
Total productive maintenance

Objectives: At the end of this lesson you shall be able to

- explain the concept of TPM
 - state advantages of TPM
 - explain the concept of OEE
 - describe the components of OEE and their effects.
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Total Productive Maintenance(TPM) concepts

TPM aims to maximize overall equipment effectiveness. Establishes a complete system of productive maintenance for the machines/equipments entire lifespan is implemented by various departments. [Engineering, Operations, Maintenance, Quality and Administration]

TPM can be considered as the medical science of machines.

TPM involves every single employee, from top management to all the operators on the shop floor. TPM raises and implements productive maintenance based on autonomous small group activities.

TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipments.

The goal of TPM is to an extent increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity.

Downtime for maintenance is scheduled as a part of the manufacturing day. In some cases as an integral part of the production process.

The goal of TPM is to stop the emergency and unscheduled maintenance.

Form different teams to reduce defects and self maintenance.

Advantages of TPM

- Avoids wastage in quickly changing economic environment.
- Produces goods without reducing product quality.
- Reduces maintenance cost.
- Produces a low batch quantity at the earliest possible time.
- Ensures the non defective goods to the customers.

- Reduce customers complaints.
- Reduce accidents.
- Follow pollution control measures.
- Favourable change in the attitude of the operator.

Overall equipment effectiveness (OEE)

Overall equipment effectiveness (OEE) is a concept utilized in a lean manufacturing implementation. OEE is described as one such performance measurement tool that measures different types of production loses and indicate areas of process development. The OEE concept normally measures the effectiveness of a machine center or process line, but can be utilized in non-manufacturing operation also.

The high level formula for the lean manufacturing OEE is

$$\text{OEE} = \text{Availability} \times \text{Productivity} \times \text{Quality}$$

Availability

The availability is part of the above equation measures the percentage of time the machine/equipment of operation was running compared to the available time. For example if the machine was available to run 20 hours but was only run for 15, then the availability is 75 percent 15/20. The five hours when the machine didn't run would be set up time, breakdown or other downtime. The 4 hours the company did not plan to run the machine is rarely used in the calculation.

Performance

The performance part of the equation measures the running speed of the operation compared to its maximum capability often called the rated speed. For example, if a machine produced 80 pieces per hour while running, but the capability of the machine is 100, then the performance is 80% (80/100). The concept can be used multiple ways depending on the capability number. For example, the machine might be capable of producing 100 pieces per hour with the perfect part, but only 85 on that particular order. When the capability of 100 is used for the calculation, the result is more a measure of facility OEE.

Quality

The third portion of the equation measures the number of good parts produced compared to the total number of parts made. For example if 100 parts are made and 95 of them are good, the quality is 95% (95/100).

Combining the above example into the OEE equation the OEE is

$$\text{OEE} = 75\% \times 80\% \times 95\% = 57\%$$

Autonomous Maintenance

Autonomous Maintenance put simply is the restoration and prevention of accelerated deterioration and has a major positive effect on OEE. It is a step by step improvement process, rather than production teams taking on maintenance tasks.

- Understanding the equipment functions and safety risks.

The seven steps of Autonomous Maintenance

1 Initial cleaning (Initial inspection & registration)	<ul style="list-style-type: none"> - Detect problem of the lives and restore the original state. - Start managing the line autonomously (5s, Minor stops, quality) autonomously - Create & perform temporary "cleaning/lubrication produces"
2 Source of contamination & Hard-to-reach areas	<ul style="list-style-type: none"> - Solve "sources of contamination" and hard to reach clear (Cleaning, Inspection lubrication)
3 Standard of cleaning & lubrication	<ul style="list-style-type: none"> - Develop tentative standards for cleaning lubrication and inspection.
4 General Inspection	<ul style="list-style-type: none"> - Provide training on their equipments, products and materials, inspection skills and other Am skills.
5 Autonomous Inspection	<ul style="list-style-type: none"> - Develop a routine maintenance standard by operations.
6 Standadize autonomous maintenance operation	<ul style="list-style-type: none"> - Standadize routine operation related to work place management such as quality inspection of products, life cycle of jigs, tools, set up operation and safety
7 Autonomous management	<ul style="list-style-type: none"> - Autonomous team working.

