

OMGT222

PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 8: PREDETERMINED TIME SYSTEMS



By Mauro Spies

Learning Outcomes

- Describe PTS (Predetermined Time Systems)
- Describe the uses of PTS
- Describe the different forms of PTS
- Explain different MTM-2 categories
- Prepare and conduct a simple MTM-2 study

Predetermined time standards

- A **Predetermined time system (PTS)** is a work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance
 - By examining a given operation, identifying the basic motions that make it up & referring to PTS tables which indicate standard times for each type of motion performed under given circumstances, you can derive the standard time for the operation a whole

Motion classification

- **PTS systems** provide information about manual work cycles in terms of basic human motions. There are two main sets:
 - The object-related classification is employed in the majority of PTS systems and almost all the data systems relating to main occupational groups or specifically designed for use within a plant, where reference may be made to the characteristics of parts, e.g. grasp a 6X6X6 mm object
 - The behaviour-related systems classify motions according to what they look like to an observer, e.g. a movement of the empty hand for a distance of between 5 and 15 cm followed by a grasping action made by a simple closing of the fingers defines the GET motion in the MTM-2 system

Origins of PTS

- Frank **Gilbreth** was the pioneer of motion classification whose “therblig” subdivisions of hand and hand & eye motions were the key concept in the development of motion study
- A considerable number and variety of PTS systems were produced during and following the Second World War. Among these was a system which has become very widely used throughout the world, Methods – Time Measurement (MTM)
 - **MTM-2** is a simplified form of MTM

Time and Motion Study – Lowry, Maynard, and Stegemerten – system performance rating

Uses of PTS

- Use of each system is unique to that system although the general procedure is similar
- Work elements of a job are analyzed and recorded on a left hand/right hand chart showing all motions
- This allows the analyst to study the method used and may help in method improvement
- Motions required to complete the work are identified and time is allowed for them based on the PTS system used
- PFD allowance is then applied to determine standard time

Advantages of PTS systems

- PTS systems offer a number of advantages over stop-watch time study. With PTS systems one time is indicated for a given motion, irrespective of where such a motion is performed
- A PTS system, which avoids both rating and direct observation, can lead to more reliability in setting standard times and are more acceptable to unions
- PTS systems are not too difficult to apply and can be less time consuming than other methods

Advantages of PTS systems

- Some PTS systems are particularly useful for very short repetitive time cycles such as assembly work in the electronics industry, while others are most suited for long cycle, low repetition jobs
- It is possible to define the standard time even in the design stage thus allowing refinements before production starts on the operation
- PTS systems are useful in providing information on learning time, developing learning curves and in determining cost data

Criticisms of PTS systems

- There are many different kinds of PTS systems in use, over 200 of them, and many are proprietary
- PTS systems are complicated and difficult to learn, especially if you have to learn several of these systems, and should only be used after training
- They cannot cope readily with movements under abnormal conditions, e.g. while wearing protective clothing or movements made in an abnormal position
- You cannot use PTS systems alone, since machine time, waiting time & other occasional elements still need to be measured by other techniques
- They may not be as accurate as time study

Examples of PTS systems

- **MODAPTS** (Modular Arrangement of Predetermined Time Standards) – relatively easy to use, used in industrial, office and material handling tasks
- **Work Factor System** - more commonly used system and is based on the principle that the time required to perform a fundamental motion is consistent. Additional time is needed based on
 - Body member used
 - Distance moved
 - Degree of manual control required
 - Weight or resistance varies with body member used and sex of operator

Examples of PTS systems

- **Methods Time Measurement (MTM)** – most widely used PTS system
- Has several different forms like MTM-1, MTM-2, etc. for various applications
- We will be using MTM-2 for the balance of the course
- The **time unit** for all MTM systems is a **tmu** (time measurement units), which represents one hundred-thousandth of an hour or 0.0006 minutes or 0.036 seconds

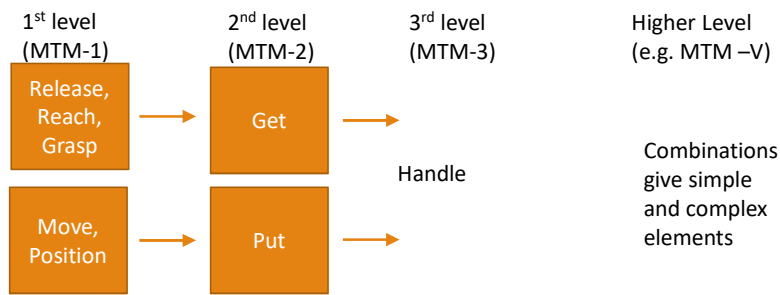
Scope of application of data

Table 21. Scope of application data

Degree	PTS system	Scope of application
1- Universal	MTM-1, 2, 3; Work Factor	Transferable throughout the world and applicable in all manual work areas
2- General	Master Clerical Data (office) MTM-V (machine shops)	Transferable but within a work area
3- Specific	Standard data for particular departments in a plant	Not transferrable without validation studies

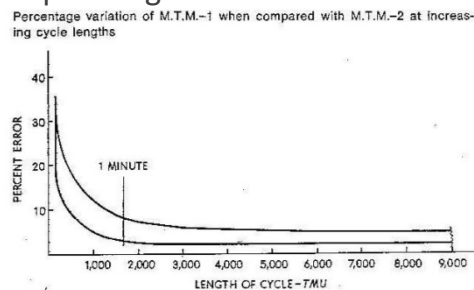
Different forms of PTS systems

Figure 130. PTS data levels: Basic Motions



When can MTM-2 be used

- MTM-2 can be used if:
 - Cycle time > 1600 TMU (1 min, with $\pm 5\%$ accuracy)
 - Cycle is not highly repetitive
 - No complex finger motions are involved



MTM-2 system

The system most likely to be used by the work study person is MTM-2. The following categories constitute the MTM-2 system:

Category	Code
GET	GA, GB, GC
PUT	PA, PB, PC
REGRASP	R
APPLY PRESSURE	A
EYE ACTION	E
FOOT MOTION	F
STEP	S
BEND AND ARISE	B
WEIGHT FACTORS	GW, PW
CRANK	C

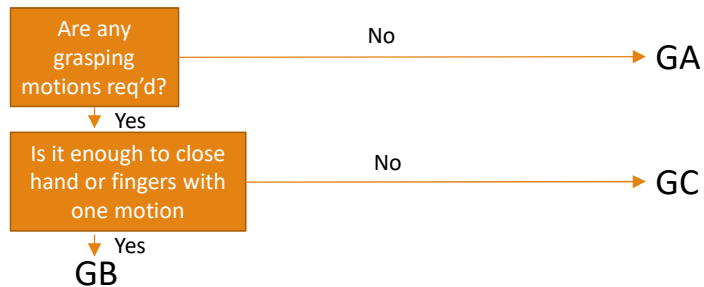
“MTM and BSI rating scale”, in Work Study Management Services (London), Feb. 1969, p97

GET (GA, GB or GC)

- **GET (G)** is an action with the predominant purpose of reaching out with the hand or fingers to an object, grasping the object and then releasing it
 - Scope of GET
 - **Starts:** with reaching out to object
 - **Includes:** gaining control & subsequently releasing control of the object
 - **Ends:** when object is released
 - Need to consider 3 variables in selection of GET:
 1. Case of GET, distinguished by grasping action
 2. Distance reached
 3. Weight of object or its resistance to motion

GET (GA, GB or GC) – cont'd

- Cases of GET are judged by the following:



Examples:

GA, putting palm of hand to side of box to push it across a table

GB, getting an easy to handle object like an 1" cube which is lying by itself

GC, getting the corner of a page of a book to turn it over

GET (GA, GB or GC) – cont'd

- Distance Variable

cm Over	cm Not over	Code
0.0	5.0	-- 5
5.0	15.0	--15
15.0	30.0	--30
30.0	45.0	--45
45.0	-	--80

GET WEIGHT (GW)

- **GET WEIGHT (GW)** is the action required for muscles of the hand and arm to take up weight of the object
 - **Scope of GET WEIGHT**
 - **Starts:** with the grasp on the object completed
 - **Includes:** muscular force necessary to gain full control of the weight of the object
 - **Ends:** when object is sufficiently under control to permit movement of the object
 - GET WEIGHT occurs after the fingers have closed on the object in the preceding GET. It must be accomplished before any movement can take place
 - No GW when weight or resistance is < 2Kg/hand, otherwise 1tmu is assigned per Kg (incl. first 2 Kg)

MTM-2 data card

Time in tmu						
Code	GA	GB	GC	PA	PB	PC
-5	3	7	14	3	10	21
-15	6	10	19	6	15	26
-30	9	14	23	11	19	30
-45	13	18	27	15	24	36
-80	17	23	32	20	30	41
GW: 1 per 1 kg				PW: 1 per 5 kg		
A	R	E	C	S	F	B
14	6	7	15	18	9	61

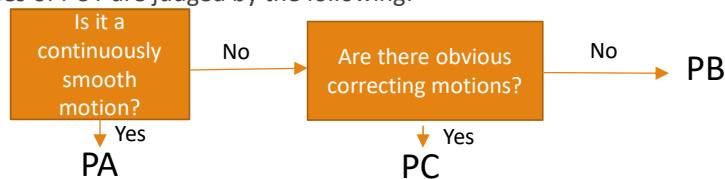
Warning: Do not attempt to use these data unless you have been trained and qualified under a scheme approved by the International MTM Directorate

PUT (PA, PB or PC)

- **PUT (P)** is an action with the main purpose of moving an object to a destination with the hand or fingers
 - **Scope of PUT**
 - **Starts:** with an object grasped & under control at initial place
 - **Includes:** all transporting & correcting motions necessary to place an object
 - **Ends:** with object still under control at destination
 - **Need to consider 3 variables in selection of PUT:**
 1. Case of PUT, distinguished by correcting motions employed
 2. Distance moved
 3. Weight of object or its resistance to motion

PUT (PA, PB or PC) – cont'd

Cases of PUT are judged by the following:



- An example of PA is tossing aside an object
- An example of PB is the action of putting a 12 mm ball in a 15 mm diameter hole
- An example of PC is inserting a Yale or similar key in a lock
- A correction is not likely to be confused with a short PA. A correction is a very short unintentional motion at the terminal point; a PA is purposive, usually of easily discernible length
- The motion distance is handled in a similar manner to GET
- When there is an engagement of parts following a correction, an additional PUT will be allowed when the distance exceeds 2.5 cm.

