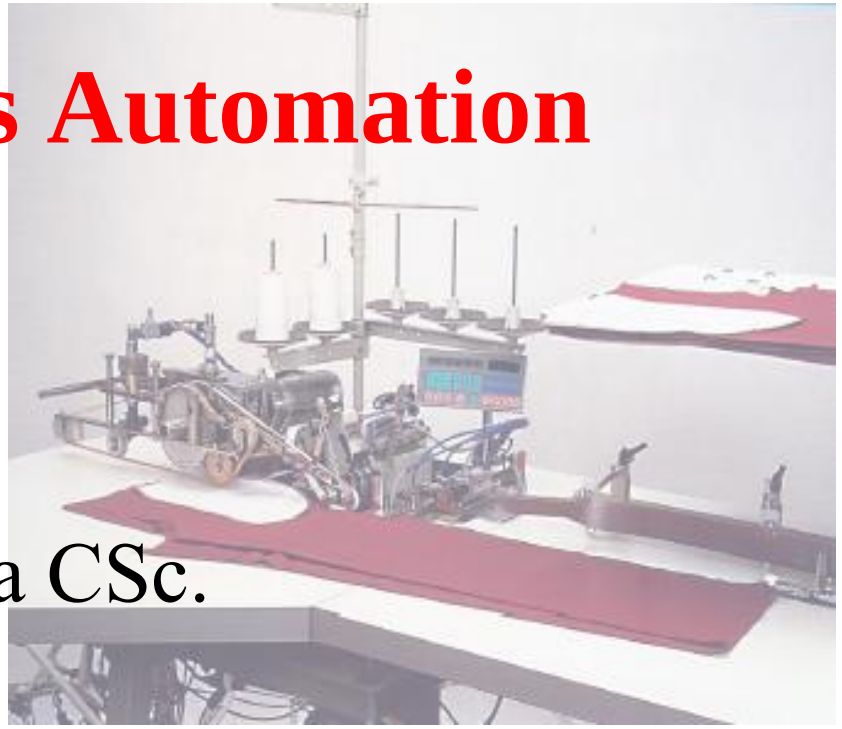
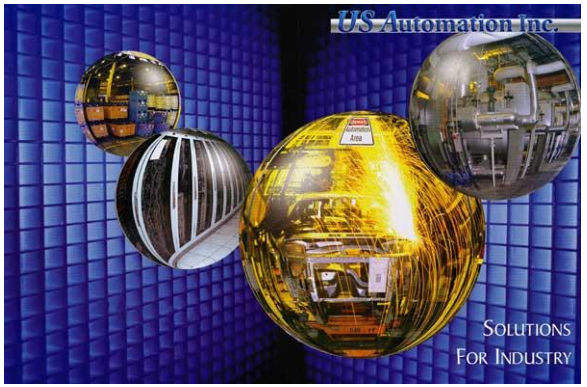
Sewing Process Automation



Doc. Ing. Antonín Havelka CSc.

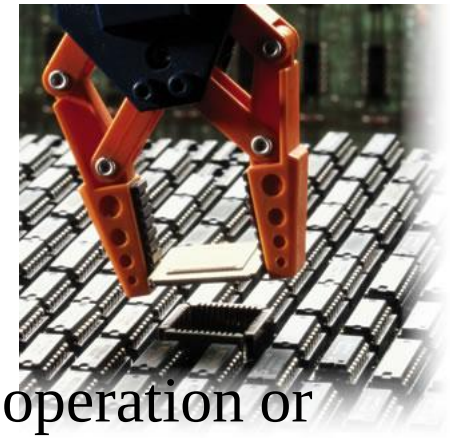
Definition of Automation

- **Machine**
  - Mechanic equipment produced by man (human) for simplification and acceleration human labour.

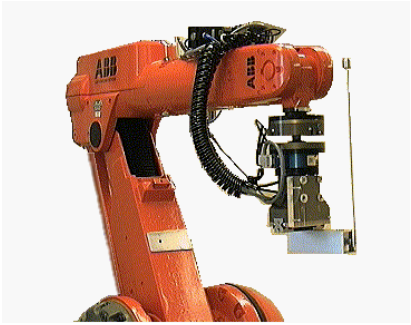


- **Mechanization**
  - Process to use machine to do something that used to be done by hand;
  - For elimination hard work in the presence of worker.

Definition of Automation

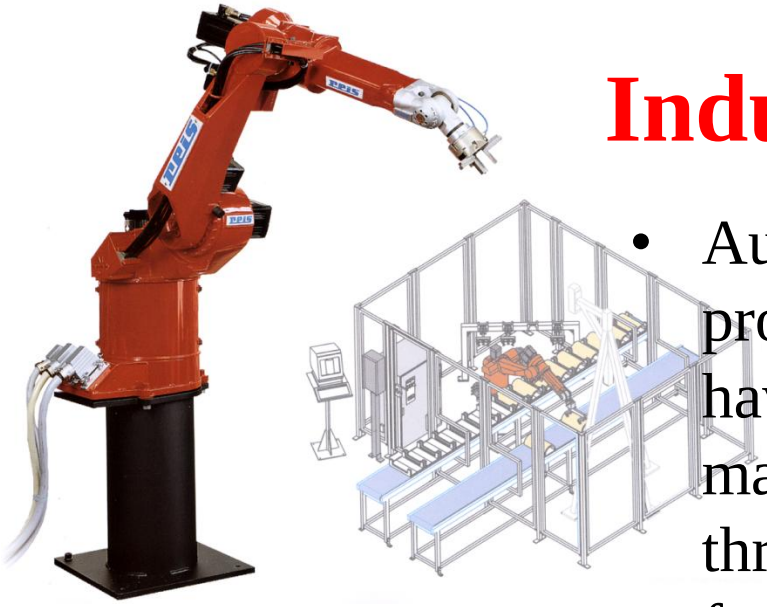


- **Automation**
  - Automatic, opposed to human, enables an operation or control of a process, equipment or a system, or the techniques and equipment used to achieve this most applied to computer (or at least electronic) control of a manufacturing process. Elimination of hard and mental work of the human being.
  - Replacement of human workers by technology as system in which a workplace or process has been converted to one that replaces or minimized human labour with mechanical or electronic equipment.



Definition of Automation

- **Special automation- ROBOTS**
  - 1967 1st robot fy Unimate USA, year 2000 there are more then 1000000 pcs robots. (K. Čapek, Czech writer drama RUR – the Robot is the name for artificial man)
  - from small scale production to large scale production
  - Number of robots per 10000 workers 1st JAP,USA,DE,IT…



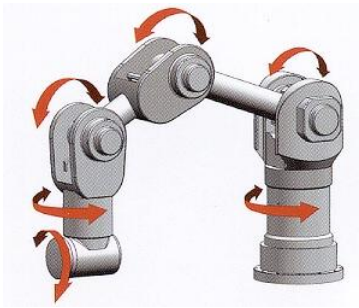
Industrial Robots

- Automatic ,servo controled ,re-programmable multifunctional ,manipulator having multiple axes capable of handling materials, parts, tools, or specialized devices throught variable programmed operations for the performace of a variety of task.

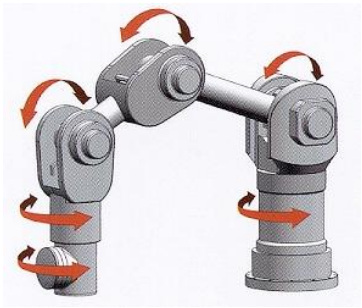
- Automatic - servo controled - mutifuctional-manipulator- mutiple axis (three axes) - handling-task (for example: handling, welding, graindig, cutting, machining, painting)

Industrial Robots

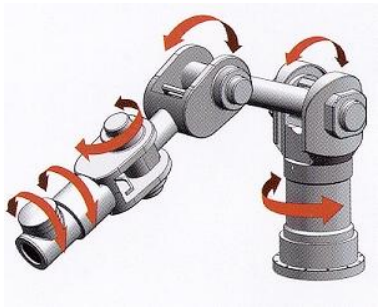
- Manipulator configuration:
- Cartesian –XYZ coordinates- (3 prismatic j.)
- Cylindrical coordinates- (2 prismatic j.+1 revolute j.)
- Polar coordinates- (1 prismatic j.+2 revolute j.)
- Antropomorfic- (3 revolute j.)
- Scara- (3 revolute joints-parallel)



