3. How might Acceptance sampling conflict with the goals of "World-class" operations.

Besides all listed in para 2 above preferences and advantages in adopting the acceptance sampling method in practice for many companies and organizations (industry, trade, transport, etc.), the method also features several disadvantages. These might, in particular situations, make it unsuitable or completely unfit to use. Inherent disadvantages of AS are:

- There are certain risks of accepting defective lots and rejecting good lots.
- More time and effort is devoted to planning and documentation.
- Less information is usually provided about the product

If we consider, for example some specialized and high-tech manufacturing processes, space and aviation, aerospace industry, microelectronics and all applications where requirements and responsibilities for defective components and products are much higher, AS is not an applicable method. In such applications very strict 100% inspection is usually performed on each individual component, parameter or event. For an aircraft engine, for example, the quality of component parts, parameters, assembly and functioning must be checked more than a single time. In some cases, multiple inspections and tests have to be carried out to prove the required quality and fitness for the purpose. Also, in the production of bearings, the production of balls, rollers, bearing rings involves 100% automated control and ranking in size and class. The same inspection is also involved in the production of a number of elements for the electronics – integrated circuit boards, chips, standard electronic component, etc.

Question 7: A cutting test on a steel bar

a)

i. A cutting test on a steel bar was performed and the following values were noted;

Fc – shear force = 680 N

Ft – thrust force = 380 N

R - resultant force (N)

Fs – shear force on shear plane (N)

F – friction force along rake face (N)

N- normal force to rake face (N)

ϕ - shear angle = 20 °

α- rake angle = 10 °

τ- mean friction angle (degree)

Draw a force diagram, to scale, to show the graphical relationship between these parameters.

ii. For this test the following values were noted;

w- width of cut = 3.5 mm

t1- undeformed chip thickness = 0.21 mm

t2 – deformed chip thickness = 0.60 mm

Determine R, τ, F, Fs, cutting ratio, the apparent coefficient of friction μ between tool and the chip, and the apparent shear stress τs of the cut material.

ii. For this test the following values were noted;

w- width of cut = 3.5 mm

t1- undeformed chip thickness = 0.21 mm

t2 – deformed chip thickness = 0.60 mm

Determine R, τ, F, Fs, cutting ratio, the apparent coefficient of friction μ between tool and the chip, and the apparent shear stress τs of the cut material.

iii. For this test the cutting speed was 1 m/s, and the mass flow rate = 3.5 g/s.

Specific heat capacity of the work material was C = 500 J/kg°C.

Determine the temperature θs at the shear plane assuming 90% of head is transported with the chip and the original work material temperature was

θo = 20°C. The velocity along the shear plane is given by;

$$V_s = \frac{V_c}{\cos(\phi - \alpha)}(\cos \alpha)$$

surface toughness and reducing cohesion between particles thus facilitating fracture. Friction forces decrease as a result of this action of the coolant.

Coolant	Shear Force, %
Operation without liquid	100
Mineral water	97
Emulsion	90
Mineral oil	85
Vegetable oil	75

Improvement through steam generation

Method	Cutting speed, %
No cooling operation	100
Usual cooling	125
Steam generation cooling	143

Question 8: Electro-discharge machining (EDM) requirements & properties

a)

i. **Explain why for Electro-discharge machining (EDM) a servomechanism and is essential to the control of the feed.**

ii. **Explain the requirements and properties of the EDM dielectric fluid**

b)

i. **An electrochemical machining (ECM) process, using a 9mm x 9 mm square tool, is applied to a zinc workpiece. A feedrate of 0.5 mm/s is required. Determine an expression for the volumetric removal rate w (mm^3/s) and hence the current setting I (A) needed. The density of zinc is $\rho = 7.13 \times 10^{-3}$ g mm^{-3} and the process has a current efficiency of 90%. Would a machine rated at 1.4 kA be sufficient for the job?**

Assume that m = e.I.t where;

m = mass of material removed (g)

e = electrochemical equivalent of zinc = 0.34×10^{-3} g/As

I = current (A)

t = time during which current is applied (s)

ii. **List the advantages and disadvantages claimed for ECM**

Question 9: Hard and soft automation

a) i. Distinguish between "hard" and "soft" automation.
ii. List some of the advantages claimed for mechanical automation in manufacturing.

b) Automatic control systems in CNC are often called servomechanisms. Explain what they are and what their purpose is. Your answer should include mention of open and closed loop systems, transducers and servomotors.

c) The end of an industrial robot wrist is usually termed an "end effector". List tools and devices, which end effectors, are commonly equipped with?

a) i. Automation can generally be defined as the process of following a predetermined sequence of operations with little or no human labor, using specialised equipment and devices that perform and control manufacturing processes.