PUT WEIGHT (PW)

- PUT WEIGHT (PW) is an addition to a PUT motion depending on the weight of the object moved
- Scope of PUT WEIGHT
 - **Starts:** when the move begins
 - **Includes:** the additional time, over & above the move time in PUT, to compensate for additional time required in moving heavy objects over the same distance
 - **Ends:** when the move ends
- PW assigned when resistance to movement >2Kg/hand
- 1 tmu for PW5 for 2-5Kg, 2 tmu for PW10 for 5-10Kg, etc.

REGRASP (R)

- **REGRASP (R)** is a hand action with the purpose of changing the grasp on an object (6 tmu)
 - Scope of REGRASP
 - **Starts:** with the object in the hand
 - **Includes:** digital & hand muscular readjustment on an object
 - **Ends:** with the object in new location in the hand
 - A single REGRASP consists of no more than three fractional movements

REGRASP (R) – cont'd

- Digital & muscular readjustments, while performing an APPLY PRESSURE are included in APPLY PRESSURE & a REGRASP should not be assigned in combination with APPLY PRESSURE
- If the hand relinquishes control & then secures another grasp on the object, the action will be a GET & not a REGRASP
- An example of R is changing the grasp on a pencil in order to get into the position for writing

APPLY PRESSURE (A)

- APPLY PRESSURE (A) is an action with the purpose of exerting muscular force on an object (14 tmu)
 - Scope of APPLY PRESSURE
 - **Starts:** with the body member in contact with the object
 - **Includes:** the application of controlled increasing muscular force, a minimum reaction time to permit the reversal of force and the subsequent releasing of muscular force
 - **Ends:** with the body member in contact with the object, but with the muscular force released

APPLY PRESSURE (A) – cont'd

- APPLY PRESSURE is the action of exerting muscular force on an object
 - To achieve control, to restrain or overcome resistance to motion
 - The object is not displaced more than 6 mm during this action
 - Over a short time period but longer than a GET or PUT
 - Can be performed by any body member & is recognized by a noticeable hesitation when force is applied
 - An example is pushing a button or a final tightening action with a screwdriver or wrench

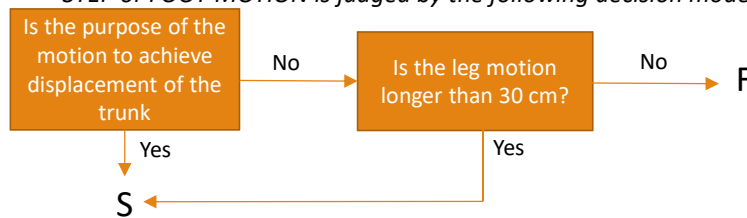
EYE ACTION (E)

- EYE ACTION (E) is an action with the purpose of either: recognizing a promptly distinguishable characteristic of an object or shifting the aim of the axis of vision to a new viewing area (7 tmu)
 - To recognize an object, no mental time other than simple perception
 - Shift line of vision to new area, normal area of vision is 10 cm circle at 40 cm
 - Do not overdo, GETs and PUTs have E already included
 - Example of E is determining if a coin is showing head or tail

FOOT MOTION (F)

- FOOT MOTION (F) is a short foot or leg motion when the purpose is not to move the body (9 tmu)
 - Short foot or leg motion, less than 30 cm, where the purpose is not to move the body
 - e.g., move the foot to activate a pedal

STEP or FOOT MOTION is judged by the following decision model:



STEP (S)

- STEP is either a leg motion with the purpose of moving the body or a leg motion longer than 30 cm (18 tmu per step)
 - Scope of STEP
 - Starts: with the leg at rest
 - Ends: with the leg at the new location
 - e.g., making a single step to the side to enable the arm to reach further
 - To evaluate walking, count the number of times the foot hits the floor

BEND AND ARISE (B)

- BEND AND ARISE is a lowering of the trunk followed by a rise (61 tmu)
 - Vertical displacement of the body
 - Bend, stoop, kneel on one knee
 - The criterion is that, with this motion, you are able to reach below the knee even if you do not actually do so
 - Kneeling on both knees = 2B

CRANK (C)

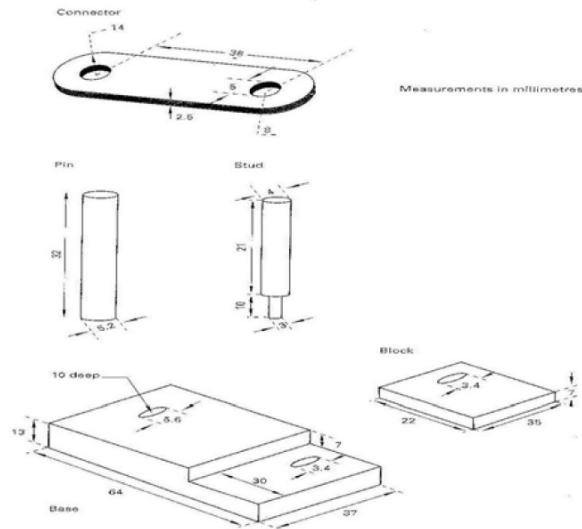
- CRANK is a motion with the purpose of moving an object in a circular path of more than half a revolution with the hand or finger (15 tmu per revolution)
 - Hand/fingers move object in circular path $> \frac{1}{2}$ revolution
 - If $< \frac{1}{2}$ revolution, use G and P
 - May also need GW, to overcome initial friction, one value of GW for a continuous set of revolutions or one value for each intermittent revolution
 - May also need a PW for sticky crank, one value of PW per revolution
 - Weight or resistance affects the value of GW & PW
 - Example of C is turning a hand wheel through one revolution

- Use MTM Methods Analysis Chart

- Summarize motions
- Consider special cases:
 - Principle of simultaneous motion – simultaneous difficult [C] motions can not be done as quickly as with one hand only, add a penalty
 - Principle of limiting motion - for two different times for each hand, use longer one
 - Principle of combined motion - for two combined motions in one hand, use longer time
 - R as part of GC or PC is not counted
- Add TMUs (ratings are included) & convert to minutes
- Add allowances as in Time Study to get standard time

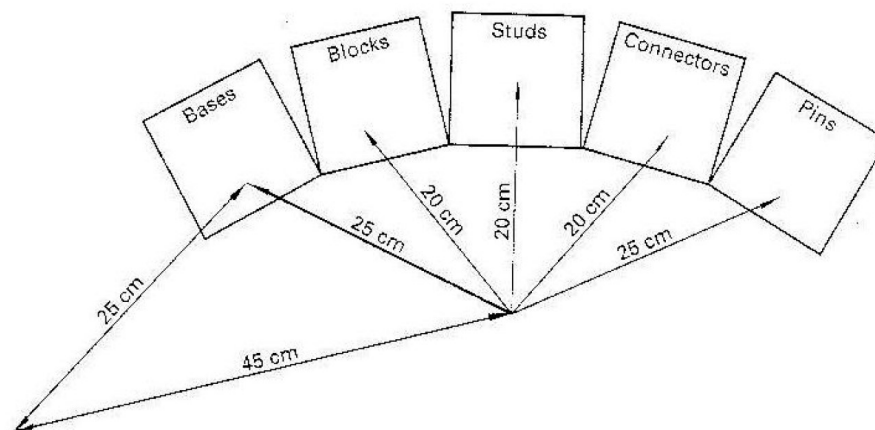
Example: Base assembly

Figure 131. Base assembly



Base assembly workplace layout

Figure 132. Base assembly workplace layout



Base assembly instructions

- Assemble Base assembly as follows:
 - Use LH to get Base from the box & place it on the bench and use RH to get Pin from its box & place it on the Base
 - Get a Block from the box with LH while getting a Stud from its box with RH & locate the stud through the Block
 - Fit the Block-Stud assembly to the Base with the RH with the LH assisting
 - Get a Connector from its box with RH & locate to Stud with LH assisting & then locate it to Pin with LH
 - Pick up finished base assembly with LH and place it on the conveyor

Base assembly MTM-2 analysis sheet

Time in tmu				MTM-2 data card		
Code	GA	GB	GC	PA	PB	PC
-5	3	7	14	3	10	21
-15	6	10	19	6	15	26
-30	9	14	23	11	19	30
-45	13	18	27	15	24	36
-80	17	23	32	20	30	41
GW: 1 per 1 kg				PW: 1 per 5 kg		
A	R	E	C	S	F	B
14	6	7	15	18	9	61

MTM-2 analysis sheet, base assembly

MTM Methods Analysis

Page: 1 of 1

Operation: Assemble Base		Remarks: See sketches of parts and layout				
Study No.:						
Date: 20 / 02 / 2020						
Analyst:						
Description	No.	LH	TMU	RH	No.	Description
Get base from box		GC30	23	G-		Get pin from box
			14	GC5		
Put base on bench		PA30	30	PC30		Locate pin to base
Get block from box		GC30	23	G-		Get stud from box
			14	GC5		
Move block stud		P-	30	PC30		Locate stud through block
Assist location		P-	26	PC15		Fit assembly to base
			23	GC30		Get connector from box
Assist location		GB-	30	PC30		Locate to stud
Locate to pin		PC5	21			
Pick up assembly		GC15	10			
Place on conveyor		PA80	20			
			264			

Bolt-Washer-Nut Assembly



That's it for today!

If you have not read the Chapter 7 please do it soon.

Next week: Chapter 8 – Work Sampling

Questions?
Comments?



