

## USE OF NESTING WORKSTATIONS IN ASSEMBLY

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### Abstract

*Over the years there has been a fixed idea that components just enter the assembly floor and that assembled products leave it subsequently after certain operations have been executed on such products. Besides, there is a common notion that only small and simple products can be assembled on the so called “assembly nests”; however, the dimensions of objects assembled inside these keep increasing. Nowadays, even an aircraft, a boat, etc. can also be assembled on a moving trolley. This is possible given to the fact that the trolley with the product and with the operators themselves may come to the same storage of parts, while the system does not need to be balanced in time. On the other hand, in assembly nested layouts, the productivity of one operator is usually higher than the productivity on the line station and this because such lines are not often time balanced. Besides, this is also enhanced by the fact that more than one operator can work on a single nest. In this regard, the present paper seeks to identify the ways of combining or assembling components into products, and to analyse quality of the above-mentioned assembly approaches.*

### Key words

*Assembly systems, assembly nest, assembly configurations*

## INTRODUCTION

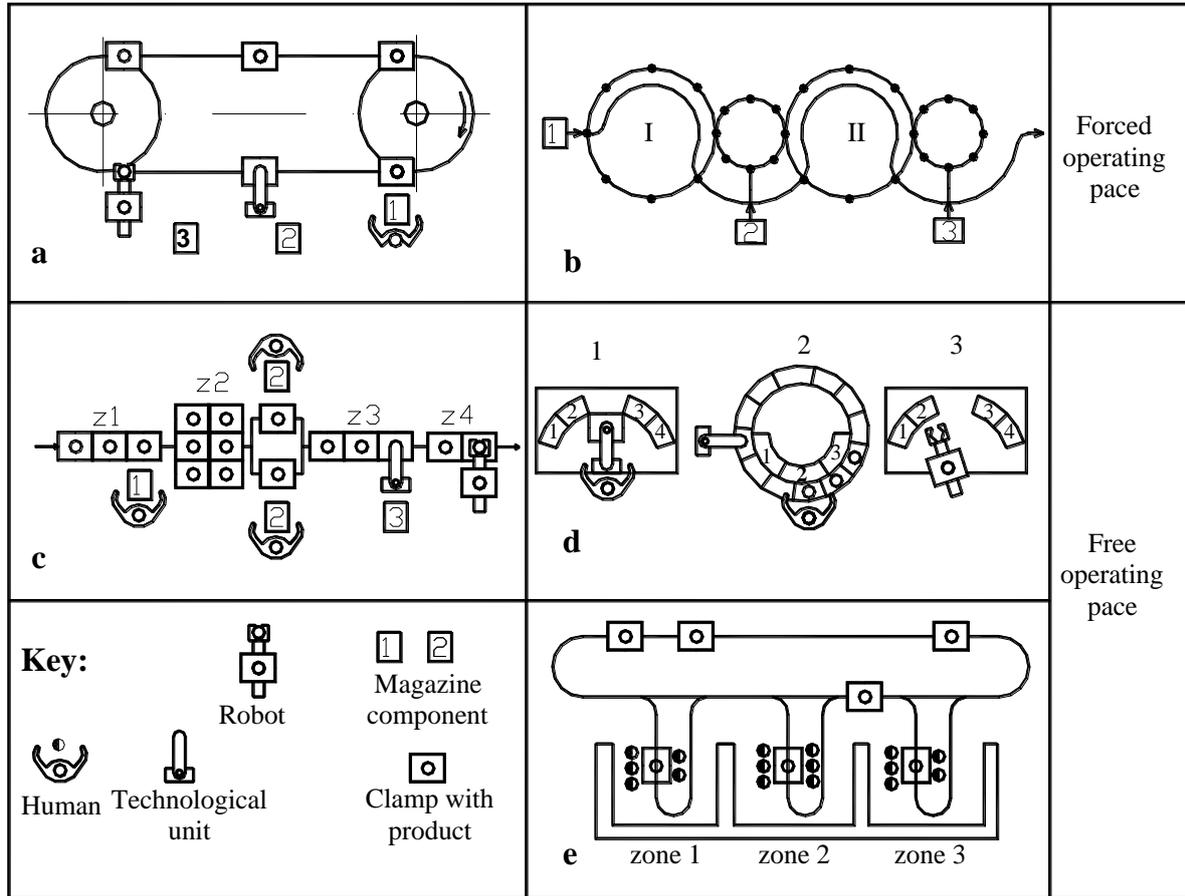
The aim of this paper is to provide an overview of well-known [1] and novel assembly systems, as well as the fundamentals of assembly theories to help the reader select the assembly system meeting the requirements for productivity, flexibility [2], humanisation and the assembly unit labour costs over the life of the assembly system.

