

Abstract: Production of clothing is inevitably transforming into a flexible, agile manufacturing, which aims to track the dynamic changes of fashion. Modern production business system should be capable of designing rapidly, should have the ability for flexible changes because of production of new models of apparel products, the ability for quick adjustment of production capacities, the ability for technology of integration and the production with increased variants of apparel products in required quantities. This can be achieved by modern organization of production, such as Just-in-Time, Toyota Production Systems, Total Quality Management and Lean Production.

Keywords: JIT, TQM, lean production, garment industry.

6.1 Production management

In order to secure the survival of the fashion industry in a turbulent environment, it is necessary to meet the customer requirements with respect to quality, price and delivery term. These criteria can be fulfilled only with the restructuring of existing business and production systems by introducing modern technology, changing forms of organization and participation of motivated workers. Over the past few years new concepts and forms of organization have been developed in Japan, USA and Germany, most of which are simultaneous engineering, lean production, fractal manufacturing, business process reengineering and virtual production.

Today, clothing manufacturers are faced with the request to be flexible and be able to offer a wide variety of products to customers. The leading trend in today's business world is the development of time-based competition. This concept is based on the development of new products and production faster than the competition

OBM (Original brand name manufacturing) is production process which allows placement into domestic and foreign fashion market because it is based on the creation of mark trade and brand, not the "no name" products. It is a great challenge for each garment manufacturer to create a brand, especially for small and medium sized enterprise production business systems which lack the resources and marketing teams that large companies have. On the other hand, sensitivity and

rapid changes of the market dictate the pace and “looking for” creating a fashion mark trade with which it can survive and grow in a competitive environment.

In order to survive and be competitive on world markets, manufacturers need to work on:

- (1) production of fashion products with a larger share of added value,
- (2) developing mark trade and creating brand,
- (3) development of distribution channels and
- (4) continuing education and training of professionals.

Production of fashion products with larger share of added value relates to the investment in the production of its own products and investment in the CMT (Cut-Make-Trim), but with a larger share of your own materials, auxiliary equipment and the construction of fashion products. These are tangible and intangible assets, i.e.

- development of new products and clothing materials, production processes or services, a significant improvement of existing products, production processes or services with higher added value (consultancy, testing, research, production samples – prototype),
- investment in the development and acquisition of new technologies – machinery and equipment,
- acquisition of industrial skills (know-how), special knowledge and skills and
- vocational training of workers for new technologies in the processes.

Mark trade is one of the basic characteristics of the product and serves to differentiate one specific product from other, similar ones on the market. Performance of mark trade, as one of the basic characteristics of fashion products, depends on the feelings and opinions of specific product consumer. Due to major changes in fashion trends, developing of fashion mark trade exists in all parts of textile garment chain. The existence of the fashion mark trade brings a number of advantages:

- Achieving greater income.
- Possibility of planning proposals.
- PBS image formation.
- Better correlation between production and sales.
- Greater information and identification.

Mark trade and its strategy became one of the important sources of competitiveness, and the immediate benefits of their application are:

- Separating from competition.
- Increasing the value of the product at consumers.
- Enabling easier and faster launching of new fashion products.

Development of fashion mark trade has to include intangible investments into:

- Creating one's own brand
- Designing
- Prototyping
- Commercialization in one's own production
- Professional training staff

When making a fashion brand it is particularly important to create a basic style and brand strategy, and what features we will give to our fashion product, how we will promote it and invest into it. Branded fashion products on the market, unlike not-branded ones, have the following advantages:

- They are easily recognizable.
- They are demanded more.
- Consumers trust them more.
- Customers are more loyal to them.
- They are more resistant to competition.
- They could be sold at a higher price.

In the fashion industry there is great danger that the brand could become old-fashioned or be overcome by competition. Branding as a continuous process through which more developed types of brands are applied (umbrella, source, range, product) enables increased productivity and sells branded fashion products.

Development of distribution includes finding effective forms of distribution through its own network and trade chains. This refers to the development of its own distribution network and cooperative forms of distribution through which grouped small and medium manufacturers are centralized according to the product characteristics with respect to their complementarity. Besides, it is important to continue with creating alternative forms of distribution, such as franchise, internet and more.

6.2 Flexible manufacturing systems

Development of the world telecommunication systems nowadays allows the increase of sale and purchase of various fashion products all over the world, causing shortening of product life cycle and reducing time to introduce products to the market. On the other hand, there comes the global competition and the market can survive only if they reduce all unnecessary costs and expand the range of production, and consumers are considered individually, not as a statistical average size. Therefore, it is necessary to adjust production to market demands, i.e. to apply a flexible production model or flexible

manufacturing system which is capable of adjusting to modern requirements quickly and easily.

The trend of production, as the only answer to mass production, is flexible manufacturing. Flexible manufacturing connects continuous production flows and suspension of production, i.e. uses the advantages of these trends, trying to eliminate the drawbacks of both flows. The aim is to make the flows of materials within production continuous with maximum flexibility of production. This means that the system can promptly respond to the requirements of each customer, without coming to a standstill in production, accumulation of unfinished products, etc. Manufacturers of clothing should apply technological innovations, which will lead to achieving the highest possible level of automation of production. In fact, the goal of automation is not the mass production of large series of products at the lowest possible price, as it used to be, but creating a flexible system that can quickly meet specific customer requirements and which allows easy and rapid reorientation from one type of production to another one. This system is the only one which allows manufacturers to adapt to market conditions effectively not sticking two collections a year, but six or more.

Flexibility is a derived value obtained as the ratio of the number of different products and the size of a series or as a reciprocal value of time required for the preparation of production. There are many models of flexible manufacturing systems, or approaches to measurement flexibility, and some of them are as follows:

- (1) According to Professor Dragutin Zelenovic's (Zelenovic, 1986) model of flexibility of production system is a measure of their ability to adjust to his surroundings and the demands of the work process in a given time and given environmental conditions. There are
 - Flexibility of structure, which represents the likelihood that the data structure will adapt to environmental conditions, projected work process and disturbances in the process of work. The flexibility of structure includes flexibility of flow structure and flexibility of spatial structure.
 - Flexibility of process, which represents the likelihood that the given process of work will adapt to environmental conditions successfully and quickly.
- (2) According to D. Bennett (1988) PBS flexibility is a key factor in competitiveness. Traditional performance measurement systems are not enough to comprehend the right way PBS should behave in a more unstable environment. When considering this issue the authors start from the notion of "strategic" flexibility, which consists of: the flexibility of resources (business process, work, supply and delivery system) and two levels of system flexibility.

- (3) When considering the flexibility of company P. Bolwijn (1986) distinguishes two basic aspects of flexibility such as: time and changes. When researching the aspects of time Bolwijn suggests the following measures of flexibility: the smaller the duration of the production cycle, the greater the flexibility of the system; a number of hierarchical levels indicates a lower flexibility of the system; if the number of organizational units of production increases, so does the duration of transport and waiting for the production, which causes the lower level of flexibility; and complexity of organization, which is expressed by the complexity of structures and procedures. When considering the aspects of changes, Bolwijn differs the flexibility of financial sub-systems, flexibility of knowledge, procedural flexibility and functional flexibility.
- (4) When considering the flexibility of production systems Carl-Henric Nilsson and Hakan Nordahl (Nilsson and Nordahl, 1995) start from the input/output analysis and differ the flexibility of system output, the transformation in the system and input into the system.

Flexibility of output from the system is the ability of system to respond to changing requirements of environment, i.e. a constant uncertainty, which refers to product specification, time and quantitative dimension of production. In this sense, there are flexibilities of product variation, product development within the stipulated time, the delivery of parts in the planned deadlines and production volume.

Transformation flexibility of the system is obtained by transforming measures of flexibility in the output into the characteristics of the system, where you get a matrix measure of flexibility/features of the system.

Flexibility of input into the system includes flexibilities of all systems engaged before the transformation: procurement, suppliers and transport.

Flexible technological process of production of clothing reduces development time, reduces costs per unit of product, enables the flow of products and rational usage of the machine park, reduce inventories, increases labour productivity, enables humane, lighter and faster performance, reduces fatigue of workers and increases the quality of products based on the creation of a successful fashion brand and reputation in the market.

In order to make a technological system of production flexible it is necessary to:

- Improve continuously.
- Apply new knowledge and experience in management.
- Apply new knowledge in the field of clothing technology and information systems.
- Design workplace so as to achieve a faster handling of work object for any technological process of making (different models and items).

- Conduct regular employee training.
- Work on the acceptance of change.
- Analyze technological operations and procedures of work and carry out their optimization.
- Design workplaces ergonomically.
- Improve internal transport.
- Apply the techniques of network planning of production.
- Define the quality of each fashion product.
- Tend towards “zero defects” and reduce the warehouse of finished products.
- Achieve the team responsibility of all employees.
- Create recognizable fashion mark trades.

6.3 New methods, tools and techniques of garment production organization

Due to the increased competition and survival in the market, garment manufactures must design production systems that are able to respond to customer demands as soon as possible, minimize production costs and produce a cheap product. New methods of modern organization of production can be Just-in-Time, Toyota Production Systems, Total Quality Management and Lean Production.

JIT (Just-In-Time) is a concept which appeared in the twenties of the 20th century. There are indications that a Ford used it when the ore arrived “exactly on time” to turn into steel for body cars and McDonald’s to fry hamburgers. However, in 1970 Toyota showed that it could be applied to all industries.

For the development and progress of each PBS a necessary factor is synchronized and precise work that finally gives a quality product. Quality is what consumers consider most important product characteristics, and it is achieved by introducing quality into production. Quality is based on the JIT system in production process since it provides information on what and how we should work to avoid possible mistakes and shortcomings in the work. JIT system is necessary to improve all aspects of control of both the input of raw materials and the intermediate control, and stimulate the workers to make more effort in performing the job, in order to avoid making mistakes and unnecessary repairs.