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PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 9: WORK SAMPLING



By Mauro Spies

Learning Outcomes

- Define work sampling
- Describe the standards set with work sampling
- Describe the procedure involved in conducting a work sampling study
- Establish activity standards based on work sampling study

Definition of Work Sampling

- **Work sampling** or activity analysis:
process of making sufficient random observations
of an operator's activities
to determine the relative amount of time
the operator spends on the various activities
associated with the job

Need for work sampling

- It would require many analysts if we want to get a complete & accurate picture of machine idle time & reasons for that, in a plant, by continuously observing all machines & noting when or why they were stopped
- If we could glance at all machines in the plant at an instant to see how many were idle & repeat this at 20 or more different times & if the results were the same each time, we could have also have confidence in this result
- Since both previous options are unrealistic, we use the work sampling technique which involves making tours of the plant at random intervals & noting which machines are idle & why

Sampling

- Sampling is mainly based on probability. Probability has been defined as “the degree to which an event is likely to occur”
- A simple and often-mentioned example that illustrates the point is that of tossing a coin
- The law of probability says that we are likely to have 50 heads and 50 tails in every 100 tosses of the coin. The greater the number of tosses, the more chance we have of arriving at a ratio of 50 heads to 50 tails
- The size of the sample is therefore important, and we can express our confidence in whether or not the sample is representative by using a certain confidence level

Establishing confidence levels

- Let us go back to our previous example and toss five coins at a time, and then record the number of times we have heads and the number of times we have tails for each toss of these five coins. Let us then repeat this operation 100 times
- If we considerably increase the number of tosses and in each case toss a large number of coins at a time, we can obtain a smoother curve, such as that shown in figure 89

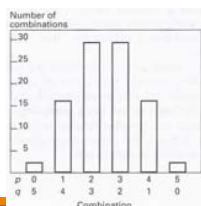
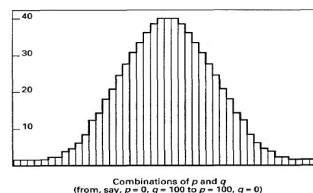


Figure 89. Distribution curve showing probabilities of combinations when large samples are used



Standards set with work sampling

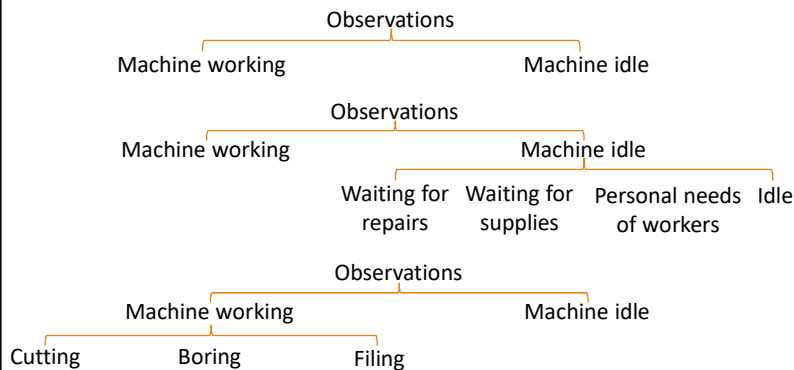
- It is not the purpose of work sampling to set time standards
- Through work sampling we can determine, with reasonable accuracy, how much time an operator spends on a certain activity, e.g., producing a certain product
- Through historical records, we can determine production rates for that product
- This allows us to determine standard times
- May be more economical than time study

Conducting a study

- Establish the purpose or objective of study – see example in next slide
- Identify the subjects of the study – who or what is to be studied
- Identify the measure of output or types of activities to be studied
- Establish a time period during which the study will be conducted
- Define the activities to be studied

Conducting a study

- Before making actual observations, we need to decide on the objective of our work sampling



Conducting a study – cont'd

- Determine the number of observations needed for the desired accuracy and confidence level
- Schedule the observations
- Inform the personnel involved
- Record the raw data
- Summarize the data

Determine sample size

- Sample size can be determined by the following formula:

$$n = Z^2(1 - P)/(P)(A^2), \text{ where}$$

Z is a representative of the confidence level

A is the desired accuracy

P is the preliminary estimate of the percentage of time spent performing a particular activity

- You need to conduct a small trial study to determine P, which should be based on the work element requiring the least amount of the operator's time
- The observations from the trial study can be included in the main study

Scheduling observations

- Once sample size is determined and based on the time period established, we can determine how many observations need to be made per hour/day, etc.
- To ensure that our observations are made at random, we can use a random table as in Table 8-3 on page 311

TABLE 8-3 Random Numbers Between 0700 and 2000

1395	1038	1807	0948	1235	1477	0929	1928
1294	1638	1444	1190	1447	1009	1657	1240
1545	1891	0730	0729	1777	1317	1598	1149
1295	1025	0859	0833	1689	1556	0812	1254
0704	1563	1549	0721	1299	1829	1955	1338
1621	0727	1565	1137	1186	0766	1458	0718
1581	1795	1108	0839	1106	1645	1746	0851
1310	1778	1023	1152	1413	0812	1344	1954
1456	0954	1452	1523	1585	1735	1686	1057
0837	1306	1779	1447	1051	1538	1617	1414
0735	1876	1088	0732	1552	0724	1401	0727
1630	1036	1703	0804	1360	1372	1218	1940
1721	1334	0849	1765	1427	0734	1413	1723
1859	1607	1012	1266	0922	1602	1038	1103
0955	0970	0831	0917	1877	1649	0842	1624
0916	0941	1338	0802	1750	1536	1116	1259
1498	1529	1992	1725	0817	1143	1663	1547
1318	0834	1812	1593	0819	1494	1673	1658
1133	1655	1502	1261	1877	1806	1649	1887
1801	1232	1124	1373	1928	1546	0740	1985
1934	1102	1982	1918	1953	0885	1018	1787
1324	1395	1623	1627	1387	1017	1893	1481
1833	1735	1097	1979	1358	1156	1092	1150
0870	1475	0751	1383	0759	1869	1689	1199
1503	1650	1720	1341	1404	1563	1857	0816
1326	1422	1638	1627	1878	1417	0804	1691
1532	0707	0728	1763	1513	1001	0721	1881
0938	1237	1214	0702	1403	1784	1487	1021
1394	1133	1632	1784	0936	1812	1691	1656
0731	1119	1459	0752	1845	1723	1849	0810
1957	0906	1500	0768	1144	1712	1994	1363
0822	1840	1748	1628	0734	1755	1399	1824
1470	1777	1015	1833	0742	1429	1462	1531
0957	0752	1335	1551	0855	1977	1581	1555
1994	1700	1296	0859	1351	1295	0930	1427
0751	1549	1111	1219	1282	1859	1350	1716
0713	0747	1163	1189	1557	0758	0952	2000
1178	0830	1350	0914	1332	1065	1935	0917
1280	1404	1038	1028	1354	0916	0989	1591
1648	0801	1319	1833	0726	1932	1989	1717
0874	0835	1538	1641	0713	1119	0963	1367
0810	1222	1944	1060	1554	1462	0941	0839
1507	0748	1985	0997	0817	1638	1291	1448

Example – Work sampling results

Table 8-7 Maintenance Work Sampling Results

Activity	Frequency	Percentage
Minor Repair	812	26
Preventive Maintenance	1107	36
Emergency Repair	214	07
Housekeeping	444	14
Record Keeping	129	04
Tool Keeping	44	02
Personal	162	05
Idle	200	06

Advantages of work sampling

- Provides an economical procedure to measure high-cycle time & low repetition-rate jobs
- Can be performed on multiple operators, simultaneously
- More economical to randomly sample time utilization rather than continuous observation
- Conducted over a longer time period, so hard for operators to “fake it”
- Can be completed at discretion of analyst – can be interrupted without loss of validity

Advantages of work sampling

- Establishing sampling risks ahead of time, such as 95% confidence level and accuracy within 5%, provide a degree of reliability
- Less tedious than time study
- Operators are not as uncomfortable at being watched since it is not done over a continuous period

Limitations of work sampling

- Standards derived through work sampling are not as good as time study
- There is no opportunity to study the appropriateness of the work methods being used
- Analysts may not be able to productively use the time between making observations and so this method may not be as economical as expected
- May be difficult to practically study several operators simultaneously

Limitations of work sampling

- Cannot provide detailed analysis of work performed as can be provided by time study
- May be difficult to sell the results to the operator or supervisor if they cannot understand the statistical theory behind it

That's it for today!

If you have not read the Chapter 8 please do it soon.

Next week: Chapter 11 – Improving Productivity

Questions?
Comments?

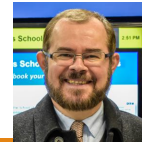


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PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 1: PRODUCTIVITY-INTRODUCTION



Mauro Spies

Learning Outcomes

Define the productivity concept and its importance in competitiveness

Discuss the relationship between quality of life and productivity

Identify why productivity is a problem in the U.S. and Canada

Identify ways to improve productivity

Define basic work content

Productivity

Productivity measures the extent to which output can be extracted from a certain input or

Productivity = Output/Input

Output is Goods & Services, e.g., cars, TV's, clothes, education, daycare, repair, services, etc.

Input is Labour, Capital & Management

Productivity

Effectiveness with which the resources input

- personnel, materials, machinery, information

in a plant are translated into customer satisfaction oriented production outputs

- involving marketing, engineering, production, and service activities

Requires definition and measurement

Key: quality, or quality improvement

Knowledge check /participation

Define

Labour

Capital resources

Inputs

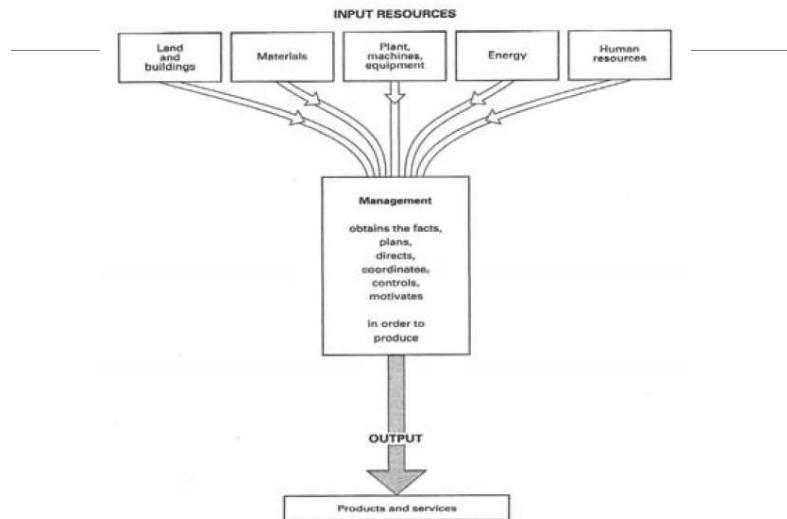
Labour is human resources required to perform

- Operational activity,
- Keep accounts,
- Buy & sell, etc.

Capital resources are required to acquire

- Land & buildings,
- Materials to be converted into products or used in creating a good or service,
- Machines & equipment are tools needed to build products as well as to maintain working environment
- Energy like electricity, gas, oil, etc.

Role of Management



Productivity measurements

Single factor productivity

- Labour productivity
- Machine productivity, etc.

Multi factor productivity

- e.g., Labour, materials & energy

Total factor productivity

- Includes all inputs like labour, materials & overhead

Productivity increase

This is management's task

- Increase output
- Change mix of output
- Decrease inputs
- Change mix of input resources

Practice problem

Julius Merz, the Plant Manager at Shiu Mills, knows that his current operation produces 1,000 square metres of fabric for each ton of raw cotton.

Each ton of raw cotton takes 10 labour hours to process.

He feels that if he uses better quality raw cotton, he will be able to produce 1,100 square metres per ton of raw cotton with the same labour hours.

What will be the impact on productivity (measured in square metres per labour-hour) if he purchases the higher quality raw cotton?

