Efficient flow and human centred assembly

The success of an interactive approach

Netherlands Organisation for Applied Scientific Research (TNO)

TNO Industrial Technology and TNO Work and Employment
G.H. Tuinzaad, J.W. van Rhijn, J. van Deursen, E.A.P. Koningsveld
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Authors G.H. Tuinzaad, J.W. van Rhijn, J. van Deursen, E.A.P. Koningsveld

With the co-operation of:
Th. M. van Sprang (Roberine)
J. Weijs (Inalfa Roofsystems)
M. Smulders (JVH Gaming Products)
P. Verberne (Kverneland Geldrop)
J.W. Dooge (Bakon Food Equipment)
E. Borren (Moba)
A. van der Heijden (Ahrend Productiebedrijf St. Oedenrode)
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M. de Jong (JM de Jong DUKE Automatenfabriek)

Preface

New market requirements, the need for efficiency and improved working conditions make it essential to employ the newest insights and experiences in the assembly process.

TNO Industrial Technology and TNO Work and Employment have combined their expertise in the areas of assembly engineering and ergonomics into an integrated approach, whereby, with the workers' participation, assembly flow processes are made more efficient and more human centred.

This book describes this approach and its success in practical situations. Nine companies have opened their doors to you to let you see what results and advantages have been achieved.

It is intended that this book will help you to relate your situation to that of others and enable you to generate ideas which will allow you to better respond to changes in your environment.

It is an honour for TNO to be able to advise and help you with this process.

Jan A. Dekker
Chairman, TNO Board of Directors

Delft, The Netherlands, October 2000

Contents

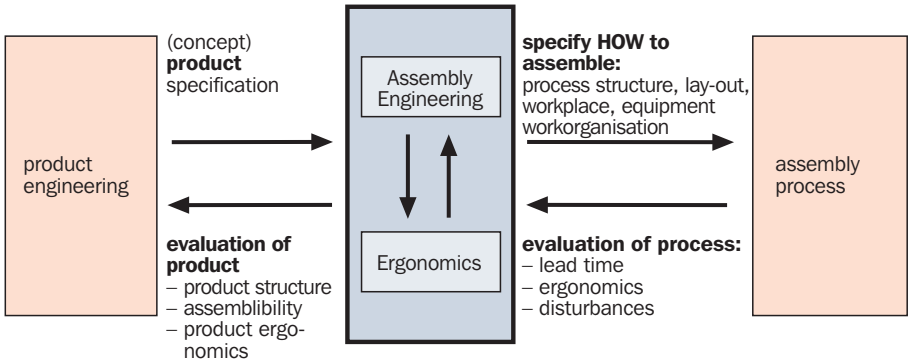
1 Why a smarter arrangement of the assembly process is necessary

Assembly oriented companies experience an ever-increasing demand from the market for variation in the final products and ever shorter delivery times. There is also an increasing pressure to reduce the cost price whilst retaining or even increasing quality. In addition, companies are being made more responsible for good working conditions on the work floor by government regulations, the tight labour market and recognition of the value of good employees. Integration of optimum assembly processes and optimum effort from employees is becoming increasingly important. However many companies are still approaching these two areas separately.

Inquiry among more than one hundred managers in the Dutch assembly industry shows that promoting a stimulating working environment is one of the most important points for attention in the next few years. The way in which people function will steadily become a more important factor in the innovation of production processes. This is confirmed by international R & D programmes. The 5th Framework Programme of the European Commission emphasises amongst other goals the need for 'improving human potential in manufacturing innovation'.

The need to improve the layout of assembly processes and workstations has been clearly signalled by TNO in projects with companies. There was a great deal of interest shown in this theme during the workshop 'Smarter Production Layout', which was held as part of the TNO knowledge exchange market in Utrecht in April 1999. This workshop showed that in the future innovation in production and assembly must be coordinated with attention for working conditions. An integrated approach must be used so that greater efficiency and reduced lead time as well as improvements in the productivity of the personnel by means of a reduction in the physical stress and risk of absenteeism can be striven for at the same time. TNO Industrial Technology and TNO Work and Employment have responded to this by combining their expertise.

This integrated approach has now been applied in many small and medium size companies that manufacture final products or assemblies in many variations and in numbers from a few hundreds to ten thousands per year. Because of the relatively low production numbers, the assembly processes in these companies are mostly manual, so people and their workstations form an essential chain in the realisation of the final product. In some cases, the existing situation was improved, in others a new work process for an existing or a new product (range) was developed.



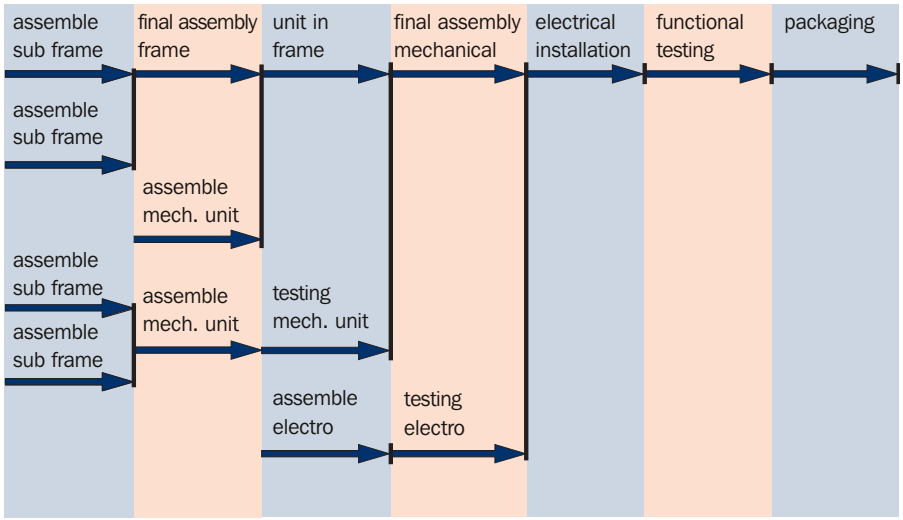
Positioning of the assembly engineering expertise of TNO Industrial Technology and the ergonomics expertise of TNO Work and Employment, in the area of product development and realisation of the assembly process.