All processes of JIT system go through receiving, processing, transmission and using information, it is filled with constant receiving and submitting information.

Aiming to make the effects of JIT system positive, it is necessary to have good relations among people in the organization, staff training, upgrading

and expanding the horizons of employees. It is also necessary to modernize production so that each employee understands how important and useful it is. JIT system is a good organization where each worker knows exactly and clearly what he should do. Experience of JIT system helps to understand how large business world systems operate and what is necessary to keep its market position.

JIT is an economic term that represents the strategy of reducing costs in the production of clothing where the calculation helps to achieve less storage of basic textile materials (lining, interlining, thread, buttons, etc.), i.e. raw materials or just avoiding the storage of finished garments. This tends to flexible production for a known customer, without storage, it shortens the time of making clothes, synchronizes the technological process of work and balances capacities.

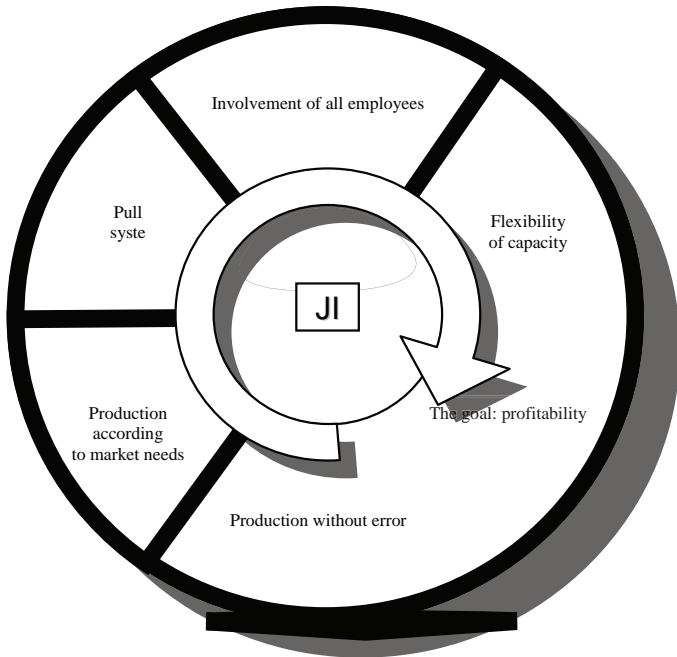
In order to make JIT method successful in garment industry, many requirements must be met, such as:

- (1) Quality.
- (2) Minimal inventory.
- (3) Reliable and solid cooperation relationship with suppliers.
- (4) Suppliers located near the company, with reliable transportation available.
- (5) Production size in correlation with demand.
- (6) Team work, employees responsible for maintaining their equipment, bosses, coaches and mentors respect their employees and participate in the production process actively.
- (7) Customer satisfaction.

The essence of application of JIT concept in the technological process of making clothes is that every activity is directed at the right time and in the right place in the appropriate quantity and quality, without the waste of all forms of work.

Basic characteristics of the concept of JIT in the production of clothing are (Figure 6.1.)

- Market-oriented production – customer requirements determine the system of production. It produces garments according to the market research or for a known customer according to the defined quality of garment.
- No storage production – a direct link between manufacturer and customer.
- Transmission planning in production facilities (for example, through the Kanban) and the usage of simple methods of planning that everyone can understand.



6.1 JIT concept.

- Thinking of production without error, because the manufacturer bears full responsibility for the quality.
- Streamlining of internal transport of materials and flow of work objects from one sewing machine to another.
- Reduction of production cycle – at the same time, the phases of cutting, sewing, and finishing are carried out simultaneously (as soon as part of the planned amount of textile material is cut, bundles are “inserted” into a sewing room and parts of finished garments go into trimming).
- Quality of products and organization of assurance organization. Quality is not what the manufacturer believes is, the quality is what the customer thinks it is.
- Pull-system (“pulls” material into production when required, and reduces the maximum unfinished production and simplifies planning).
- Motivation of employees.

It is very important to engage all employees, or the culture of PBS, i.e. the relation of employees to work. System of “the respect of people” includes

- the application of teamwork,
- extension of the work of employees (for example, every employee is trained to work on three machines – ordinary sewing machine, automaton

and/or special sewing machines) with the inclusion and maintenance and setting machinery and equipment

- encouragement of personal responsibility and a sense of ownership over job.

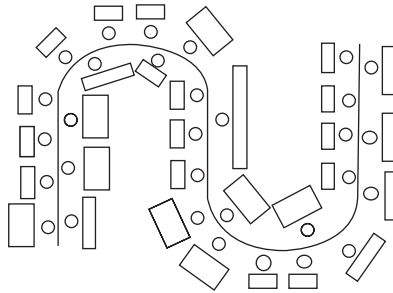
Therefore, it is necessary to use a basic working method – the method for inclusion in the chain of responsibility:

- Discipline – application of safety standards.
- Flexibility – to remove hierarchical barriers.
- Equality – gender of employees.
- Autonomy – delegating responsibility down.
- Development of employees – increase competitiveness.
- Quality of working life – regulation of working space.
- Creativity – development of jobs.
- Total employee involvement – to give employees more rights, responsibilities and working space.

JIT reveals weaknesses in the technological process of making clothes. Temporary supplies among operations prevent the spreading of interruption of the production process in a technological operation. Real problems are hidden by removing these supplies, the problem spreads quickly, and all the operations in the chain of production stop. It motivates all the people in the chain to solve new problem together, and also to prevent from occurring anywhere in the chain. Therefore, it is necessary to make the control of time making of each technological operation and merge more operations into one, thereby reducing the technological development time, increasing productivity and reducing the price of fashion products.

In the JIT approach in the technological process of making clothes, the layout of workplaces can be according to the Modular Production System (MES). Modular manufacturing is a technological concept used in the Japanese and American automotive industries, which have slowly been introduced into garment industry. Hunter (1990) who defined the modular plant as one made up of many product centres in each of while the complete garment is made by small group of workers. Lowson (1999) produced a comparison of the time taken by traditional bundle systems and team/modular system which suggest that production turnaround time can be reduced from weeks to minutes. In a modular system, processes are grouped into a module instead of being divided into their smallest components.

The modular system was first implemented at company Toyota in 1978 as part of JIT, and was known in the 1980s in the West as the Toyota Sewing System. Monden (1998) gave this system a U-turn layout (Figure 6.2) and

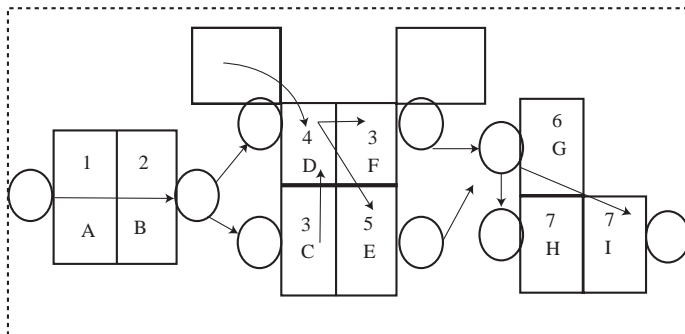


6.2 U-turn layout.

claimed that the main advantage of that system was that the amount produced can easily be arranged by changing the number of operators working in the system. The modular system works on the principle of pull-type production systems, in which the job order comes from the last step to previous steps. Because of this, the amount of work in process is low, even working when no inventory is possible.

The Modular Production System is expressed with team work (up to ten people, then the leader is not necessary, and 20 machines) that allows adjustment to frequent changes in designing clothes, models, small and medium sizes of work order and frequent changes of the order of technological operations. Application of this system leads to reducing of workers' sickness, increasing of production and quality and reducing of downtime in production. Such a system would allow a faster flow of materials (Figure 6.3), rational usage of the existing machine, increased productivity and quality in small batches and allow industrial production to measure (Made to measure).

The Modular Production System allows flexible production of garment, because each workplace can be, for example, equipped with ordinary sewing machines, special machine (for example, overlock machine or special machine with two needles) and steam iron, through a divided system of work where an employee does three technological operations.



6.3 Flow of materials in the layout modular system.

Adoption of a Modular Production System in garment industry can really bring competitive advantages. That advantage stems from the increased productivity of human labour, reducing supplies of unfinished production, reducing the duration of the production cycle, as well as reducing the space needed for production. On the other hand, adoption of modular system requires profound changes in philosophy and the organization and functioning of production system, since it is necessary to switch from the old, individual method of work to the new, team work, and thereby be governed by the principles of quality, where human resources are the aspect which is of the utmost importance.

6.3.1 Toyota production systems

After the Second World War Japan, faced with prejudices that their products are cheap and of poor quality, introduces the importance of quality and thus creates TQC (Total Quality Control). The basic principle of this concept is that all employees, from managers to workers in production, view a product from the standpoint of consumers. Therefore, quality controls are done with planning and designing with pre-secured quality without waste. It took years to develop special methods of quality management in order to find causes of errors and thereby creating a strategy of quality Zero defect – the concept of American consultant Philip B. Crosby's.

Japanese economy went through a serious rise in the late seventies and early eighties. As a result, the Japanese system of work organization, management and industrial relations has become one of the main subjects of studies of many theorists, and so-called Learn from Japan began to apply, more or less successfully, in other countries.

One of the most successful models for solving problems in production management is the Toyota Production System (TPS). Creator of the Toyota Production System Shingeo Shing (Shing, 1989) defined it as a system that eliminates all the unnecessary things.

TPS is a set of well-known techniques and methods for solving problems, the philosophy about responsible behaviour and returning of values to customers, employees, properties and society. The characteristics of the Toyota production system are

- producing only necessary amounts and types of products within the stipulated time, with the minimum stock,
- employees at all levels participate in the business,
- the system is oriented to the product,
- covers the entire production process to sales of finished products,
- important place is for the quality and costs and

- the heritage of Japanese tradition, history and culture the innovative behaviour of employees is based on.