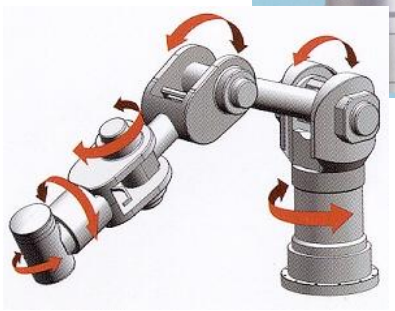
90^0 - Standart



180^0 - Standart



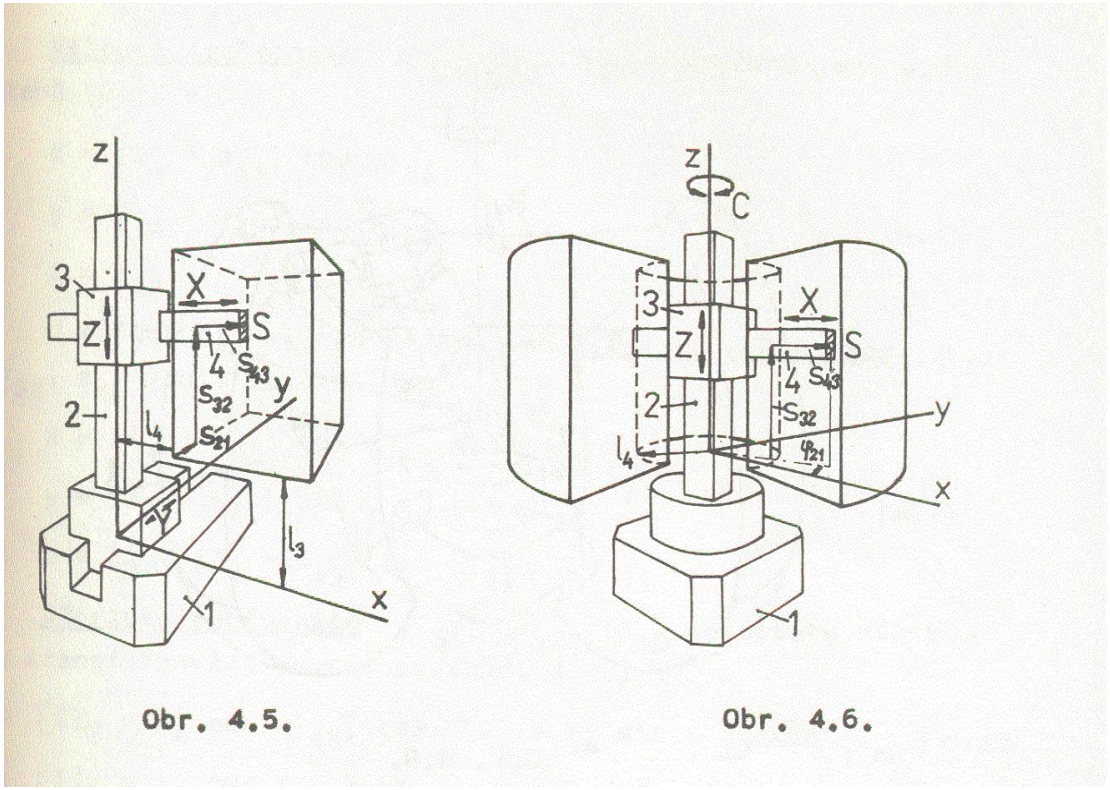
90/180^0 - Special



90/90^0 - Special

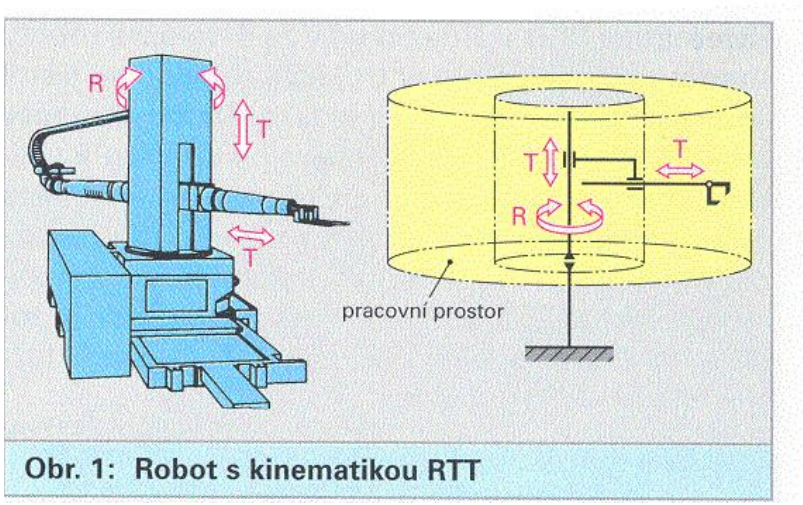
Industrial Robots

- Cartesian coordinates XYZ (fig4.5)
- Cylindrical coordinates (fig4.6)

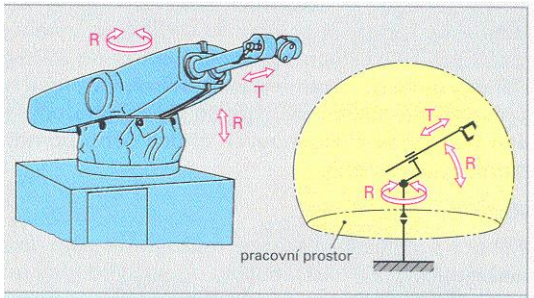


Industrial Robots

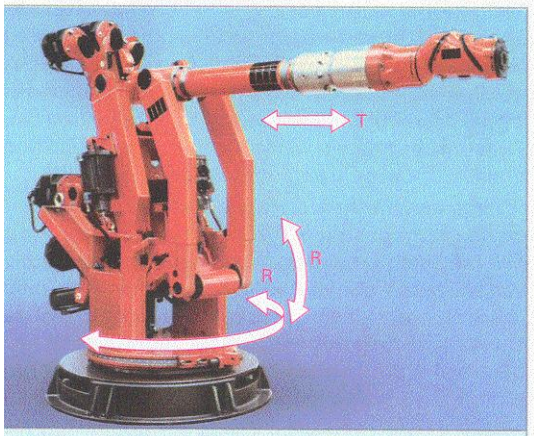
- Polar coordintes >>
- Cylindrical cordinates



Obr. 1: Robot s kinematikou RTT



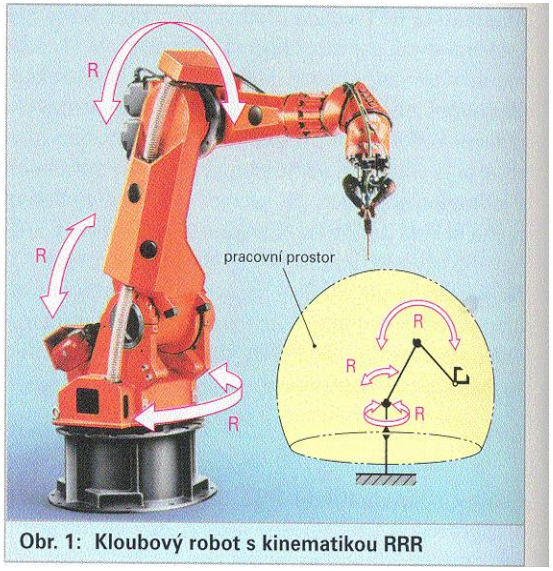
Obr. 2: Robot s kinematikou RRT



Obr. 3: Robot s kinematikou RRT a výsuvným mechanizmem s paralelogramem

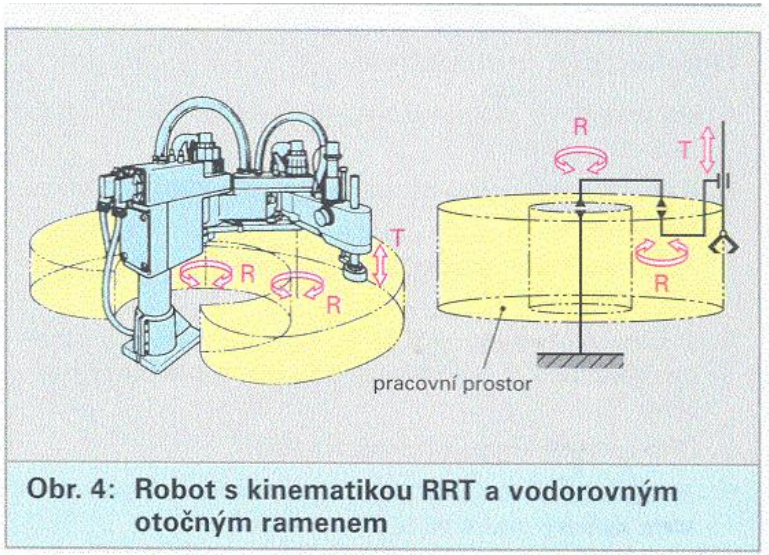
Industrial Robots

- Antropomorfic (jointed arm)



Obr. 1: Kloubový robot s kinematikou RRR

- Scara -(3 revolute joints-parallel)



Obr. 4: Robot s kinematikou RRT a vodorovným otočným ramenem

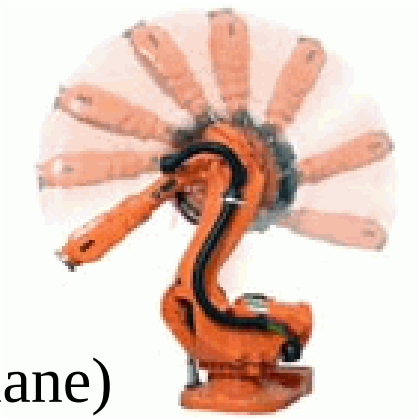
Examples of Control Activity in process of production

- start of machine
- system start up
- control of machine
- task management
- control operation parameters
- optimisation
- diagnostic
- Tele-control of machines

Degree of Automation

1. **Operating of machines**
2. **Automatic regulation**
3. **Automatic control of machines**