Experience has shown that the approach can lead to an increase in productivity of between 15 and 20% and a reduction in the physical demands to an acceptable level. Active participation of the workers is an essential part of the approach. In this way unexpected and unknown qualities of the employees are often discovered. In addition, it allows as broad a base as possible for the acceptance and carrying out of improvements and has more than once formed the foundation for a permanent culture of improvement.

2 The integrated approach

A working group is always used for the investigation of an assembly process and the workstations and the formulation of (potential improvements of) the process plan. This working group consists of representatives from assembly, process planning, product engineering and management under guidance of an assembly engineer and an ergonomist from TNO. It is essential to have commitment from the CEO or the board of directors for such an improvement scheme. All concerned contribute their knowledge, experience, and ideas in a series of group sessions so that the best possible plan for the defined product group and/or the process can be formed. This active participation of the personnel creates a basis for the acceptance of the improvements within the company and also ensures that all knowledge present in the company is actually utilised. It also results in a lasting improvement in communication between the various disciplines and departments.

The approach encompasses the following activities:
- Form the working group and establish aims.
- Analyse the process structure according to the TNO work method MAS (participatory assembly process scheme), and analyse the present layout and material flow.

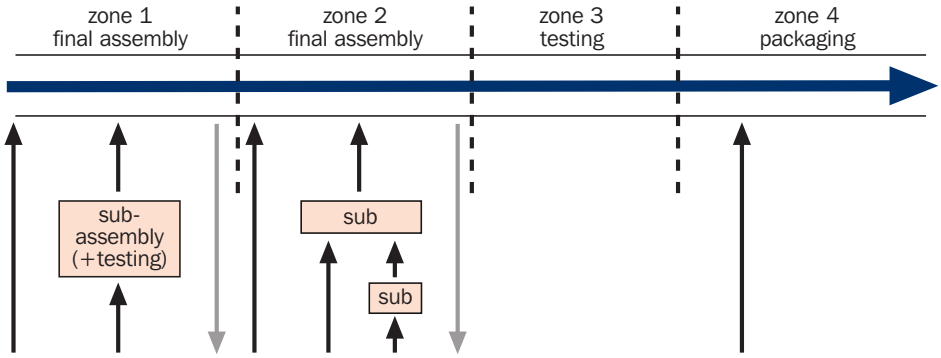


MAS is a graphical visualisation of the structure of the process of sub-assembly, intermediate testing, assembly of modules and parts into the final product, testing and preparation for sending.

- Identify bottlenecks in the material flow and ergonomics by means of checklists and observation and relate these back to all assembly personnel.
- Define the improved process through the following steps:
  - Consider alternative assembly concepts, for example at one fixed working position, in an assembly flow, in fixed zones or moving with the product (shopping).
  - Consider alternative concepts for intermediate transport where flow assembly is chosen.
  - Order the layout of workstations and determine the manner of transport of the product through the process.
  - Organise the workstations as regards location of parts, tools and working height.
  - Simulation of the workstation using the TNO Ergomix tool is optional.
- Guidance through any testing period and the introduction of improvements.
- Evaluation of the effects.

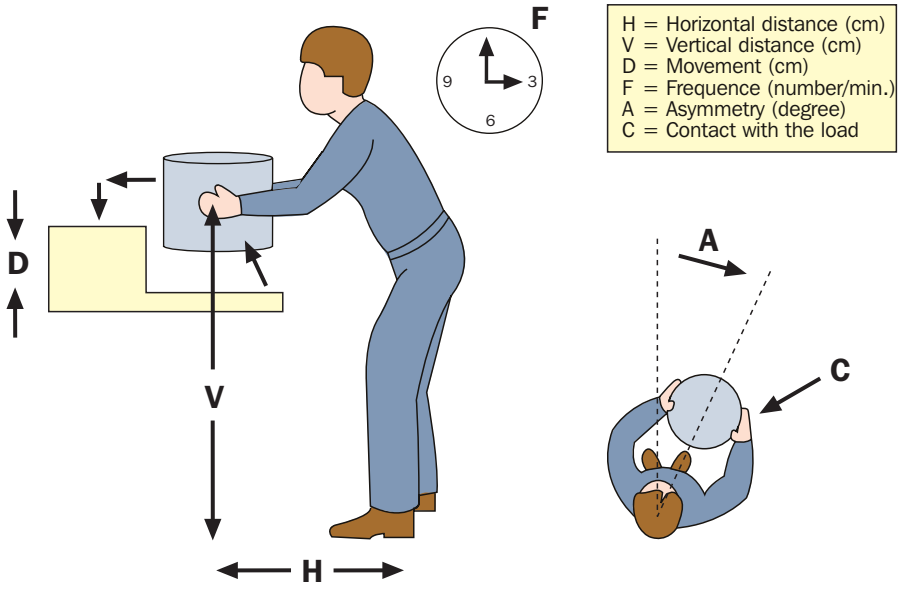
3 Focal points work flow and ergonomics

A smooth flow of orders through the process is determined by:
- Ordering the workstations according to the logical assembly flow.
- Spreading the workload evenly(balancing) over the successive workstations.
- A short transport distance between the workstations.
- Intermediate testing (this makes final testing smoother).
- Ordering the location of parts per workstation/zone.
- Separate working areas, parts locations and transport routes.
- Gear the number of parts to the usage.
- Provide handling and assembly equipment specifically suitable for the task.