Productivity increase

Labour Productivity

1,000 m² → 10 labour hours

Productivity 1 = $1,000 \div 10 = 100 \text{ m}^2 / \text{hour}$

1,100 m² → 10 labour hours

Productivity 2 = $1,100 \div 10 = 110 \text{ m}^2 / \text{hour}$

Productivity increase = $\text{Productivity 2} \div \text{Productivity 1}$

Productivity increase = $110 \div 100 = 1.1$ or 10% increase

Multi-Factor Productivity

$$\text{Productivity} = \frac{\text{Output}}{\text{Labour} + \text{Material} + \text{Energy} + \text{Capital} + \text{Miscellaneous}}$$

Also known as total factor productivity

Output and inputs are often expressed in dollars

Multiple resource inputs ⇒ multi-factor productivity

In-class assignment 1

Emeka Raj is currently working 10 hours per day to produce 300 toys.

He thinks that by changing some of the materials used for making the toys at an increased cost of \$0.10 per toy, he can increase his production to 400 toys per day.

Current total **material cost per toy is \$1.00**, he spends **\$50** in the necessary expendable **supplies per day; energy costs are \$50 per day**; and he feels that he should be making **\$15 per hour** for his time.

From a multifactor productivity standpoint, has his productivity increased with the new material and if so, by how much?

$$\text{Productivity} = \frac{\text{Output}}{\text{Labour} + \text{Material} + \text{Energy} + \text{Capital} + \text{Miscellaneous}}$$

$$\text{Product 1} = \frac{300 \text{ toys}}{\frac{\$15}{\text{hour}} * 10 \text{ hour} + \$50(\text{supplies}) + \$50(\text{energy}) + \$1 * 300(\text{materials})}$$

$$\text{Productivity 1} = \frac{300}{550} = 0.5455$$

$$\text{Product 2} = \frac{400 \text{ toys}}{\frac{\$15}{\text{hour}} * 10 \text{ hour} + \$50(\text{supplies}) + \$50(\text{energy}) + \$1.1 * 400(\text{materials})}$$

$$\text{Productivity 2} = \frac{400}{690} = 0.5797$$

$$\text{Productivity increase} = \frac{0.5797}{0.5455} = 1.063 \text{ or } 6.3\% \text{ increase}$$

Productivity & quality of life

For a society or country,
productivity improvements mean

- extracting the highest possible output from available resources

More for every citizen

Improved standard of living

Higher quality of life

Productivity in the global environment

Nations compete for scarce resources

Competition in selling goods & services

- Off-shoring
- Hollowing of manufacturing
- Etc.

Knowledge society

Why is productivity a problem in North America?

Are our workers inefficient, inept or lazy?

Are our labour costs too high?

Is our management too focused on short term profits?

Are we not providing training to our workers?

Are we not making enough investments in technology?

Are we adequately analyzing and measuring our work methods to identify opportunities to improve productivity?

Ways to improve productivity

Increase worker productivity

- Work simplification
- Training
- Job redesign – job enlargement/enrichment
- Incentive plans

Supervisory training

Improved layout, workflow and material handling

Improved quality

Suggestion programs

Do productivity improvements lead to job losses or job creation?

If a new process reduces labour requirements it will cause some workers to be redundant

- Job losses

This new process will reduce cost for the company making it more competitive

- Increased sales
- More jobs

In the long run productivity increases lead to more jobs

Productivity challenges in service economy

Labour intensive

May be difficult to automate

May not be easy to evaluate quality

May require very specialized knowledge

Could be focused on unique attributes

Ethical challenges in increasing productivity

- Produce safe products
- Safe workplace
- Environmentally friendly
- Community involvement

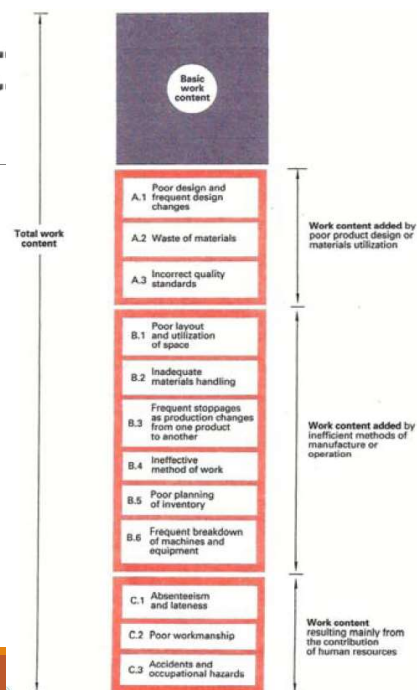
Work content

Work Content

- is the amount of work contained in a job or process

Basic Work Content

- is the irreducible minimum time theoretically required to produce one unit of output

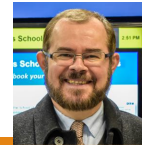


That's it for today!

If you have not read the Chapter 1 please do it soon.

Discussion for next week: Methods Analysis (Chapter 2)

Questions?



Mauro Spies

OMGT222

PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 2: METHODS ANALYSIS



Mauro Spies

Learning Outcomes

- Define how to properly approach a problem
- Identify the principles of the scientific method of solving problems
- Explain the total time to do a job, its components and how to reduce ineffective time
- Discuss the inter-relationships between work study and management, supervisor and the worker

Methods analysis

- A systematic approach to solving problems
- Approach a problem in a logical, organized fashion
- “Much of a manager’s success depends on his or her ability to identify the causes of problems and develop workable solutions for resolving them” – James Hayes, President American Management Association

Scientific method

- This method is a structured procedure to help solve problems
- Consists of a number of steps
 - Define the problem
 - Gather information
 - Develop alternatives
 - Evaluate the alternatives
 - Implement the solution
 - Follow-up

Define the problem

- Important to dig deep and look for the root cause of problem
- Be careful to identify the problem and not a symptom
- Do not restrict yourself and get sidetracked by assumptions, beliefs or how the problem is currently being addressed

Loosing employees and having high turn over=inexperience workforce, high training costs,
poor customer relations

Low salaries!!

Gather information

- Sometimes called situation analysis
- Write down everything you know about the problem
- Note any assumptions that must be made about the problem
- Note any constraints that need to imposed on a solution (real and fictitious)



Develop alternatives

- Develop as many different alternatives as possible
- Do not evaluate alternatives at the initial stage
- Brainstorming is a good technique to use



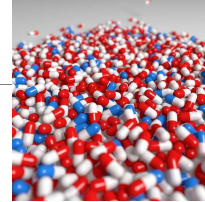
Evaluate the alternatives

- Compare the advantages and disadvantages of alternate strategies in helping to solve the problem
- Develop greater details about the remaining alternatives as you narrow the list
- Determine the “best” solution based on the original problem definition based on criteria such as cost, timeliness, etc.



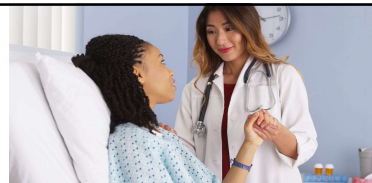
Implement the solution

- Need to “sell” the solution to the stakeholders to minimize resistance
- Improving productivity involves changing how people perform tasks, so involve those people in developing the new methods
- Install the new method after training the individuals affected by it



Follow-up

- Measure the improvement from the new method
- Determine if any new problems have arisen from installing the new method
- Ensure that workers do not fall back on the old method



Work Study



- Work study is the systematic examination of the methods of carrying on activities so as to improve the effective use of resources and to set up standards of performance for the activities being carried
 - Simplify/modify method of operation
 - Reduce unnecessary/excessive work
 - Reduce waste of resources
 - Set up a time standard

Work Study – cont'd



- Why is work study such a valuable tool?
 - Means of raising productivity by reorganizing work and does not normally require capital
 - It systematically ensures that no factors affecting efficiency are overlooked when analyzing original & new operations
 - Most accurate means of setting standards of performance which leads to effective production planning & control
 - Contributes to improvement of safety & working conditions

Work Study – cont'd



- Why is work study such a valuable tool?
 - Savings start as soon as work study is applied & continue as long as improved operation is in place
 - It is a tool that can be applied everywhere, in manufacturing, offices, stores, distribution centres, restaurants, farms, etc.
 - It is relatively cheap and easy to apply
 - One of the most penetrative tool of investigation which will show up weaknesses in other functions that affect the operation that is being examined

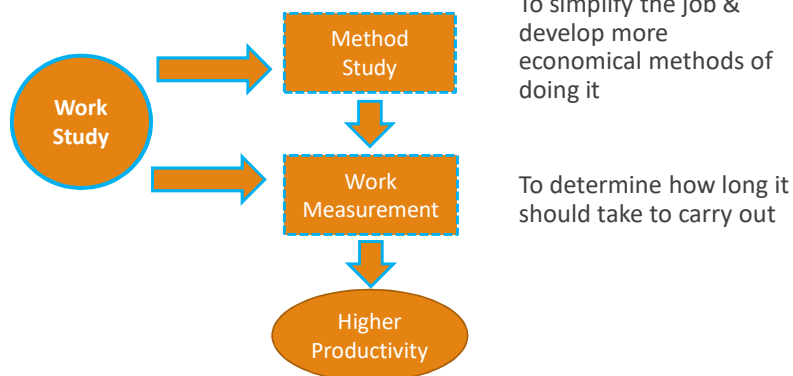
Work Study – cont'd



- Techniques of work study & their relationship
 - **Method Study** is the systematic recording and critical examination of ways of doing things in order to make improvements*
 - **Work Measurement** is the application of techniques designed to establish the time for a qualified worker to carry out a task at a defined rate of working*

* As adopted in BSI: Glossary of terms used in Management services, BSI 3138 (London 1991)

Work Study – cont'd



Work content



- Time taken by a worker or machine to carry out an operation or to produce a quantity of product
 - Basic work content
 - Theoretically minimum time to produce one unit of output
 - Excess work content
 - Poor design or specifications
 - Inefficient methods of manufacture or operation
 - Inefficient application of human resources



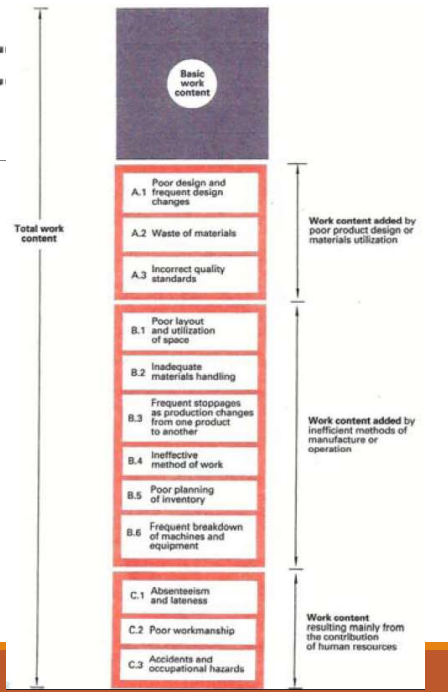
Work content

Work Content

- is the amount of work contained in a job or process

Basic Work Content

- is the irreducible minimum time theoretically required to produce one unit of output



