MINIMIZING THROUGH PUT TIME OF SPARE PARTS MANUFACTURING FOR ALTERNATOR DRIVE TURBINE OF A FERTILIZER FACTORY

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CERTIFICATE

This is to certify that the work presented in this thesis was done by me under the complete supervision of Dr. Ahsan Ali Khan, Professor and Head, Department of Industrial and Production Engineering, BUET, Dhaka, Bangladesh. It is also certified that this thesis work has not been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT:

Fertilizer sector is one of the important sectors in the industrial belt in our country. A number of equipment of mechanical, electrical, instrumental etc are being used to produce urea and ammonia in fertilizer factories. Among the equipments, turbine plays a vital role to drive different pumps, compressors, alternators etc. To maintain them in a well balanced condition it is necessary to provide with proper maintenance works for the prime movers i.e. turbines. To facilitate maintenance job smoothly and sustain the maximum output of the turbines, it has meticulously been tried in this work to procure some of the spare parts of the alternator drive turbine locally thereby replacing the imported spare parts of those kinds These items have been proposed to be manufactured at the local workshop of Zia Fertilizer Co. Ltd. (ZFCL). This is the best way for procurement of spare parts although there are several other ways for procuring them. There are a lot of activities involved in manufacturing them. Studying the spare parts, selecting their lot sizes, identifying non-critical and non-precision items, suggesting about the material; their functions, preparing process sheets etc. have been done in this work. Moreover, a computerized process planning has been adopted to determine the minimum manufacturing time or the best possible time for their manufacturing as well as criticality of the jobs with the aid of a computer software of critical path method

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CHAPTER - ONE

INTRODUCTION

- General Introduction
- Present situation of Zia Fertilizer Co. Ltd.
- Background of the study.
- Aims and objectives.
- Organization of the thesis.

INTRODUCTION

1.1 General Introduction:

The world is advancing to get the touch of developed technology. For receiving this, the role of manufacturing technology and the sophisticated machines and equipments is prominent.

If the views are extended towards world's economic policy, it is observed the important activities of NAFTA, EC etc. and in the south Asia region the treaty SAFTA. Commensurating with this treaty an economic concept has been promulgated in the world and to bring into harmony, Bangladesh has also accepted this which is free trade economy. To survive at this competitive market the best quality products at minimum cost should have to be ensured. Several input factors such as technology, man, machine and equipment etc. are the deciding factors for attaining good quality products with minimum production costs.

Modern manufacturing / production technology is solely related to computer technology. In the first world and other developed countries like Japan, they have been using computerized design and manufacturing technology for many years. CAD / CAM, MIS (Management Information System), MRP-I, MRP-II, Robotics etc. are the efficient tools for efficient production and management function which ensure less cost of production and the best quality products

But Bangladesh lags behind the modern technology in some of the fields. Manufacturing concerns of this country have been following the conventional method of manufacturing processes. But a very few no. of these concerns have adopted computerized manufacturing processes for producing garments accessories, but in the government sectors it is almost nil. Rather, they are gradually sinking down. The manufacturing concerns in the government sectors like BITAC, BISCIC and other private workshops etc. are seldom capable of supplying highly precision as well as good quality products.

There are several problems involved in manufacturing spare parts locally. Among them unavailability of skilled and experienced man power as well as modern machine tools, very narrow size of the market, scarcity of fund flow, poor industrial growth rate and unfamiliarity with the modern manufacturing technology come ahead. Observations reveal that due to the above mentioned factors quality products could not be attained as well as cost of production could not be brought under control.

Zia Fertilizer Co. Ltd. (ZFCL) is a state owned factory. About 8-10 crore taka has been expending per annum for the procurement of spare parts from abroad. So if it would be possible to manufacture a portion of imported items locally, then a lot of foreign currency could be saved. Even if it is possible to manufacture them in the workshop of Zia Fertilizer Co Ltd. (ZFCL), then the cost would be unimaginably low.

There are many activities involved in manufacturing processes of the spare parts. If the process such as scheduling, calculating machining time or distribution of the jobs among the machining facilities, could be done using computer program or computer software and it will still lower the cost, ensure maximum utilization of valueble machines and manpower.

In the present work a computer software named 'Management Scientist, version 2.0' has been introduced to determine the minimum or best possible time for manufacturing a few number of spare parts using existing machining facilities of the factory.

1.2 Present Situation of Zia Fertilizer Co. Ltd. (ZFCL)

Zia Fertilizer Co. Ltd. established in 1981, is a state owned fertilizer producing factory having capacity of 1600 MT of urea and 930 MT of ammonia per day. Earlier it was named as 'Ashugenj Fertilizer and Chemical Co. (AFCC)'. Eventually it was handed over to the state owned Bangladesh chemical industries corporation (BCIC) in the year 1983 as per decision of the Government. It is located at Ashuganj under Brahmanbaria district - approximately 100 km north-east of Dhaka. The site stands by the east bank of river Meghna, about 2 km south of Ashuganj rail station and Dhaka-Sylhet highway.