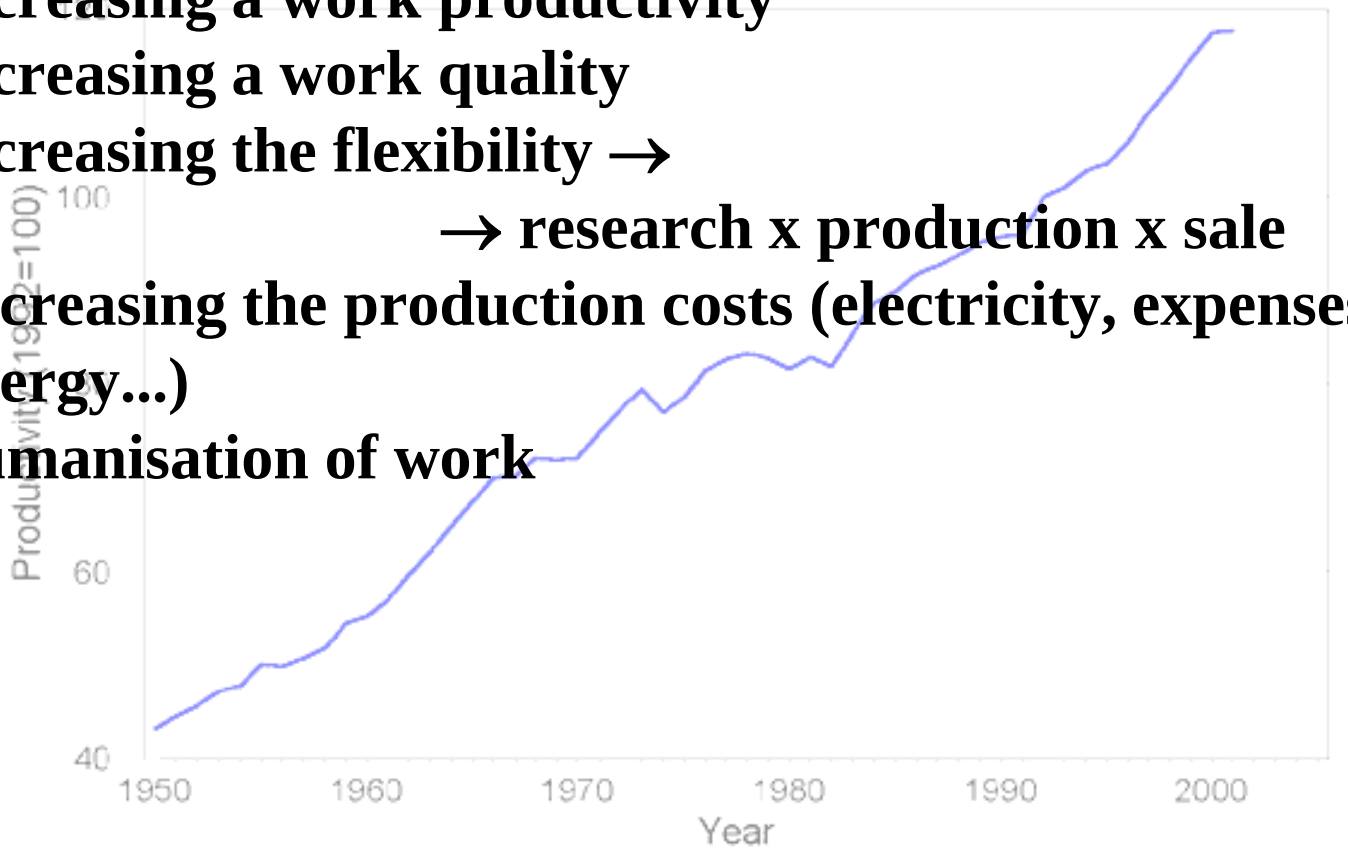
Reasons for Automation



- humanization of a human labour
- elimination of dangerous work of workers
- elimination of workers faults (landing of airplane)
- elimination of an unhealthy work (heat, humidity,chemical industry,radioactivity...)
- machine automation can obtain higher quality of production (car painting)
- robots can perform a very difficult activity (assemblimg)
- workers are not able to work as fast for some operations (parts of computers)
- workers are not able to do as much work (operators in modern telecom net)

Aims of Automation

- **increasing a work productivity**
- **increasing a work quality**
- **increasing the flexibility →**
  → research x production x sale
- **decreasing the production costs (electricity, expenses, energy...)**
- **humanisation of work**



Aims of Automation
Secondary aims

- **prestige**

- **comfort**
  - **car window lifter**

- **relaxation**
  - **playstation**

- **human ecology**

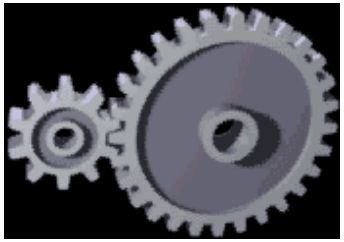
Effectiveness of Automation in Manufacturing Process
Sewing Process

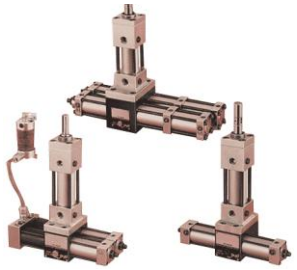
1. changes in particular technologic operations
2. application of new modern materials
3. change of product design
4. application of high efficiency machines
5. improvement of logistic and transport systems
6. automation of the whole technologic process

For automation in the sewing process the solutions mentioned in points 4 and 5 are mostly used.
Increasing of the sewing machine efficiency depends mainly on an application of modern drivers at sewing machines.

Motion Units

- **The most important for automation is an energy transfer.**
- **In a motion system we recognize these motion units:**
  - mechanical
  - electric
  - pneumatic
  - hydraulic

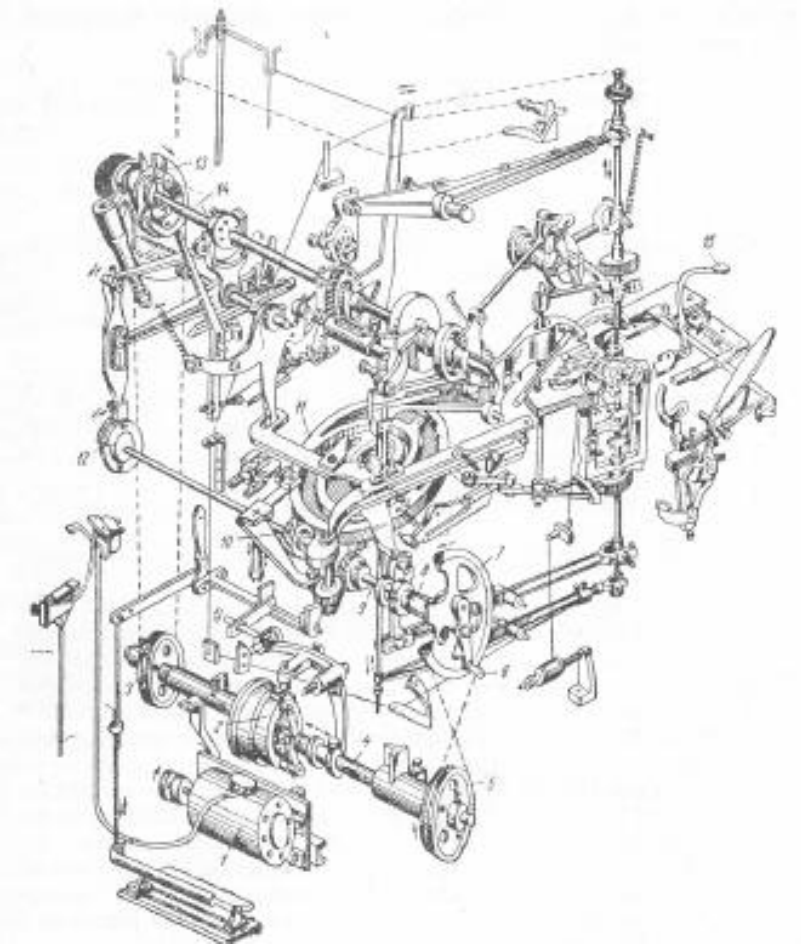




Mechanical Motion Units

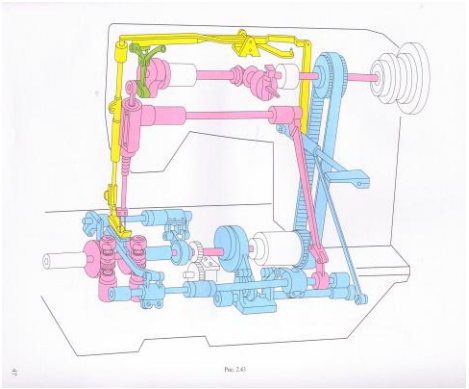
- **mechanical motion units**

  consist of:
  - Gear sets
  - Disk cams
  - Levers
  - Connecting rod
  - Clutches
  - Cams, crankshafts
  - Chains
  - next mechanical parts



Mechanical Gears and Control

- the oldest type



- advantages
  - cheap
  - exact
  - high-speed
  - reliable
- disadvantages
  - special-purpose (not flexible)
  - more complex motion → complicated mechanisms

Only the most common types of motion units – electric, pneumatic and hydraulic – are compared in the following table.

Comparison of signals properties for power transmission

Criterion/ signal	pneumatic	hydraulic	electric
Force at linear motion	forces are limited by the lowest pressure and S of piston by about 35-40 kN, in idle state without any consumption	in consequence of high pressures (an order of tens MPa) high forces are possible	poor efficiency, it is impossible to overload, big energy consumption also within an idle state, small forces
Force at rotation	full torque moment also in idle state, without energy consumption in an idle state	full moment also in idle state, but the biggest consumption in this state	small starting torque
Linear motion	simple realization, big acceleration, high speed (about 2 m/s)	simple realization, big controllability	complicated and expensive - mechanic transfer, at short stroke by el. magnet, for small forces linear motor

Comparison of signals properties for power transmission

Criterion / signal	pneumatic	hydraulic	electric
Rocking or rotary motion	rotary motion also at very high speed (5x10-4 min-1), significant operating expenses, noisy, poor efficiency, rocking motion directly or within a gear	rocking and rotary motion, lower speed of motion than pneumatics, good efficiency	better efficiency at rotary drives, rotary motion within a gear, limited speed
Controllability	simple force controllability by a pressure change (regulators of pressure), and simple speed controllability by change of flow in upper parts of speed range (rapid aerating valve, choking), speed partly depends on the load	very well force and speed controllability, small speeds are well adjustable (incompressible medium)	only at limited range and by significant expenses

Comparison of signals properties for power transmission

Criterion/ signal	pneumatic	hydraulic	electric
Reach of transmission	maximum 1000 m (with a distance a transmission time is increasing)	up to about 100 m (beats, with distance inertial forces are increasing)	unlimited
Price of energy	high in comparison with electricity, dependent on a technical state of a mechanism and intensity of utilization	high in comparison with electricity	the lowest price
Overload	overloadable without consequences	overloadable without consequences	it is impossible to overload, only by significant expenses

Comparison of signals properties for power transmission

Criterion/ signal	pneumatic	hydraulic	electric
Size / efficiency / weight	small / middle / small	small / very big / small	big / small / big
Ecology	noisy outlets (silencers), if the air is oiled, also pollution of the environment (unsuitable in pharmacy etc.)	at high pressure noisy pump, environment is polluted by a medium leaking through untightness	noisy contactors and electromagnets