In hard, or fixed-position, automation, the production machines are designed to produce a standardized product, such as engine blocks, valves, gears, or spindles. Although product size and processing parameters (such as speed, feed, and depth of cut) can be changed, these machines are specialised. They lack flexibility and cannot be modified to any significant extent to accommodate products that have different shapes and dimensions. Machines used in hard-automation applications are usually built on the building block, or modular principle. They are generally called transfer machines, and consist of the following two major perform and control manufacturing processes.

In hard, or fixed-position, automation, the production machines are designed to produce a standardized product, such as engine blocks, valves, gears, or spindles. Although product size and processing parameters (such as speed, feed, and depth of cut) can be changed, these machines are specialised. They lack flexibility and cannot be modified to any significant extent to accommodate products that have different shapes and dimensions. Machines used in hard-automation applications are usually built on the building block, or modular principle. They are generally called transfer machines, and consist of the following two major components: powerhead production units and transfer mechanisms. Because these machines are expensive to design and construct, their economic use requires mass production of parts in very large quantities.

It has been stated that hard automation generally involves mass-production machines that lack flexibility. In soft (or flexible) automation, greater flexibility is achieved through computer control of the machine and its various functions using a lot of programs. Soft automation is an important development because the machine can be easily and readily reprogrammed to produce a part that has a different shape or dimensions than the one just produced. Because of this capability, soft automation can produce parts with complex shapes. Advances in flexible automation, with extensive use of modern computers, have led to the development of flexible manufacturing systems with high levels of efficiency and productivity.

ii. Some of the advantages, which are claimed for mechanical automation, are presented below:

ii. Some of the advantages, which are claimed for mechanical automation, are presented below:

- Responsiveness to shorter product life cycles, changing market demand, and global competition.
- Emphasis on product quality and its uniformity through better process control.
- Better use of materials, machinery, and personnel, and reduction of work-in-progress inventory, thus improving productivity and lowering product cost.
- Better control of production, scheduling, and management of the total manufacturing operation, resulting in lower product cost.

- Standardization of process plans, thus improving the productivity of process, reducing lead times, reducing planning costs, and improving the consistency of product quality and reliability.
- Parts can be produced randomly and in batch sizes as small as one and at lower unit cost.
- Direct labor and inventories are reduced, with major savings over conventional systems.

b) Automatic control systems are sometimes called servomechanisms. They may be a complex array of electromechanical components or it may be just a simple mechanical device. These are power units, which control the line of movement of the tool and/ or the work.

An *open loop system* is the simplest form of servomechanism. It is characterised as a system, which lacks feedback i.e. there is no sensing device to confirm the action of the control signal.

A closed loop system is characterised by the presence of feedback. It makes use of an error detector that returns a signal proportional to the difference between input and feedback i.e. error activated and strives to make the error zero.

Typical CNC servomechanisms include the following components:

i) *Transducers* which is defined as any device that senses an output condition and transforms the sensed information into a form that which can be understood by the servo system. A device that outputs a voltage in direct proportion to a measured linear movement is a typical example.

ii) Servomotors, or drives, are devices that convert electrical command signals to mechanical motions. Digital to analogue converters may be required to convert digital commands from the machine control unit to a continuous voltage, which in turn is used as the control signal to the axial drive.

c) In the terminology of robotics, an end effector can be defined as a device which is attached to the robot's wrist to perform a specific task. The task might be work such as handling, spot welding, spray painting, or any of a great variety of other functions. The end effector is the

Grippers are used to hold either workparts or tools. The most common grasp methods used in robot grippers are:

- Mechanical grippers, where friction or the physical configuration of gripper retains the object
- Suction cups (also called vacuum cups), used for flat objects
- Magnetized gripper devices, used for ferrous objects
- Hooks, used to lift parts off conveyors
- Scoops or ladles used for fluids, powders, pellets, or granular substances.

There are a limited number of applications in which a gripper is used to grasp a tool and use it during the work cycle. In most applications where the robot manipulates a tool during the cycle, the tool is fastened directly to the robot wrist and becomes the end effector. A few examples of tools used with robots are the following:

- Spot welding gun
- Arc welding tools (and wire-feed mechanisms)
- Spray painting gun
- Drilling spindle
- Routers, grinders
- Heating torches.

surfaces: properties & applications

a) **Briefly explain the meaning of 'surface integrity' in relation to manufactured surfaces and their properties and applications.**

b) **Engineering parts require varying surface characteristics according to their function. List reasons for these varying requirements.**

c) **A magnified pen recording from a stylus type surface texture measuring instrument shows a pattern approximating to a series of triangles H = 6 mm the horizontal magnifications were x 20 and x 2000 respectively. Determine a relationship between H and Ra and hence the Ra (μm) value. Is this in the normal range for a turned surface? What factors do you think caused this regular pattern to be produced on the work?**

d) **When considering the evaluation of fine manufactured surface using light interference methods, with the aid of a sketch show that the difference in separation between adjacent interference fringes is equal to λ/2 where λ is the wavelength of monochromatic light of an incident ray L_1 .**

a) In manufacturing processes, surfaces and their properties are as least as important as the bulk properties of the materials. Surface integrity describes not only the topological (geometric) aspects of surfaces, but also their mechanical and metallurgical properties and characteristics. Surface integrity is an important consideration in manufacturing operations because it influences the properties of the product, such as its fatigue strength and resistance to corrosion and its service life.

and its service life.