Important elements of the TPS are

- reduction of a preliminary final time,
- simultaneous operation of workers on more machines,
- quality and
- Kanban system.

6.3.1.1 *Kanban*

Kanban system is a part of the Japanese manufacturing philosophy that quick and easy methods manage the production. Taiichi Ohno introduced Kanban system in the 50s of the previous century, in order to control the production and introduced JIT at Toyota Company.

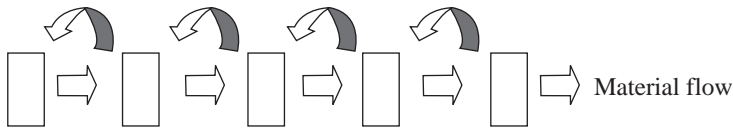
Operational planning in its classical sense does not exist, but it is done in manufacturing plants with very short planning horizon. Basic principles of Kanban in a Toyota production system are as follows:

- Continuous improvement of labour productivity, product quality, and efficiency of changing tools, etc.
- Efficient and simple methods for achieving high quality, i.e. the identification of the causes of errors and not finding products with defects.
- Efforts in production process to reduce or eliminate parts that do not contribute to increasing the value of the product (change of tools, transportation, administration, etc.).
- Systematic guidance to reducing the unfinished production
- A reasonable level of inventories of raw materials.
- Bottlenecks in the production process are localized quickly, simply and safely.
- Fast and visual control of the production system.
- Flexibility to market demands.

Kanban is a technique that works on the designing of production plants. Kanban is the signal board of communication about the needs of material and tells the worker about the production of other parts or quantities visually. Kanban system is also understood as a system that “pulls”, unlike the traditional “push”, parts along the production line – such as JIT or Material Resource Planning (MRP). The problem with the Kanban system is the inability of planning the production. Unlike MRP systems, where the real plan of production is based on previous experience, Kanban depends on the orders and the rhythm of production. In such circumstances the system is more vulnerable to shortages of resources.



6.4 Storage before and after the introduction of Kanban system.



6.5 Production lines in the Kanban system.

The storage of auxiliary materials (thread, buttons, hangers, labels, etc.) before and after the introduction of Kanban system is shown on Figure 6.4.

With Kanban systems work order is delivered to the perpetrator who performs the final operation, and he takes the case from the perpetrators of previous operation, he from the perpetrators of previous operation, etc. (Figure 6.5).

6.3.1.2 PPORF or 20 keys

Program 20 keys or PPORF (The Practical Program of Revolution in Factories and Other Organizations), was developed by a Japanese professor Iwao Kobayashi (1995), and was first implemented in the Toyota Company. It includes 20 practical and integrated methods for improving competitiveness with improving the product, their faster delivery and lower prices. Today, the method is implemented in about 700 companies in 55 countries, which:

- achieve strategic business objectives,
- improve the speed of learning and innovation,
- increase the productivity and flexibility for better acceptance of market demands,
- eliminate all types of waste,
- motivate employees and
- improve competitiveness, profitability and long-term success.

The system includes 20 keys:

- Key 1 Cleaning and organization – creating a nice and functional workplace workers are proud of and usage of tools for several different operations which increases productivity.
- For example, because of the large number of bales of textile material on the floor next to the machine for cutting and sewing it is necessary to clean and organize the space around them. Workers in cutting room and sewing room must have a clean and ergonomic workplace with special equipment for sewing (for sewing different seams and hem).
- Key 2 Rationalization of system – allows the natural flow of the organization of production of various items (shirts, blouses, work clothing) and the development of technological documentation for each product (see Chapter 2).
- Key 3 Activities of small groups – using the experience and ideas of all employees in the PBS, or a small group of employees who discuss problems and product quality.
- Key 4 Reduce Work in progress – for reducing the amount of finished products in stock.
- Key 5 Rapid change of technology – improves flexibility and ability to meet customers' demands and eliminate waste by reducing the time of changes in the workplace. Therefore, it is necessary to conduct market research and marketing analysis.

The new technology for garment production needs flexibility for manufacture in accordance with market requirements. Fast changes in technology as well as customers' expectations make a producer keep improving his fashion products and quality in order to keep his position on the market. Markets researches, consumers' wishes, requests, and criteria mean inevitable and dominant task for a producer of garments, because by obtaining all these information a production can be directed, business planned with advanced defined aims and strategies. Marketing enables greater flexibility and better organization for more successful reaction to market demands.

Market analyses are perhaps difficult procedures for fashion industry, because they need time to see strong sides and opportunities although they are too eager to identify weaknesses and threats. It is important to be aware that once when weaknesses are identified, some steps to change them can be taken by training, so there is possibility to make it a strong side. That's why BSC (Boston Consulting Group), SWOT and Ansoff's matrix are useful techniques used to find out strong and weak points in a fashion industry.

- Key 6 Kaizen business (Japanese Kai = change + Zen = good) – real improvements in costs and productivity are achieved and maintained by analysis of procedures that add value, reduce unnecessary movement, combinations and simple procedures. The production of clothes does different garments of different colours and textile materials and that's why each technological operation must be analyzed.
- Key 7 Zero defect in the production – the introduction of sewing machines and devices in order to eliminate the control of entire cycle.
- Key 8 Related manufacturing – simplification of processes and production lines, reducing and removal of the storage and excessive inventories.
- Key 9 Maintenance of machinery and equipment – preventive maintenance of machines for cutting, sewing and finishing (Total Production Maintenance) to increase the performance of the equipment above 95%.
- Key 10 Control of production time and the commitment – creating a positive working atmosphere and good scheduling of technological operations.
- Key 11 Quality Assurance – clothing quality assurance using CAD/CAM systems and CNC sewing machine with on-line monitor for control of stitches.
- Key 12 Developing partnerships with suppliers and customers.
- Key 13 Eliminating waste – during the process of technological development, especially in the technological cutting process, there are losses of textile materials, which can be systematized into the following losses: losses in the ends of cutting layouts, losses between patterns (the difference between gross and net areas of cutting layouts), the breadth of material losses, losses as the rest of the textile windings, losses due to material errors, losses due to form and shape of garment, losses due to inadequate number of cuts in cutting layouts and overlapping cutting layouts.
- Key 14 Motivation of workers to make improvements and teamwork.
- Key 15 The diversity of skills and training of staff training of all employees, training on new processes and using new technologies, but also the training of managers about supporting the staff.
- Key 16 Production Schedule – defining the flow of production and modelling process, for example a modular system.
- Key 17 Control performances – for example, control the rhythm every two hours in sewing room.
- Key 18 Using information technologies – such as applying CAD, CAM and CAP for better preparation and organization of production.
- Key 19 Saving energy and materials – the application of CAD/CAM.
- Key 20 Using technology for strategic advantage – using new technologies with the benchmarking and development of new fashion products.

Application of PPORF method or system of 20 keys in garment industry allows:

- reducing the cost of procurement and storage of textile materials,
- easier adjusting to new products demanded by the market,
- reduction in staff absence by 14% to 20%,
- continuous flow of material,
- ensuring product quality and
- respecting deadlines.

6.3.2 Total quality management

TQM (Total Quality Management) was created by American professors WE Deming and JM Juran who failed to realize their ideas about the quality of SQC (Statistical Quality Control) in America, but they faced the approval in Japan. After the success of Japanese products in the world market in the eighties, the West became interested in this concept and the concept of TQM appears as a response of the West to the very successful Japanese business concept of Kaizen.

TQM is defined as an approach to quality management in PBS, based on participation of all employees, focused on long-term success by meeting the needs of consumers. TQM is a way to improve the functioning of the PBS continually, on all its levels and using all available resources.

Basic principles of TQM are

- Quality can and must be managed.
- All employees are responsible for the quality.
- Problems must be prevented, not just fixed.
- Quality must be controlled.
- Improving the quality must be a continuous process.
- Objectives are based on customer requirements.
- Management must be involved.
- Improving the quality requires planning and organization.

TQM is applied in order to improve effectiveness, efficiency, flexibility and competitiveness. It requires the entire PBS to be organized and committed to quality in all its segments, in each activity and production unit, so that every employee understands its importance and its commitment.

There are five key components that every PBS must constantly examine and measure in order to realize the level of weakness and productivity. Each of these parts is of strategic importance for the functioning of TQM, and they are connected and dependent on each other. These are as follows:

- (1) Product – meets the requirements of management, all the employees, customers or consumers.

- (2) Process – ensures the product quality. Processes must be evaluated to understand if they meet specific standards and expectations of a PBS. Otherwise, the process must be corrected to ensure that the product is of satisfactory quality.
- (3) Management team – to ensure the success of TQM it is necessary to have a trained team and the division of responsibilities.
- (4) Commitment – researches show that TQM is successfully implemented in the PPS which has a high degree of commitment of workers and management. By their participation in the implementation process, managers can see if the improved processes give the desired results. On the other hand, workers by their assessment in problem solving become motivated to work because their results are recognized.
- (5) Organization – an organization can be successful only if there is teamwork. Their creativity, enthusiasm, objectivity and motivation enable functioning of TQM.

Teamwork is a combination of skills, experience and knowledge. A team in TQM provides

- Flexibility, as teams gather, develop, direct and dissolve easily in order to ensure the permanence of structure and process.
- Commitment, because teams are committed to clear goals to which PBS tends.
- Synergic response of teams to challenges, because each complement the skills and experience.
- Motivation, because the work of the individual and his responsibility are important for the team, but the role and performance of each individual have impact on team members.

In order to reach the exact JIT and Quick Response System (QRS) in today's garment production, when planning and specification of quality control garment it is necessary to determine its purpose in accordance with the requirements of customers, to specify the characteristics of products and qualitative values. Quality is the source of rationalization, profitability, competition means, factor of productivity and a precondition for security and creating new jobs.