The process structure for a flow assembly in one line consists of a number of zones in final assembly and a number of sub-assembly workstations coupled to the appropriate zone in the line that they are supplying.

In addition to a smooth flow of the orders, good working conditions are of great importance. The physical load becomes (too) high in particular due to:
- Lifting heavy parts and tools.
- Standing in one place for a long time.
- Bending frequently or far in order to pick up parts.
- Unsuitable posture when carrying out assembly work: working bent over, working above one's head, working in a twisted position.
- Repetitive work: often having to stretch, one-sided assembly work, vibrating tools.
- Insufficient/unclear information leading to faults and inefficiency.
- Working environment: uncomfortable climate, too much noise and inadequate lighting.
- Work organisation: high pressure of work, monotonous work.



The maximum acceptable lifting weight varies per situation and depends on a large number of factors.

Frequent bending when picking up both heavy and light parts increases the load on the back.
Picture taken from a video recording.

TNO adheres to international standards for all of these potential health hazards. Exceeding these values at work ('red work situations') leads to an increased incidence of back, shoulder, arm and wrist complaints. By redesigning the process and the workstations, it is possible to reduce the physical load to an acceptable level.

Working in a twisted posture increases the physical load unnecessarily and is often unnoticed.

4 Experiences from practice, conclusions

During the past few years, TNO Industrial Technology and TNO Work and Employment have applied the integrated approach to various companies. The results can be summarised as follows:

- Productivity can be increased by 15 to 20 % depending on the original situation.
- The physical load can be reduced to a safe level so that there is less risk of absenteeism. 'Simple' solutions can lead to considerable improvement.
- The MAS work method has proved to be an excellent instrument for the analysis of a process structure and the differences between product variants. MAS forms an important basis for assessing the feasibility of alternative assembly concepts and for the ordering and arranging of the layout and the workstations.
- In general there is too little awareness of the risks of physical load in companies which are oriented to assembly work. The integrated approach regarding the effects on material flow and ergonomics has already proved its worth in practice. The demonstration of physical limiting values and specific bottlenecks in the personal work situation has made participants aware of this.
- Before improvements are introduced in local workstations the whole process structure must first be optimised.
- Applying the principles of ergonomics at an early stage prevents expensive adaptations later on.
- Active participation of workers is essential. This not only increases the quality and applicability of the plan but also creates the necessary acceptance for carrying through the improvements. Commitment from the management/directors is also an essential condition.
- A smart arrangement of the assembly process begins at the stage of product design. The time-to-market can be reduced further by developing the product and the process in parallel. This prevents time consuming alterations to the product and/or the product process later on.

Roberine: professional mowing machines

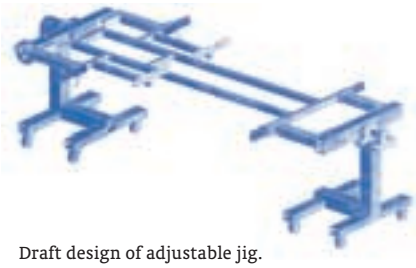
Roberine specialises in the development, production and sales of professional mowing machines for Western Europe, North America, Australia and Japan. The product range varies from compact three-wheeler mowers with a single grass bin to large four-wheel drive mowers with a cabin and four grass cages. The company has 150 employees and produces about 1 000 mowers per year, spread over seven different types.

The core activities in the production are welding, grinding, spray painting and assembly. The manufacture of a lot of the parts is contracted out. The company has two lines for the final assembly, each with special workstations for pre-assembly of sub-assemblies such as the motor, half shafts, lever arms and tanks.

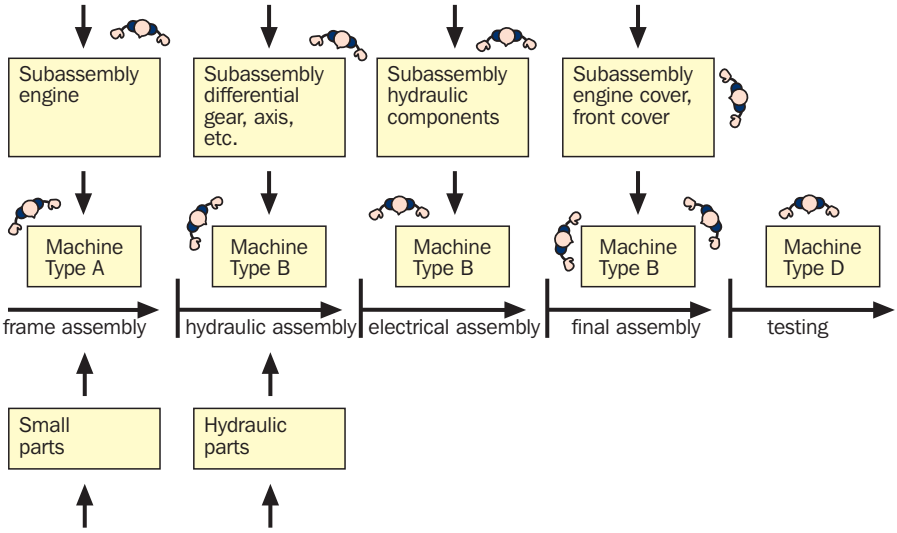
Roberine not only wished to improve the efficiency of the assembly process and the flow of orders, but also to reduce the physical load and to rearrange the layout of the workstations. The necessity for improvement became even more apparent because of the rapid growth of 20 to 30% per year and the fact that in the past little attention had been paid to the ergonomics of the workstation.

The assembly process was charted using MAS for each of the seven different types of mowers, with attention for the annual production rates and the large number of options.

An improved assembly line arrangement has been developed by taking account of details from the MAS, video recordings of the assembly process, the requirements of the product capacity and wishes regarding the use and flexibility of personnel. In doing so, the distribution of the work over the various workstations has been fixed in relation to delivery of the parts at the fixed sites. Because the personnel can carry out more than one task, they can be employed at different stations.