Routine maintenance

Objectives: At the end of this lesson you shall be able to

- state the need for routine maintenance
 - describe the functions of routine maintenance
 - state the advantages of routine maintenance.
-

Routine Maintenance

- In order to get trouble free service from productive equipment.
- Following activities is necessary to carry out.
 - i Lubrication
 - ii Periodic inspection
 - iii Adjustments of various parts
 - iv Cleaning

All the above maintenance operations are carried out while the machine is running or during pre-planned shutdowns.

This type of maintenance may prevent breakdown of equipments.

Routine maintenance should not interfere with production schedules.

Planned preventive maintenance (PPM), more commonly referred to as simply planned maintenance (PM) or scheduled maintenance, is any variety of scheduled maintenance to an object or item of equipment. Specifically, planned maintenance is a scheduled service visit carried out by a competent and suitable agent, to ensure that an item of equipment is operating correctly and to therefore avoid any unscheduled breakdown and downtime.

Along with condition based maintenance planned maintenance comprises preventive maintenance, in which the

maintenance event is preplanned, and all future maintenance is preprogrammed. Planned maintenance is created for every item separately according to manufacturers recommendation or legislation. Plans can be date-based, based on equipment running hours, or on the distance travelled by the vehicle. A good example of planned maintenance program is car maintenance, where time and distance determine fluid change requirements. A good example of condition based maintenance is the oil pressure warning light that provides notification that you should stop the vehicle because engine lubrication has stopped and failure will occur.

Planned maintenance has some advantages over condition-based maintenance (CBM), such as:

- Easier planning of maintenance and ordering spares.
- Costs are distributed more evenly.
- No initial costs for instruments used for supervision of equipment.

Disadvantages are:

- Less reliable than equipment with fault reporting associated with CBM.
- More expensive due to more frequent parts change.
- Requires training investment and on going labour costs.

Parts that have scheduled maintenance at fixed intervals, usually due to wearout or a fixed shelf life, are sometimes known as time-change interval or TCI items.

Maintenance schedule

Objective: At the end of this lesson you shall be able to

- describe the normal procedure followed in machine tool maintenance in shop floor.
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Any kind of action or activity there should be some procedure and sequence likewise maintenance also has some normal procedure to execute the maintenance activity without any confusion. If maintenance is not followed any procedure there will be time loss and the machine and equipment could not be ready in time. The procedure guides the maintenance people how to start, execute, where to inspect and how to complete the maintenance in time. The maintenance is carried out with the following procedure.

- Initial cleanup
- Identification of fault
- Dismantling
- Inspection
- Identification of cause for defect
- Inspection and replacement/ Repair of spares
- Reassembling

- Trial run
- Inspection with standards
- Maintaining records

Initial cleanup

Main machine, connected accessories, lubrication system, panels and adjacent parts are to be cleaned first.

Identification of fault

The fault of the machine is to be identified by visual inspection and getting information from the complaint and justified the same.

Dismantling

The fault area is dismantled with the referring to the manual and all the spares are kept separate in a tray and preserved safely.

Inspection

All the dismantled parts such as gear, bearing, shaft, key, etc. are cleaned and inspected for any damages. Any damages/breakage is recorded in the maintenance checklist.

Identification of cause for defect

The defect in spare parts thoroughly examined and analysed the causes for damage and the same has to be rectified.

Inspection and replacement/ repair of spares

The damaged or broken spares are procured from stores/ repaired and the same is inspected to the standards.

Reassembling

The next course of action is assembling the parts in reverse manner of dismantling order.

Trial run

After completion of assembling the machine is to run first manually and all the lubrication, electrical connection to be given. Finally the machine should run on is trial run for some time and observed for any unusual sound from the machine.

Inspection with standards

The machine is finally checked/inspected for geometry accuracy safety hazards etc., according to the manufacturer standard any other recommended standard as required by the nature of maintenance work carried.

Maintaining records

All the activities related to fault attended, spares changed, etc. to be recorded in the inspection report/maintenance record, machine history cards suitably for future reference.