Electric drivers

- Electric drivers are the most modern and efficient kind of driving mechanism
- Last model of BMW car has 700 electric drivers

- **Basic properties:**
  - **Speed** — **0-5000 rpm**
  - **Shaft torque** — **Mn = 0,05 – 25 Nm**
  - **Overloading of torque** — **Mn = 5 – 7 DC motors**; **Mn = 2 – 2,5 AC motors**
  - **Range of power** — **Pn = 0,01 – 7,5 kW**
  - **Electric brake time** — **τ_R < 0,1 s**
  - **Max of reversation** — **2500 h^{-1}**
  - **Max of acceleration** — **ε – till $10^4 s^{-2}$**

Electric drivers

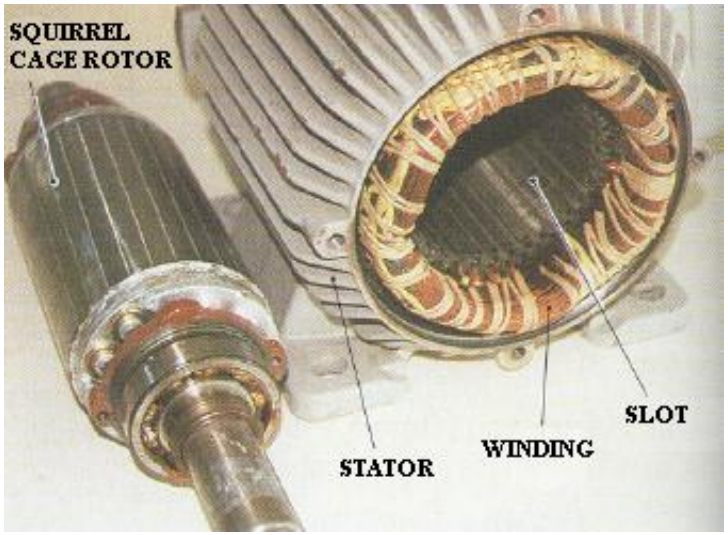
- **DC motors, AC motors, Step motors**
- **For sewing machines are used**
  - **AC motors drivers**
  - **AC brushless drivers**
  - **DC motors drives**

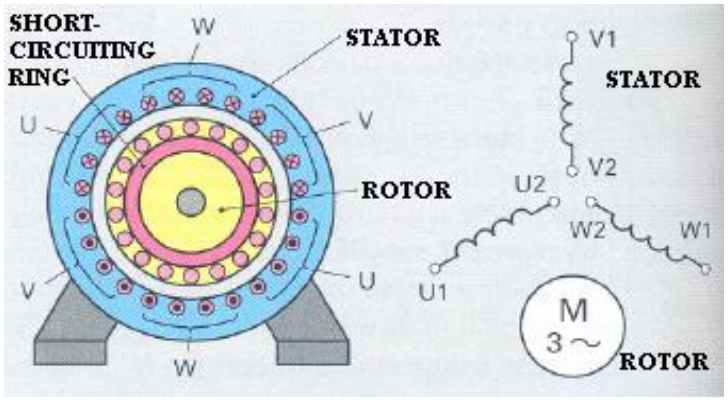
Classic AC three-phase motor

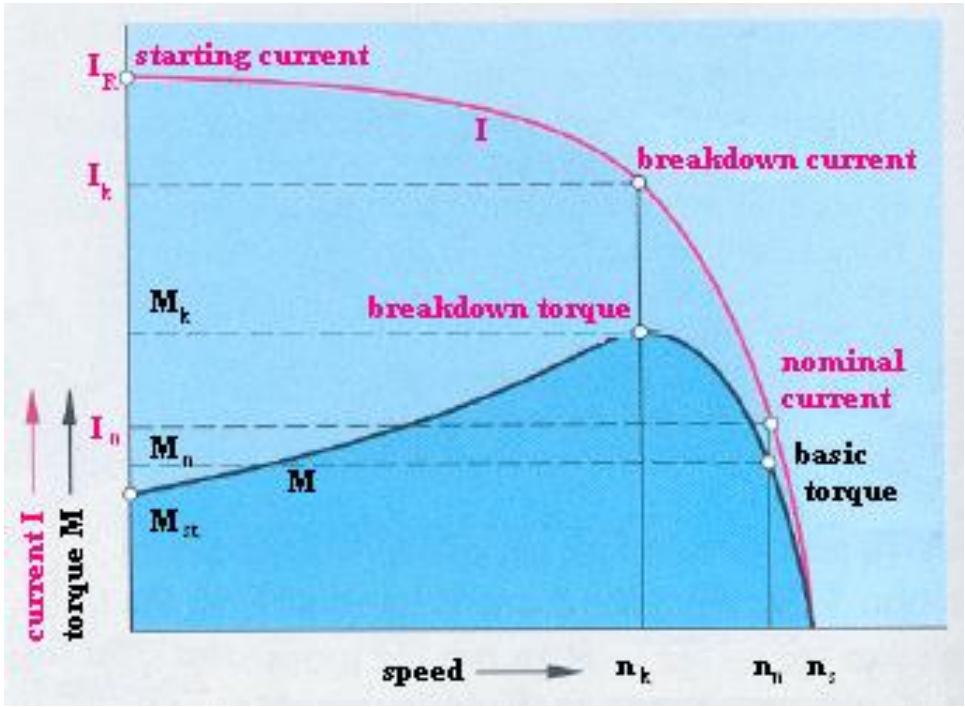
- This type of motor has been used as driver for all sewing machines.

This motor is used for each simple sewing machine, speed is controlled through an interaction between a slip clutch and a full speed driving wheel, but the clutch runs with relatively slow controls responses and its performance depends on its quality.

Classic AC three-phase motor

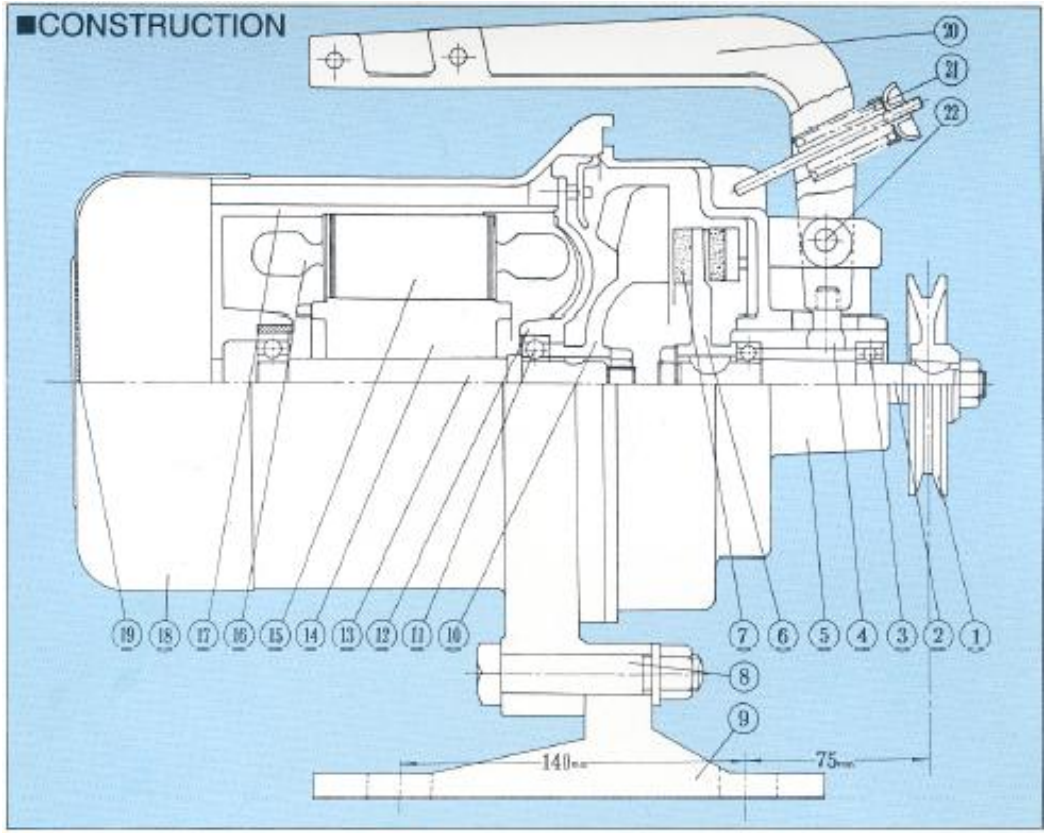






Classic AC three-phase motor

- This motor is very simple but, speed regulation is a problem and is still provided with coupling. It is not possible to stop exactly at a desired position

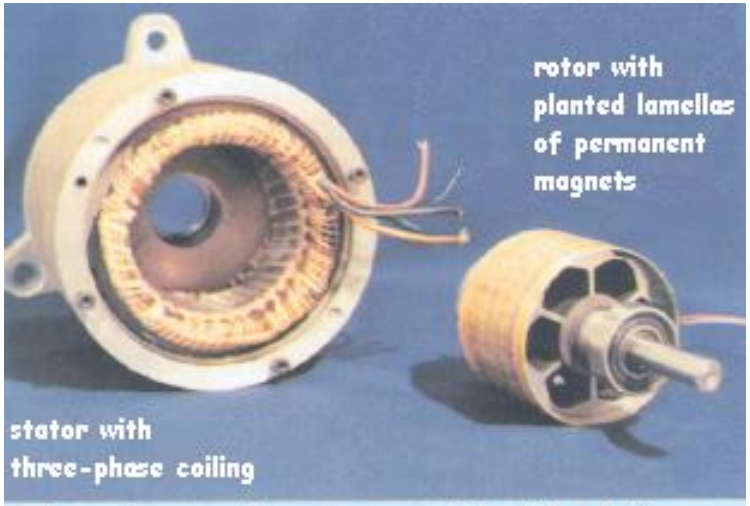


1	Pulley	2	Clutch shaft	3	Rubber washer		
4	Clutch lever	5	Pulley Side end bracket	6	Mounting base for Clutch plate		
7	Clutch ring	8	Stop ring	9	Side base		
10	Fly wheel	11	Ball bearing (6203)	12	Center bracket		
13	Rotor	14	Clutch shaft	15	Stator		
16	Polyester enamelled wire	17	Frame	18	End cover		
19	Nets anti-dust	20	Handle	21	Spring	22	Pin

