural harvest and postharvest sector often demand a high degree of self-motivation from the workers. Their motivation, on the other hand, highly corresponds with the payment and the demanded performance. The works manager has to supervise, motivate and control the worker's performance to achieve the enterprise's goals.

Preliminary experiments [1] to optimise the placing of products on sorting and processing lines in the horticultural sector showed that the performance capacity of workers is corresponding with their motivation. An increased speed of the conveyor belt also increased the performance, but however it resulted in a greater scattering of performance data. This study clearly highlighted the importance of ergonomic design.

The capacity of modern processing plants is continuously increasing whereby the worker's performance has to increase at the same time. To make use of the full machine capacity more than one worker is usually needed for placing the products on the belt.

With MTM the theoretical length of time needed for placing one piece on the conveyor belt is calculated for an optimal and an unfavourable work place design and is then compared with the achieved results from the 3-D-motion analysis.

### Method

MTM is a method to calculate the time quota of a process. For this the production process is divided into the smallest possible elements, like reaching, grasping, moving or positioning. The time quota of each of the elements depends on their specific variables.

The examined process, placing spears of asparagus on a conveyor belt, can be divided into the most common motion elements (*Fig. 1*).

The time for each motion element is taken from the MTM chart, regarding their specific variables, and in sum represents the theoretical time value for placing one spear.

### Results

The time needed for reaching the product is influenced by the distance between worker and product. The same is valid for moving the product into the right position. In addition, moving the product is also influenced by the precision demanded when the movement stops. The duration for the motion element grasping is mainly affected by the size of the object and the necessary selection of pieces. The time needed for positioning depends on whether the fit of the object has to be loose or tight and on the precision by means of object-symmetry. Releasing the product generally takes 2 Time Measurement Units (1 TMU = 0,036 s).

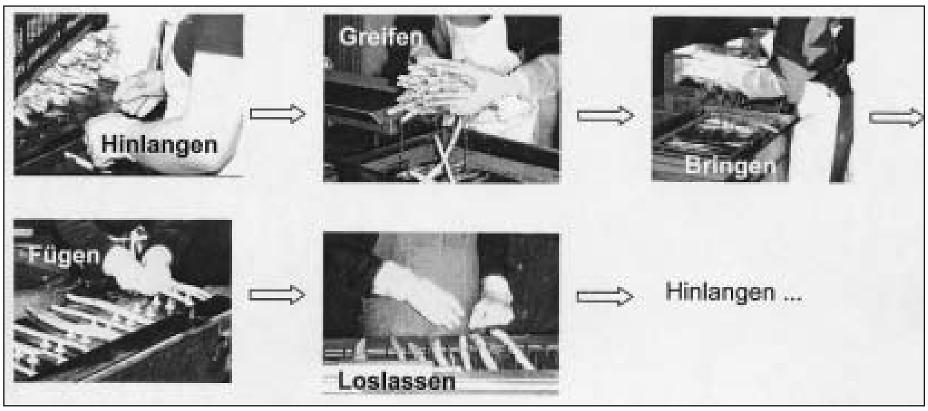


*Fig. 1: Description of the motion elements for placing asparagus on a conveyor belt*

Based on the results from the 3-D-motion analysis the estimated mean distance between the product and the conveyor belt for the optimised man/machine interface was 35 cm. Within the real work process the worker takes a bundle of spears at a time. The amount of spears in a bundle depends on their diameter and shows a greater variation at a smaller diameter. For the comparison of the motion-analysis-data with the MTM calculation a grasped bundle of five spears is assumed.

The time quota calculated via MTM is 0,5 s per piece. Another 1,5 TMU have to be added for the eye travel (ET), whose time value is influenced by the distance travelled (35 cm) and the distance from the eyes to the work surface (70 cm). Then the overall value is 0,6 s per piece, which allows an hourly capacity of 6000 pieces. Therefore the placement of 91 spears (amount of spears for one cycle in the motion analysis) theoretically takes 54 s.

In the preliminary experiments the performance was considerably lower than the values calculated based on MTM (*Fig. 2*). MTM 1 represents the optimised man/machine interface. The average performance for the motion analysis here was 4000 spears per hour, which equals 0,9 s or 25 TMU / piece.