From the beginning, ZFCL has been contributing to build the national economy by depositing revenue to the government treasury as well as removing unemployed problem of the country through creating employment opportunities for a huge number of people of this country But gradually its contribution to the development of the national economy and providing employment opportunities are reducing. This is due to the fact that the cost of production of urea and ammonia and other allied expenses have increased tremendously. Moreover, the government has imposed restrictions on raising the selling price of fertilizer for political and social reasons. Nevertheless, due to ageing most of the machines and equipment, experience frequent break down and thereby to overcome this situation proper maintenance works with proper spare parts and equipment are rendered. For procuring these spare parts from abroad ZFCL has to spend a lot of foreign currency. In these circumstances, the management has decided to reduce import of spare parts and various unnecessary expenses which will inturn result less production cost and ultimately maximise the profit.

1.3 Background of the study:

There are six divisions in Zia Fertilizer Co Ltd. Among them maintenance and technical services (MTS) division is responsible for carrying out various engineering activities like maintenance program, fabricating and manufacturing spare parts, installation of different machines and equipment etc. Machinery maintenance (MM) is one of the departments of MTS division where maintenance and other associated works of all the rotary equipment are generally executed Among the rotary equipment, turbine is the one of the vital items. It is a capital item So for smooth operation of turbine it is essential to provide better maintenance facility for it and thereby recovering its output. Since there is no standby unit for the turbine, it is essential to carry out the maintenance works properly.

Among the turbines the alternator turbines' spare parts manufacturing program has been taken in the present work. This is because there are two no. of alternator drive turbines. Both the turbines are running at under load condition This is due to the fact that the power grid of ZFCL is connected with PDB's (Power development board) national grid and ZFCL has to pay a fixed amount of charge for a fixed amount of (MW) power drawing from national grid whether consuming the maximum permissible value or less. So most of the demand for power is met from PDB's power. Therefore it would be possible to shut completely one turbine and operate the other with introducing the locally manufactured spare parts at shut down turbine and their performance could be easily observed. If these spare parts malfunction, the turbine could be shut all at once and for this it would not hamper the production process of the factory. As a part of the manufacturing process of spare parts, it is essential to allocate the jobs properly to the machines as well as to determine minimum or the best possible manufacturing time. This can be achieved by using CPM and a computer software of CPM would give the best solution

Above all, there are a numerous valuable as well as sophisticated machine and equipment and skilled men power available at the workshop of ZFCL, so by combining the performance of man and machine it would be possible to manufacture some of the selected spare parts.

1.4 Aims and objectives:

A lot of foreign currency is required to import the valuable and essential items required for maintenance of alternators drive turbines A greater lead time is also involved for their procurement. Although ZFCL is a state owned factory, it could not get relief from the various formalities and difficulties of administrative complexities Vendors also raise the price of the spare parts every year With a view to avoiding the difficulties mentioned above the following aims and objectives have been set for the present work:

i) To study the spare parts commonly used for maintenance of alternator drive turbine

ii) To identify the non-critical and non-precision items and study their functional properties.

iii) To select the materials for the spare parts and develop their manufacturing process.

iv) To determine operation time for manufacturing them individually

v) Determining minimum time for manufacturing the selected spare parts by CPM using the computer software.

1.5 Organization of the thesis:

In chapter - two, selection of spare parts have been made as well as their functional properties, using area have also been discussed Various machines and their specifications which are required to manufacture the selected spare parts alongwith a brief description of ZFCL workshop have also been presented in chapter - three In chapter - four, different steps for manufacturing process such as calculation of manufacturing time, process sheets have been shown. An introductory discussion on critical path method (CPM) has also been included in this chapter. A discussion on results and recommendation and conclusion have been made in chapter - five.

CHAPTER - TWO

SELECTION OF SPARE PARTS COMMONLY USED FOR ALTERNATOR DRIVE TURBINE

- Introduction
- Identifying the non-critical and non-precision items
- Lot sizes of the selected spare parts
- Functions of the selected spare parts
- Causes for changing / replacing spare parts
- Recommended material for the spare parts

2.1 Introduction:

Earlier it was mentioned that the alternator drive turbine consists of about 358 no. of spare parts [fig. no. 2.1]. Among them rotor is a very complex and complicated one. Blades, balance piston etc. are the integral part of the rotor [part no.180]. Trip bolt for the speed governor system [fig. no. 2.2] is embedded to the non driving end of the rotor separately in order not to reduce the shaft section [fig no. 2.1, part no. 266 (bold line)]. The portion of shaft of that part has been integrated with the main shaft Controllers have different parts and with these parts it is a complete one [fig. no. 23]. Emergency stop valves, high pressure (HP) valves and low pressure (LP) valves have certain shape and special material to withstand high temperature and pressure [fig no. 2.4]. Top casing and bottom casing have also specific shape and material [fig. no. 2.1, part no. 02 and 03]. For steam sealing labyrinth seals are used which are fitted to turbine casing [fig no. 2.1, part no. 125]. Oil retaining rings, casing bolts and nuts etc are also the important components of a turbine.