In Figure 1, the author [3] suggests the following classification of assembly systems.

It illustrates how components enter the assembly hall and assembled products leave it subsequently. This paper will describe possible methods of bonding or assembling the components to products on their way through the assembly hall on the one hand, and analyse the quality of the above-mentioned methods of assembly on the other hand.

Described in detail are:

- mechanised assembly nests,
- automated assembly nests.



**Figure 1** Scheme of assembly systems [3]

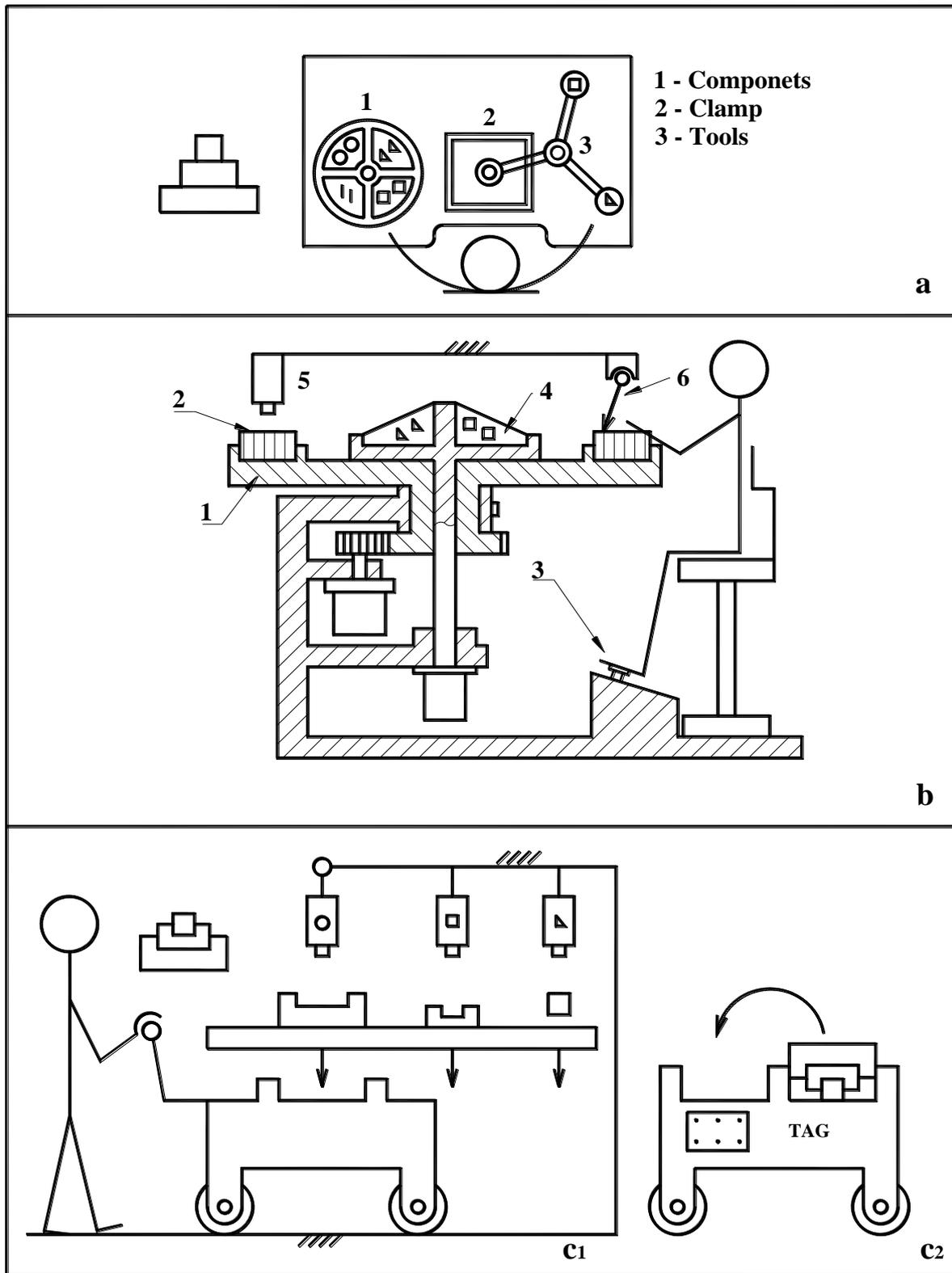
*a – synchronous line, b – rotor line, c – asynchronous line, d – nest workstations, e – group assembly*

The description of each of these assembly systems comprises the explanation of its working principle, application area, calculation of the system productivity, calculation of the productivity per operator (pcs/h), the degree of flexibility and finally the level of humanisation.