Poor design or specifications

• Issue:

- Poor design & frequent design changes
 - Non standard parts – long assembly time
 - Excessive variety of products – small batches

• Response:

- Introduce proper product development methodology
- Design reviews

Poor design or specifications cont'd

- Issue:

- Material waste

- Work content increased if excessive material to be removed
 - Waste of material

- Response:

- Proper material utilization

- Reduce waste
 - Re-use waste

Poor design or specifications cont'd

- Issue:

- Incorrect quality standards

- High tolerances – extra machining & material waste
 - Low tolerances – higher rejects

- Response:

- Implement appropriate quality control

- Proper quality standards
 - Inspection methods

Inefficient methods

- Issue:

- Poor layout and space utilization
 - Inefficient use of space adds cost
 - Improper layout creates wasted movement, time & effort

- Response:

- Create better layout and process plan
 - Reduces unnecessary movement and work

Inefficient methods – cont'd

- Issue:

- Inadequate material handling equipment
 - Lack of appropriate material handling equipment

- Response:

- Use of appropriate material handling equipment reduces time & effort

Inefficient methods – cont'd

- Issue:
 - Frequent stoppages as production changes from one product to another
- Response:
 - Proper production planning & control
 - Reduce ineffective time for machines, equipment and labour

Inefficient methods – cont'd

- Issue:
 - Ineffective work methods
 - Sequence may be OK but certain operations may be cumbersome
- Response:
 - Perform method study
 - Devise better work method to reduce ineffective time

Inefficient methods – cont'd

- Issue:

- Poor inventory planning
 - Too much inventory adds costs
 - Too little inventory adds delay through work stoppages

- Response:

- Inventory control defines proper inventory levels
 - Raw material
 - Work-in-process inventory

Inefficient methods – cont'd

- Issue:

- Frequent breakdown of machines & equipment
 - Creates idle time
 - Could create bottlenecks

- Response:

- Institute preventative maintenance programs
 - Prevent delays
 - Ensures longer life

Human resources

- Issue:

- Absenteeism/lateness/work slowly
 - Lower productivity
 - Could produce bottlenecks

- Response:

- Create satisfying work environment
 - Proper management
 - Effective HR policies

Human resources – cont'd

- Issue:

- Poor workmanship
 - Job needs to be redone
 - Wasted material

- Response:

- Provide training to staff

Human resources – cont'd

- Issue:

- Accidents & occupational hazards
 - Impacts morale
 - Increased absenteeism

- Response:

- Create better working conditions
 - Improves morale
 - Reduces absenteeism

Work study & people factors

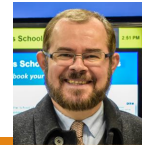
- Work study will be successful only when management, supervisors and workers are all supportive
- People will pay attention to these activities only when management is visibly behind them
- Work study will show up current shortcomings – it is important to focus on the opportunities to make supervisors and workers work easier, more rewarding and/or more satisfying

That's it for today!

If you have not read the Chapter 1 & 2 please do it soon.

Discussion for next week: Work Analysis (Chapter 3)

Questions? Comments?



Mauro Spies

OMGT222

PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 3: WORK ANALYSIS: GRAPHIC PRODUCTIVITY ANALYSIS



Mauro Spies

Learning Outcomes

- Construct the following charts for an existing operation:
 - Operations process chart
 - Flow process chart
 - Flow diagram
 - Left-hand/Right-hand chart
- Critically examine the current method
- Prepare above listed charts for proposed method
- Apply graphical tools to improve the productivity of the operation charted

Introduction

- Charts tell what is happening in graphical form.
- In addition, a careful, questioning attitude can help determine why the current method is being used and can help identify potential areas for improvement.
- These methods and tools can be used effectively to increase productivity.

Record the facts

- **Operations process chart** provides an overall picture by recording the main operations & inspections of a process or activity in sequence only
- **Flow process chart** sets out the sequence of the flow of a product or procedure by recording all events under review, for worker or machine or material, etc.
- **Flow diagram** represents the movement of materials between activities as depicted on a pictorial layout of a process

Process chart symbols



Operation indicates the main steps in a process, method or procedure where the part, material or product is usually modified or changed



Inspection indicates an inspection for quality and/or check for quantity



Transport indicates the movement of workers, materials or equipment from place to place

Process chart symbols – cont'd



Temporary storage or delay indicates a delay in the sequence of events like work waiting between consecutive operations



Permanent storage indicates a controlled storage in which material is received into or issued from a store upon authorization

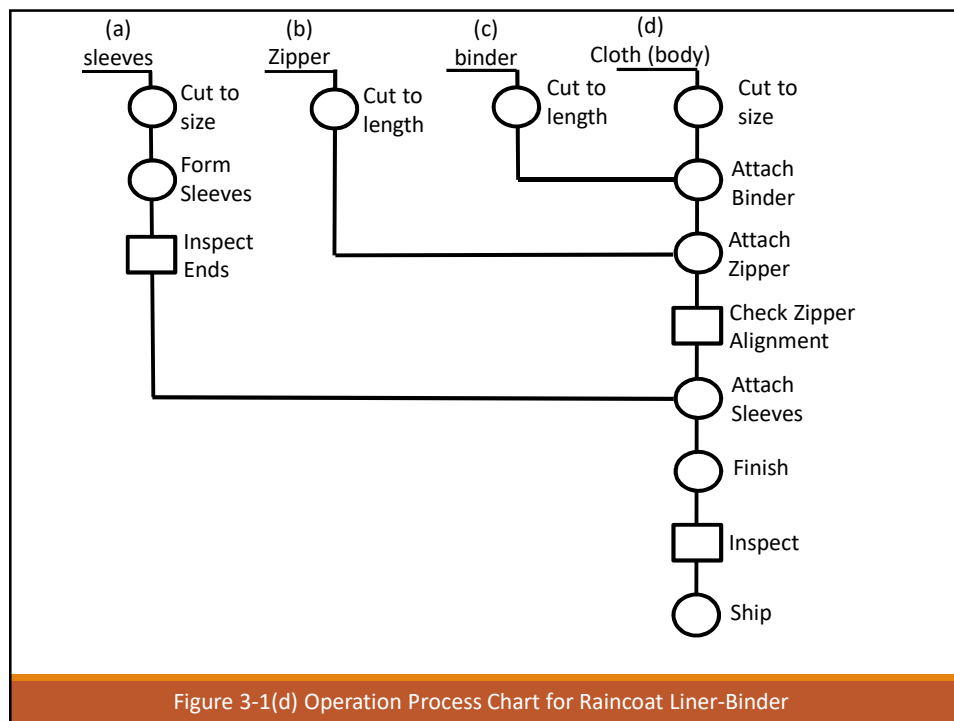
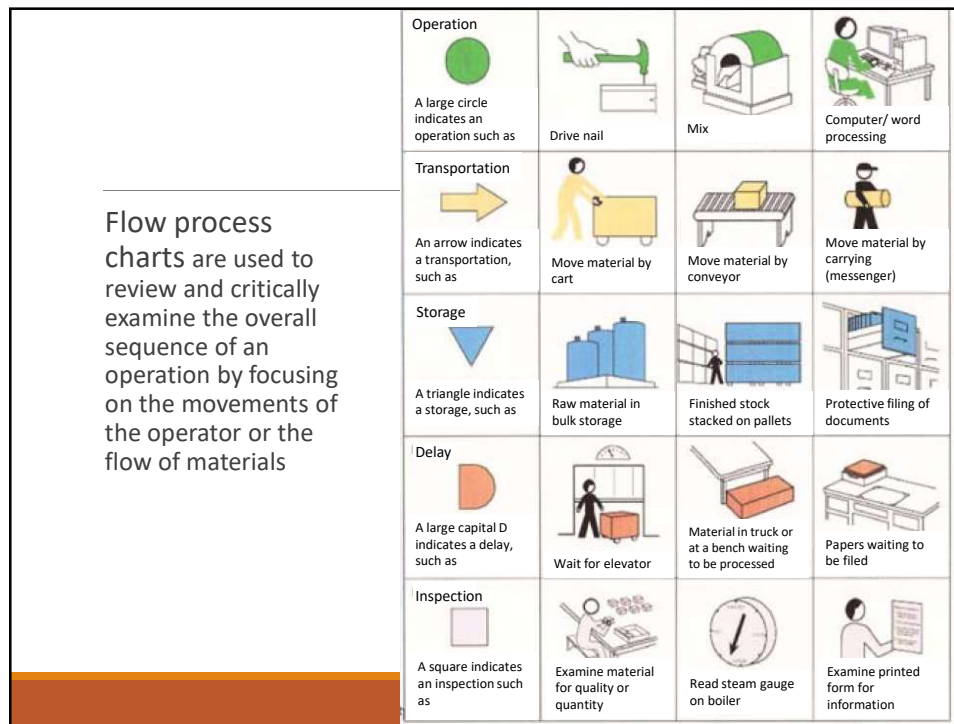


Figure 3-1(d) Operation Process Chart for Raincoat Liner-Binder

Sr. No.	Description	Distance(m)	Time	Symbol				
				●	➔	◐	■	▼
1	Check oil level							
2	To oil barrel location							
3	Fill the mist oil into machine							
4	To the raw material storage rack							
5	Identify the raw material location of required grade							
6	To the crane location							
7	Move the crane to the desired location							
8	Adjust the crane rope to hold the bundle, insert							
9	Move the raw material to cutting machine using							
10	Remove the wire to separate the bars from bundle							

Flow process chart

- A graphic, symbolic representation of the work performed or to be performed on a product or service as it passes through some or all the stages of a process.
- Typically, the information included in the chart is quantity, distance moved, type of work done, and equipment used.
- It sets out the sequence of the flow of a product or procedure by recording all events under review, for worker, machine or material, etc.