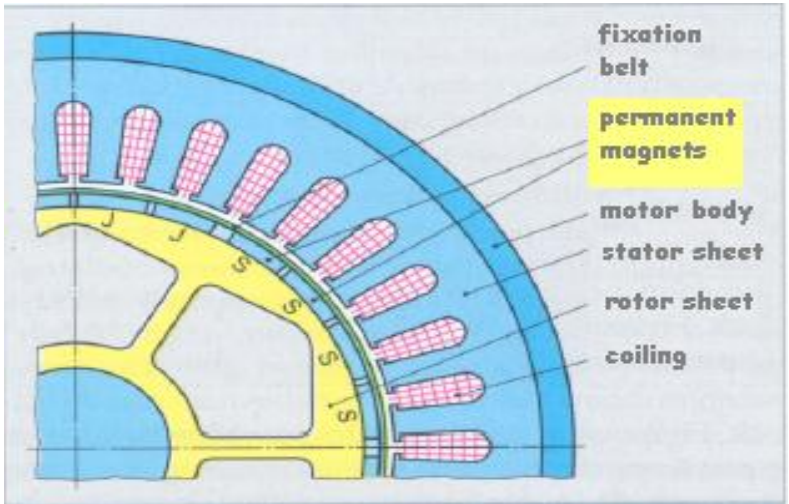
Modern 3-phase Motors With Permanent Magnet

- The most modern AC with permanent magnet armature → brushless motor
- used for the most recent sewing machines
- allow to perform many automatic additional functions
- able to stop exactly at a desired position
- stop-motor

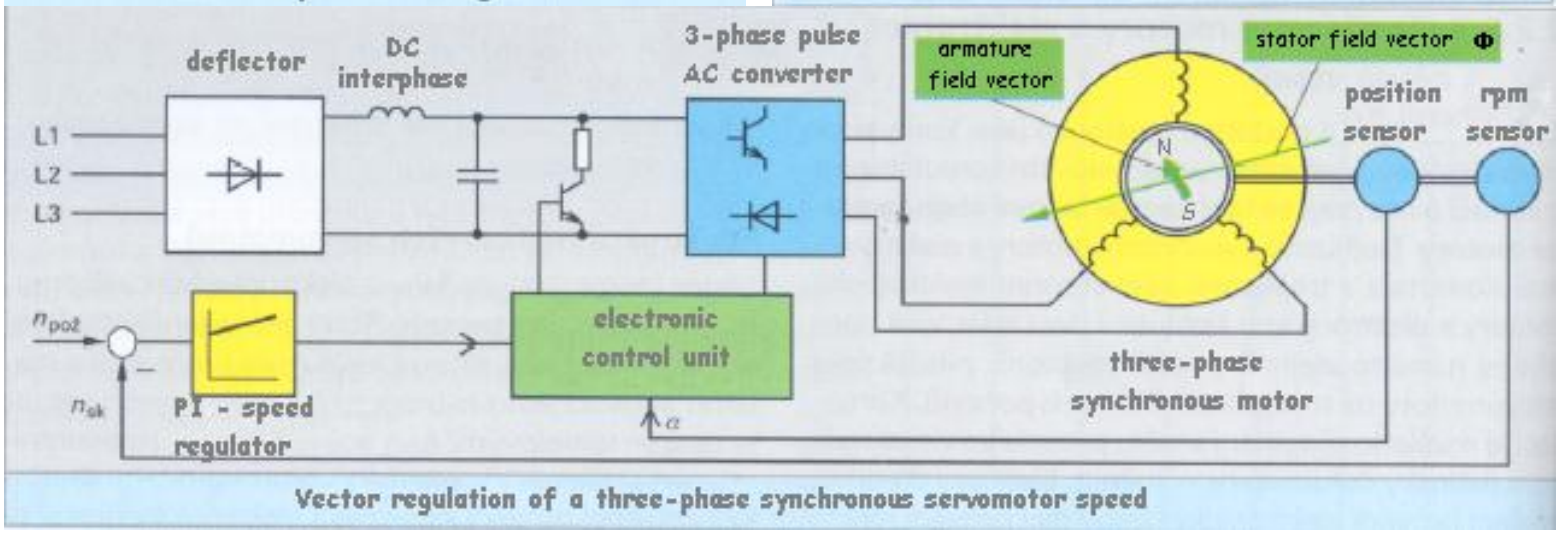
AC Motor With Permanent Magnet



Three-phase synchronous servomotor with a hollow rotor with permanent magnets



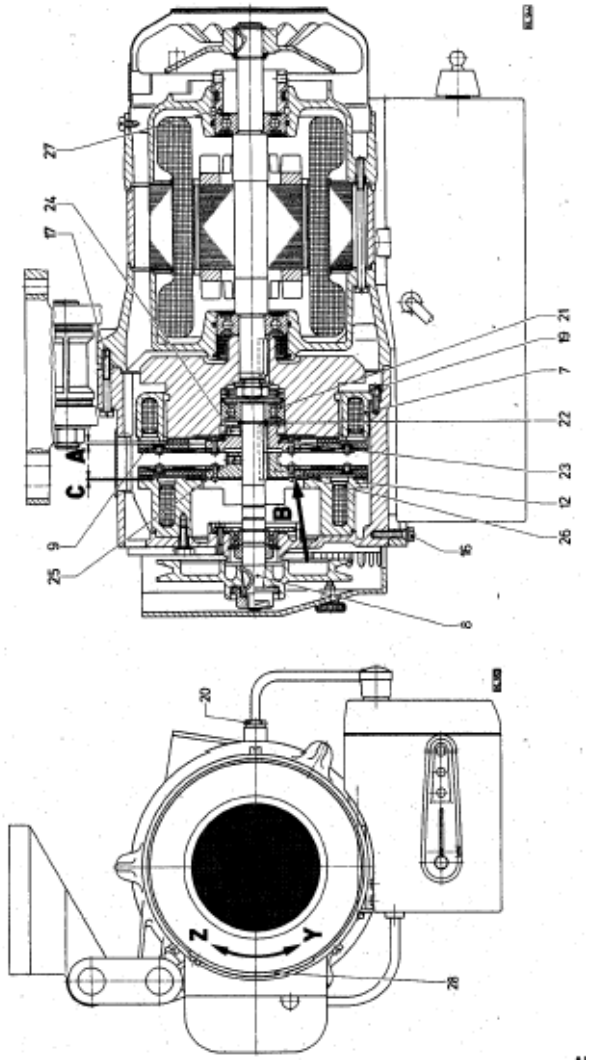
Three-phase servomotor with permanent magnets



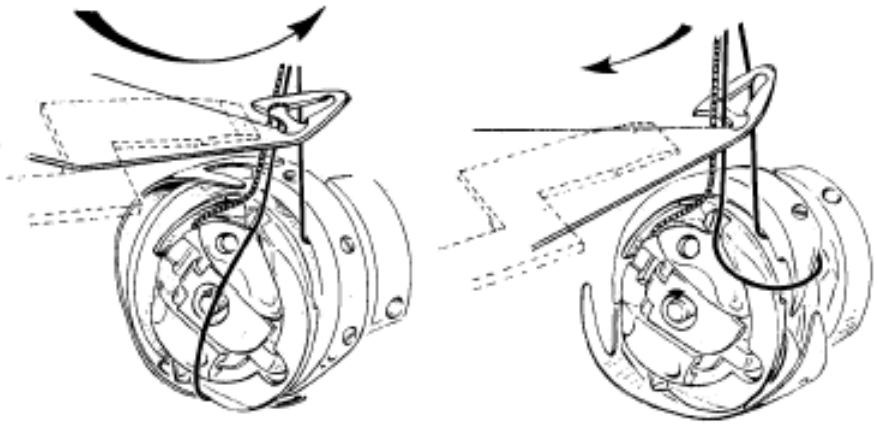
Vector regulation of a three-phase synchronous servomotor speed

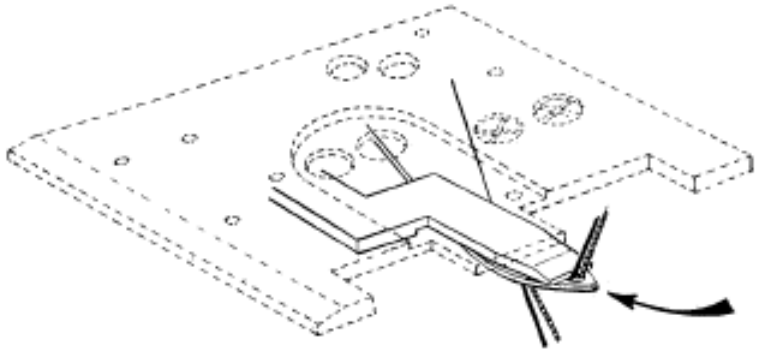
Classic Electronic Motor – Stop Motor

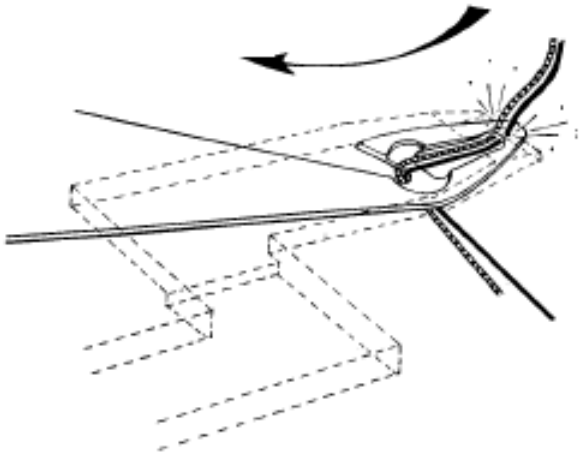
Electronic motors, which use non contact clutches, still need controlling of coupling forces between the two non contact clutches to transmit the kinetic energy of motor's main shaft to the sewing machine's main shaft. There is some fluctuation of speed stabilisation, mainly, when the sewing machine runs at a low speed (during the thread cutting process).