Therefore, surface integrity pertains to properties such as fatigue life and corrosion resistance, which are influenced strongly by the type of surface produced. Factors influencing surface integrity are temperatures generated during processing, residual stresses, metallurgical (phase) transformations, surface plastic deformation, tearing and cracking.

Several defects caused and produced during manufacturing can be also identified. They may be responsible for lack of surface integrity. These defects are usually caused by a combination of factors, such as defects in the original material, the method by which the surface is produced, and lack of control of process parameters that can result in excessive stresses and temperatures.

Question 11: Bored holes - plug and gap gauges

a) A plate cam, 25 mm thick, has a bored hole at its centre of rotation in which a keyway, 5 mm wide and 4 mm deep, is to be broached

i. Given the empirical expression; broach tooth pitch (mm) = 1.77 sqr(bore length), determine, the length of the cutting portion of the broach and the maximum force required to pull it through the hole if the rise per tooth of the broach is 0.09 mm, and the force to remove 1 mm^2 of metal is 2500N.

ii. Explain why knowledge of this force is desirable for manufacturing purposes.

b) The following values are taken BS 4500 and refer to a 'average location' for round hole and shaft of 50 mm nominal diameter. What is meant by a 'nominal' diameter?

Hole H7 +0.025 mm
+0.000 mm

Shaft g6 -0.009 mm
-0.025 mm

Draw a simple diagram representing the hole and on it show, with numerical values;

i. nominal diameter

ii. tolerances

iii. deviations

What kind of fit is achieved?

Sketch suitable plug and gap gauges to check this hole and shaft.

Indicate the GO and NOT go sizes.

a)

i.

$$p = 1.77\sqrt{25} = 1.77 * 5 = 8.85\text{mm}$$

Number of teeth Z= 4/0.09=44.44 -> 45 mm

Length L= p x Z = 398.25 -> 400 mm 8.85 x 45

Number of teeth in contact - z c = H /p = 25/8.85 = 2.82 -> 3

The force F = area x z c x k = (5x0.09)x3x 2500 = 3375 N

ii.

The force F = area x Z c x K = (5x0.09)x3x 2500 = 3375 N

ii.

Knowledge for this force is needed when considering the capabilities of the machine where broaching is going to be carried out.

b)

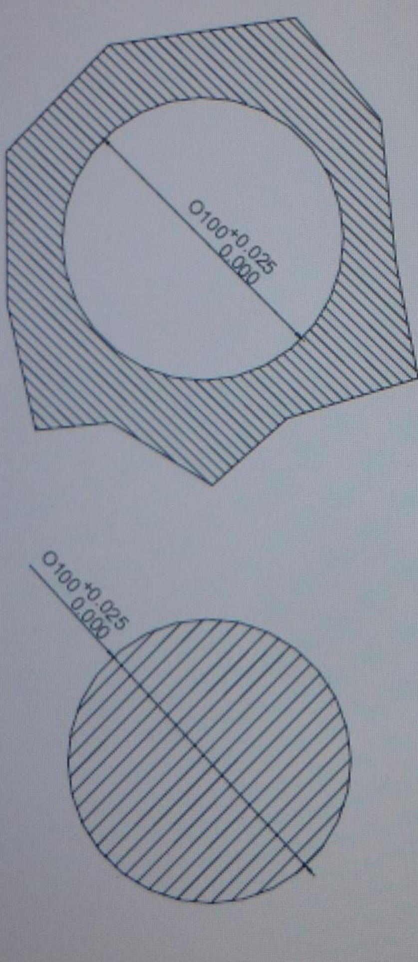
The nominal diameter is the dimension calculated from the static or kinematic strength of the material by considering kinematic and dimensional chains or taking into account other conditions and considerations and rounding them to the closest highest value in the standard.