Flow process chart

- Used for recording because it gives a complete picture
- Illustrates clearly how job is carried out
- Must be based on direct observation and should be reviewed with supervisor
- Should be very neat and accurate
- Should have a heading showing name of product, material, etc., job, location, chart # & No. of sheets, observer's name, date, key to symbols & summary of distance, time & cost
- Check for completeness & accuracy

Man/Worker Type
Flow Process Chart

Flow Process Chart				Summary			
Activity : Routine work				Event	Present	Proposed	Savings
Location : Physiology lab				Operation	7		
Date: Dec. 10, 2005				Transport	8		
Operator : P.K		Analyst : R.K		Delay	1		
Method and Type: <u>Classical</u> Proposed				Inspection	1		
Type: <u>Operation</u> Material Machine				Storage	1		
Layout				Time (min) for 2 patients	21.7		
Site 1 Site 2 Microscope ☐ Patient ☐				Distance	48 m		
				Cost			
Event Description	Symbol	Time (in Minutes)	Distance	Remarks			
Own seat	    						
To work station 1	    	1.0	10 m				
Get new syringe and open syringe wrapper	    	1.5					
To patient	    	0.2	2 m				
Take blood sample	    	2.2					
To work station 2	    	0.2	2 m				
Take glass plate and drop blood sample on plate	    	0.8					
To work station 1	    	0.6	5 m				
Get new syringe and Open syringe wrapper	    	1.5					
To next patient	    	0.2	2 m				
Take blood sample	    	2.2					
To work station 2	    	0.2	2 m				
Take glass plate and drop blood sample on plate	    	0.8					
Take 2 glass plates to microscope	    	0.5	5 m				
Samples	    	1.8					
To own seat	    	2.0	20 m				
Record result in register	    	1.0					
Wait for patients	    	5.0		Average			
To Work Station 1		1.0	10 m	Next cycle			
A	A	A	A	A	A	A	A

Flow Process Chart: Material Type

**FIGURE 13. FLOW PROCESS CHART—MATERIAL TYPE: ENGINE STRIPPING,
CLEANING AND DEGREASING**
(Original Method)

[illegible]

Flow Process Chart: Material Type (cont.)

[illegible]

Flow Process Chart:

Receiving & inspecting aircraft parts

Process Flow Chart		Worker/ Material / Equipment Type			
Chart No.	Sheet No. 1 of 1	Summary			
Subject charted	Activity	Present	Proposed	Saving	
Case of BX 487 Toe-places (10 per case in cartons)	Operation	2			
	Transport	11			
	Delay	7			
	Inspection	2			
	Storage	1			
Method: Present / Proposed	Distance	56.2			
Location: Receiving Dept.	Time (work.h)	1.96			
Operative (s)	Clock No.	Cost			
See remarks columns		Labour	\$ 10.19		
Charted by: Date:		Material	-		
Approved by: Date:		Total	\$ 10.19		
Description	Qty 1 case	Distance (m)	Time (min)	Symbol	Remarks
Lifted from truck: placed on inclined plane	1.2				2 labourers
Skid on inclined plane	6		10		2 labourers
Skid to storage and stacked	6				2 labourers
Await unpacking	-		30		
Case unpacked	-				
Lid removed: delivery note taken out	-		5		2 labourers
Placed on hand truck	1				
Trucked to reception bench	9		5		2 labourers
Await discharge from truck	-		10		
Case placed on bench	1		2		2 labourers
Cartons taken from case opened					
checked replaced contents	-		15		Storekeeper
Case loaded on hand truck	1		2		2 labourers
Delay awaiting transport	-		5		
Trucked to inspection bench	16.5		10		1 labourer
Await inspection	-		10		Case on truck
Toe-places removed from case and cartons	1		20		Inspector
inspected to drawing: replaced					
Await transport labourer	-		5		Case on truck
Trucked to numbering bench	9		5		1 labourer
Await numbering	-		15		Case on truck
Toe-Places withdrawn from case and cartons	-		15		Store labourer
cartons numbered on bench and replaced					
Awaits transport labourer	-		6		Case on truck
Transport to distribution point	4.5		6		1 labourer
Stored					
Total	56.2	174	2 10	7 2 1	

Figure 30. Flow process chart: Inspecting and marking incoming parts (original method)

Flow diagram

A graphic, symbolic representation of the location of activities or operations and the flow of materials between activities on a pictorial layout of a process.

Usually used with a flow process chart.

Flow diagram: Receiving & inspecting aircraft parts

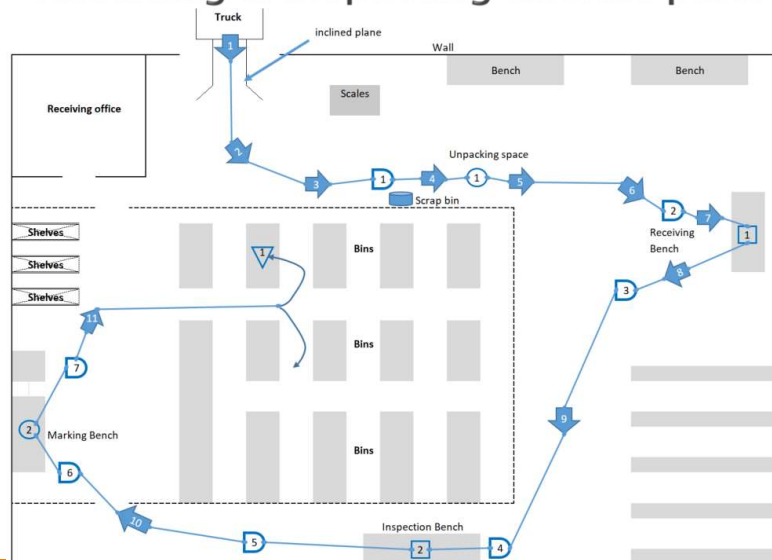


Figure 29. Flow diagram: Inspecting and marking incoming parts (original method)

Examine critically: The questioning technique

The questioning technique is the means by which the critical examination is conducted with each activity being subjected, in turn, to a systematic and progressive series of questions

Examine critically: Primary questions

- Purpose: What is actually done?
Why is it done?
- Place: Where is it done?
Why is it done there?
- Sequence: When is it done?
Why is it done then?
- Person: Who is doing it?
Why does that person do it?
- Means: How is it done?
Why is it done that way?

Eliminate
or
Combine
or
Rearrange
or
Simplify

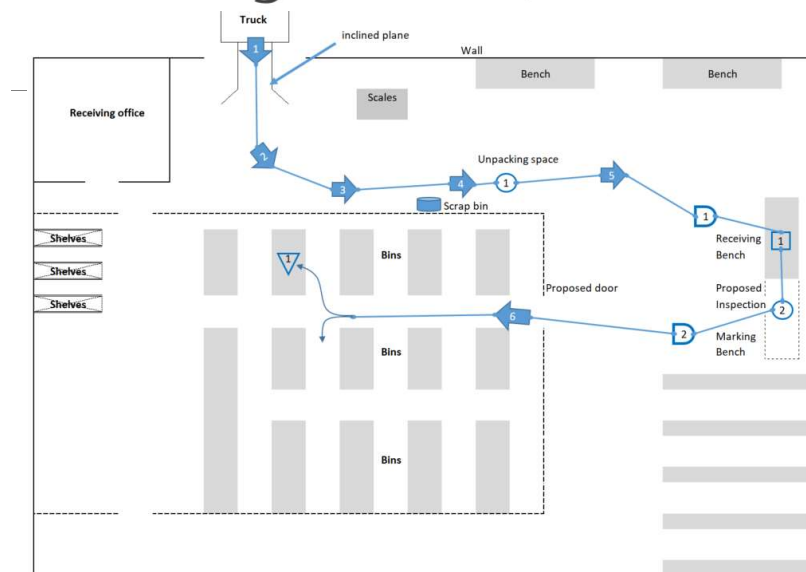
Examine critically & Develop improved method: Secondary questions

- Purpose: What is actually done?
Why is it done?
What else might be done?
What should be done?
- Place: Where is it done?
Why is it done there?
Where else might it be done?
Where should it be done?
- Sequence: When is it done?
Why is it done then?
When might it be done?
When should it be done?

Examine critically & Develop improved method: Secondary questions – cont'd

- Person: Who is it doing it?
Why does the person do it?
Who else might do it?
Who should do it?
- Means: How is it done?
Why is it done that way?
How else might it be done?
How should it be done?

Flow diagram – Improved method



Flow Process Chart:

Improved method

Process Flow Chart				Worker / Material / Equipment - Type			
Chart No.	Sheet No.	1 of 1	1	Summary			
Subject charted				Activity	Present	Proposed	Saving
Case of BX 487 Toe-places (10 per case in cartons)				Operation	2	2	-
Activity				Transport	11	6	5
Receive, check, inspect and number toe-places and store in case				Delay	7	2	5
Method: Present / Proposed				Inspection	2	1	1
Location: Receiving Dept.				Storage	1	1	-
Operative (s)				Distance	56.2	32.2	24
Clock No.				Time (work.h)	1.96	1.16	0.8
See remarks columns				Cost			
Charted by: Date:				Labour	\$ 10.19	\$ 6.03	\$4.16
Approved by: Date:				Material	-	-	-
				Total	\$ 10.19	\$ 6.03	\$4.16
Description	Qty 1 case	Distance (m)	Time (min)	Symbol	Remarks		
Lifted from truck: placed on inclined plane	1.2			○→	2 labourers		
Skid on inclined plane	6	5		●	2 labourers		
Placed on hand truck	1			□	2 labourers		
Trucked to unpacking space	6	5		○→	1 labourer		
Lid taken off case	-	5		□	1 labourer		
Trucked to receiving bench	9	5		○→	1 labourer		
Await unloading	-	5		□			
Cartons taken from case and toe-places placed on bench counted and inspected to drawing	-	20		○→	Inspector		
Numbered na replaced in cse	-			□	Store labourer		
Await transport labourer	-	5		□			
Tucked to distribution point	9	5		○→	1 labourer		
Stored	-	-		□			
Total	32.2	55	2	6	2	1	1

Left hand/Right hand chart

- This chart is one on which the motions made by one hand in relation to those made by the other hand are recorded using standard process chart symbols
 - Hands do not generally make Inspections
 - Transportations are movements of the hands from one location to another in the workplace
 - Holds are generally considered to be Delays
 - Idle hands are also charted as Delays

Two-handed process chart symbols



Operation: is used for the activities of grasp, position, use, release, of a tool, component or material



Inspection: the inspection symbol is not used in Left hand/Right hand chart



Transport: s used to represent the movement of the hand to or from the work, a tool or material

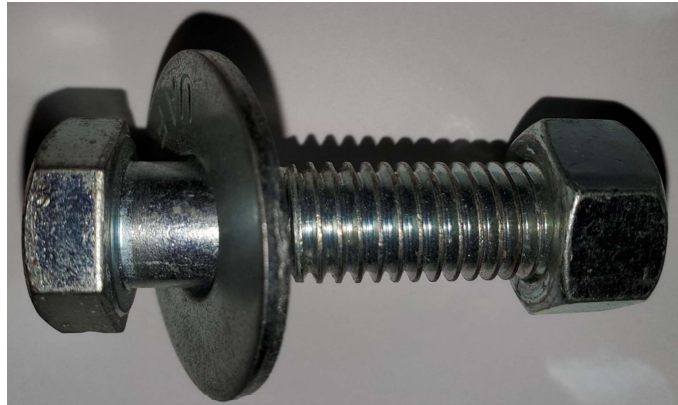


Delay: The symbol is designated as hold and is used to represent the activity of holding the work, a tool or material — that is, when the hand being charted is holding something, or is idle