Among the spare parts some of them can not be manufactured locally due to their complicated shape and high degree of accuracy as well as speciality in materials. In the present work only those parts that have simple shapes, don't require high accuracy and materials required for them are available in the local market have been selected to be manufactured using existing facilities of the workshop

2.2 Identifying the non-critical and non-precision items:

The spare parts which have high degree of dimensional accuracy, then they can be termed as precision items and whenever their failure would detriment the failure of the system, then the spare parts can grouped as critical items Nevertheless there are some minor characteristics which are liable for making an item as critical, these are high unit price. complex manufacturing technology, critical using area etc

In the present work, only non-precision and non-critical spare parts have been selected for manufacturing them locally as because slight dimensional variation would not substantially affect the function of the turbine. Moreover, failure of such items would affect temporarily but would not result in complete shut down of the turbine. To avert risk of failure of the spere parts which would be manufactured locally, only non-critical items have been selected There are some limitations of facilities available at the workshop of ZFCL, so only non-precision items have been selected. Therefore it is justified to select non-precision and non-critical items for manufacturing them locally.

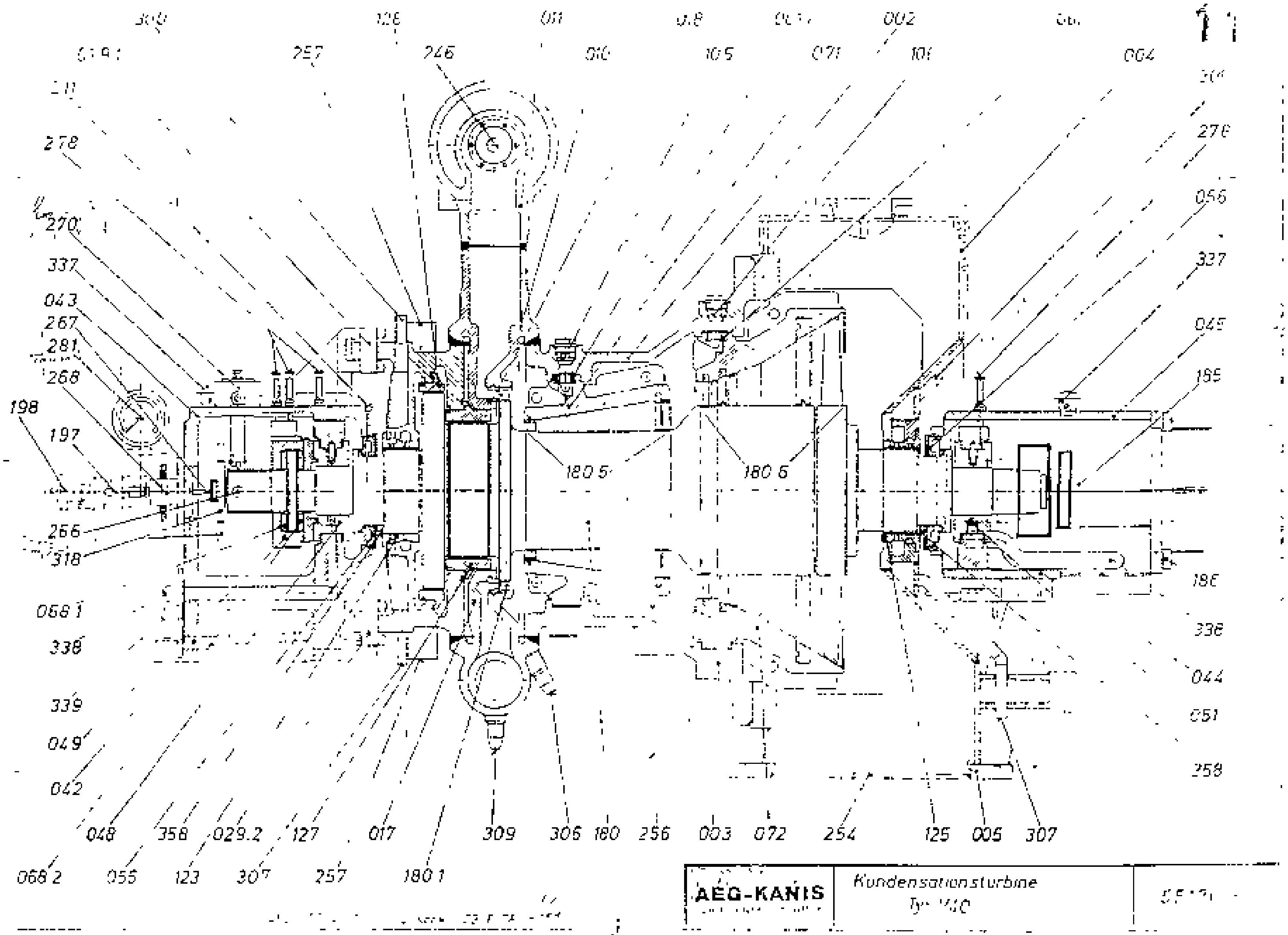
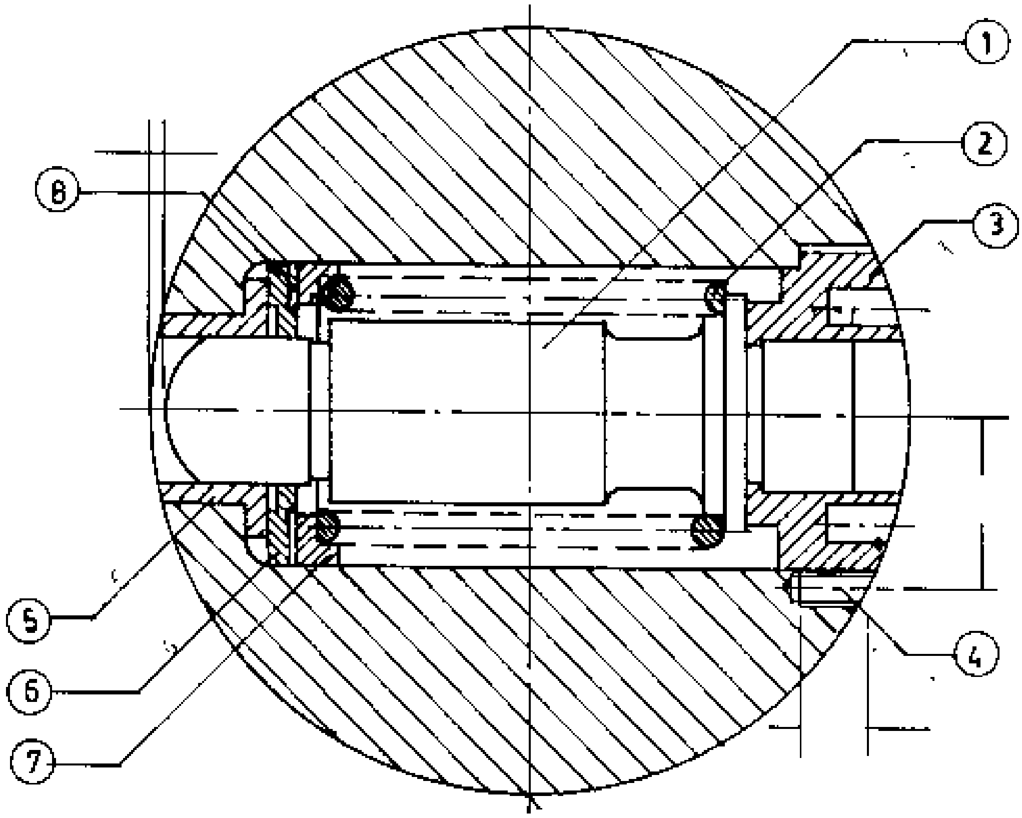