Draft design of adjustable jig.



The new process structure.

This flexible use of personnel contributes to a better balancing of the assembly line. The layout of the various workstations was then carefully studied and attention given to the development of supporting tools and equipment. The layout of the assembly areas has been improved ergonomically: the location of parts has been made more accessible and at working height, aids for lifting and ingenious transport aids have been developed and a start has been made with the development of a jig with adjustable angle to improve the working posture. It is expected that an adjustable jig will improve both the ergonomics and the productivity considerably. A crude analysis of the benefits (reduction in absenteeism, increase in productivity) shows that the costs (development and production costs) of a simple adjustable jig can be recouped within one year.

Results

Roberine expects an improvement in efficiency of 15% and a reduction of the lead time of 25% from the improved arrangement of the assembly lines and the pre-assembly places and the introduction of new aids. Because of the personnel's direct involvement in carrying out the project, many improvements have already been made. The video recordings have been a useful aid in improving the consciousness of the importance of ergonomics.

Inalfa Roofsystems: sliding roofs

Inalfa Roofsystems in Venraij develops, assembles and sells OEM sliding roof systems for cars and trucks (e.g.: Volvo, General Motors, Daimler Chrysler and Renault). OEM (Original Equipment Market) implies that such a system is built-in as an option during the assembly of the vehicle. Inalfa Roofsystems (900 personnel world-wide) is the world's second largest supplier of sliding roofs.

The project was initiated because of the need to set up an assembly cell for a new sliding roof for Opel. Inalfa chose to base the assembly concept on the existing Volvo shop concept. The product is situated on a moveable carrier that the personnel move along the parts and sub-assemblies supplied. The product is assembled while walking, shopping from one line zone to the next. The total working time is about nine minutes. Some actions requiring a very high degree of precision (riveting and testing) are automated.
This concept has the following advantages over the traditional assembly line: an increase in productivity of 20%, an increase in worker satisfaction and an increase in capacity flexibility by using more or less personnel.

The assembly process was video recorded at each station using a trial assembly. This revealed the bottlenecks. The forces required to fit the mechanism and the pre-assembly of the glass were measured.

The trial assembly.
This picture is taken from a video recording.

Results

The bottlenecks were judged according to the ergonomic criteria (limiting values) for lifting, working posture and force required. Those bottlenecks registered as 'red' were dealt with first. By making improvements in the equipment and in the product design, the forces required for fitting the mechanism and the glass panel, for example, have been reduced.
Next the logical order for the parts and tools according to the assembly process was determined, as well as the position and dimensions of the racks and the trolleys for provision of the parts. Then the various workstations were laid out correctly with regard to the position of the tools and assembly equipment and the walking and working spaces. In order to do this, an 'Ergomix' simulation of the workstations was used: the operator sees himself projected in the workstation drawing and can carry out all assembly actions. The workstation can be optimised for working height, availability of parts, tools etc. in direct consultation with the operator. This resulted in improvements to both the height at which the cover plate, mechanisms, sunshade and glass panel are supplied, as well as the distance needed to reach them.

The height at which the glass panel is supplied is simulated and improved using Ergomix. These pictures come from the video recordings made during the Ergomix.

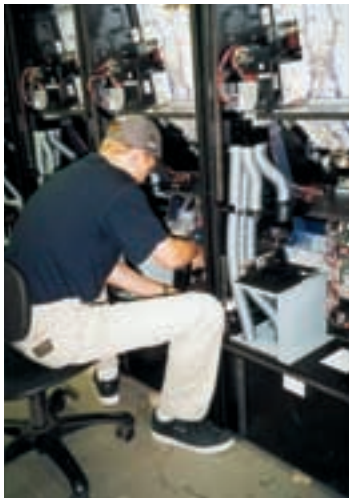
Jos Weijs, Production manager at Inalfa Roofsystems, is positive about the integrated approach: 'We were very enthusiastic about the great deal of flexibility with which the observations could be made during the project. The participation of the future assembly workers was also of a high standard. We now look at ergonomics in a different light. The people who were involved in the project have had a very positive experience and can apply the new insights directly.'

JVH Gaming Products: gambling machines

JVH Gaming Products in Tilburg is specialised in the development, production, sales and exploitation of games of skill and gambling machines. The main market is Europe. About 8 000 machines are produced per year. The company expects a considerable production increase over the next few years.

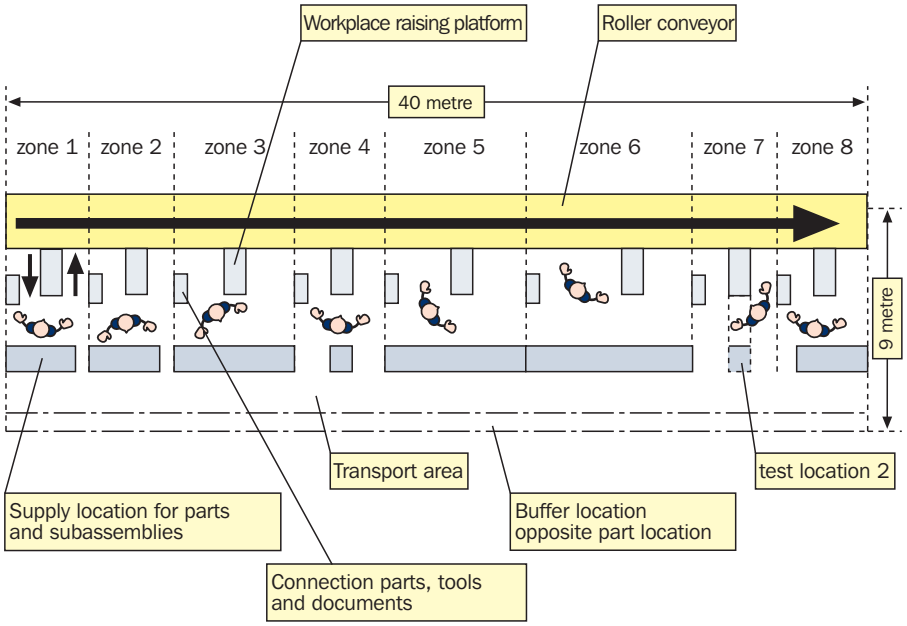
In the present situation, the machines are built in batches of 75 per week. Each machine is assembled at one fixed position, both the pre-assembly on tables and the final assembly on the floor. The batchwise assembly results in an accumulation of material, cyclical movements in the flow, and it occupies a lot of space. The lead time of the final product in the assembly area is long in relation to the actual amount of work required on the final product. In addition, 25% of the time is spent walking. The original situation involves working at universal sites so that these cannot be designed specifically for the work, resulting in awkward working postures. The expected increase in production volume and the need for higher productivity were the driving forces for improving the assembly process. The project has been carried out by TNO in co-operation with the technology transfer network Syntens in the Dutch Modern Production Programme.