BS 4500

D = 50 mm

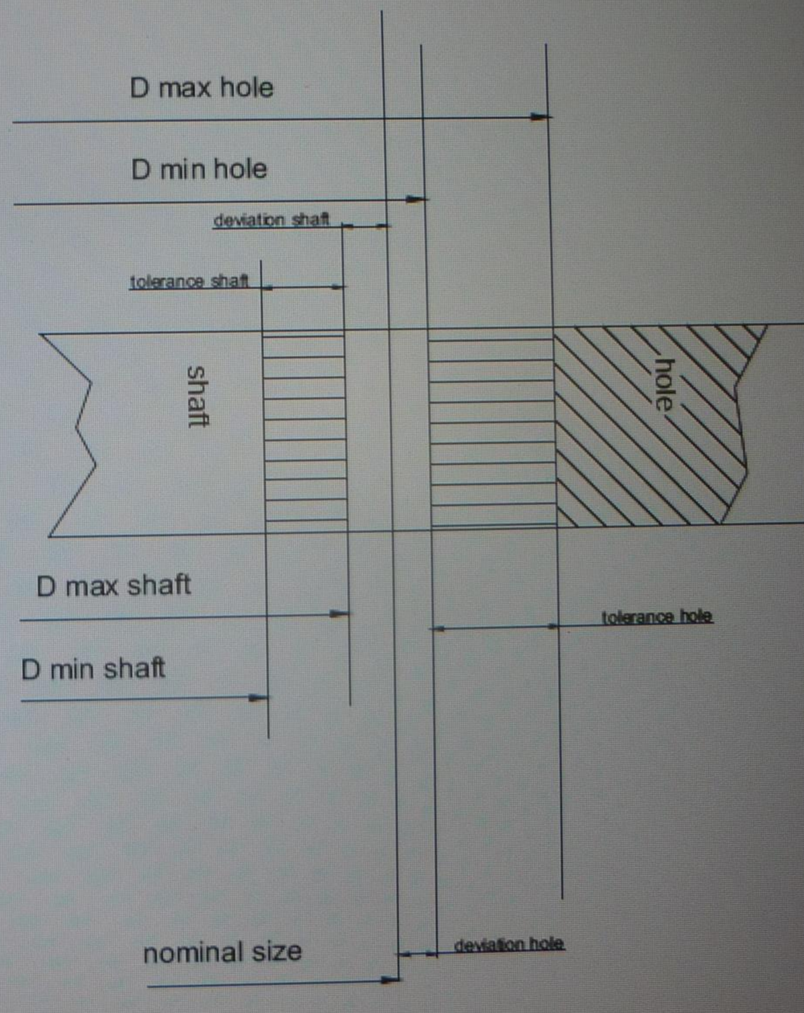
Hole ϕ 50 H7

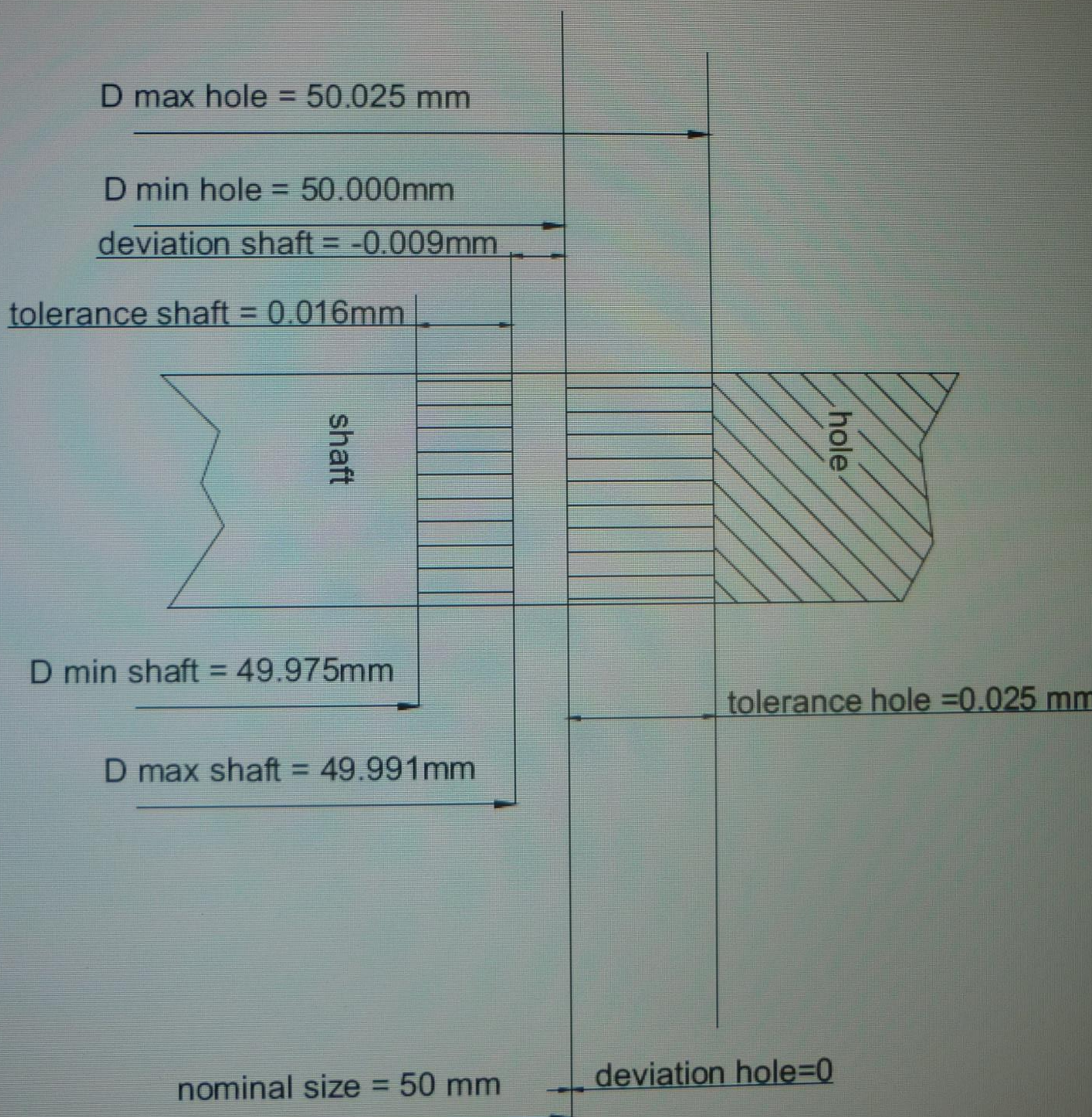
Shaft ϕ 50 g6


O100+0.025
0.000
O100+0.025
0.000

O50 H7

O50 g6


D max hole
D min hole
deviation shaft
tolerance shaft
shaft
hole
D max shaft
D min shaft
tolerance hole
nominal size
deviation hole


D max hole = 50.025 mm
D min hole = 50.000mm
deviation shaft = -0.009mm
tolerance shaft = 0.016mm
shaft
hole
D min shaft = 49.975mm
tolerance hole =0.025 mm
D max shaft = 49.991mm
nominal size = 50 mm
deviation hole=0

Question 12: Integrated Manufacturing Systems: a facility of large and small machines

In a manufacturing facility three large and two small process machines need to be taken out of service for tool changing servicing. The frequency of this activity is primarily dependent on the production schedule. The work is carried out by a team of specialist engineers. The sequence of events has been observed and can be broken down into the following operations:

- an electrician disconnects the power supply 10 minutes
- a pair of men pull the machine from its mountings 2 hours
- a finer removes the fittings 20 minutes
- a tool engineer changes the tooling and resets the machine datums

The machine is reinstalled to its production location in reverse order of the above operations. There is one large space and one small space available for this work and small machines can be serviced in either space but the large machines require a large space.