In dealing with garments it is necessary to satisfy the individual tastes of buyers, design and fashion trends, ensuring individuality and resolve issues of durability, endurance and comfort, because creating a successful fashion mark trade and reputation in the market is based on the quality of garment.

The quality of each clothing production requires

- (1) product quality,
- (2) quality of materials,

- (3) quality of process
- quality of market research,
 - quality of design
 - quality of procurement of materials
 - production quality and
 - quality of sales.

Quality of production and material is defined by national standards and the contracts of sale. According to the ISO definition of quality is: “Quality is the set of all the properties and characteristics of products or services related to the ability to meet the established or indirectly expressed needs”.

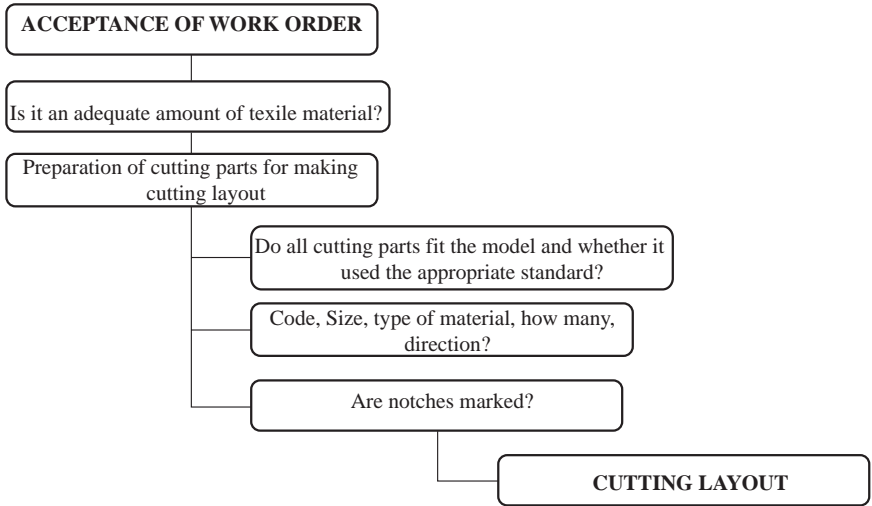
PNQ method (Price Non Quality) or Problem Solving Skills method is a simple method which is based on determining critical errors, determining the corrective measures and implementing corrective measures. This method integrates a number of basic tools for quality improvements such as flowcharts, check sheets, histogram, pareto diagram and ishikawa diagram.

Methods of quality can be divided into three groups:

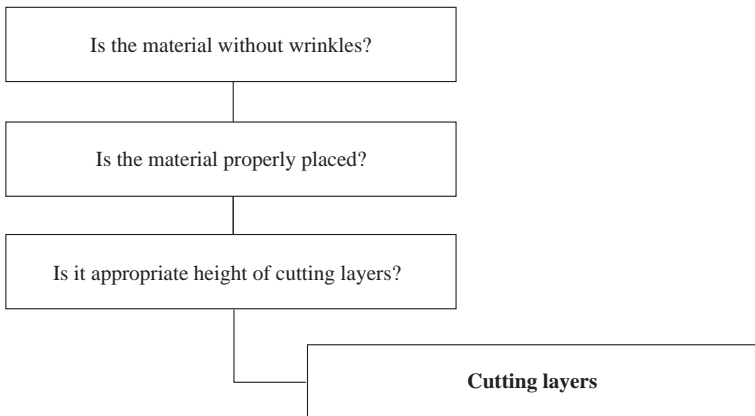
- (1) Basic tools of quality – Histogram, Scatter diagram, Correlation diagram, ABC-Pareto diagrams, Ishikawa diagrams and Control Charts,
- (2) Complementary tools of quality – Flowcharts, Nominal group technique, A guide for organizing meetings, Affinity Diagram, Fault tree diagrams, Matrix Diagram, PDPC (Process Decision Program Chart) diagram and
- (3) Methods and techniques of quality – brainwriting and brainstorming, SWOT analysis, FTA analysis (Fault Tree Analysis), Value analysis, Network diagram, Kanban, Rolling, Poka-yoke, Zero defect, FMEA method and QFD method.

Methods and techniques of improving quality can also be classified as:

- Statistical methods and techniques,
 - Engineering methods and techniques and
 - Managerial methods and techniques.
- (1) Flowcharts or algorithm allows a simple graphical representation of workflow of the process it examines.
For example, control design-constructional and technological preparation of production process of cutting can be made by applying the flowchart of the process. Before the technological process of cutting it is necessary to check the: cutting parts (Figure 6.6), cutting layers (Figure 6.7) and cutting layout (Figure 6.8).
 - (2) Check sheets shows all kinds of errors and their frequency. As an example of Check sheets in Table 6.1 the analysis of commonest errors in design-



6.6 Flowcharts for control design-constructional preparation.

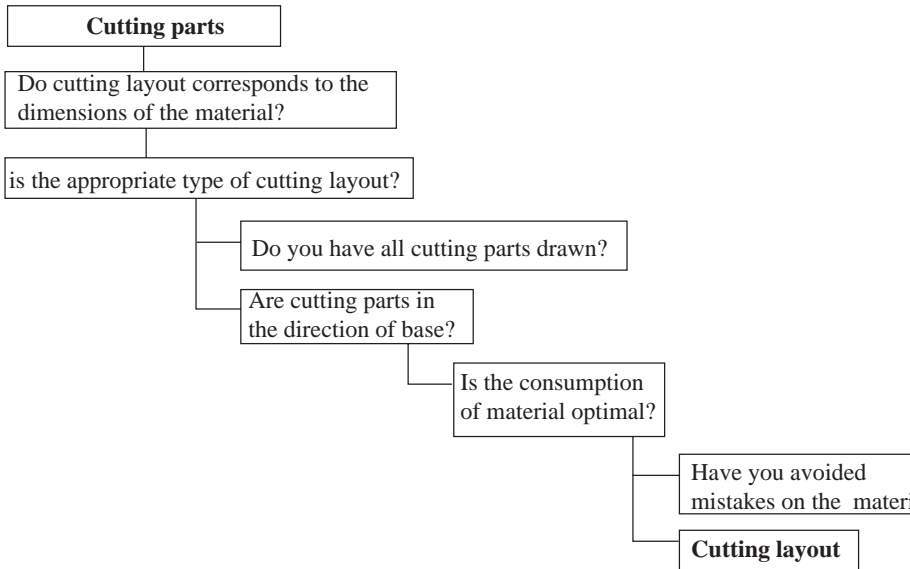


6.7 Flowcharts for control cutting layers.

construction preparation during several months (May to October 2009) is shown.

The technological process of sewing often bears a large number of errors so the intermediate control in sewing room is necessary in order to avoid:

- material damage due to mechanical needle penetration forces, transport, fineness of thread, machine safety,
- drop of penetration parameters due to non-compliance,
- uneven density of stitches,
- unsatisfactory weld strength and elasticity, uneven weld width,
- botch darts, pleat, topstitches,



6.8 Flowcharts for control cutting layout.

Table 6.1 Analysis of errors in design-construction preparation

Type of error	Number of errors, f_i	Relative frequency,	Cumulative frequency, f_k (%)
Cutting parts do not fit the model	2	4.25	4.25
Bad positioning of cutting parts	3	6.38	10.63
Unsigned indentation	10	21.27	31.90
Lack of cutting part	7	14.89	46.79
No percent for stretching	2	4.25	51.04
Deviations in grading	5	10.23	61.27
Bad cut	8	17.02	78.29
No grading all cutting parts	3	6.38	84.67
Large consumption of materials	2	4.25	88.92
Missing cutting part in cutting layout	3	6.38	95.75
Inadequate size of cutting layout	2	4.25	100
Σ	47	100	

Table 6.2 Analysis of errors in the men's shirts

Type of error	Number of errors, fi	Relative frequency,	Cumulative frequency, fk (%)
Weld cracking	4	4.59	4.59
Bad cutting threads on the seam	28	32.10	36.69
Bad consolidation stitches	15	17.24	53.93
Incorrect sewing board	6	6.89	60.82
Bad closed board with topstitch	3	3.44	64.26
Uneven hem	8	9.19	73.45
Uneven making holes	5	5.74	79.19
Unequal length side	8	9.19	88.38
Wrong sewing button	4	4.59	92.97
Stains	3	3.44	96.41
Wrong label	3	3.44	100
Σ	87	100	

- interfusion of cutting parts,
- curvature of sewing parts, asymmetry, spacing, position,
- botch set by size, shape, tension, curvature,
- bad cutting threads, etc.

List of collected errors is displayed in Table 6.2 and they are identified in the production on a random sample of 250 men's shirts.