The processes of the various types were charted with the help of MAS. Following this, the most important bottlenecks have been analysed according to the criteria for flow and ergonomics. Next a method has been defined in interaction with the working group in which the final product proceeds in phased flow through a number of final assembly zones including testing and preparation for sending. Various transport options were compared with each other. Finally a roller conveyor was chosen together with a lifting table per zone to bring the machine up to the correct working height during assembly. Work can be carried out either sitting or standing. The number and sort of parts required and at what



The original situation required a large amount of working while bent forward.

working height these must be delivered to the assembly line has been established per zone. New recyclable packaging material has been developed in co-operation with the suppliers so that a reduction in the handling of extra packaging material by both JVH and the suppliers can be achieved. Finally the space required for the new flow process and the sub-assembly workstations has been determined.



Rough scheme of new layout.

Results

The project group started with no pre-conceived preferences and all possible options have been reviewed. Choices were made by comparing the plus and minus points of the various options. The aim of achieving a more efficient and assembly friendly process with increased flow rate has been achieved with the proposed flow process.

It is expected that there will be an increase in productivity of about 20% with the new method.

The physical loading will be reduced to an acceptable level by means of the improved specific design of the workstations.

The project has also led to recommendations for an improvement in the design of future generations of gaming machines.

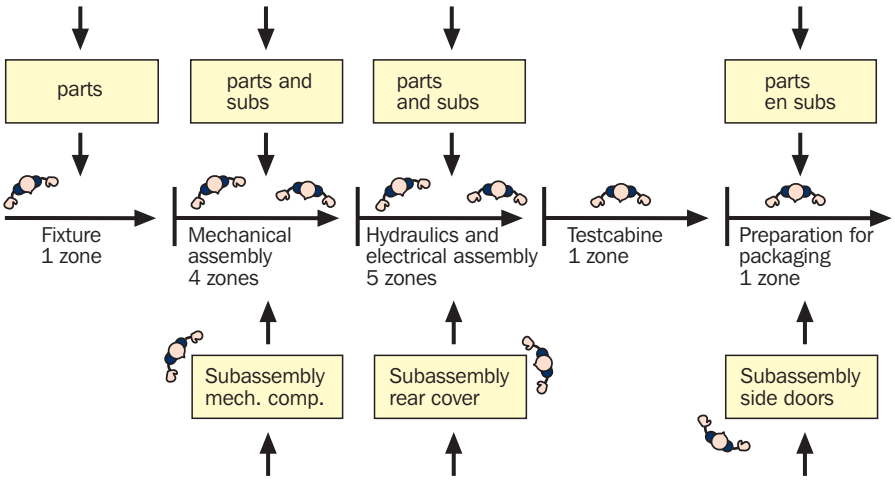
Kverneland Geldrop: round balers

Kverneland Geldrop is specialised in the development and production of drum mowers, maize cutters and round balers; agricultural machines without their own power. The company forms part of the Norwegian Kverneland group. The production has been radically altered in the last few years; Kverneland now produces more customized and larger machines with a large number of variations and options.

Kverneland has developed a new round baler which is to replace the older one. In setting up the new assembly line, the following questions were posed: To what degree will the use of split or endless belts would influence the assembly process? How can the output of the line be adjusted to seasonal influences? And how can the physical load of the assembly work be restricted?

A layout for the assembly of the new round baler has been made by the project team, which consisted of product engineers, assembly workers and production process planning assisted by TNO. A design for the line, including the necessary sub-assembly workstations, has been made using the MAS and allowing for the desired production tempo of four to ten machines per day. Which parts and sub-assemblies, how many of these, how they are to be delivered, and what (special) assembly equipment are required to lighten the assembly task or to make it possible – all these questions have been determined per zone. In the first instance, it appeared that it would be necessary to have three jigs in order to make the basic frame at the required speed. However this would be very costly and disadvantageous for the supplying of parts and handling.

By reducing the tasks to be carried out on the jig to a minimum, it finally became possible to use just one.
In order to be able to vary the production tempo on a line, it is necessary for the employees to be able to work at more than one workstation. Various possibilities were discussed with the project team. The final, provisional choice has been made to split the line into two sections with four and five workstations respectively. Each of these has a few permanent workers who can be assisted by additional personnel, depending on the desired production volume.



The new process structure.

Results

An assembly line has been designed in a very short time. The participatory, systematic approach has led to a design which has broad acceptance and where the necessary aids have been defined beforehand. Particular emphasis has been paid to the ergonomics and here clear improvements have been made in comparison with the existing assembly line. For example, by resting the machine on its back during a large part of the assembly, the amount of high reaching has been considerably restricted.

Assembly of the chain wheel.