Preventive maintenance

Objectives: At the end of this lesson you shall be able to

- **state the need for preventive maintenance**
 - **describe the functions of the P M department**
 - **state the advantages of P M**
 - **state the advantages of maintenance records and periodic inspection of machines.**
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Need for Preventive maintenance

The machine tools are of high precision, and are sensitive and expensive.

They must be handled and maintained carefully in order to give good and long service.

The basic function of the maintenance department is the upkeep of the machines and equipments in good operating condition.

Earlier the maintenance of the equipment used to receive attention only when the equipment suffered some set-back or breakdown as a result of some minor/major fault. Such breakdowns not only brought a serious production hold-up but also used to upset the production flow of the industry where the other equipment also had to stand idle. This resulted in a more cautious approach to the maintenance of the equipment and this brought up the more scientific way of tackling the maintenance problem, through preventive maintenance. (P M)

Preventive maintenance

Preventive maintenance consists of a few engineering activities which help to maintain the machine tools in good working order.

The basic activities of preventive maintenance are the:

- Periodic inspection of machines and equipments to uncover conditions leading to production breakdowns or harmful depreciation
- Upkeep of machines and equipments to avoid such conditions or to adjust, repair or replace them while they are still in the initial stages.

Advantages of preventive maintenance system

- Less down time in production.
- Improves quantity and quality of product.
- Standby equipment is not needed which saves capital investment.
- Lower unit cost of manufacture.
- Reduces major and repetitive repairs of machines.
- P.M. helps in prolonging the life of the machines and reduction in un-expected breakdowns.

Functions of preventive maintenance department

- Periodic inspection of machines and equipments as per the 'Check- lists'. (Annexure I)
- Lubrication of machines and equipments as per the manufacturer's instruction manuals.
- Servicing and overhauling of machine and equipment as per the P M schedule.
- Keeping basic records of each machine and equipment. (Annexure II)
- Analysis of inspection reports and systematic review of reports of machines and equipments.

Periodic inspection of machines and equipments as per the check-list

The check-list items for the inspector about all the points to be checked on individual machines. While preparing the check-list of the machine, make sure that no machine part or item that is omitted needs attention. The inspection of machine tools like lathe and drilling machine includes the following.

- Driving system and feeding system
- Lubricating and coolant system
- Slides and wedges and gibs
- Belts, bearings, clutch, brake and operating controls
- Guideways, lead screws and their mating parts

After inspection of each machine, the inspector has to make out the list of parts which need repairs or spares for replacement.

Frequency of inspection

The frequency of inspection depends on the age, kind of machine and its operating conditions. Frequent inspection of machines and equipment may be expensive and frequency with long intervals may result in more breakdowns. A good balance is needed to bring optimum savings.

Lubrication of machines and equipments

The length of time a machine will retain its accuracy and give satisfactory service depends on the lubrication and care it receives. It is essential that lubrication of machines should be carried out systematically at regular intervals as recommended in the service manual supplied by the machine manufacturer.

The manufacturer’s manual contains all the necessary details like grade of oil, grease, oiling and greasing points and also indicates the time intervals of lubrication.

Maintenance records (Annexure III)

Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyse

Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyse the cause of a fault and rectification.

Maintenance records analysis

Systematic review and regular analysis of the equipment records will help to:

- Re-design the weak part which gives repetitive trouble
- Substitute with better material for high cost items
- Minimise frequent breakdowns
- Reduce the cost of production.

Preventive Maintenance Programme

Name of the Machine :
Machine Number :
Model No. & Make :

Location of the machine :

Annexure I

CHECK-LIST FOR MACHINE INSPECTION

Inspect the following items and tick in the appropriate column and list the remedial measures for the defective items.