On the bases of the list of collected errors the degree of preparation can be calculated:

$$P = (\text{number of detected errors} / \text{number of possible errors}) \cdot 100 \quad [6.1]$$

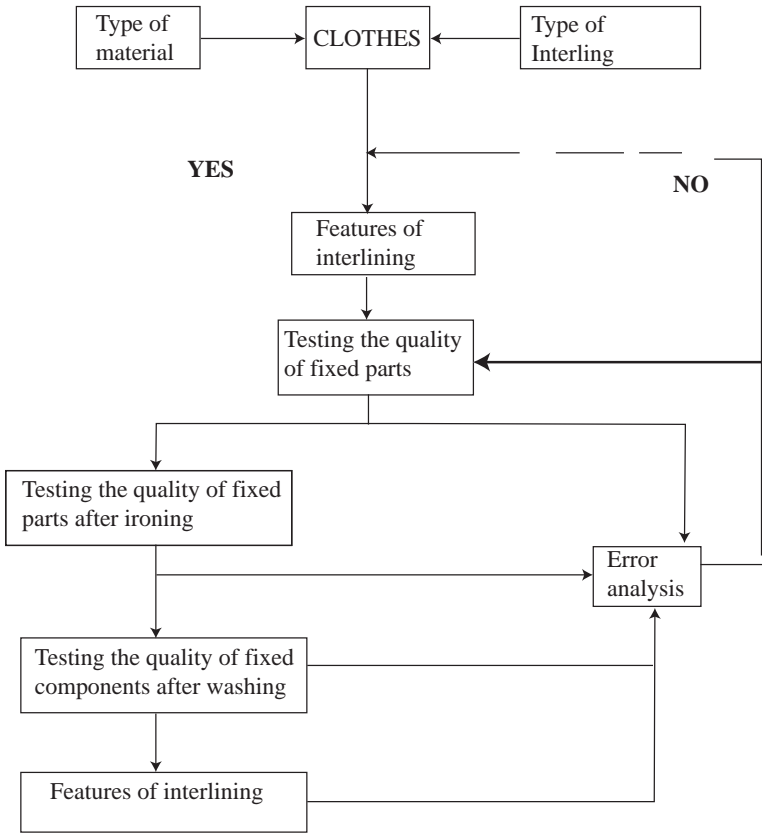
Where: the number of possible errors = 250 pieces • 11 elements examined

The degree of preparation of analyzed men's shirts is $P = 3.16\%$

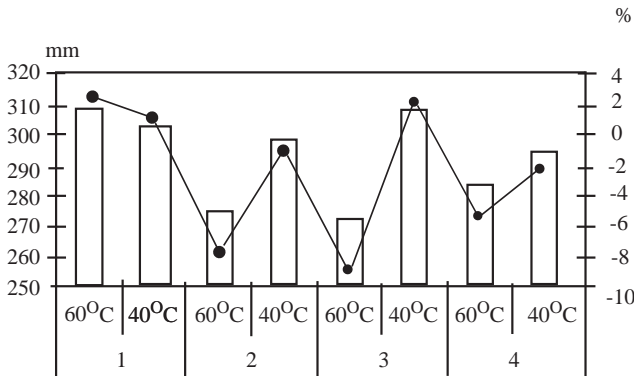
For 250 products surveyed the number of errors is 87, so it can be concluded that every third product does not fit the prescribed requirements of quality.

Figure 6.9 shows the example for flowchart of the process for the selection of adhesive interlining.

(3) Histogram displays the data according to their frequencies. In Figure 6.10 an example of histogram analysis obtained by collecting four samples of t-shirts by width after the first wash at 60°C and 40°C is shown.



6.9 Flowchart of the process for the selection of interlining.



6.10 Collecting samples of four T-shirts by width after the first wash at 60°C and 40°C.

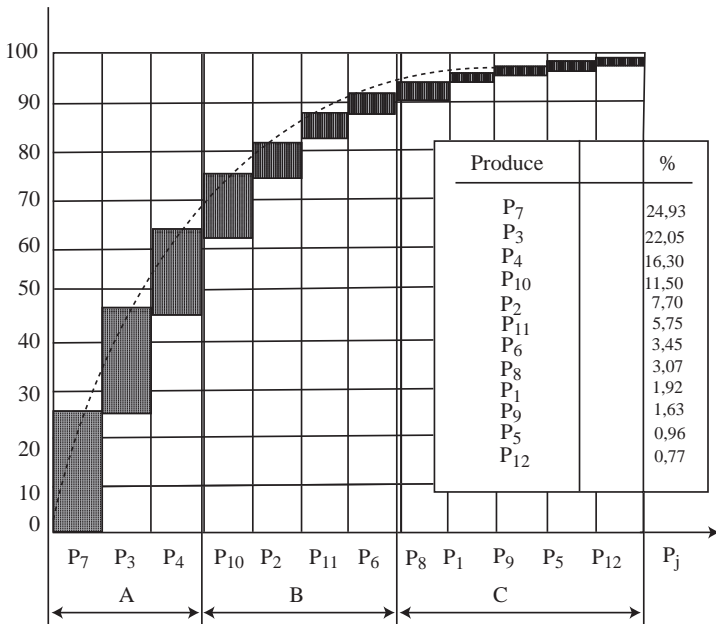
- (4) Pareto chart or the ABC diagram allows defining the most important problems and discovering their causes. In 1906 Vilfredo Pareto, Italian economist, sociologist and philosopher defined the rule that 20% of causes are responsible for 80% of errors. Pareto chart provides: ranking according to degree of importance of appearance, determination and separation of the critical areas of the observed size and direction towards solving the problem. Applying Pareto chart in the process of improving the quality of the area includes: management (analysis of sizes of basic indicators of business), marketing (analysis of market trends), development (characteristic trend analysis), production, cash flow management and logistics.

Figure 6.11 shows the example of Pareto chart for the analysis of the production profits.

- (5) Ishikawa Diagram, Fishbone Diagram or Cause and Effect Diagram provides a complete analysis of a problem or error, because it observes the environment, methods, material, man and machine.

Ishikawa Kaoru (1990) defined that the causes of problems are related to several categories:

- The 5 Ms:
 - Machine.
 - Method.



6.11 Pareto chart for the analysis of the production profits.

- Materials.
- Measurement.
- Man.
- The 4 Ss:
 - Surroundings.
 - Suppliers.
 - Systems.
 - Skills.
- The 8 Ps:
 - Price.
 - Promotion.
 - People.
 - Processes.
 - Place/Plant.
 - Policies.
 - Procedures.
 - Product or Service.

Categorize 4 Ss and 8 Ps recommended for service sector.

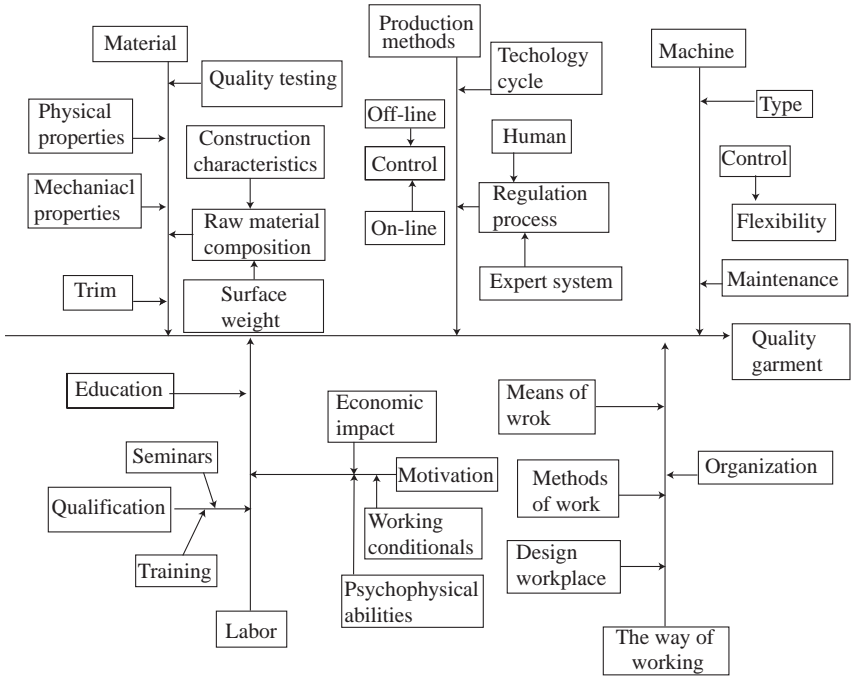
Figure 6.12 shows the example of Ishikava diagram of cause impact on the quality of clothing

- (6) In order to achieve the cause-effect impact for making quality clothing, it is necessary to keep carrying out a Deming PDCA (Plan-Do-Check-Act). The process of continuous improvement is based on the concept which was developed by an American expert on quality William Deming in the fifties of the previous century. In this cycle of continuous quality improvement, shown in Figure 6.13, production can be achieved without deviations and errors, if such was set as a goal.

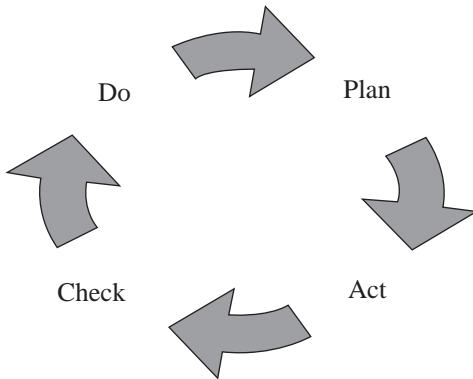
To make a cycle realized it is necessary to ensure all requirements for quality such as:

- implementation of methods and techniques to detect errors and discrepancies and the reasons for their emergence,
- continuous education and motivation of employees to achieve JIT production and quicker placing on the market (Time to Market)
- quality control as a prevention,
- norms of quality, rather than norms of quantity.

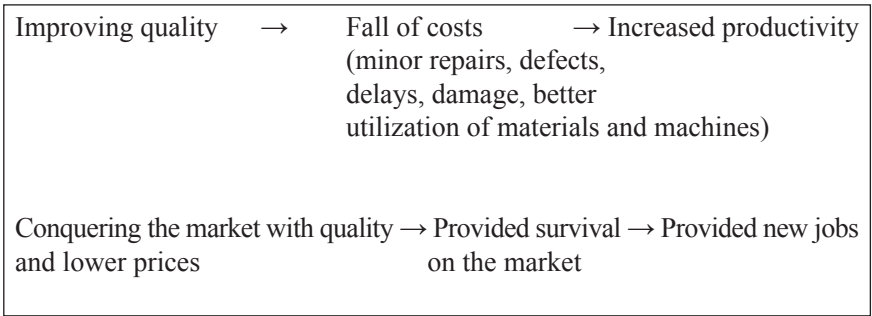
When planning and specification of quality control garment it is necessary to determine its purpose in accordance with the requirements of customers, give precise product features and quantitative values.