Figure : 2.1 Rotor with other auxiliaries

KONDENSATIONSTURBINE / CONDENSING TURBINE

Nr.	Kondensationsturbine	Condensing turbine
002	Turbinengehäuse, Oberteil	Turbine casing, upper
003	Turbinengehäuse, Unterteil	Turbine casing, lower
004	Abdampfgehäuse, Oberteil	Exhaust casing, upper
005	Abdampfgehäuse, Unterteil	Exhaust casing, lower
010	Düsenkasten	Nozzle chest
011	Ventilkasten	Valve chest
017	Unterer Düsenkasten	Nozzle chest, lower
018	Düsensegment	Nozzle element
029.1 029.2	Führungsteile	Guide elements
042	Vorderer Lagerkörper, Unterteil	Bearing pedestal, lower, governor end
043	Vorderer Lagerkörper, Deckel	Bearing pedestal, cover, gov.end
044	Hinterer Lagerkörper, Unterteil	Bearing pedestal, lower, coupling end
045	Hinterer Lagerkörper, Deckel	Bearing pedestal, cover, coupl. end
048	Vorderes Radiallager	Journal bearing, governor end
049	Axiallager	Thrust bearing
051	Hinteres Radiallager	Journal bearing, far end
055	Ölabstreifring, vorn	Oil retaining ring, governor end
056	Ölabstreifring, hinten	Oil retaining ring, coupling end
061.1 061.2	Ausricht- und Führungselemente	Alignment and guide elements
068.1	Lagerklötzchen, vorn	Bearing pads, governor end
068.2	Lagerklötzchen, hinten	Bearing pads, journal bearing end
071	Leitschaufelträger 1	1st guide blade carrier
072	Leitschaufelträger 2	2nd guide blade carrier
105	Führungsbolzen für Leitschaufelträger 1	1st stator guide pin
106	Führungsbolzen für Leitschaufelträger 2	2nd stator guide pin
123	Vordere Wellenlabyrinthbuchse, außen	Labyrinth seals, governor end, outside
125	Hintere Wellenlabyrinthbuchse, außen	Labyrinth seals, far end, outside
127	Ausgleichskolbenlabyrinthbuchse, innen	Inside labyrinth seals, balance piston
128	Ausgleichskolbenlabyrinthbuchse, außen	Outside labyrinth seals, balance piston