Items to be checked	Good working/satisfactory	Defective	Remedial measures
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all feeds			
Lubrication system			
Coolant system			
Carriage & its travel			
Cross-slide & its movement			
Compound slide & its travel			
Tailstock’s parrallel movement			
Electrical controls			
Safety gaurds			

Inspected by

Signature

Name :

Date :

Signature of in-charge

History sheet of machinery & equipment

Description of equipment:	
Manufacturers' address:	
Supplier's address:	
Order No. and date:	
Date on which received:	
Date on which installed and placed:	
Date of commissioning:	
Size: Length X Width X Height	
Weight:	
Cost:	
Motor particulars:	Watts: r.p.m: Phase: Volts
Bearings/Spares record:	
Belt specification:	
Lubrication details:	
Major repairs and overhauls carried out with dates.	

MAINTENANCE RECORDS

Sl.No	Name of the machine	Nature of fault rectified	Date	Signature of in-charge

Difference between breakdown maintenance and preventive maintenance

Sl.No.	Breakdown Maintenance	Preventive Maintenance
1	Maintenance is undertaken only after breakdown	Maintenance is undertaken only before breakdown
2	No attempt is made to prevent breakdown	Maintenance is made to prevent breakdown
3	This is unpredictable activity	Predictable activity
4	Maintenance cost less	Cost of maintenance is high
5	Not suitable for equipments like cranes, hoists, pressure vessels	Can be applied to all types of equipments
6	Results in production loss and more "Down time"	Such disadvantages are eliminated

Reactive Maintenance

The oldest maintenance approach is reactive. Equipment is not repaired or replaced until it breaks. In this maintenance equipment fails with little or no warning so this could be down until replacement parts arrive, resulting in income loss. In this maintenance cost and down time increased and also create safety issues. Reactive maintenance can be suitable in some situation such as for non critical and low cost equipment with little or no risk of capital loss or production loss.

Importance of breakdown maintenance and preventive maintenance in productivity

The importance of an effective maintenance program cannot be overlooked because it plays such an important role in the effectiveness of lean manufacturing. As in personal health care insurance, maintenance may be considered the health care of our manufacturing operation, business or service operation. The cost of routine maintenance is very small when its compared to the cost of a major breakdown at which time there is no production.

Purpose of maintenance

The importance use of routine maintenance is to ensure that all equipment required for production is operating at 100% efficiency at all times. Through short daily inspections, cleaning, lubricating and making small adjustment small problems can be detected and corrected before they become major problem that can shutdown a production line. A good maintenance program requires company wide participation and support by everyone ranging from the top executive to the shop floor personel.

Inspection, types of inspection and gadgets for inspection

Objectives: At the end of this lesson you shall be able to

- **retrieval of data from machine manual**
 - **state the need of inspection**
 - **state the function of inspection**
 - **list out the type of inspection**
 - **discuss the each type of inspection**
 - **list out the gadgets used for inspection.**
-

Retrieval of data from machine manual

Manual is one of the integral and necessary literary part that the operator has to know before handling and operating the machine. It will be provided by true manufacturer along with the supply of the machine.

Manual furnish all information about the machine like size of the machine, foundation and erection method, safety procedure to be followed, operating procedure and periodical maintenance required.

The machine manual will also provide about the required power supply, safety precaution grade of lubrication oil to be used etc., availability of suitable spare parts and details of dealer/supplier has to be provided in the manual otherwise use of any other parts will not suit and the machine will get damaged.

We have to refer and follow manual if any problem/defects arises during operation of the machine.

The manual will also provide the brand and type of tools that can be used, time period/life of the tools to be replaced based on the usage and periodical inspection to be carried out.

In general manual to provide information right from starting of the machine, operating method of machine and stopping the machine, in case of emergency to stop the machine.

Inspection

Inspection is necessary for any machine/equipment where remarkable risk to health and safety may arise from wrong installation, re-installation or any other circumstances. The purpose of inspection is to find whether machine can be operated, adjusted and maintained safely. The need for inspection and inspection intervals to be determined through risk assessment.

The summary of inspection should be recorded and same should be kept atleast until the next inspection of that machine. Machine/equipment that required inspection should not be used unless the machine has been inspected.

If the machine/equipment obtained from any other source (eg. hired). One should be ensure that physical evidence of last inspection is accompanied with the machine, such as inspection report, some form of tagging, labelling system or colour coding.