This motor can for example realize a thread trimmer

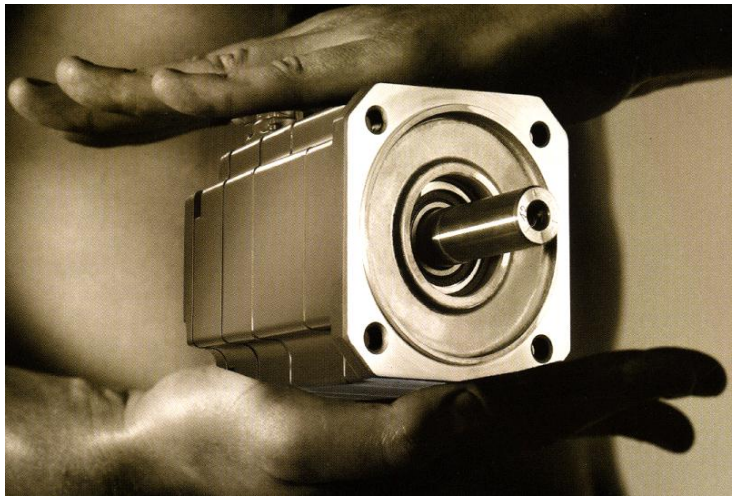






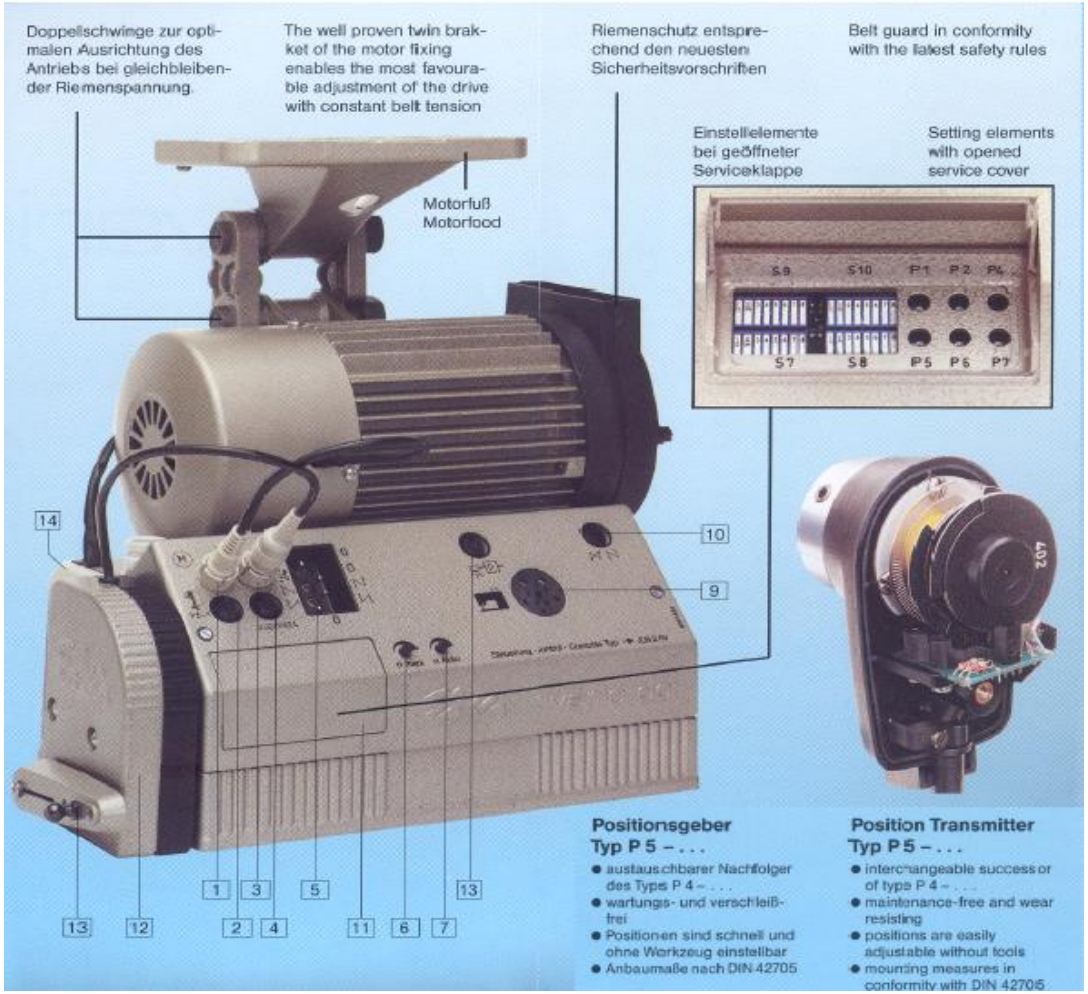
Technical Parameters
AC drive

torque	**5 Nm**
max torque	**10 Nm**
speed	**0 ÷ 6.000 rpm**
acceleration	**3.500 1/s²**
power	**0,8 kW**



Due to servomotor controller's accurate torque control with directly digital control on both speed and position, sewing machine's torque control , speed control (high speed or low speed sewing) and position control (like needle positioning) can be transmitted to its main shaft directly through the motor shaft, with performance, response rate and stability better than those of servomotor with the high performance rate earth permanent magnetic material.

Vario DC Motor



This Motor Allows:

- **automatic number of stitches + back tack**
- **small size of motor → placement in a head of the sewing machine** [Brother]

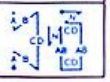
Possibilities of Servomotors

- **thread trimmer (rest thread 2 – 2,5 mm)**
- **presser food lifter**
- **thread wiper**
- **back tack stitch**
- **number of stitches**
- **thread release**

Extra Automatic Equipment

- **thread break detector**
- **needle cooler**
- **automatic bobbin changer**
- **needle thread monitor**
- **bobbin thread monitor**

Machine control specifications

• Version / • Function	• Version / • Funktion	• Version / • Fonction	• Versión / • Función	EC-321	EC-221	EC-121	EC-21
Automatic thread trimmer	Automatischer Fadenabschneider	Coupe-fil automatique	Cortahiros automático	√	√	√	√
Wiper	Fadenwischer	Tire-fil	Retrirahilos	√	√	√	√
One touch type reverse feed	Schnellschalt-Rückwärtstransport	Entraînement reversible à simple commande	Inversor de puntada por pulsador	√	√	√	√
Auto-lifter	Auto-Lifter	Releveur automatique	Elevación automática	√	√	√	√
Sewing speed control	Nähgeschwindig-keitsregler	Commande de vitesse de couture	Control de la velocidad de cosido	√	√	√	√
Needle up	Nadel hoch	Remontée d'aiguille	Aguja arriba	√	√	√	√
Soft-start	Soft-Start	Départ en douceur	Arranque suave	√	√	√	√
Manual count-down control	Manueller Rückwärtszählregler	Commande de comptage à rebours manuel	Control manual de inversión puntada	√	√	√	√
Reverse feed stitch for start/end	Rückwärtsstiche am Anfang/Ende	Points arrière pour début/fin de couture	Remates al comienzo y al final	√	√	√	
Continuous reverse feed stitch	Fortlaufendes Rückwärtsnähen	Point arrière continus	Inversor de puntada continuo	√	√		
Pattern sewing	Musternähen	Exécution de configurations	Cosido de patrones	*			
Program pattern memory	Programm-Muster-speicher	Mémoire de configura-tions programmées	Memoria de costuras programadas	√			
Setting for needle up/down stop	Einstellung für Nadel-hoch/tief-Stopp	Programmation pour arrêt avec aiguille en haut/bas	Mando aguja arriba/ abajo	√			

* Programmable within 15 steps
* Bis zu 15 Schritte programmierbar
* Programmable en 15 étapes
* Programmable hasta 15 pasos

Direct Drive Mechanism

Drive Placement
Built-in Motor System

Low noise and low vibration

Integration of the motor and the machine head and the adoption of a timing belt make sewing machine operation much quieter and reduce machine vibration.