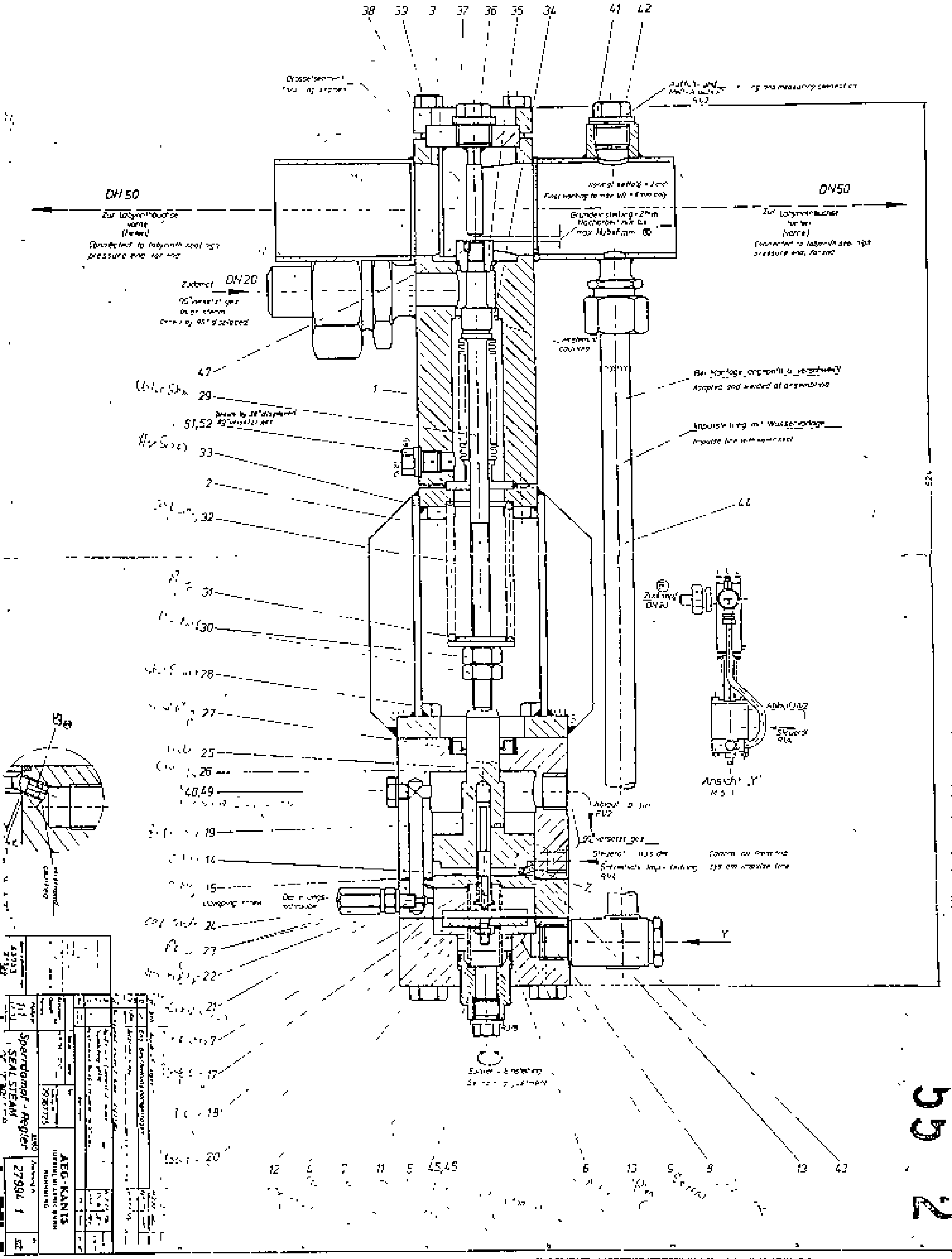
150	Läufer	Rotor
180.1	Regelradbeschaufelung	Impulse blading of control stage
180.5	HD-Überdruckbeschaufelung	HP-Reaction blading
180.6	ND-Überdruckbeschaufelung	LP-Reaction blading
185	Zahnkupplung	Double gear tooth coupling
186	Kupplungsverschalung	Coupling guard
197	Drehzahlregler	Governor
198	Drehzahlsollwerteinsteller	Set point adjuster
245	Schiebeventile	Consecutive compound valves
254	Abdampfstutzen	Exhaust nozzle
256	Anzapfstutzen	Bled steam nozzle
257	Umfuhrungsleitung	Pressure equalizing line
266	Drehzahlwachter - SS-bolzen	Overspeed governor trip bolt
267	Düsenanordnung für Wellenlagewächter (Axialwächter)	Nozzle assembly for axial displacement trip
269	Wellenlagewächter (Axialwächter)	Axial displacement trip
270	Schnellschlußvermittler	Emergency relay
278	Lagerthermometer	Bearing thermometer
281	Tachometer	Tachometer
300	Sperrdampfleitung	Seal steam supply line
305	Wrasendampfleitung	Waste steam nozzle
306	Turbinengehäuseentwässerung	Turbine casing drain
307	Labyrinthbuchsenentwässerung	Labyrinth seal drain
309	Düsenkammerentwässerung	Nozzle chamber drain
311	Sperrluft	Seal air
319	Getrieberad	Pinion
337	Lagerkorperentlüftung	Bearing block vent
338	Schmierölzulauf	Lube oil supply
339	Schmierölrücklauf	Lube oil return
350	Abdeckblech, Wellenlabyrinth	Baffle plate, labyrinth gland



1. Eccentric bolt
2. Compression spring
3. Cover nut
4. Grub screw
5. Guide bush
6. Anvil
7. Spring washer
8. Adjust washer