Function of Inspection in maintenance

- 1 Periodic inspection of machines and equipments as per checklist (Annexure 1)
- 2 Keeping basic records of each machine & equipments.
- 3 Preparation of list which need for repairs (or) spare for replacements.
- 4 Analysis of inspection report and systematic review of reports of machines/equipments.
- 5 Assigning of frequency of inspection.

The following Annexure 1,2 and 3 are the formats used in maintenance inspection.

Annexure I

INSPECTION CHECK-LIST			
Name of the machine :		Location of the machine :	
Machine No :			
Model No :			
Inspect the following items and tick in the appropriate column and list the measures for the defective items.			
Item to be checked	Good working/Satisfactory/Status	Defective	Remedial measures
Availability of machine manual			
Safety guards			
Installation			
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all the feeds			
Lubrication system			
Coolant system			
Sliding part and its travel			
Safety and limit switches			
Electrical controls			
Proper lighting			
Emergency stop			
Alarm speciality			
Condition of work holding devices			
Condition of tool holding devices			
Condition of accessories and attachments			
Chip collection and disposal			

Conclusion of inspection

Recommendations

Inspected by

Signature

Name :

Date :

Signature of incharge

Annexure II

EQUIPMENT RECORD

History sheet of machinery & Equipment

Description of equipment	
Manufacturer's address	
Supplier's address	
Order No. and date	
Date on which received	
Date on which installed and placed	
Date of commissioning	
Size: Length x Width x Height	
Weight	
Cost	
Motor particulars	Watts/H.P./ r.p.m: Phase: Volts:
Bearings/ spares/ record	
Belt specification	
Lubrication details	
Major repairs and overhauls carried out with dates	

Lubrication survey

Objectives: At the end of this lesson you shall be able to

- state the benefit of lubrication survey
- prepare the cost estimation.

How does a Lubrication survey work?

Lubrication survey of all equipment that requires lubrication.

- By points of lubrication
- Recommended LE products
- Application methods
- Drain or lube intervals
- Special remarks

The materail is compiled and a report is returned with the recommended lubricants for all of your equipment included.

What are the benefits of a Lubrication survey?

- A key part of a good preventive maintenance program.
- Product consolidation
 - Reduces inventory requirements
 - Minimizes product misapplication
- Assists maintenance personnel in seeing that all lubrication points are lubricated as scheduled.
- Reduces downtime and repair parts. Minimizes time spent with OEM manuals researching proper lubricants.
- Easily updated by your LE Representative to keep the survey effective.
- Increases equipment life.

Increase your profitability

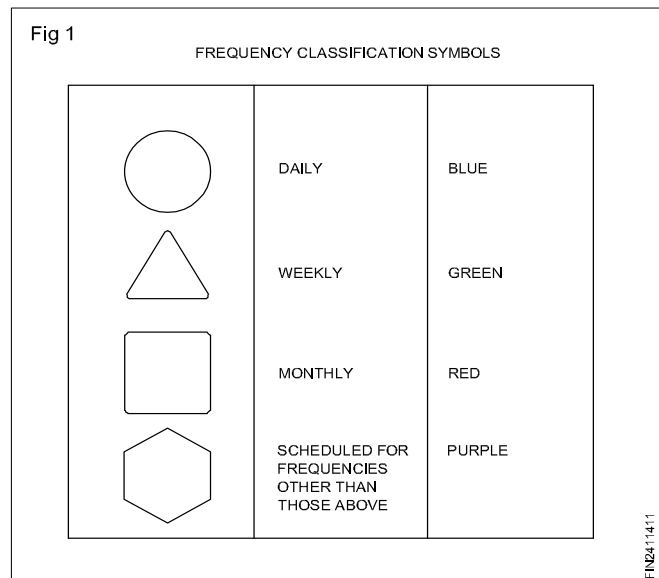
Preventing equipment downtime is directly reflected in increased productivity. A refocus from the repair maintenane philosophy to the preventive approach is needed.

Hints for lubricating machines

- Identify the oiling and greasing points
- Select the right lubricants and lubricating devices
- Apply the lubricants

The manufacturer’s manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer’s manual.

These places are indicated in the maintenance manuals with symbols as shown in Fig 1.