An Example of an Automated Workplace for Pockets Sewing

Examples of Automation Applications

- This kind of servo-control drive for sewing machine and modern pneumatic drive with computer control system allow to do automatic production of many operations and goods. For example:
  - **Belt - Robots, car seats**
  - **Labeling - Automation,**
  - **Velcro - Automation (company RSG).**
  - **Different form pockets, automatic serging of front and hind trousers, serging of long workpieces trousers, sewing flaps, waistband, sewing for attaching the trousers bottom binding….**

Automatic Manipulation of Fabric In Garment Industry

= handling operations in sewing process must be as short as possible

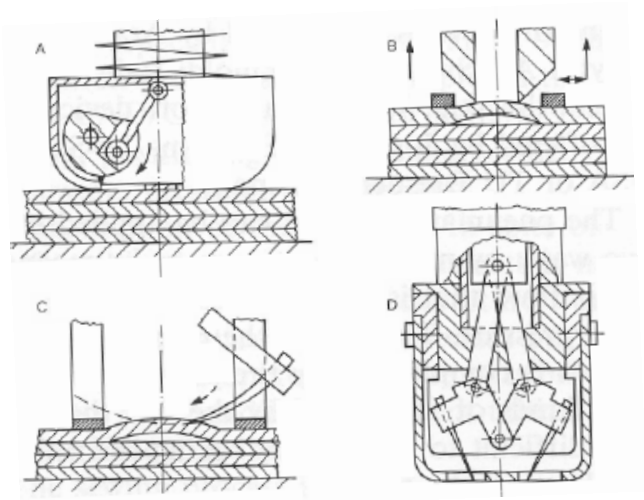
⇒ Therefor it is important to automate fabric handling by means of handling equipment with special picking heads (effector)

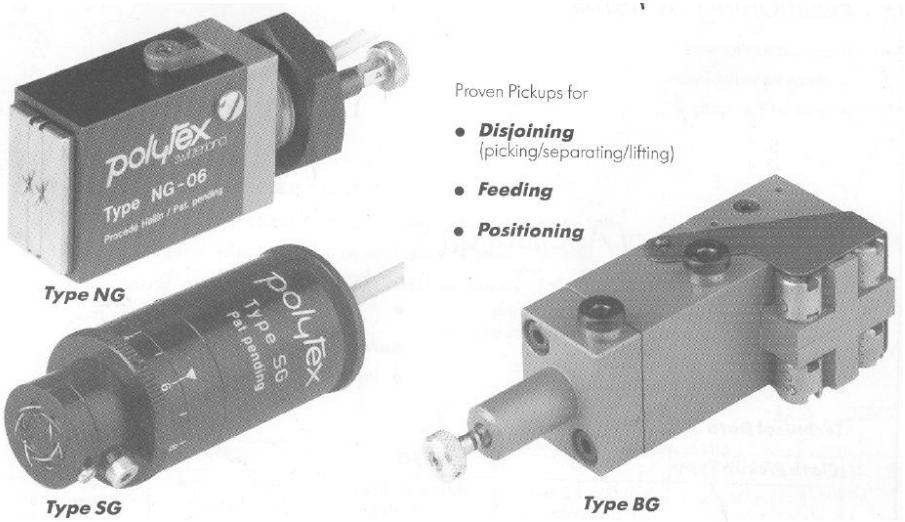
- fabrics have bad properties from view of handling
  - fabrics thickness
  - low stiffness
  - permeability
  - elasticity
  - adhesive forces between fabrics sheets

Picking Heads

Picking heads for textile fabrics can be divided to:

- mechanical – needles
- pneumatic – suction pods
- adhesive – adhesive belts
- electrostatic – (do not apply)
- friction – roller

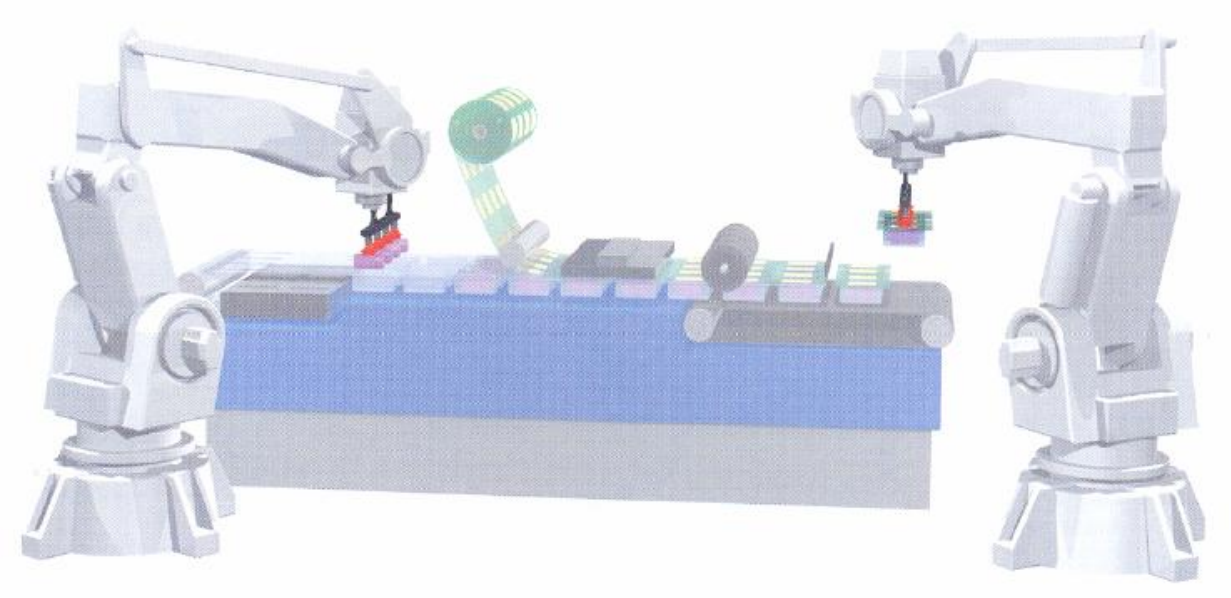




For real application the best and the most reliable material picking was realized within a mechanical picking gripper, so called “cat-claw”

Textile faculty, Department of clothing tested the reliability of cat-claws and for many fabrics with good results.

For many textile fabrics it is possible to use a pneumatic pick up effectors. The air permeability is not so important. The problem of the reliable picking is mainly separating layers of textile fabrics.



Pneumatic effectors-vacuum

- Very sipmle application
- Active effectors - it is possible to control the force
- Passive effectors - it has a steady force for handling
- Source of suction : 1/Vacum pumps (- expensive)
- Source of suction: 2/Ejectors- active end effectors, simple control, single or group applications.Application: glass,metal sheets,wooden tables,textile
- Basic principal ejector is flow of the preassured air trhough the ejector

Pneumatic effectors-vacume

- Shorter response time
- Lower energy cost
- Higher operation reliability
- Many of the cups are available in a version where the body and the sealing surface are of different hardness . This gives the cup both strength and stability as well as flexibility to adapt itself to uneven surfaces.
- For increased stability and for the flexibility to handle objects that are hard to grip with vacuum, a stabilizer should be used.The Stabilizer reduces the need for using many suction cups for safe and stable lifting.
- Dual-hardness cups are ideally suited for applications where micro-leakage can occur, for example when a suction cup does not properly conform to a handled material, such as corrugated cardboard.

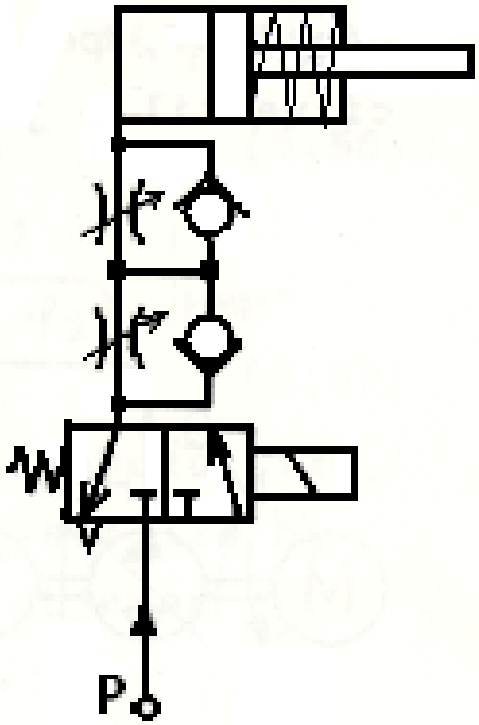
Pneumatic Drive
Basic mean for automation of sewing machine

- Properties of pneumatic drives
  - Speed: 8 m/s (common speed 2-3 m/s)
  - Air pressure: 1,6 MPa (defines a force $F = S.p$)
  - Power < 1kW

- **Advantages**
  - **High speed (thread trimming)**
  - **Direct motion**
  - **Simple design**
  - **Reliability**
  - **No fire risk**
  - **No backward conduction of air**

- **Disadvantages**
  - **Difficult control of speed, mainly slow speed**
  - **Small force**
  - **Softness caused by compressivity of air**
  - **Expensive energy**