6.12 Ishikawa diagram cause impact on quality.



6.13 The PDCA cycle.



6.14 Displaying chain reaction: quality – costs – productivity – the conquest of the market.

Continuous improvement of quality of clothing causes a chain reaction, and inevitably affects productivity, as shown in Figure 6.14.

- (7) Poka-Yoke method is the most popular method for ensuring quality without errors. This method of quality control is done during or immediately after a process, not just to define quality in the end. Today, this method is fully implemented in Japan and with the help of auxiliaries (mechatronic devices with stop or sound or light signal) Poka-Yoke detects errors in the object of work and the process stops.
- (8) QFD (Quality function deployment) method is mostly used in quality management processes in Japanese companies, and so their experience is being followed in application and in the way of introduction into use. Japanese society for QC recommends QFD for defining “the voice of the customer” (VOC), as a scientific process. The voice of the customer is also the motivating factor for the QFD method, and as such determines success or failure of the product and service on the market. Barnard and Wallace (1994) have integrated QFD as a compulsory method for development strategy defining.

QFD is a powerful tool that enables significant improvements in the product/process characteristics. However, it is not a short-term solution to the product development problems. QFD provides systematic approach to creation of the team outlook, on what needs to be done, the best ways to do it, the best order in which the proposed tasks have to be accomplished and on the staffing and resources that are required to enhance customer’s satisfaction. It is also a good format for capturing and recording/documenting the decision making. Applied through the Kaizen philosophy under TQM, QFD is a highly developed form of integrated product and process development in existence. Companies that were using QFD for the product development have experienced, in average:

- 50% reduction in costs,

- 33% reduction in the product development time,
- 200% of increase in productivity.

Based on research Bagozzi (1994) QFD method is based on the VOC. Application of QFD in the development of new methods or improvement of products includes

- (1) customer requirements,
- (2) product characteristics,
- (3) critical parts
- (4) critical operations and
- (5) steps to be taken.

Implementation of the QFD method in clothing industry is represented through four principles of work in four phases:

- phase 1 – translates customer's demands into the product features,
- phase 2 – translates the product features into features of its parts,
- phase 3 – translates features of parts into technology of fabrication and
- phase 4 – translates technology of fabrication instructions for technical documentation.

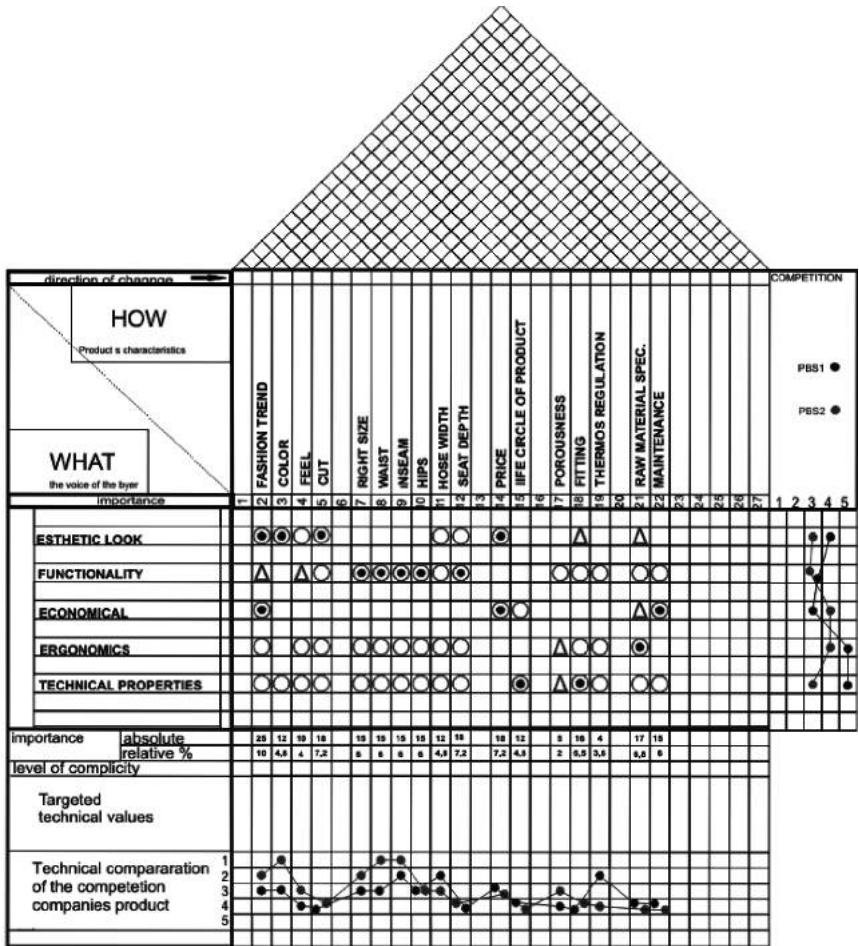
On the basis of these principles four houses of quality are formed. As an example the first house of quality was given based on the research of professor Danijela Paunovic (2009) in Serbian garment industry in the Figure 6.15 is phase 1 and establishment of significant characteristics of the garment product.

(9) The FMEA (Failure mode and effects analysis) method performs the identification of all possible errors in the product and the possible risk of their occurrence. The buyer will accept the purchase of fashion products and the overall risk quality installed in that product. FMEA method is a means to identify risks, detect their causes, risk assessment and proposing measures for reducing their occurrence.

The objectives of FMEA method, by definition, are the SMART (Specific, Measurable, Achievable, Related to the customer, Time targeted) objectives for several reasons:

- clearly and unambiguously defined goal of applying FMEA method is the key to success,
- measurable targets can be seen in the pre-defined risk factor priorities which we want to achieve and
- the basic goal of FMEA is to reduce the possibility of errors.

The method is based on defining and determining functions, errors, causes, consequences and other relevant parameters.



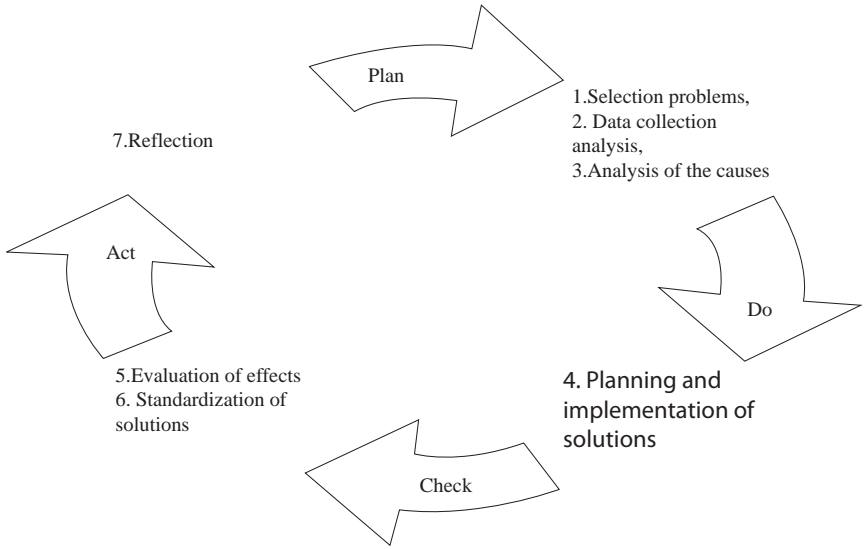
6.15 House of quality – phase 1 and establishment of significant characteristics of the product.

(10) Seven step method provides answers to questions:

- How did we do?
- What to do to improve the quality?

Continuous repetition of seven steps within the PDCA cycle develops many habits (Figure 6.16):

- understanding of the problem,
- development and promotion,
- teamwork and
- diagnostic process.



6.16 Method of seven steps within the PDCA.

Table 6.3 shows the most frequently used tools of quality when applying the methods of the seven steps according to Lazic (2005).

(11) Brainstorming and Brainwriting are techniques of generating and collecting ideas: for development of new products, solving management problems, improving product quality and improving sales and marketing products.

Table 6.3 The most frequently used tools of quality when applying the methods of the seven steps

Seven-step	Control Tools	PDCA
Selection problems, data collection and analysis, analysis of the causes	Flowchart; Pareto chart; Histogram; Scatter diagram; Ishikava diagram	Plan
Planning and implementation of solutions	Fault tree diagrams; Matrix Diagram	Do
Evaluation of effects Standardization of solutions;	Cheklsits; Pareto chart; Scatter diagram; Ishikava diagram; Control charts	Check
Reflection		Act

Implementation process of brainstorming involves a few steps:

- introduction to the rules
- defining issue,
- presenting ideas,
- evaluating ideas,
- proposing action and
- adoption of the plan.

Brainstorming is a technique in which a group of six to 12 participants can lead to: complete problem solving, forming a list of possible solutions or a list of ideas that make a plan for finding a final solution.

Brainwriting is a group technique (up to six participants) aimed at the development of ideas, but unlike brainstorming, participants record their ideas. This technique eliminates possible influence of leaders to the opinion of participants, as well as the possible direct or indirect impact on restraining a free and unlimited presentation of ideas.

Japanese industry nowadays develops a separate system of work organization and management, significantly different from the European and American one. It is not only a new organizational form, but also new models of work motivation. A key factor in motivation is reflected in the possibility of creative engagement of all employees through the innovative group. Every worker knows that, if he wants to, he can take part in improving working conditions and production through groups. Quality circles, the production of Zero Defect and timely supply of tape production (JIT) are some of the elements that constitute what is called the art of Japanese management.

6.3.3 Lean production

Lean production (Kaizen techniques originally) is a result of the analysis conducted at the Institute of Massachusetts Institute of Technology (MIT), which was performed for the U.S. automotive industry, with the aim to find a key success of Japanese manufacturers.