## MATERIALS AND METHODS

### Mechanised assembly nests

The mechanised assembly nest is an assembly system (Figure 2) where one operator assembles the whole product. The operations beyond the typical human capabilities and the tasks related to handling objects and components are mechanised; a human operator performs just highly sophisticated operations such as orientation of parts and their placement into the holes.



**Figure 2** Mechanised assembly nest [8]  
*a – single, b – batch, c – mobile.*

In terms of this type of nests, there are besides authors like [4], who make special emphasis on the fact that the nests should be only directly mechanised, should avoid mountable electrical or pneumatic actuators, and should be modular in nature.

The bonding actions are performed by motorised tools or bonding stationary units [5, 6]. The time standard for assembly of one product is defined by the well-known “Methods-Time Measurement” (MTM) system, as the sum of the standardised times of elementary operator movements to be carried out during the assembly [7].

MTM [9] system assumes that the operator works in the optimum ergonomic conditions of the working environment (temperature, clean air, noise, ventilation), the optimum body position (standing, sitting, semi-sitting), the use of both hands and legs, rests for legs, arms and forearms (in fine assembly), lighting, breaks, job rotation, adjustment of the workplace dimensions to the body of operator and others.

Figure 2a shows an example of a single mechanised nest, where the operator in a sitting position assembles tiny products such as watches, manometers and others, counted in pieces.

The dimensions of products are up to 150x150x150 mm, the number of parts about 20, weight of the product up to 15 kg.

Figure 2b illustrates an example of a batch mechanised nest, which is suitable for the products packed and counted in batches of e.g. 10 pieces of products, such as printed circuit boards manufactured in small batches, or stationery.

The nest consists of a step conveyor (workbench) (Figure 2b, pos. 1) containing the grippers for (n) products (pos. 2) of a single dose. Impulses for the next step of the workbench (pos. 1) are given by the operator through the switch (pos. 3).

In the middle of the workbench, there is a segmented bowl with components (pos. 4), which proceeds according to the loaded program activating also the bonding units (pos. 5) and the light indicator (pos. 6) which shows the location where to insert the component (e.g. in the assembly of printed circuit boards).

During the final revolution of the workbench (pos. 1), the operator puts (n) the assembled products into the palette.

Nearly all the work in the assembly nest is performed by technology; the operator carries out only sophisticated jobs, where automation [10] would not be cost-effective.

The operator’s productivity in a batch nest is higher than in the single nest, since the times of insertion, bonding and turning the bowl overlap and the movements are motorised.

Figure 2c1 illustrates a mobile nest with a trolley operated by a worker; Figure 2c2 shows a mobile nest with an unmanned trolley on rails that stops at the place designated by an operator (at the tag).

A mobile nest is designed for the low-series to mass assembly of medium-sized objects. An object is assembled directly on the trolley which is then transferred to the shipping warehouse. A manually operated trolley is suitable for the products up to the volume of about 1m<sup>3</sup> and the weight of about 25 kg. The motorised trolley can be used for larger objects assembled in smaller batches.

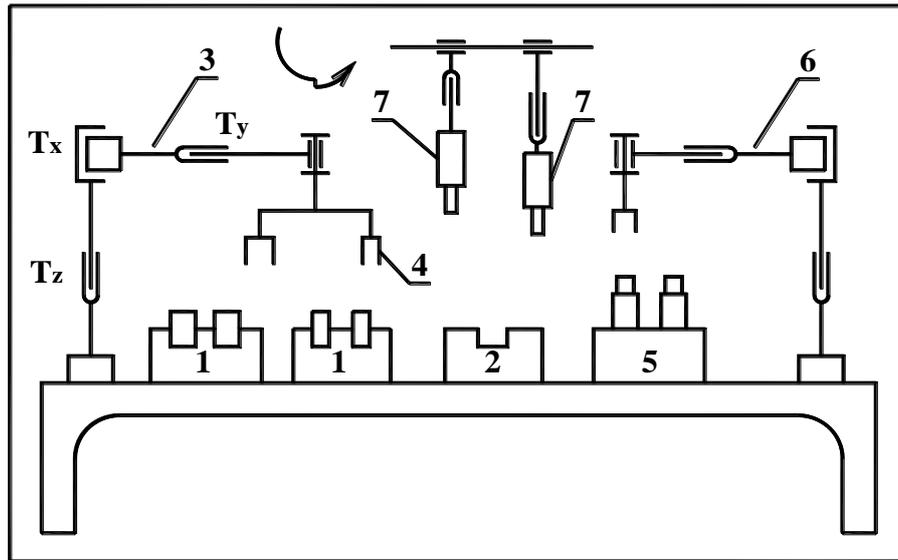
In Table 1, the handling operations on a line and in a mobile nest are compared.