The run time for the entire machine process varies from 5 to 25 hours. The time to change tooling and reset machine datums varies from 4 to 6 hours.

A closed discrete simulation of this facility is required to check if it is feasible to increase the number process machines in the facility, there is sufficient space to add one large machine within the existing site.

a) Identify and indicate the entities within the system [6 Marks]

3 Theory of Wind Energy

The principles concerned with converting the potential energy of fluids into useful power relies on three basic fundamentals: conservation of mass, energy and momentum, so it is useful to discuss these before examining the operation of wind turbines.

3.1 Conservation of Mass:

The *continuity equation* applies the principle of conservation of mass to fluid flow. Consider a fluid flowing through a fixed conduit having one inlet and one outlet as shown in Figure 3.1

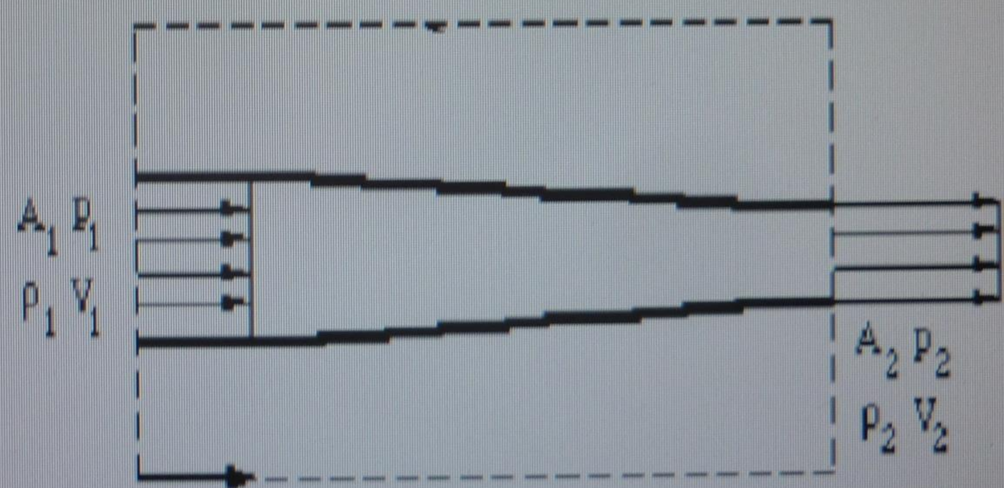


Figure 3.1 Conservation of mass of a fluid flowing in a duct/pipe

a) Defining entities

- Large machine 1
- Large machine 2
- Large machine 3
- Large machine 4 (additionally included to check if it is possible to install it in the production premises)
- Small machine 1
- Small machine 2
- Power supply specialist
- Two men for separation from the foundations
- Mechanic
- Tooling engineers