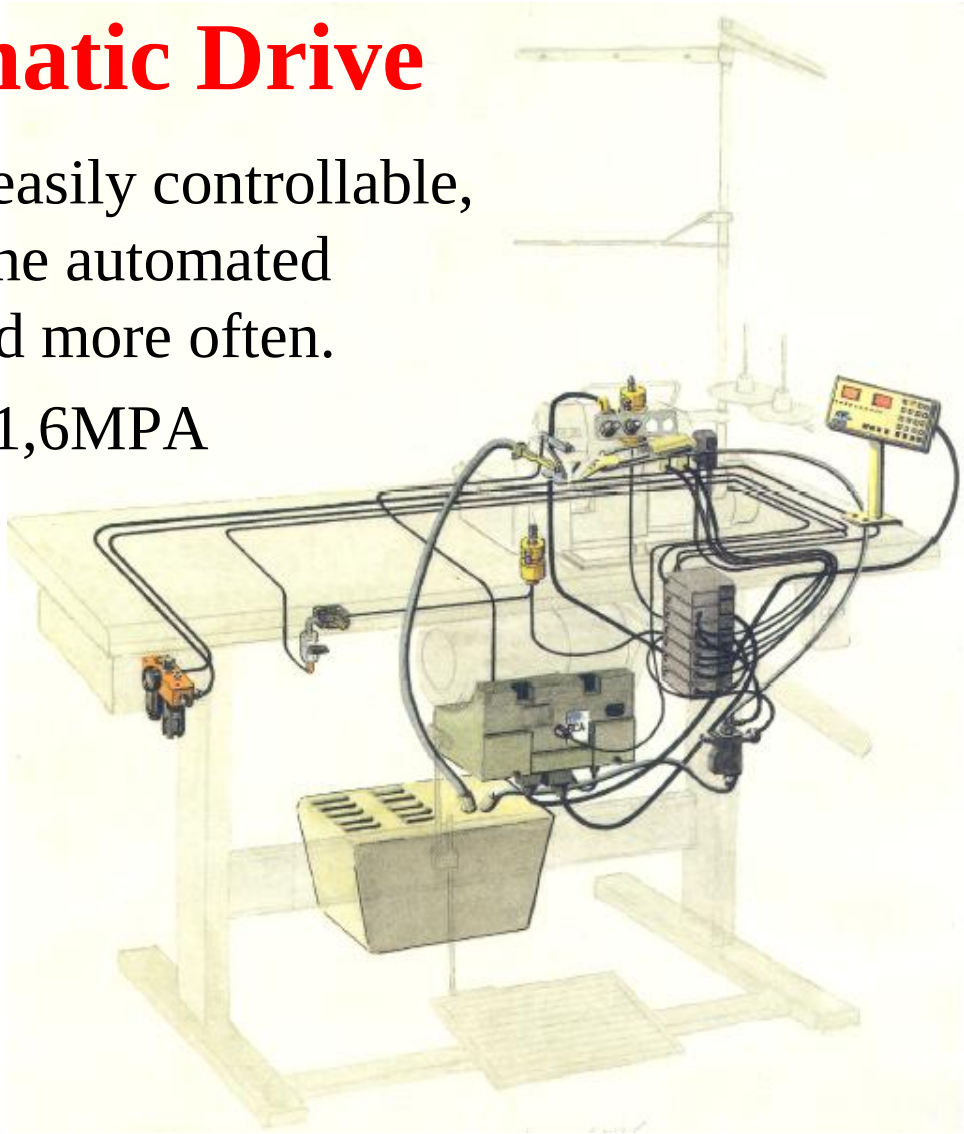
Example of a Simple Pneumatic Drive



Pneumatic Drive

- Pneumatic drives are very easily controllable, therefore they are used in the automated sewing operations more and more often.
- Speed max 8m/s, pressure 1,6MPA
- Simple realization

  linear motion



Real possiblites of automation applications

1. training of workers (ergonomic of working place)
2. better utilization of machine, (thread trimmer,back- tack stitch, number of stitches ..) applications of logistic (transport of cut pieces in sewing process)
3. changes in particular technologic operations (bonding of zips)
4. application of high efficiency machines (labeling, buttons automat, pocket automat….)
5. improvement of logistic and transport systems (coveyors, special truks)
6. automation of the whole technologic process (big order or one type of production – shirt, T-shirts, throusers..)

Next possibility of automation is an improvement of logistic and transport system.

In clothing industry transport and material handling is a great deal of the whole technological process. Scientific branch called *logistic* deals with optimization of transport and material handling, transport of energy and transport of information.

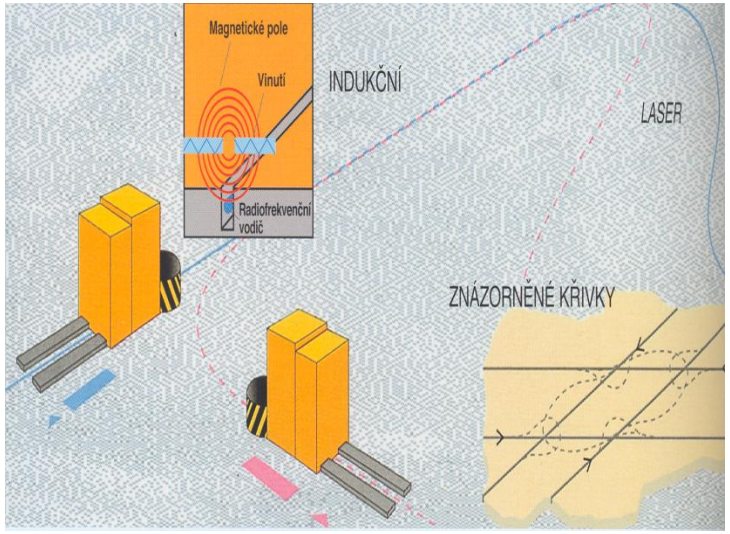
In production process there must be material + energy + information at the right time in the right place. Time is a very important factor.

At EU approximately 40% of workers deal with handling and transport of material in production. This time is, of course, non-production time. Application of logistic rules is important for: Improving of productivity,

- Reduced – through put time,
- Allowing true quick response to market demands,
- Improving quality control.

Transport systems

- Tables
- Chute
- Trolley
- Conveyor belt
- Automatic trolley
- Coveyor hanging system

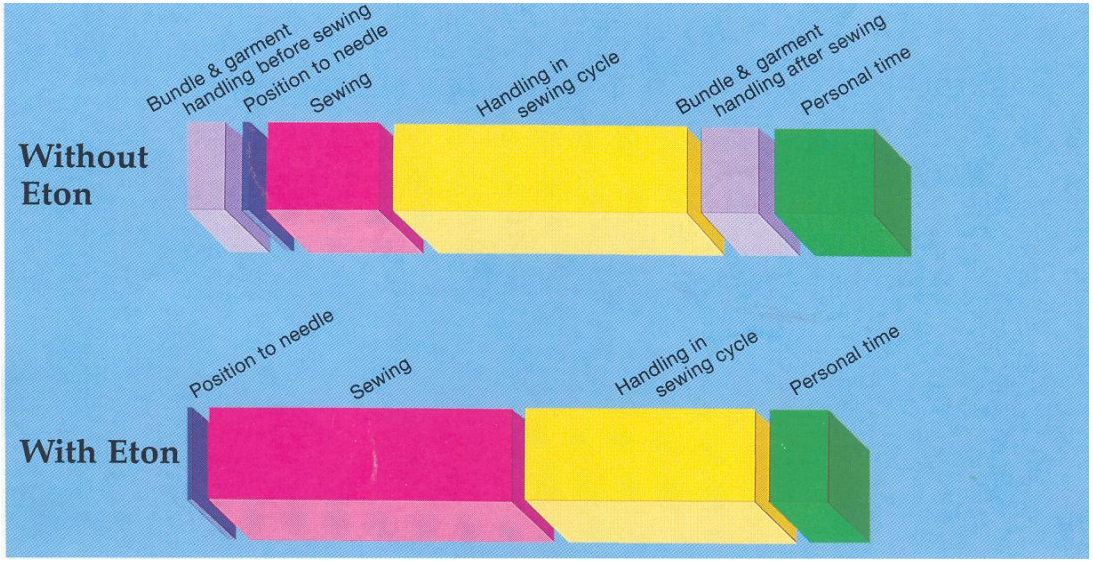


Transport –hanger conveyor

- It is main capability of automaticly delivering a piece of cloth to a target work station according to a planned work flow schedule.
- Not only physically moves products, but it also serves as a very sophysticted process control tool for management.
- Special software can plan the daily production target, the system will indicate the number of labor involved.

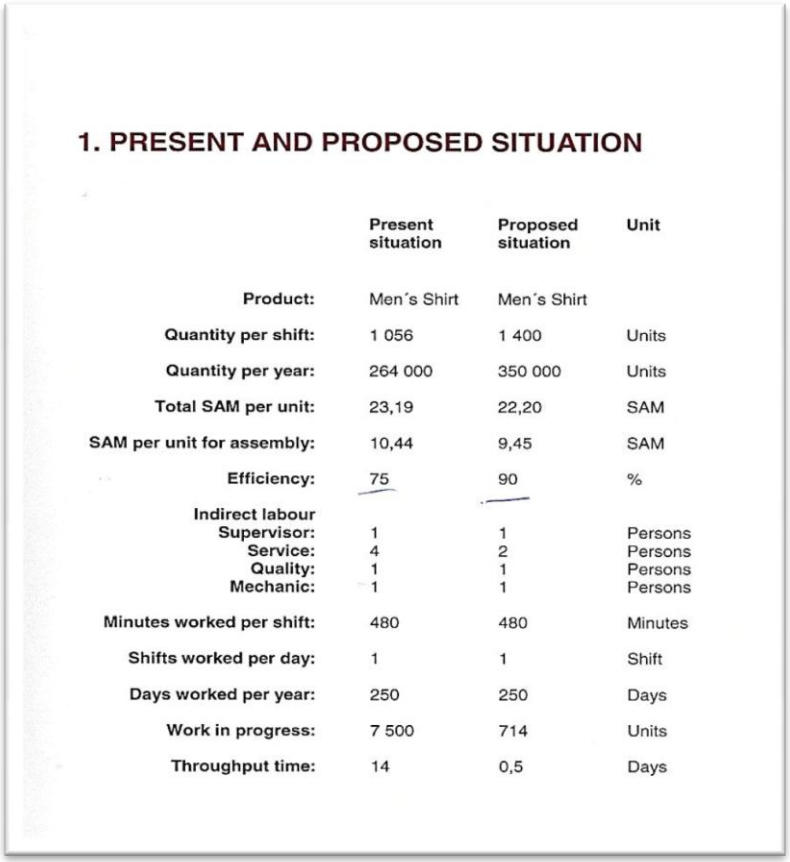
Transport –hanger conveyor

There are many transport systems and means in garment industry. One of the best hanging conveyors : Eton.



Transport –hanger conveyor

- Benefits:
- Improved productivity
- Saves floor space
- Reduces throughput-time
- Monitors order status
- Provides ideal ergonomic conditions
- Reduces direct and indirect costs



1. PRESENT AND PROPOSED SITUATION

	Present situation	Proposed situation	Unit
Product:	Men´s Shirt	Men´s Shirt	
Quantity per shift:	1 056	1 400	Units
Quantity per year:	264 000	350 000	Units
Total SAM per unit:	23,19	22,20	SAM
SAM per unit for assembly:	10,44	9,45	SAM
Efficiency:	75	90	%
Indirect labour			
Supervisor:	1	1	Persons
Service:	4	2	Persons
Quality:	1	1	Persons
Mechanic:	1	1	Persons
Minutes worked per shift:	480	480	Minutes
Shifts worked per day:	1	1	Shift
Days worked per year:	250	250	Days
Work in progress:	7 500	714	Units
Throughput time:	14	0,5	Days

Thank you for your attention