<b>Table 1</b> Comparison of handling operations	
<b>Line:</b>	<b>Mobile nest:</b>
<b>1</b> Loading parts into crates	<b>1</b> Assembling parts in a positioner
<b>2</b> Moving parts to the station	<b>2</b> Assembling on a trolley
<b>3</b> Garbling parts into boxes	<b>3</b> Unloading the object from the trolley
<b>4</b> Assembling parts in gripper	
<b>5</b> Stepping the gripper	
<b>6</b> Unloading the object from the gripper	

As inferred from above, the assembly of an object directly on a trolley saves many operations leading to significant time reductions [11].

### Automated assembly nests

Figure 3 shows an automated assembly nest. It is fundamentally a single nest in which the parts from palette (pos.1) are inserted into the clamp by a triaxle robot (pos. 3) with a revolver (pos. 4) containing various effectors. The assembled products (pos. 5) are taken from the clamp (pos. 2) by a robot (pos. 6) and put into palettes (pos. 6). Bonding is performed automatically by a bonding unit (pos. 7).



**Figure 3** Automated assembly nest [8]

1 – palette, 2 – oriented components, 3 – robot for components, 4 – effectors, 5 – assembled objects, 6 – robot for products, 7 – bonding units, stationary tools

### Features of assembly nests

The assembly nest is older than the assembly line itself. A watchmaker in a medieval manufacture made parts and then assembled clocks in the same place. Similarly, even the same Taylor counted on illiterate operators who carried out a short-term operation with a little content on the line.

Meanwhile, the level of education has increased and so have the skills of operators who get higher job satisfaction when working with higher content, scope and personal accountability for quality.

Mechanisation has freed operator from burdensome and stereotyped acts; now, s/he performs just highly sophisticated tasks which are difficult to be automated for some technical or economic reasons.

In this sense, at the time of a saturated market, the above-described nests are becoming popular again mainly for their flexibility. According to the changing market demands, one, two or more nests can work simultaneously.

The nests do not need balancing time; the operations with significantly different times (T1, T2, T3 ...) may follow in a random order.

<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>
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**STEP – time of assembly of one product:**

$$T_H = \sum T_i \quad [s] \tag{1}$$

where:

$T_H$  – step of assembly of one product [s],

$T_i$  – time of assembly of  $i$ -th part [s].

**Productivity of a nest:**

$$P_H = \frac{3600}{T_H} \quad [ks/h] \tag{2}$$

where:

$P_H$  – productivity of a nest [ks/h].

## RESULTS AND DISCUSSION

From the previous analyses it was possible to come to the conclusion that the productivity of a single operator in the nest is usually greater than his/her productivity on the station line; this is due to the fact that the line is not time-balanced, and usually operators must wait until the slowest workstation or the bottleneck stops working.

Similarly, it was possible to understand that each nest needs all the bonding technology necessary for the assembly of a product, and that, besides, the cost of bonding machines in a nest system was higher than in a line system.

Also, it was possible to reflect on the fact that the conventional belief that the nests can be used to assemble only small and simple products was not totally correct, and that dimensions of the objects assembled in these nests keep growing nowadays. This was refuted by a simple fact that even a moving trolley could be nowadays used to assemble an airplane, boat, etc., and this is because such trolley with the product is wheeled to the box of components, and the system does not have to be time-balanced.

## CONCLUSIONS

The paper briefly addressed the topic of nested layouts or configurations in assembly. It discussed the advantages and weak points of this with regard to other popular assembly approaches as it is the case of the same assembly line. Several types of assembly nests were discussed, i.e.: the mechanised and automated ones, and emphasis was made on the productivity of those based on the well-know MTM analysis. The paper contributed to a better understanding of false misconceptions usually related to nesting configurations, especially those related to the size limitations for products to be assembled in the nests. The advantages of such configuration have even led some companies to rewarding long-time operators by moving them from the line to the nest filled with parts for a complete work shift. In this regard, operators can leave the workplace (e.g. for a personal break) and complete their daily workload later, which represents and enhanced flexibility if compared to the assembly line. Besides, sometimes, even more operators can work in one nest at the same time, e.g.: assembly of aircrafts, or other project productions of a similar size and nature.

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