- Large bay
- Small bay

b) To build the cycle of activities I will need to describe each entity involved in the

b) **To build the cycle of activities I will need to describe each entity involved in the production premises:**

Entity	**Status**
Large bay (the cycle is similar to that for the small bay)	In action (A) Idle (Q)
Power supply specialist (the cycle is similar to that for the two men for separation from the foundation and for the mechanic)	- disconnecting (A) - waits (Q) - connecting (A)
Tooling engineer	- works on the large bay (A) - waits (Q) - works on the small bay (A)
Large machine 1 (the cycle is similar for the rest of the machines)	- waits for tool change (Q) - disconnecting cables (A) - waits (Q) - separation from foundation (A) - waits (Q) - coupling disconnection (A) - waits (Q) - tool change (A) - waits (Q) - coupling connection (A) - waits (Q) - fastening to the foundation (A) - waits (Q) - connecting cables (A) - finished machine (Q) - operates according to the production schedule (A)

Large bay (small bay) – Figure 12.1

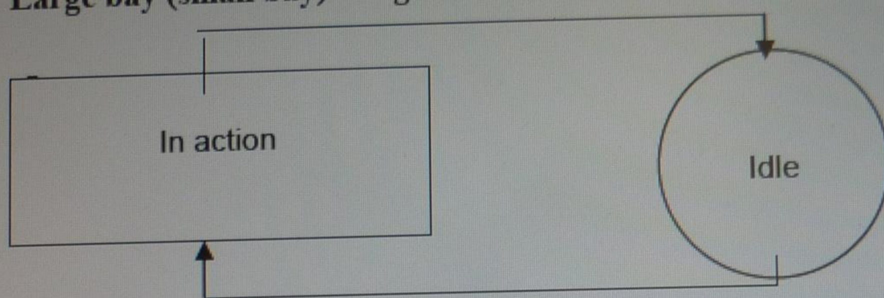


Figure 12.1

Power supply specialist (two men for separation from the foundation; mechanic) – Figure 12.2