Notes on Two-handed process charts

- Study the operation a few times before starting to record
- Chart one hand at a time
- Do not record more than a few symbols at a time
- Start at the beginning of a cycle with the action of picking up or grasping a fresh part
- **Only record actions at the same level when they occur at the same time**
- **Actions occurring in sequence should be recorded at different horizontal levels**
- List everything done by the operator to avoid combining activities unless they occur at the same time

Bolt-Washer-Nut Assembly



Bolt Washer Assembly

- A production operation requires an operator to perform a relatively simple assembly
- A bolt – washer – nut assembly
- The bolts, washers, and nuts are found in containers directly in front of the operator
- Operation begins when operator reaches for a bolt with the left hand
- The left hand will pick up the head of the bolt
- The operator grasps the bolt and moves it back in front of him
- The left hand holds the bolt by the head as the right hand reaches for and grasps a washer

Bolt Washer Assembly

- The washer is brought to the bolt and placed over the end
- The right hand, before releasing the washer, slides it down the bolt until it is flush with the head of the bolt
- After releasing the washer, the right hand reaches for the nut
- After grasping the nut, the right hand brings it to the bolt and screws it on it before releasing it
- The left hand puts the finished assembly aside

Left hand/Right hand chart

Chart No. 1 Sheet No. 1 of 1 Operator:
Drawing and Part: Analyst: MS
Operation: Bolt Washer Assembly Date: Sep/01/2020
Method: Present / Proposed

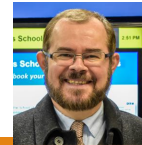
		Two-handed Process Chart								
		Summary						Work place Layout		
		Present	Proposed	Difference						
Method	L.H.	R.H.	L.H.	R.H.	L.H.	R.H.				
Operations	2	6								
Transports	2	4								
Inspections	0	0								
Delays	10	4								
Totals										
Left-hand description							Right-hand description			
Reach for bolt		X					X	Idle		
Grasp bolt	X						X	Idle		
Move bolt to work area		X					X	Idle		
Hold bolt			X		X			Reach for washer		
Hold bolt			X	X				Grasp washer		
Hold bolt			X		X			Move washer to bolt		
Hold bolt			X	X				Washer onto bolt		
Hold bolt			X	X				Release washer		
Hold bolt			X		X			Reach for nut		
Hold bolt			X	X				Grasp nut		
Hold bolt			X		X			Move nut to bolt		
Hold bolt			X	X				Nut onto bolt		
Hold bolt			X	X				Release nut		
Set aside	X						X	Release washer		

That's it for today!

If you have not read the Chapter 1 - 3 please do it soon.

Discussion for next week: Work Methods Improvement
(Chapter 4)

Questions?
Comments?



Mauro Spies

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PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 4 & 5: WORK METHODS IMPROVEMENT



Mauro Spies

Learning Outcomes

- Define methods improvement
- Explain how methods improvements relates to productivity improvements
- Understand the use of and be able to apply the principles of motion economy to the work improvement process
- Explain the classifications of movements
- Describe some basic principles regarding work design that reflect the capabilities and limitations of people and machines

Methods improvement

- Methods improvement is the process whereby a task is analyzed and possible changes are identified that will
 - Increase the productivity of the worker, or
 - Make the job easier to perform, or
 - Both of the above

How Method Improvement results in Productivity improvement

- Can the operation be eliminated?
- Can the operation be combined with others?
- Can the sequence of activities be changed?
- Can the activities be simplified?
- Are we using our human resources appropriately?
- Are we using our machine resources appropriately?

Apply the questioning technique

- Purpose
 - Ensure the job is necessary
- Place
 - Ensure that it is being done where it should be
- Sequence
 - Ensure that it is in the right place in the sequence of operations
- Person
 - Ensure that it is being done by the right person
- Means
 - Determine the means by which the job is done and simplify as is economically justified

Therblig analysis

- Frank Gilbreth (1868-1924) was pioneer of motion classification
 - Making detailed critical analysis of work methods stimulates ideas for method improvement
 - Evaluation of alternative methods can be done by simple comparison of number of motions
- Lillian Gilbreth (1878-1972) worked more on the human side
 - People more important than machines
 - Worked to reduce fatigue for workers

Therblig analysis

Frank and Lillian Gilbreth said that every motion could be subdivided in to a combination of 17 basic motions – **Therbligs**

Reach	Move	Release
Grasp	Preposition	Use
Assemble	Disassemble	Search
Select	Position	Inspect
Plan	Unavoidable delay	Rest
Hold	Avoidable delay	

Effective Therbligs in **bold**. Rest ineffective.

Principles of motion economy

- Use of the human body
 - Deals with the most effective use of the body as required in a production situation
- Arrangement of the workplace
 - Deals with the most effective layout of the work area
- Design of tools and equipment
 - Deals with appropriate design of tools and equipment for ease of operation by the operator

Use of the Human Body

- 1) Both hands should begin and end their motions at the same time. Both hands should never be idle at the same time
- 2) Hand motions should be made simultaneously. They should be made symmetrically away from and toward the centre of the body
- 3) The motions of the hands should be performed to take advantage of the natural rhythms set up by the hand motions of the body
- 4) Whenever possible, momentum must be used to overcome resistance to movement
- 5) Motion paths should follow continuous curved paths when the motion requires reaches or transports of objects

Use of the Human Body

- 6) The lowest classification of basic motions should be used
 - a. **Class I** motions involve work that can be performed by the fingers acting alone
 - b. **Class II** motions involve work that can be performed by the fingers and the wrist
 - c. **Class III** motions involve work that can be performed by the fingers, wrist and lower arms
 - d. **Class IV** motions involve work that can be performed by the fingers, wrist, lower arms, and the upper arms or shoulders
 - e. **Class V** motions involve work that can be performed by the entire body, including the fingers, wrist, lower arm, upper arm and shoulder, and other body motions

Use of the Human Body

- 7) Ballistic-type motions are easier, and hence more productive, than other types of motions
- 8) Work should be designed so that the operator can use the preferred hand whenever possible
- 9) Outside stimulations, such as flashing lights, should vary inversely with the internal stimulations that the job itself creates

Use of the Human Body

- 10) If the hand must handle heavy loads over extended periods of time, the thumb and middle finger should be used
- 11) When gripping tools, the portions of the fingers closest to the palm should be used
- 12) When the hands perform twisting motions, the elbows should be bent
- 13) The feet are not capable of productively operating pedals when the operator is in a standing position

Workplace arrangement

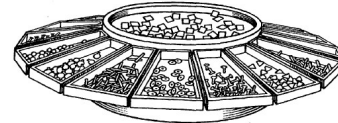
- 1) Tools and materials should be placed in fixed locations at the workplace
- 2) Gravity bins and drop delivery should be used whenever possible
- 3) Tools and materials should be located in the normal working area
- 4) Good posture will increase worker productivity
- 5) Machines should be located so that they are available at the point of use

Workplace arrangement

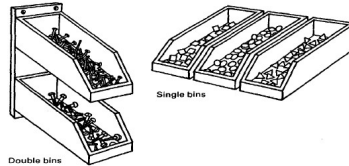
- 6) Specialization of tools and operator skill should be encouraged
- 7) Comfortable environmental conditions should be provided
8. The workplace and work method should be designed so that the operator does not have to deal with any static loads
9. The workplace should be designed to minimize and/or eliminate the use of the eyes

Various bins & motion economy devices

Figure 52. Various bins and motion-economy devices

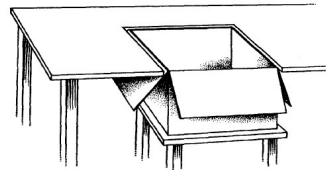


Rotating bin



Double bins

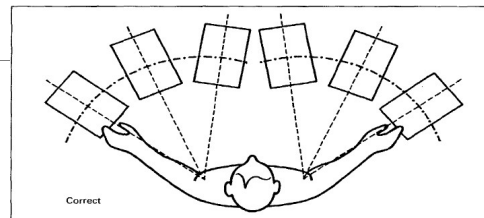
Single bins



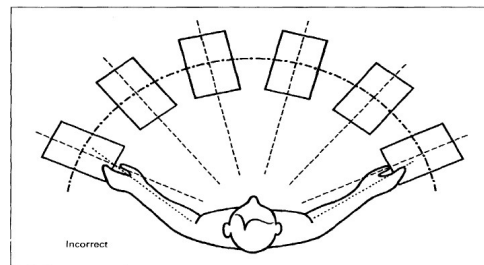
Depression in a table to hold flaps of a carton for packaging operation

Semi-circular & circular working arrangement

Figure 50. Semi-circular and circular working arrangement



This is a correct and better arrangement than a circular arrangement



Design of tools and equipment

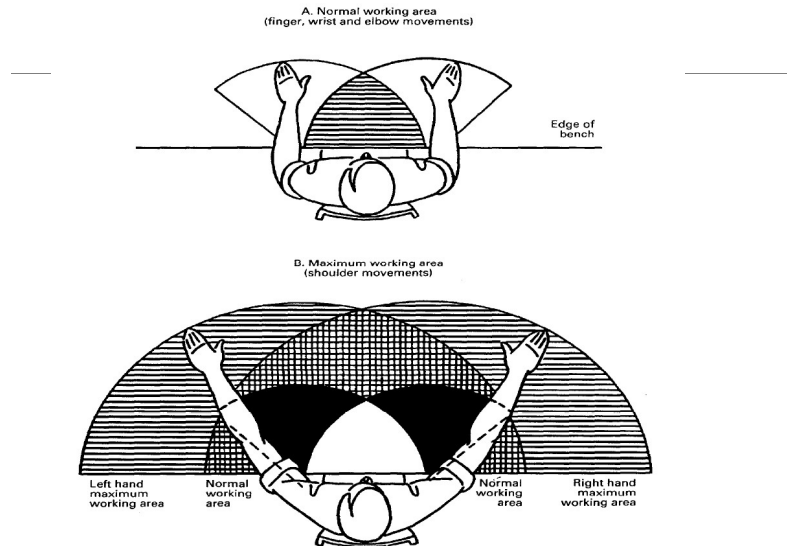
- 1) Whenever possible, multiple machining operations should occur simultaneously
- 2) Hand tools and control devices should be located within the normal work area, should be easily accessible to the operator, and should be operated by the muscle group that is best suited to that type of operation
- 3) Tools and materials should be prepositioned
- 4) Handling of tools and materials by the operator should be kept to a minimum

Design of tools and equipment

- 5) Jigs and fixtures should be used to hold parts in position
- 6) Tools should be designed for use by either hand
- 7) The surface where a tool is held by the operator should be slightly compressible, slip-free, and comfortable enough to be held for extended periods of time
- 8) Power-assisted tools should be used whenever possible
- 9) Use people where they are more effective and use machines where they are more effective

Normal & maximum working areas

Figure 49. Normal and maximum working areas



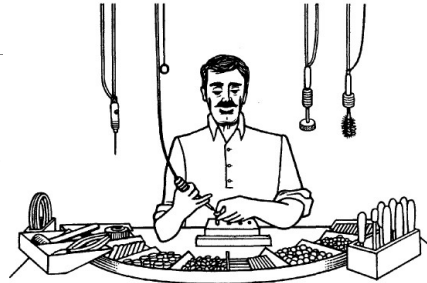
Notes on design of jigs, tools & fixtures

- A **jig** holds parts in an exact position and guides the **tool** that works on them
- A **fixture** is a less accurate device for holding parts which would otherwise have to be held in one hand while the other worked on them
- The designer's objective in providing jigs & fixtures is primarily accuracy in machining or assembly and also to free up both hands for the work
- Jigs & fixtures should be designed such that positioning the work piece on them should require minimal movement from the operator

An example of a workplace layout

Figure 53. An example of a workstation layout

1) A fixture has been provided for holding the work piece, leaving both the operator's hands free for assembly work. The necessary tools are hung in front of the operator so that he has to make only a very short and easy movement to grasp them and bring them to the work.