The MTM calculation for the unfavourable work place design - the products were placed near ground level - was fixed on a value of 70 cm for reaching and moving. Under these circumstances the overall value is 20,2 TMU per piece including eye travel. The necessary upper body movement, due to the unfavourable work place design, is not taken into account yet. The normative time value in the MTM chart for bending down and coming up again is 2,2 s. An addition of a fifth of this value (regarding the assumed bundle of five) a theoretical hourly capacity of 3000 pieces is possible based on an MTM calculation (Fig. 2, MTM 2).

### Discussion

The time quotas for the optimised and the unfavourable work place design show a considerable difference. A drastic reduction of the hourly capacity is found in the MTM calculation due to the necessary bending down to the products. This was not confirmed by the results of the motion analysis (Fig. 2).

In accordance to the negative rating (not recommended) of a trunk inclination higher than 60° in DIN ISO 11226, MTM estimates a comparatively big effort for body movements.

The achieved performance in the motion analysis for the product supply near ground level was extraordinarily high. It should not be used as a planning quantity, because it differs drastically from the MTM time quota. The duration of the motion analysis experiments was, compared to a whole day of work with an eight-hour-shift, too short to consider the effect of fatigue on the human performance. The calculated performance rate of 3000 pieces per hour seems more realistic as an average over a complete shift.

The analysis of the factors influencing the duration of motion elements helps to optimise the work place. The reduction of distances for example has an important impact on the duration of a process. Apart from the distances the most important time factor is any kind of body movement. Time saving is mainly possible for these elements.

The big difference between the achieved performance in the experiments and the calculated MTM value for the optimised man/machine interface also needs to be explained. The analysis of work performance in practice shows that 6000 spears per hour can be achieved by one person. Although the test persons were highly motivated, they did not achieve such hourly rates. A reason for this could be that the products for the experiments were bigger, heavier and with a larger diameter than asparagus. On the other hand the grasped bundle of asparagus spears would be much bigger than the assumed five (Fig. 1), and as a result of this the theoretical hourly rate based on MTM would increase as well. The supposed time for grasping does not regard that it is a bundle of pieces and therefore it might be too short.

A disadvantage of MTM is, that the factors influencing the duration of the motion elements are primarily qualitative factors. The size of the products, the dimensions of the work place or the technical devices are not taken into account. An adjustment to the product size was not possible.

The nature of the tasks themselves, demanding a high motivation to work, might be the biggest reason for a varying performance. Motivation is not regarded in the calculations.

In conclusion, the duration for simple repetitive tasks within the horticultural sector can be successfully determined with MTM. Short cycle tasks can underlie a larger error, because forgotten motion elements have a multiplying effect. Therefore calculations should be verified in practice. The necessity to come to terms with the variables influencing the duration of the motion element helps to optimise the process.

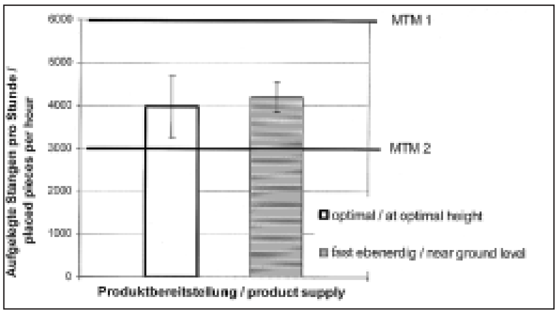


*Fig. 2: Performance of three persons placing products on a conveyor belt, compared to the theoretical capacity based on MTM*

| **Element** *Elements* | **Hinlangen** *Reach* | **Greifen** *Grasp* | **Bringen** *Move* | **Fügen** *Position* | **Loslassen** *Release* | Σ |
|---|---|---|---|---|---|---|
| Zeitwert in TMU (= 0,036 s) | 15,5/5 = 3,1 | 7,3/5 = 1,5 | 14,5/5 = 2,9 | 5,6 | 2 | 15,1 |
| Einflüsse *Influences* | 35 cm | Auswählgriff | 35 cm in ungefähre Lage bringen | ohne Druck, symmetrisch, einfach | ohne | + 1,5 ET |

*Table 1: Current time values for motion elements*