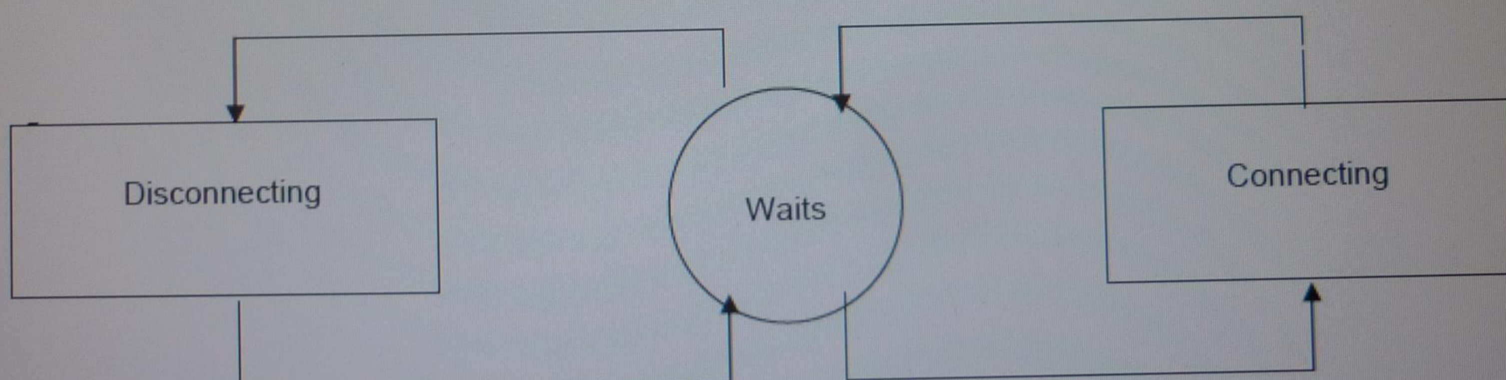


Figure 12.2

Tooling engineer – Figure 12.3

Tooling engineer – Figure 12.3

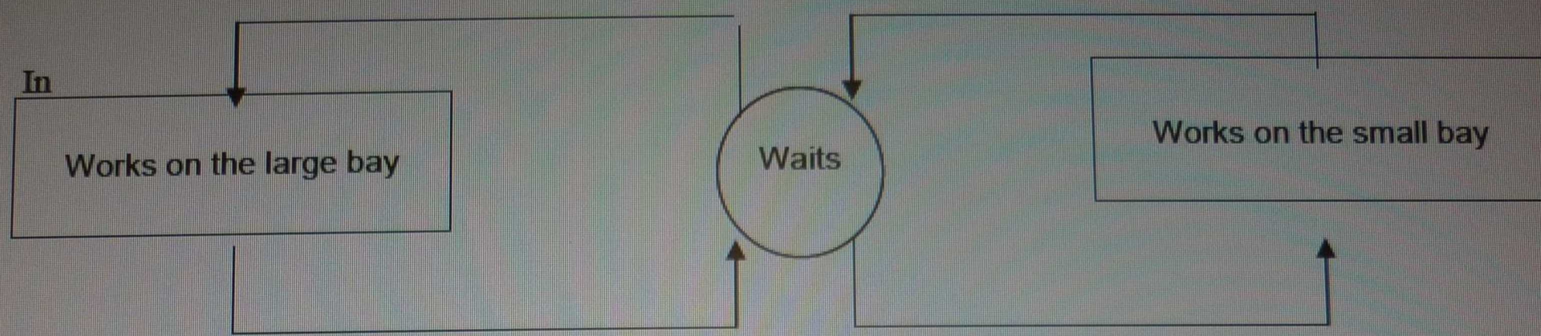


Figure 12.3

The simplified cycle of activities of the machine is as illustrated in Figure 6.4