Figure : 2.2 Trip bolt for the speed governor system

Figure · 2.3 Seal steam controller



Liste zu Zeichnung Nr. 27994.1
List to Drawing No. 27994.1

2

SPERRDAMPFREGLER		SEAL STEAM CONTROLLER
1	Steuergehäuse	Control casing
2	Federhalterung	Superstructure
3	Segment	Segment
4	Deckel	Cover
5	Hülse	Sleeve
6	O-Ring	O-ring
7	Zyl. Druckfeder	Compression spring
8	Membrane	Diaphragm
9	Schraube	Screw
10	Ring	Ring
11	Sechskantmutter M6	Hexagon nut
12	Sechskantschraube M12x75	Hexagon screw
13	Flansch	Flange
14	O-Ring	O-ring
15	O-Ring	O-ring
17	Zyl. Druckfeder	Compression spring
18	Ring	Ring
19	Steuerstift 12x66	Piston valve
20	Sicherungsring	Lock washer
21	Gewindestift M8x40	Grub screw
22	Sechskantmutter M8	Hexagon nut
23	Ring	Ring
24	Hutmutter	Cap nut
25	Kolben	Piston
26	Gehäuse	Casing
27	Radialdichtring	Seal ring
28	Sechskantschraube M12x25	Hexagon screw
29	Ventilspindel	Valve stem
30	Sechskantmutter M12	Hexagon nut
31	Ring	Ring
32	Zyl. Druckfeder	Compression spring
33	Sechskantschraube M12x25	Hexagon screw
34	Buchse	Guide bush
35	Sechskantmutter 30x45	Hexagon nut
36	Dichtring	Sealing washer
37	Sechskant-Bundschraube	Hexagon collar screw
38	Flansch	Flange
39	Sechskantschraube M10x30	Hexagon screw

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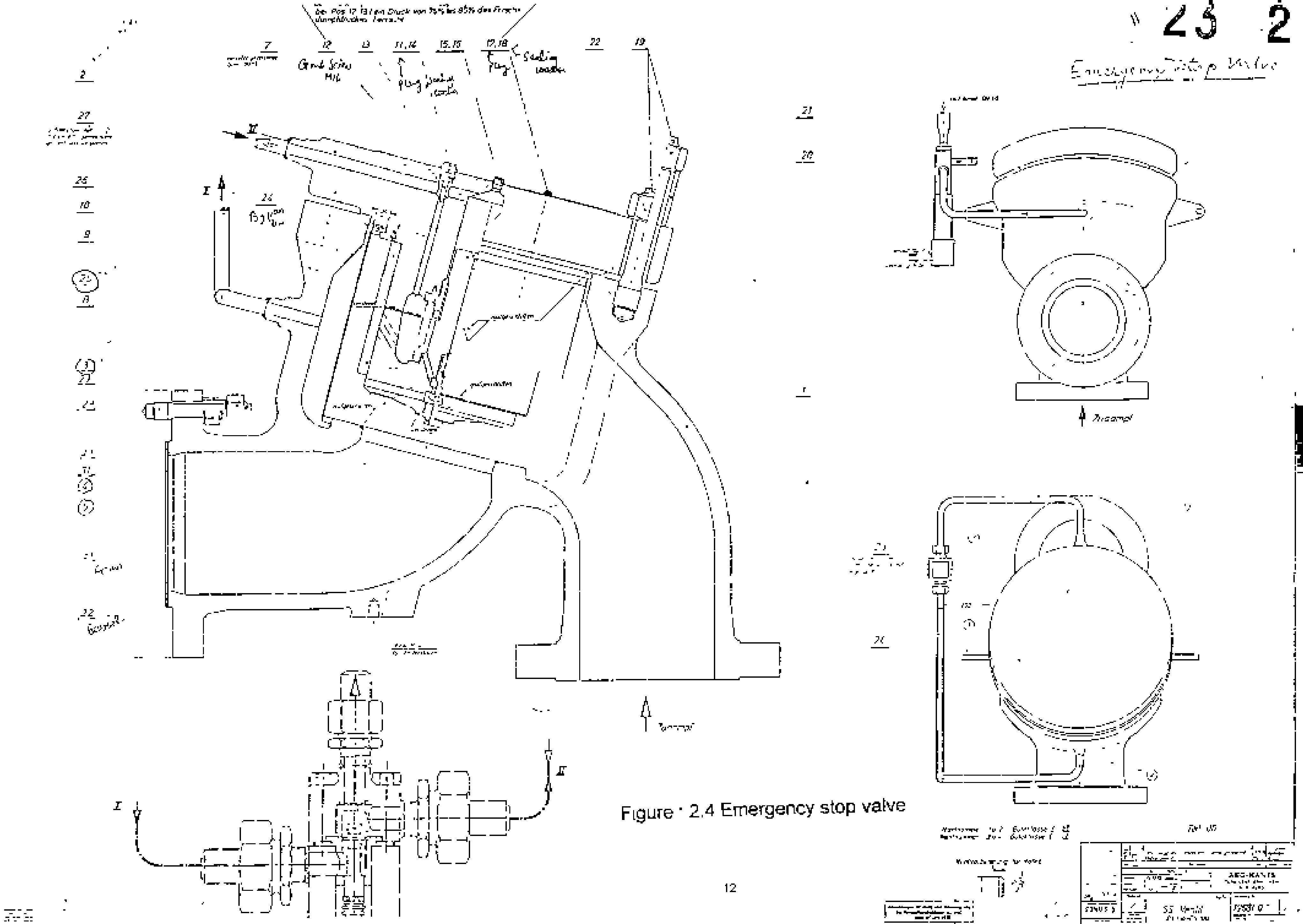


Figure · 2.4 Emergency stop valve

However, the spare parts for the alternator drive turbine which have been identified as non-precision and non-critical considering the factors which have shown in a brief in the following:

i) dimensional accuracy

ii) manufacturing technology.

iii) using area.

iv) unit price etc.