Bakon Food Equipment: gel dosage machines

Bakon Food Equipment in Goes has been active in the area of design, production and sales of machines for traditional and industrial confectioners for about 15 years. In particular, Bakon is a specialist in the area of gel, chocolate, fondant and egg yolk application and the dosage of all sorts of products such as jam, fillings and dough. Bakon produces large and complex machines for specific customer projects in industrial bakeries. It also makes smaller, handy machines, such as the gel dosage machines, for the traditional bakeries. The range of gel dosage machines, Jelly 2000, is produced in series with an output of about 500 per year.

Bakon has grown to a company with 55 employees in a short time and partly because of this it was necessary to better relate the series assembly of the gel dosage machines to the greater volume. In addition, assembly of the machines had to be faster and more efficient. The project has been carried out by TNO in co-operation with the technology transfer network Syntens in the Dutch Modern Production Programme.

The smaller machines were assembled in batches of 10 to 12. The necessary sub-assemblies were first made at universal workstations (bars at fixed heights). Afterwards, the final assembly took place at the same workstation. The system led to the following bottlenecks:

- Repeatedly having to rearrange the workstations took a lot of time.
- Because fixed workstations were not in use, it was not possible to layout workstations for the efficient execution of a fixed part of the assembly process.
- Delivery, collection and assembly of parts was complicated and took a lot of time.
- The machine was not easy to reach during the assembly.
- An adjustable working height is necessary for the assembly process because of the different dimensions of the machines and the position of the parts in the machines.

In the new situation lifting tables ensure that work can always be carried out at the correct height.

After charting the assembly process by means of MAS and analysing the original 'batchwise' process, an assembly line was designed. The necessary workstations were defined first, then the required parts and numbers of these, the assembly equipment and the amount of space needed at the particular locations were established. Because of the different working heights, it was decided to use a lifting table for the final assembly. This allows the workers to place the machine at the correct height at all times and work in a correct posture. Special workstations were also established for the sub-assemblies. Then a layout was prepared on the basis of the workstations and the space available.

Results

The project has finally led to a reduction in work time of about two hours (almost 20%), to better ergonomic conditions, a shorter lead time and a simpler supply of parts through a two bin system.

Moba: egg-sorting installations

Moba in Barneveld is specialised in the development, production, sales and service of egg sorting installations. An egg-sorting installation consists of a loader, hygiene module, crack detector, dirt detector, weighing system, blood detector and a number of packing lines. An installation usually has seven packing lines (two belts per line) and can sort around 120 000 eggs per hour. The project for redesigning the assembly line was carried out by TNO by order of SCOM (Dutch Association for Multiclient R&D).

The new generation of servo-controlled packing lines creates a need for the assembly process to be so arranged that several hundred packing lines can be delivered per year. There was also a need to improve the ergonomic working conditions at the workstations. In the original situation, the main belts and the final assembly were realised in batches on a large number of carriers placed next to each other. This arrangement resulted in a relatively long stay of the material in the process compared to the actual assembly time required. Parts and sub-assemblies had to be brought over longer distances to the workstation resulting in much extra walking, searching and physical exertion. Dealing with larger assemblies over long distances with a mobile lifting unit was time consuming and overloaded the personnel. Observations and discussions with the personnel showed that work often had to be carried out in unfavourable postures.

Using MAS, the assembly process and the necessary times for the part processes were charted with the help of the personnel. This forms the basis for the improved arrangement of the flow process to be introduced for building the belts, the final assembly, testing and performing trial runs of the packing lines. The arrangement is to a large measure determined by the amount of work required in the various processes, the product volume aspired to, the handling of the product, the in and out material flow and the amount of space required for the parts and the workstations.

In order to reduce the physical workload, it is proposed to fit high/low facilities at the assembly locations for the belts and the final assembly. The roughly four meter long belts will be transported on a moveable carrier which will allow the combined belts to be placed directly onto the high/low facility in the final product for the final assembly without the need for extra lifting equipment. After the structure of the flow process had been defined the layout in the existing space was worked out. The parts will then

have a specific location by the zone in the process where they are required. Supply of a large proportion of the parts can then be simplified via a two-bin system and according to the requirements of the assembly. This will give considerable time saving in comparison with the original situation, in which parts continually have to be counted and supplied per order.

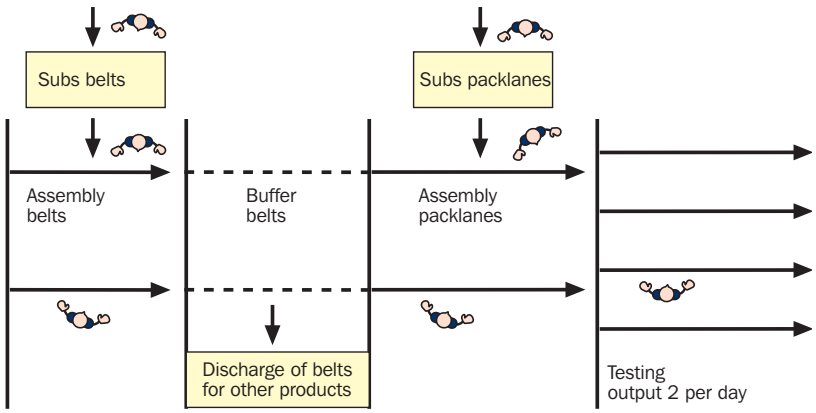
In the original situation work was carried out in batches at parallel, fixed places.

Results

Moba expects to have an increase in productivity of about 20% with the new arrangement, half of this coming from less walking to collect parts. The other half has to come from more sensible layout of the workstations. It is also expected that the physical load will be reduced to an acceptable level by improving the transport provision in combination with the high/low facility. At the same time, lengthy standing can be reduced by providing moveable saddles. In the improved arrangement, people can be deployed at more than one workstation.