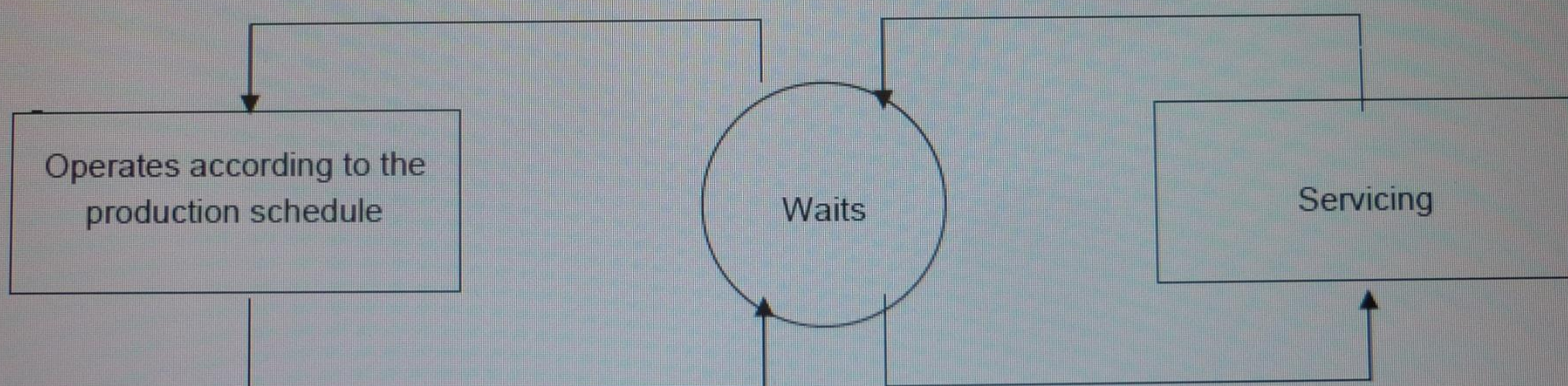


Figure 12.4

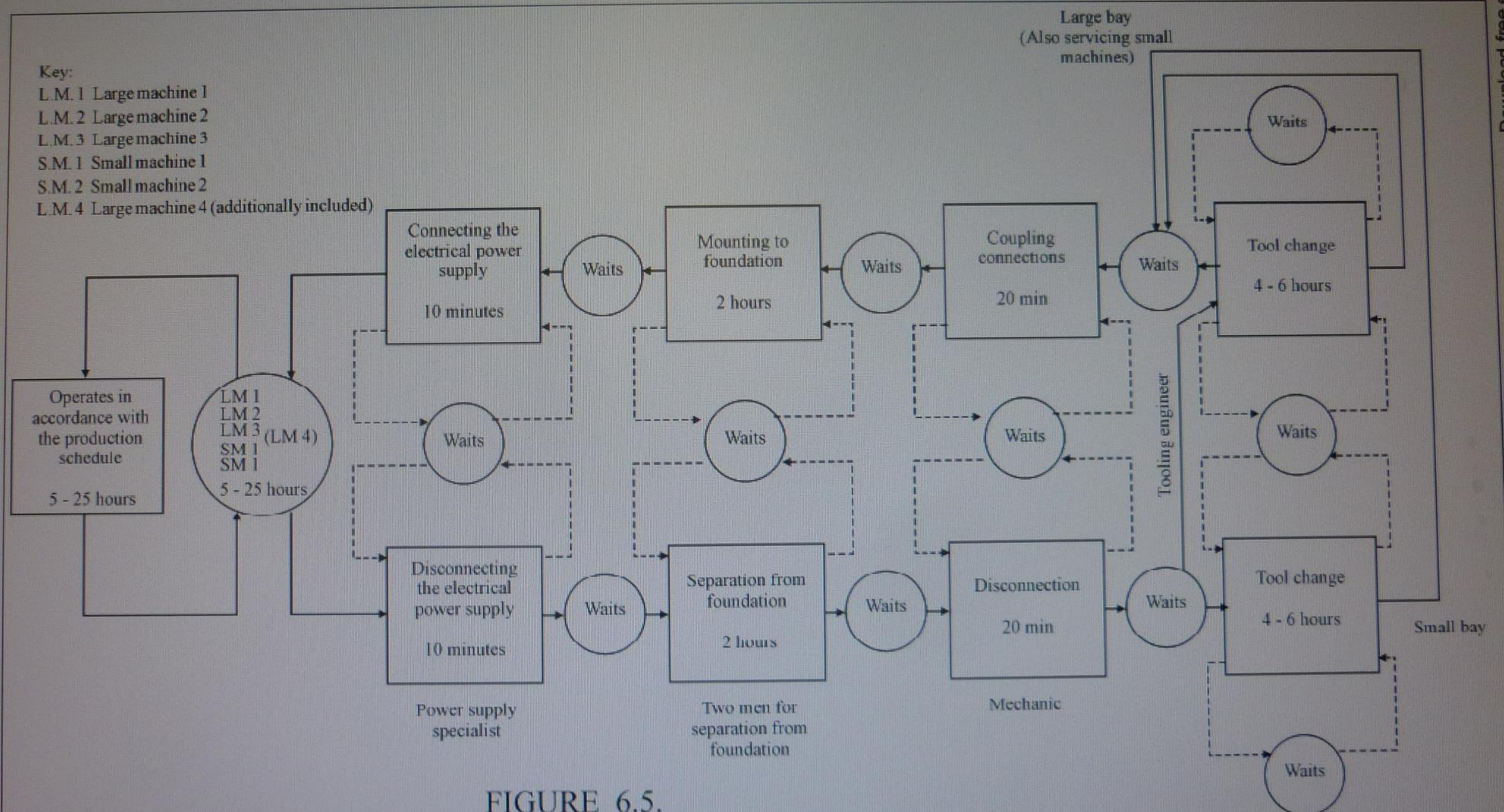

Key:
L.M. 1 Large machine 1
L.M. 2 Large machine 2
L.M. 3 Large machine 3
S.M. 1 Small machine 1
S.M. 2 Small machine 2
L.M. 4 Large machine 4 (additionally included)
Large bay
(Also servicing small machines)
Operates in accordance with the production schedule
5 - 25 hours
LM 1
LM 2
LM 3
SM 1
SM 1
(LM 4)
5 - 25 hours
Connecting the electrical power supply
10 minutes
Waits
Mounting to foundation
2 hours
Waits
Coupling connections
20 min
Waits
Tool change
4 - 6 hours
Waits
Waits
Waits
Waits
Waits
Tooling engineer
Disconnecting the electrical power supply
10 minutes
Waits
Separation from foundation
2 hours
Waits
Disconnection
20 min
Waits
Tool change
4 - 6 hours
Small bay
Power supply specialist
Two men for separation from foundation
Mechanic
Waits

FIGURE 6.5.

c) **Defining how dismantling activities will have priority over mounting activities.**

We build up a simple model where the activities

- disconnecting the electrical power supply,
- separation of the machine from the foundation base, and
- disconnection of couplings

are included in a single operational activity – dismantling and mounting in the reverse order. These activities are all carried out by the same staff.

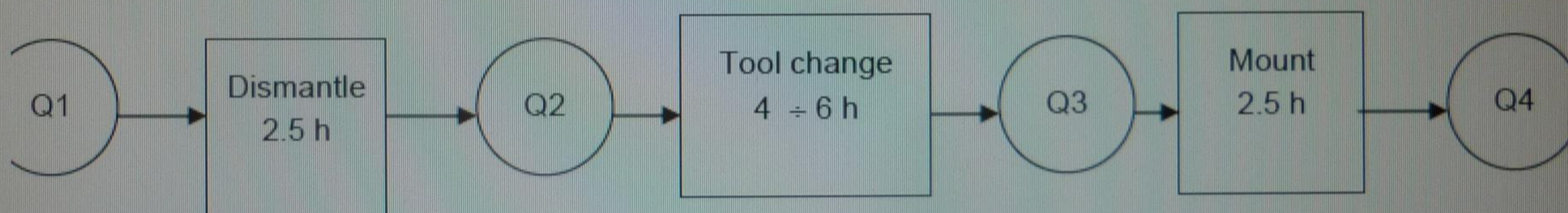


Figure 12.6

From the model built in Figure 12.6 we could draw the conclusion that there should be no activities queuing in Q1. However, it is possible to have activities queuing in Q2 and Q3. Thus all dismantling operations will be completed and activities will be queuing in Q2. Having completed all dismantling activities the team will then proceed with machine assembly and tool change operations.