The spare parts of the turbine have been analyzed and compared to the above mentioned characteristics of critical and precision items, the following spare parts have been grouped as non-critical and non-precision items:

Turbine casing bolts and nuts and coupling bolts and nuts

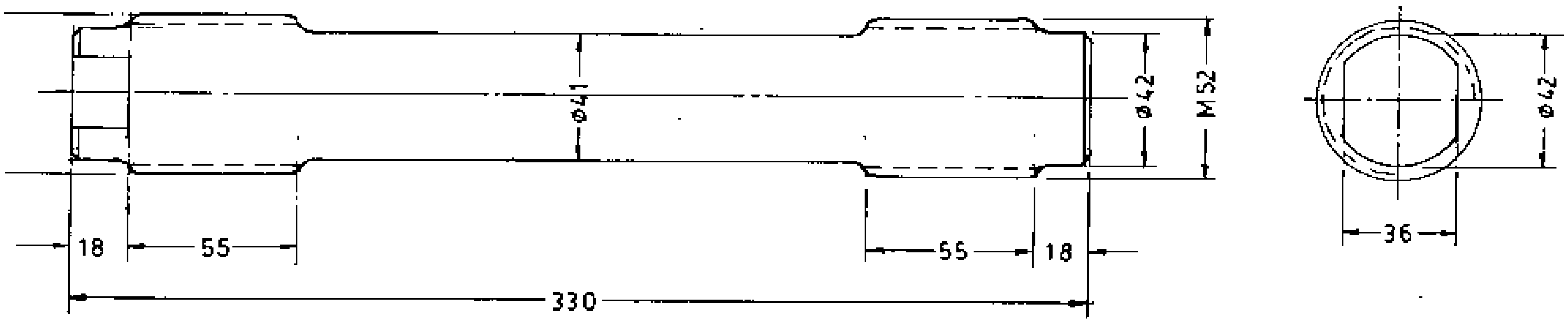
These items could easily be manufactured locally allowing a tolerable range of variation of dimensions Therefore, they can be considered to be a non-precision part. Their unit price would not be high Because for importing items from abroad in some cases the auxiliary expenses might also increase two to three times than the actual price of the items But this question is absent for locally produced products. Moreover, their using area is very simple and their failure would not make any considerable problem. So they can easily be catagorized as non-critical items [fig. no. 2.5 and 2.6]

Axial displacement disc and rotor locating ring

The simple shapes and wide tolerance have fallen them in the group of non-precision items Their manufacturing process is very simple and could be manufactured locally at low cost Their failure would not influence in operating turbine. For this they can be considered as non-critical items [fig. no. 2.7 and 2.8].

Gear coupling

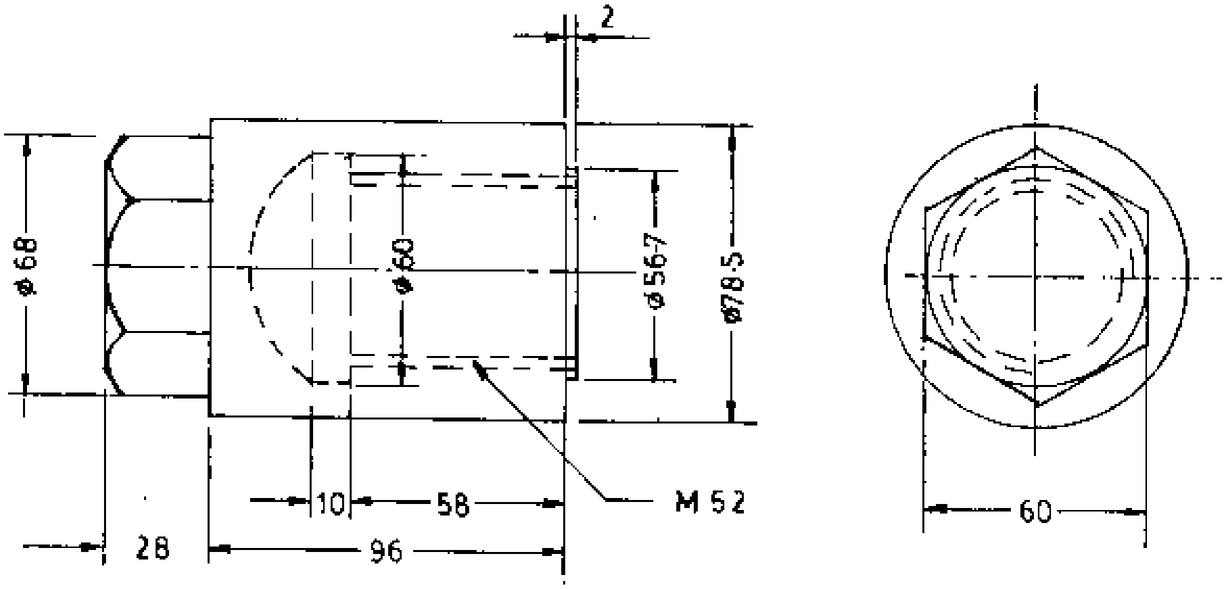
By allowing a minor amount of backlash as well as dimensional deviation, it can easily be manufactured. So this is a non-precision item Moreover, certain minor failure of its components would not detriment the function of the turbine. Therefore it could be termed as non-critical item [fig. no 2.9].