According to Eric Borren, project manager at Moba, the approach 'has made a very positive contribution to the awareness of the bottlenecks present and to the analysis of the assembly process. This formed the basis for the redesigning of the process. These sorts of changes can induce considerable resistance, causing delays. This resistance is probably fuelled by a certain amount of uncertainty about the future.'

The next step in the process is the implementation. Here, attention will be focussed on the detailed designing of the workstations, the specifications for and engineering of the assembly equipment, defining the two-bin steered parts system with stock heights, setting up an availability matrix with a training programme and finally the implementation.



The new process structure.

Ahrend Productiebedrijf St. Oedenrode: office furniture

Ahrend is specialised in the development, production and sales of office furniture. 500 people are employed at St. Oedenrode of which around 350 work in production. The production of office furniture is carried out by 60% permanent employees assisted by 40% temporary workers. The group manufactures 70 000 cupboards per year with large differences in size, colour and design.

The original arrangement had three assembly lines with fixed zones in which the office cupboards were finished according to height (high, middle, low). The parts locations in the three lines next to each other were not easily accessible for restocking. The large variation in design resulted in a large variation in assembly times and poor balancing of the work. The assembly work was spread over the whole cupboard causing regular poor working postures. Non-standard parts were delivered in boxes low to the ground. This all resulted in searching, walking, lifting and carrying (heavy) parts.

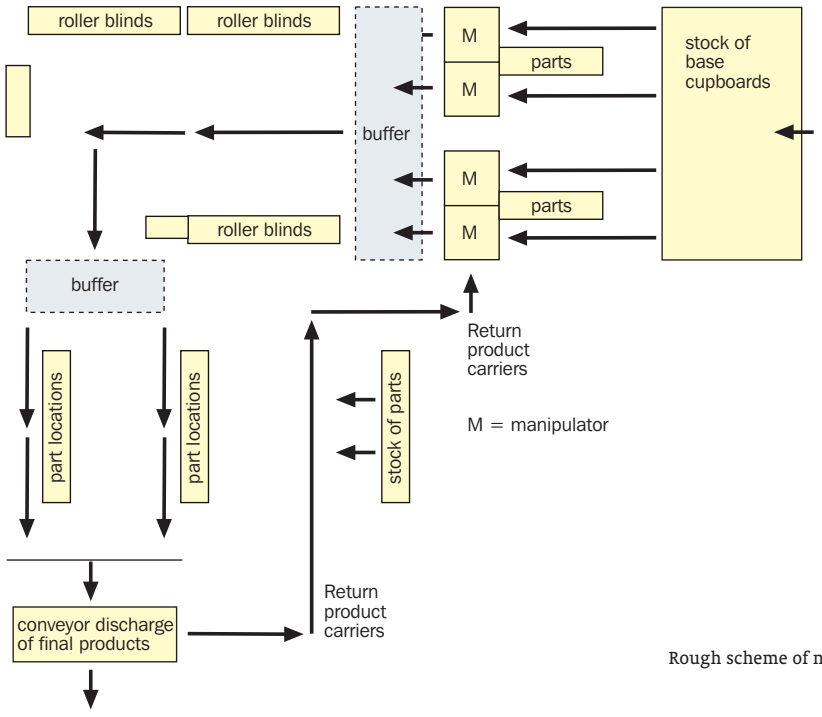
The project for redesigning the assembly line was carried out by TNO by order of SCOM (Dutch Association for multiclient R&D). The aim of the project was to achieve a (flexible) increase in production from 280 to 400 cupboards per shift per day and a reduction in the physical load. The working group charted the process of the cupboard variations using MAS. In addition, observations of ergonomic bottlenecks were recorded on video and related back to the personnel. The various assembly concepts were evaluated for their plus and minus points resulting in a final choice for one line split into two so-called "shop" parts whereby workers assemble the cupboard while walking along with it. This concept does not give any balancing problems, offers the permanent personnel a wider range of tasks whilst at the same time pro-

viding learning situations for the employment agency personnel. The cupboard is transported on a moveable carrier which can be adjusted in height.

Results

Ahrend expects to achieve an increase in productivity of 15%. This increase is a result of less walking and searching because parts will be in one fixed position directly alongside the line. Apart from this the automatic supply of cupboard structures will reduce the capacity of fork-lift trucks required. By changing the product design the assembly handling can be improved. By reducing the number of lines from three to one the number of parts on the workfloor can be reduced. Physical workloads will be reduced by placing the roller blinds vertically, by the automatic transport of pallets and by improving the working height. The working height has been established with the personnel by means of Ergomix: in this simulation worker and workstation drawing are mixed so that rapid design and evaluation is possible.

According to Mr. André van der Heijden, project leader at Ahrend, the approach has been experienced as 'complete and systematic. Because a multidisciplinary working group was used commitment and acceptance have been increased. The approach followed will now be applied at once when designing new cupboards.'



Rough scheme of new layout.

Koninklijke Nooteboom Trailers: semi low loaders

Koninklijke Nooteboom Trailers in Wijchen already has more than 115 years experience in the production of means of transport. The core expertise of Nooteboom is the translation of the customer's wishes into a finished product as quickly and cheaply as possible. Because of this, the company has a leading position in the market for trailers and low loaders for special and heavy transport. Nooteboom manufactures more than 1 000 vehicles per year spread over four product families. In addition to simple 'standard' vehicles, Nooteboom also delivers complex vehicles specifically designed for a customer.

The most important processes in the assembly are: construction of a stable basic frame in a jig, finishing welding the vehicle, fitting the shafts and components, spraying the vehicle and final assembly. In order to satisfy demand in one of the product groups, it was necessary to shorten the lead time of the product and to increase efficiency. Nooteboom wished to improve the material flow and ergonomics by for example:

– being able to work with more personnel at one vehicle;
– having an efficient layout of the workstations;

Work often has to be carried out in unfavourable postures.