2) All the small parts are close to the operator, within the “maximum working area”. Each part has a definite location, and the trays are designed with “scoop” fronts for easy withdrawal, parts being drawn forward with the tips of the fingers and grasped as they come over the rounded edge.

3) They are arranged for symmetrical movements of the arms, so that parts which are assembled simultaneously are picked up from trays in the same relative position to the operator, on either side of him.

Man vs. Machine

- Man is generally believed to be more capable of performing in the following:
 - Situations that require improvisation or adaptation
 - Tasks which involve unusual or unexpected events
 - Tasks in which there is a great deal of distracting information presented
 - Tasks involving the use of new solutions or transferring similar solutions from other tasks
 - Tasks using uncoded or raw information

Man vs. Machine

Man is more capable (cont'd)

- Situations requiring the use of subjective judgment based on experience
- Situations requiring anticipation of results
- Perceptions of complex stimuli in highly varied situations

Man vs. Machine

Skynet

Machines are more capable, usually, in performing the following:

- Storing and retrieving coded information
- Doing large quantities of work in short periods of time
- Reliably performing highly repetitive tasks
- Doing tasks where being distracted by surrounding extraneous factors detracts from productivity
- Sensing stimuli outside of the human's normal range

Man vs. Machine

Machines are more capable (cont'd)

- Maintaining constant performance over long periods of time (with appropriate maintenance)
- Exerting great force precisely and consistently
- Deductive reasoning or categorization when established discussion rules are followed
- Simultaneously handling numerous inputs

Selling the solution

- Convince the worker and the supervisor that your improvement is the better way of performing the job
 - Consult with worker and supervisor in creating new method
 - Get feedback on proposed method
 - Give them credit if you utilize their ideas
- Overcome resistance to change

Resistance to change is due to

- Inertia
- Uncertainty
- Need
- Understanding
- Obsolescence
- Downgrading
- Support
- Personality
- Resentment

Resistance to change

- Participation
- Tactlessness
- Confidence
- Timing
- Economics
- Social

Overcoming resistance to change

- Explain the need for change
- Explain the nature of the change
- Facilitate participation in creating new method
- Be tactful in introducing proposal
- Watch your timing
- Introduce major change in stages
- Emphasize personal benefit
- Show personal interest in persons directly affected by change
- Have supervisor announce changes

Long term view

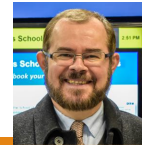
- **Technical training** to prepare individuals to adapt to and accept new ways and ideas
- **Education** – what was good enough will not always be good enough
- **Communication** – about the environment (technology, competition, economy)
- **Fairness** – assure people that they will be treated fairly in the event of change

That's it for today!

If you have not read the Chapter 1 - 4 please do it soon.

Discussion for next class: Measuring Productivity
(Chapter 5)

Questions?
Comments?

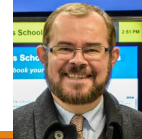


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PRODUCTIVITY: STANDARDS AND MEASURES

WEEK 6: MEASURING PRODUCTIVITY: TIME STUDY



By Mauro Spies

Learning Outcomes

- Describe the purpose of work measurement studies
- Define
 - Standard Time
 - Rating a job
 - Personal, Fatigue and Delay (PFD) Allowances

Purpose of Work Measurement studies

- **Work Measurement**

is the application of techniques designed to establish the time for an average qualified worker to carry out a task at a normal defined rate of working using a prescribed method

- The purpose of Work Measurement is to establish this time standard, normally called **Standard Time**

Work measurement techniques

- Historical data
- Time study
- Work sampling
- Standard data
- Predetermined time systems

Time Study

- **Time Study** is a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for an operator to carry it out at a defined rate of performance
 - Must be carried out after methods improvement
 - Uses stopwatch or similar device

Standard Time

- **Standard Time** is the time required by an **average worker**, working at a **normal pace**, to complete a **specified task** using a **prescribed method**
 - **Average worker** is a typical or representative worker, doing the job under investigation, who is experienced in performing that job
 - **Normal pace** is the pace at which an average worker can work at for an entire day without undue physical strain
 - Should be neither too fast nor too slow
 - Must be well defined, understood by all and remain constant
 - For example, walking at 6 Km/h on level surface

Specified task and prescribed method

- Standard time is determined for a specified task that has been well defined with a clear beginning and end
- This task should have a clear and agreed upon method of performing the work which must be followed every time the job is done
- This method should be agreed by all (worker, management, time study analyst, etc.) as the best method of doing the job, ideally established through methods improvement

Uses of Standard Time

- Developing production schedules
- Determining wage payment plans
- Estimating manufacturing cost
- Providing a base for estimating productivity increases
- Identifying employee training needs
- Appraising employee performance
- Justifying the addition of production capacity

Rating Job Performance

- **Rating** is the process of comparing the actual work being performed with the analyst's concept of normal pace and evaluating the observed performance quantitatively
- Rating generally uses the normal pace as a base of 100%
- A worker performing at a pace 20% faster than the rater's concept of normal is rated at 120%
- Ratings are rounded to the nearest 5%
- Different workers work at different paces and the same worker can work at different paces at different times

PFD Allowances

Personal, Fatigue and Delay

- Workers cannot work without a break and need rest at times for personal needs, fatigue or an allowance for other factors causing delay
- Standard time must be adjusted to reflect the PFD allowances
- **Personal allowance** is for personal needs like getting water or going to the washroom
- **Fatigue allowance** is to allow a worker to recover from work related fatigue
- **Delay allowance** is to cover delays due to machine breakdown, etc.

PFD Allowances – cont'd

- PFD allowances are expressed as a percentage and are added to the time allowed to complete a particular task being studied
- These allowances are generally constant within a company but can vary due to the working environment with, for example, larger allowances for working in extreme heat or cold, etc.
- PFD allowances can vary from 5% to 30% and can even go as high as 50%

Calculating Standard Time

Standard Time= (Observed Time)*(Rating Factor)+
(Observed Time)*(Rating Factor)*(PFD Allowance)

or

Standard Time= (Observed Time)*(Rating Factor)*
(1 + PFD Allowance)

(Observed Time)*(Rating Factor) = Basic Time or
Normal Time

Standard Time

Example 1: 4th National Bank of Marietta, GA

Determine the number of tellers on each branch

How long each teller takes to perform the tasks, for instance cashing checks

Task includes:

- | | |
|--|---------------------------------|
| Greets customer | Yes, there's more to a teller |
| Receives the check | tasks than this. |
| Examines the check | Let's focus on this one though. |
| Verifies the account | |
| Cancels the check | |
| Prepares a cash-out ticket | |
| Takes the money from the drawer | |
| Counts out the money (in from of the customer) | |
| Wishes good day | |

Standard Time

Industrial engineer studies the task observes that

Teller takes 0.41 min to complete the task

According to Bank's standards: pace is 90% of standard

Bank's PFD allowance: 13%

$$\begin{aligned}\text{Standard Time (ST)} &= (0.41) * (0.9) + (0.41) * (0.9) * (0.13) \\ &= 0.37 + 0.05 \\ &= 0.42 \text{ min}\end{aligned}$$

Standard Time

Example 2:

The data in the following table represent time-study observations on a new operation with three work elements. On the basis of these observations, find the standard time for the process. Assume a 15% allowance factor.

Element	Performance Rating	Observations (times in seconds)			
		1	2	3	4
1	120%	90.3	91.5	92.4	90.2
2	100%	30.5	32.3	29.6	31.1
3	105%	130.5	128.9	132	130.5

Average observed time for Element 1 = 91.1 seconds

Normal time for Element 1 = $91.1 \times 1.20 = 109.3$ seconds

Average time for Element 2 = 30.9 seconds

Normal time for Element 2 = $30.9 \times 1.00 = 30.9$ seconds

Example – cont'd

Average observed time for Element 3 = 130.5 seconds

Normal time for Element 3 = $130.5 \times 1.05 = 137.0$ seconds

Total Normal Time for operation = $109.3 + 30.9 + 137.0$
= 277.2 seconds

Standard Time = $277.2 \times (1 + 0.15) = 318.8$ seconds

Time Study

Conducting a time study

- Select a job to be studied
 - How the data will be collected
- Learn as much as possible about the job prior to performing the actual study
 - Historical information
 - Process instruction sheets
 - Discussions with other engineers, technologists, analysts
 - Familiarity with this or similar jobs

Time Study

Conducting a time study (cont'd)

- Identify and document:
 - Method
 - Workplace layout
 - Production equipment
 - Machine speeds and feeds (if applicable)
 - Inspection equipment (if applicable)
 - Environmental conditions
- Foreman or direct supervisor: identifies typical worker
- Discussion of the process with foreman presence

Time Study

Elemental analysis

- Divide the job into elements
 - Components of a job or task
 - Logical divisions of the job
 - Easy identifiable
 - Repeated on a regular bases during the shift
- Characteristics
 - Identifiable starting and stopping point: every element
 - No discontinuity between elements. Breakpoint: one ends the other starts
 - Frequency of each element

That's it for today!

If you have not read the Chapter 1 - 5 please do it soon.

Next steps:

- Quiz 1 attempt by Sunday
- First Test next Monday.

Questions?
Comments?



By Mauro Spies