The best guarantee for good maintenance is to follow the manufacturer’s directives for the use of lubricants and greases. Refer to the Indian Oil Corporation chart for guidance.

The lubricant containers should be clearly labelled. The label must indicate the type of oil or grease and the code number and other details. Oil containers must be kept in the horizontal position while the grease container should be in the vertical position.

Cost Estimating Methods

Engineering Estimate with this technique, the system being costed is broken down into lower level components (such as parts or assemblies), each of which is costed separately for direct labour, direct material and other costs. Engineering estimates for direct labour hours may be based on analyses of engineering drawings and contractor or industry wide standards. Engineering estimates for direct material may be based on discrete raw material and purchase part requirements. The remaining elements of cost (such as quality control of various overhead changes) may be factored from the direct labour and materials costs. The various discrete cost estimates are aggregated by simple algebraic equations (hence the common name ‘bottoms-up estimate). The use of engineering estimates requires extensive knowledge of a system’s (and its components) characteristics and lots of detailed data.

Simple estimation of material

Objectives: At the end of this lesson you shall be able to

- state the purpose of estimation
 - explain the details of formats for estimation sheet
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Estimation is the method of calculating the various quantities and the expenditure to be incurred on a particular job or process.

In case the funds available are less than the estimated cost the work is done in part or by reducing it or specifications are altered,

The following essential details are required for preparing an estimate.

Drawings like plan, elevation and sections of important parts.

Detailed specifications about workmanship & properties of materials, etc.

Hand book and reference table

A hand book is a type of reference work, or other collection of instruction. That is intended to provide ready reference. The term originally applied to a small portable book containing information useful for its owner, but the oxford english dictionary defines as "any book giving information such as facts on a particular subject, guidance in some art or occupation, instruction for operating a machine etc. A handbook is sometimes referred to as a pocket reference.

Hand book may deal with any topic, and are generally having compact information in a particular field (or) technique. They are designed to be easily consulted and provides quick answer in a certain area.

Example of engineering hand book include parry's theoretical engineers hand book, mark standard hand book for machine engineer and the CRC hand book of chemistry and physics.

Standard schedule of rates of the current year.

Estimating is the process of preparing an approximation of quantities which is a value used as input data and it is derived from the best information available.

An estimate that turns out to be incorrect will be an overestimate if the estimate exceeded the actual result, and an underestimate if the estimate fell short of the actual result.

A cost estimate contains approximate cost of a product process or operation. The cost estimate has a single total value and it is inclusive of identifiable component values.

Reference table

A reference table may mean a set of references that are author may have cited (or) gained inspiration from whilst writing an article, similar to a bibliography.

It can also mean an information table that is used as a quick and easy reference for things that are difficult to remember such as comparing imperial with metric measurements. This kind of data is known as reference data.

ESTIMATION SHEET

Part Name:	Part No.: 1	Insert Part Drawing 
Assembly:	Material: Fe310.0	
Assembly No.:	Stock size: Ø 80 ISR-70L	

Operation No.	Operation description	Lathe	Estimated time	Rate / per hr.	Tools
01	Setting and aligning job on lathe	-	10 min	Rs.100.00	
02	Set speed and feed	-	2 min	-	
03	Align cutting tool in position	-	2 min	-	
04	Turn the job	-	50 min	-	
05	Chamfer 45° angle corner	-	8 min	-	vernier bevel protractor
06	Reverse the job on Lathe	-	10 min	-	
07	Turn the job	-	20 min	-	
08	Chamfer 45° on other side	-	20 min	-	
09	Centre drilling	-	10 min	-	
10	Mount drill chuck and drill using tail stock	Drilling	03 min	-	
11	Set drill rpm	Drilling	02 min	-	
12	Drill holes	Drilling	20 min	-	
13	Set the boring tool	Drilling	15 min	-	
14	Bore to the required diameter		08 min	-	
15	Check the bore dia		10 min	-	Inside micrometer or bore dial gauge
16	Deburr the job and clean the machine	-	10 min	-	
17	Total hours		200 min		
18	Total estimation			Rs. 333.00	