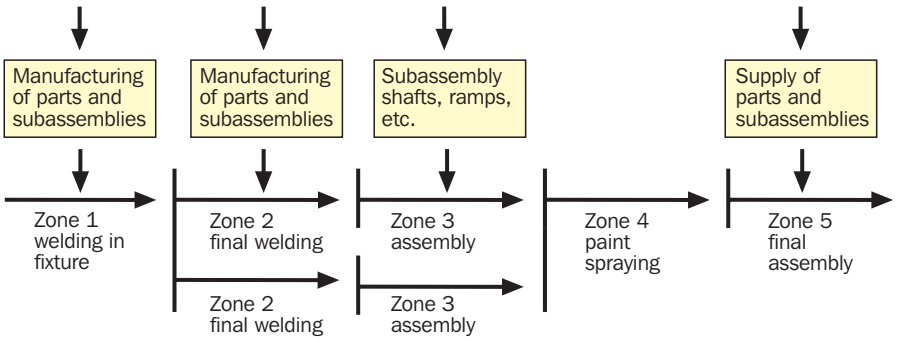
– preparing as many sub-assemblies as possible at separate locations;
– arranging the parts supplyso that the vehicles can be finished at one time;
– preparing one-off, non-standard options thoroughly so that these can be built in efficiently by assembly workers;
– being able to allow for the many options, which often have considerable influence on the amount of work, the balancing and the planning;
– using equipment to simplify the handlings and improve the working conditions. Some handlings cause considerably non-ergonomic situations: heavy lifting, working in cramped postures, large amount of force required, noise from hammering on steel plates.

The bottlenecks in the flow and in the ergonomics were first charted by a broad-based team. After this all sorts of solutions were generated. Some of these could be carried out simply in the line by the persons concerned. Others required consultation with and co-operation of other departments or suppliers.

Results

According to Nooteboom, concrete results of the project are a reduction in the order lead time by 15% and a reduction in the amount of work by 20%. Parts and sub-assemblies are delivered complete or are assembled beforehand in a different workstation. Improvements have been made in the ergonomic conditions as well, often by means of simple measures (use of a recoil-free hammer, improvement in tolerances or placing heavy parts at the right height).

As a result of the experiences with this project, similar projects have been started with TNO in other product groups.



The new process structure.

JM de Jong DUKE Automatenfabriek: coffee machines

JM de Jong DUKE Automatenfabriek in Sliedrecht is specialised in the development and assembly of coffee machines for professional use. The machines vary in size, functionality and capacity. Several thousand machines are produced per year.

The company suffered from too long an order lead time and lack of space by a continuous increase in product volume. In a project under the Dutch Modern Production programme, batchwise production at one location had already been replaced by a flow concept. At the same time attention had been given to making modules more completely as sub-assemblies. According to the director of JM de Jong DUKE, Mr. Michiel de Jong, the order lead time in the present space had been reduced by half. The assembly working time per machine had also been reduced by about 20% by a reduction in walking and looking for parts. There was now also the possibility of arranging the production process more flexibly to cope with greater product volumes.

The routing, the layout of the workstations and the organisation of the work have been further improved as a follow-up project. The layout was still characterised by large quantities of sizeable parts and sub-assemblies spread over the production floor. The flow of products from the pre-assembly locations to the final assembly was still too low. The pressure of work was very high in the testing zone and personnel spent a long time standing. There was a lot of lifting of coffee machines in the packing zone.

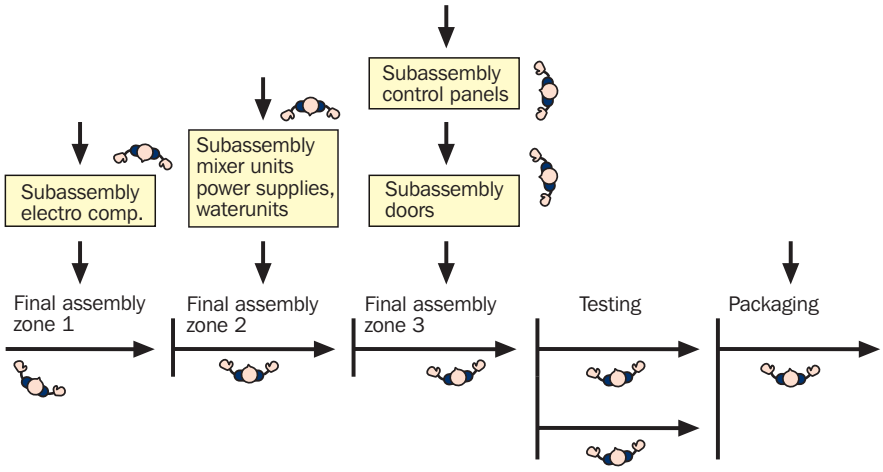
Agreements have been made with the supplier so that sheet material is now delivered directly with the machine housing. This has resulted in only 3 instead of 16 pallet places being needed for the sheeting and the amount of walking and bending for parts has been drastically reduced. Workstations that supply each other have been brought nearer to each other: there is more commitment and circulation is easier. The availability of the parts and tools per workstation has been studied. Other improvements have also been made such as better lighting, more leg room and the correct working height, purchase of moveable saddles so that personnel can alternate between standing and sitting and have sufficient room to move when working.

Lengthy standing and working while bent forward should be avoided as far as possible.

The coffee machines are placed on a revolving product carrier so that the machine can be worked on from the correct side. The busy test workstations have been changed and extended. When there is a fault, the machine is pushed out of the line so that this is no longer held up.

Results

The flow has improved and the pressure of work has been reduced. The necessity for lifting has been eliminated in the packing zone. The roller conveyor and the packing zone have been incorporated into one line and at the same height: this allows the machine to be pushed through more easily. Eventually all the measures taken have together led to an increase of 50% in the production capacity.



The new process structure.

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