Taiichi Ohno, the director of the Japanese company Toyota, was the first who practically implemented the concept of lean production. Lean manufacturing refers not only to production, but also to all other functions within the business systems, as well as relationships with manufacturers. Thus organized PBS through the centralization of technical-economic functions allow:

- reducing wearing of capital,
- reducing costs,
- increasing the adaptability of new products,
- increasing of total profits and
- timely delivery of products to a well-known buyer.

Table 6.4 Lean and traditional production

	Expensive, specialized s	Small and highly flexible
Machinery/equipment		
Goals	Win competition	Competes for customers
Culture	Solved problems	Prevent problems
Priorities	The results	The results and processes
Procedure	Static	Dynamic
Employees	The cost of and troubles	Potential and opportunities
Machinery/equipment	Expensive, specialized s	Small and highly flexible
Resolving	"Who's to blame?", crisis	"What is the solution?", a source of improvement

The comparison of lean and traditional production is shown on Table 6.3.

Lean production can be summarized as a set of individual entities, principles and measures, which provide an effective consolidated form of unbroken chain in the creation of new shares. The overall concept is planned and managed through phases so a commercial-production system can reach its goal. It is necessary to ensure connectivity and eligibility of all employees and elimination of old, inappropriate organizational structures.

Applying the principles of lean production lead, in existing production systems, to:

- shortening the cycle of production,
- reduction of capital and
- reduction of required number of workers.

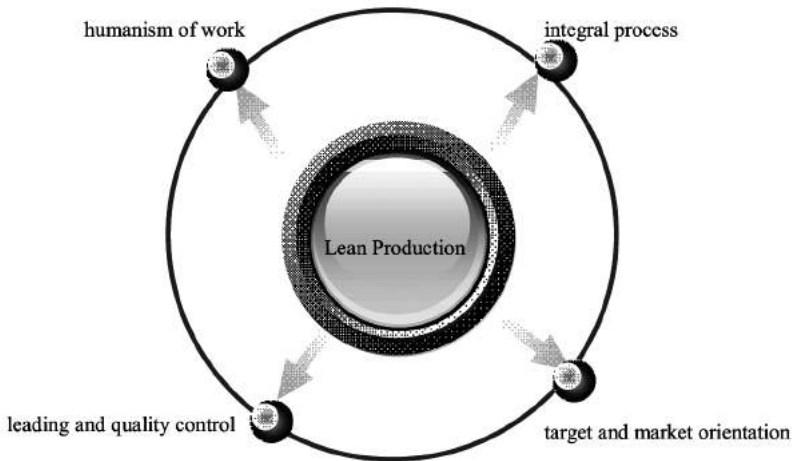
For the purpose of reducing the number of pieces in the series, it is necessary to leave the old divisions of labour and more convenient to introduce a system of team work, team responsibilities and team payment (instead of individual pay-per-action, which is today the most applicable).

The most important differences with respect to the previous mode:

- the more subcontractors than own production,
- inclusion in the sub-phases of the product and production, appropriate,
- not the principle of complete JIT (just for parts A – ABC analysis) and
- instead of self-control.

The most important instruments of lean production are:

- development and construction according to the demands of development, assembly, recycling and control,



6.17 Segments of lean production.

- producers fully responsible for time and quality of product,
- full compliance deadlines for all associates,
- uninterrupted flow of material with minimum warehouses and stockpiles,
- timely decisions (make or buy),
- timely information from the market and
- correct assessment of the capacities of their own production.

The segments of lean production are shown on Figure 6.17.

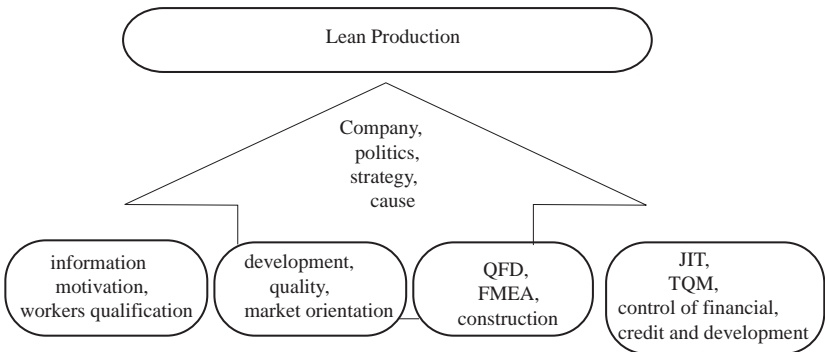
The logistic chain of supplier-produce-consumer must function properly, which means that all factors in the chain should:

- keep the same policy of business-production system,
- establish relationships that lead to a joint goal and
- remedy any possible conflicts and obstacles.

Basic elements of Lean production (Figure 6.18) are in fact the Japanese methods and systems: JIT, Kanban, TQM, TPM, Kaizen, 5S, Six Sigma, 20 keys, etc.

6.3.3.1 Techniques and tools of lean production

Techniques and tools of lean production are: Six Sigma, 5S, JIT, Kaizen, Kanban, Error Proofing, Current Reality Trees, Conflict Resolution Diagram, Future Reality Diagram, Lean Metric, SMED (Single Minute Exchange of Dies), Standard Work, Takt Time, Total Productive Maintenance (TPM), Value Stream Mapping, Workflow Diagram, ect.



6.18 Basic element of lean production.

Six Sigma methodology is a set of methodological principles and statistical tools, which together give excellent results. The methodology was developed in Motorola, in the mid-eighties of last century, and was developed for the analysis of the production process and for eliminating errors. Effectiveness and efficiency of this methodology has been proved in many leading companies (General Electric and Texas Instruments).

The name Six Sigma is a statistical concept, which refers to six standard deviations. In statistical terms Six Sigma means 3.4 defects per million opportunities (DMPO), where sigma represents the variation in relation to the average value of the process.

In business terms Six Sigma is defined as a business strategy that is used to improve business profitability by eliminating errors, reducing costs of poor quality and improving the effectiveness and efficiency of all operations in order to meet or exceed the needs and expectations of customers.

Six Sigma methodology combines tools for continuous process improvement. The processes are analyzed and resources are objectively assigned to those processes that require the most attention. Errors in the process cause processing, spoilage, additional work, increased costs, etc. Focusing on prevention of errors and their efficient and effective remedy will reduce the labour standards and costs of processes, so resources can be released for other investments, and by comparing processes objective decisions about where to deploy resources can be made.

Two main Six Sigma methodologies are applied: DMAIC (Define, Measure, Analyze, Improve, Control) and DMADV (Define, Measure, Analyze, Design, Verify).

DMAIC method is used to improve a business process, and consists of five phases:

- (1) Define – first it is necessary to define the project goal and purpose of the project and gather information about the process. At this stage the

following tools are applied: Affinity Diagram, Communications Plan, Control Charts, CTQ (Critical to Quality), Conventional Data, Kano Model, Pareto chart and SIPOC (Suppliers, Inputs, Process, Outputs, Customers) diagram.

- (2) Measure – measure the existing situation with different tools: Control diagrams, Conventional Data, Flowchart, Histogram, Measurement system analysis (MSA), Defining Operations, Pareto chart, Six Sigma Analysis and Taguchi Loss Function.
- (3) Analyze – analyze the causes using different tools: Brainstorming, Ishikawa diagram, DOE (Design of Experiments), Histogram, Testing Hypotheses, Diagram, Control diagram and Tree diagram.
- (4) Improve – various improvements of processes or their parts using different tools: Network diagram (Gantt chart), Brainstorming, Control diagrams, Failure mode and effects analysis (FMEA), Histogram, Pareto chart, PDCA cycle and Priority Matrix.
- (5) Control – control of the process itself and its outputs. This phase uses the following tools: Communications Plan, Control Charts and PDCA cycle.

DMADV method is used when it is necessary to implement the process, to design a new one or to restructure PBS. The very methodology is similar to DMAIC method. Expert team for improving the process first defines a critical level of quality. Then the optimal quality product or process is designed.

5S is a system to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. Implementation of this method “cleans up” and organizes the workplace basically in its existing configuration, and it is typically the first lean method which organizations implement.

5S, abbreviated from the Japanese, are simple but effective methods to organize the workplace. The 5S's are:

Phase 1 – **Seiri** – Sorting: Going through all the tools, materials, etc., in the plant and work area and keeping only essential items. Everything else is stored or discarded.

Phase 2 - **Seiton** – Straighten or Set in Order: Focuses on efficiency. When we translate this to “Straighten or Set in Order”, it sounds like more sorting or sweeping, but the intent is to arrange the tools, equipment and parts in a manner that promotes work flow. For example, tools and equipment should be kept where they will be used (i.e. straighten the flow path), and the process should be set in an order that maximizes efficiency.

Phase 3 - **Seisō** – Sweeping or Shining: Systematic Cleaning or the need to keep the workplace clean as well as neat. At the end of each shift, the

work area is cleaned up and everything is restored to its place. This makes it easy to know what goes where and have confidence that everything is where it should be. The key point is that maintaining cleanliness should be part of the daily work – not an occasional activity initiated when things get too messy.

Phase 4 - **Seiketsu** – Standardizing: Standardized work practices or operating in a consistent and standardized fashion. Everyone knows exactly what his or her responsibilities are to keep above 3S's.

Phase 5 - **Shitsuke** – Sustaining: Refers to maintaining and reviewing standards. Once the previous 4S's have been established, they become the new way to operate. Maintain the focus on this new way of operating, and do not allow a gradual decline back to the old ways of operating. However, when an issue arises such as a suggested improvement, a new way of working, a new tool or a new output requirement, then a review of the first 4S's is appropriate.

A sixth phase “Safety” is sometimes added.

This method emerged as the 3S, and it spreads in the latest trends up to 7S. According to some authors this is a separate method, while the others treat it as an integral part of the Lean approach.

Kaizen (continuous improvement) in the Japanese management practices is a continuation of incremental improvements and improvements in quality, technology, processes, company culture, productivity, security and governance. This method involves all employees. The basic philosophy of Kaizen management is fast, simple and easy, but constant improving of operating efficiency. Kaizen requires small financial investments, but major changes in its views, the way of work and thinking of all employees.

Kaizen method is often found in other methods and techniques (JIT, Kanban, 5S, 20 keys).

There are two levels of kaizen: system or flow kaizen focuses on the overall value stream and process kaizen focuses on individual processes.

Value Stream is all of the actions, both value-creating and nonvalue-creating, required to bring a product from concept to launch and from order to delivery. These include actions to process information from the customer and actions to transform the product on its way to the customer

6.3.3.2 Case study

In Serbian garment companies lean production is not in use. In Serbia the reorganization of few garment companies have just started (“natural” work flow of manufacturing, control tact time, training of the employees, using trolley for transport between sewing machines). But new methods for rationalizing the system of manufacturing garment are required. That's why the analysis

in a domestic company for production of men's shirts was made by trying to implement lean production systems.

Analyzing production in the company for producing men's shirts discovered several causes of bad organization such as:

- (1) Causes from the work areas of employees
 - poor organization of work,
 - poor transport material,
 - insufficient training of workers,
 - poor working conditions,
 - weak protection in the workplace,
 - fluctuation of employees,
 - inadequate schedule of work and rest,
 - inappropriate system of compensation,
 - poor interpersonal relations and
 - various subjective reasons.
- (2) Causes in the field of using automation and funds:
 - poorly organized maintenance service and repair of sewing machines,
 - unprofessional and irresponsible management of production lines,
 - chain system of installing jobs with immovable tapes,
 - insufficient knowledge about the features of machines and devices,
 - insufficient usage of capacities and
 - bad choice of machines by capacity and type.
- (3) Causes in the area of textile materials and energy:
 - accumulation of materials in the warehouse of raw materials,
 - bad utilization of textile materials (big waste),
 - insufficient control,
 - irrational use of waste (for children's clothes),
 - bad application of the basic textile materials and support,
 - application of inappropriate machines and devices,
 - errors in the construction of clothing,
 - bad schedule and the location of energy sources and
 - bad installations.
- (4) Causes due to methods, i.e. organizational procedures:
 - insufficient preparation of the production of clothing,
 - lack of coordination within the company,
 - poorly organized records and control
 - lack of work discipline

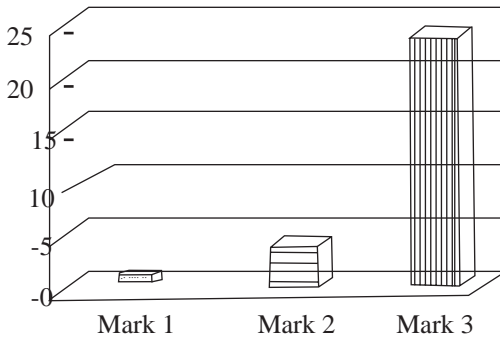


6.19 Inadequate storage of textile materials: a) plant b) cutting room.

- protection at work
- ignorance in the field of ergonomics and
- incomplete technical and technological documentation.

Before the reorganization of the company for the production of men's shirts, interviewing 26 workers in a production line was carried out and the following results were obtained by method of 5S:

- (1) The research on sorting shows that 53.8% of workers believe that there is a large number of unnecessary machinery and equipment in the facility, while 98% of workers point out that textile materials are poorly housed partly on the plant floor, and partly in the appropriate shelves and rarely in the warehouse of raw materials (Figure 6.19). Despite damaging the quality of materials, it takes free space for transport.
- (2) The research on systematization shows that employees know where supplies and tools for work are and to return them regularly on their place, but there is not enough room for manipulation between workplaces, which points out the need for planning new installation of workplaces, Figure 6.20.
- (3) Preparation of a plant and the establishment of order and cleanliness of the premises as well as tools and equipment is satisfactory in the opinion of all respondents.
- (4) The tendency towards "zero defects" is not present among the workers, because only 15.3% of workers points out their and other people's mistakes or worry about the garment quality. Others who were questioned consider that the errors should be taken care of by the supervisor at the final control of products but believe that all the employees are responsible for the implementation of production.
- (5) After going into the 5S model, 57.6% of workers would accept it, while 19% oppose to any changes (most of the workers with over 25 years of service).



6.20 Rating adequate spaces for wheelchair transport.



6.21 Sewing machines that do not participate in the technological process.

On the basis of the survey for the possibility of applying 5S, the following conclusions can be made:

- It is necessary to insert additional racks for adequate disposal of textile materials in the production plant.
- It is necessary to move from the production line those sewing machines that do not participate in the technological process (mostly inoperative, Figure 6.21), or design workplaces so flexibility is achieved by technological trolleys, regardless of the model or item that is produced, as well as a required handling space.

- It is necessary to maintain sewing machines constantly.
- Provide the equipment and auxiliary devices that will accelerate and simplify technological operations.
- It is necessary to establish more self-control than control (team responsibility).
- It is necessary to train workers constantly so that they should accept the necessary changes.
- Provide a continuous flow of material with minimal storage and inventory.

No matter whether the work is being done for the unknown or a known customer (German “Lohn” work or Cut Make Trim system), the aim is to achieve a shorter manufacture time. The garment manufacturers in Serbia work more than 80% by CMT (Cut-Make-Trim) system, although most managers know that CTM jobs have no future in the world market. Their wages are getting lower and the competition is getting larger, so they are at risk of losing clients by any raising of prices. OBM (Original brand name manufacturing) system in the production for international markets is most likely currently unattainable for everyone but the majority of manufacturing firms have a competitive apparel.

It is therefore necessary to define a flexible model of production of clothing that will shorten the time of the technological process of cutting, sawing, and finishing. Application of CAD system accelerates the construction preparation (modelling, completing, duplicating the required number of sizes and the production of cutting layer), and thereby shortens the time of shirt production. Technological process of sawing can be shortened only by investing in automated machine for laying textile material, or into a modern CAM system for depositing materials and cutting parts. In Tables 6.5,

Table 6.5 Analysis of technological cutting process

Technological process	Construction preparation (s)	Technological cutting process		
		Placing of material (s)	Cutting (s)	Thermo fixation (s)
Traditional production	10 440	108	401	59
Lean production with CAD/CAM	2880	50	200	59
Lean production without CAD/CAM	10 440	108	401	59

Table 6.6 Analysis of technological sewing process

Technological process	Technological sewing process (s)							
	Making collars	Making pockets	Making right front parts	Making left front parts	Making back	Making sleeves	Making cuffs	Montage
Traditional production	207	53	94	94	177	75	160	154
Lean production with CAD/CAM	207	25	94	69	177	75	160	154
Lean production without CAD/CAM	207	25	94	69	177	75	160	154

Table 6.7 Analysis of technological finishing process

Technological process	Technological finishing process		
	Final ironing (s)	Quality control and packing (s)	Warehouse of ready-made garment (s)
Traditional production	108	401	59
Lean production with CAD/CAM	50	200	59
Lean production without CAD/CAM	108	401	59

6.6 and 6.7 the times of technological processes of cutting, sewing and finishing are shown.

Technological process of making men's shirts consists of 60% of manual work and 40% of machine work. By the application of the study of work the resulting model can be further improved by the reduction of time, primarily of manual work in a sewing room.

In the work on the sewing machine and the automats there is still a large percentage of manual work due to poor shaping of workplace and internal

Table 6.8 Average production time and making men's shirts and suggested models

	Production time		Time for manufacturing men's shirts	
	s	min	s	min
Traditional production	12 649	210	1939	32
Lean production with CAD/CAM	4777	80	1627	27
Lean production without CAD/CAM	12 596	209	1886	31

transport. By detailed analysis of all jobs in the production line, the time of making a garment can be reduced for a few more minutes per unit of product.

In the Table 6.8 is shown that the technological process of sewing and finishing a production line can be reduced only for 1 min without the application of CAD/CAM systems.

New model of production men's shirts can be checked through the daily capacity of C_d . In one production line (sawing and finishing) there are the average of 20 workers with work time 7.5 h (450 min).

According to that, the daily capacity is:

- C_d traditional model = 391 pieces
- C_d research model = 409 pieces

Annual capacity (C_g) of a model of a production line (240 working days) and cost effectiveness of models are shown in Table 6.9.

Percentage of savings for the production of male shirt with the 99.160 pieces in relation to the average production with 93.840 pieces is 4.6 % and that increases revenue production lines a year for 69 120 euros per year.

The analysis of production in company for men's shirts demonstrates us one way for change organization in our garment manufacturing, because:

- reflects and supports target attainment and quality values for short term and long-term periods,

Table 6.9 Year capacity (C_g) and increase revenue

	Year capacity, piece	Price (16 €for 1 shirt)
Traditional production	93 840	1 501 440
New production	98 160	1 570 560
Between	4320	69 120

- development and engagement of all employees for improvement within the organization,
- resources of an organization (finance, IT, height-tech textile material and new cutting and sewing technologies) are coordinated with the quality of garment and organization values,
- overview of all processes in a garment company and change of the existing combination of processes, emphasis on shortening the technological time,
- indirect connection with customer satisfaction,
- organization will be successful only if it adequately motivates its employees,
- quantitative evaluation as better quality, increase of productivity and
- reduced stocks.

In order to make the technological system of production flexible, it is necessary to:

- Be always on the training.
- New practice of knowledge and experience in the field of management.
- New knowledge about practice in the field of garment technology and information systems.
- Set of positions to achieve a faster transport of objects and to answer any of the technological procedures (different models and articles).
- The constant practice of training workers.
- Work on the acceptance of change.
- Analyze the technological operations and procedures and make their optimization.
- Design workplace.
- Improvement of internal transport.
- Apply the techniques of network planning of production.
- Define each of the quality of fashion products.
- The trend towards the “zero error” and reduce the warehouse of finished products.
- Bringing the team responsibility of all employees.
- The creation of recognizable fashion brands.

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