Tolerance is over ± .07 and is not shown in the figure.

Turbine casing bolt

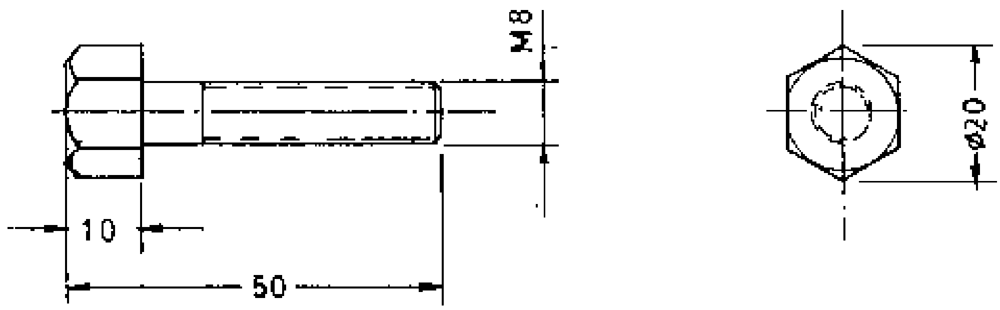
Figure : 2.5 and 2 6 Turbine casing bolts and nuts and Coupling bolts and nuts (Contd.)



1. Internal tolerance is over + 0.08 and is not shown in the figure.

2. External tolerance is over ± 0 1 and is not shown in the figure.

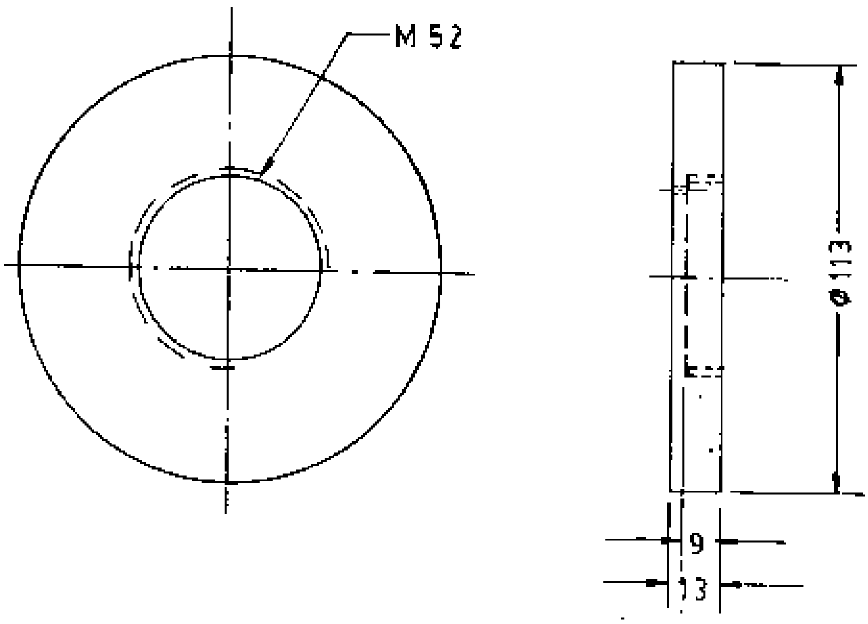
Socket type nut for turbine casing bolt



Tolerance is over - 0.08 and is not shown in the figure.

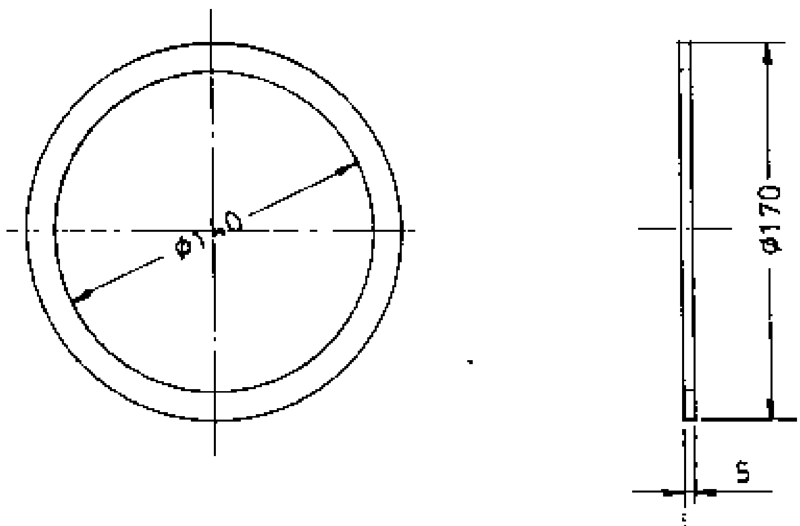
Coupling bolt

Figure · 2 5 and 2.6 Turbine casing bolts and nuts and
Coupling bolts and nuts



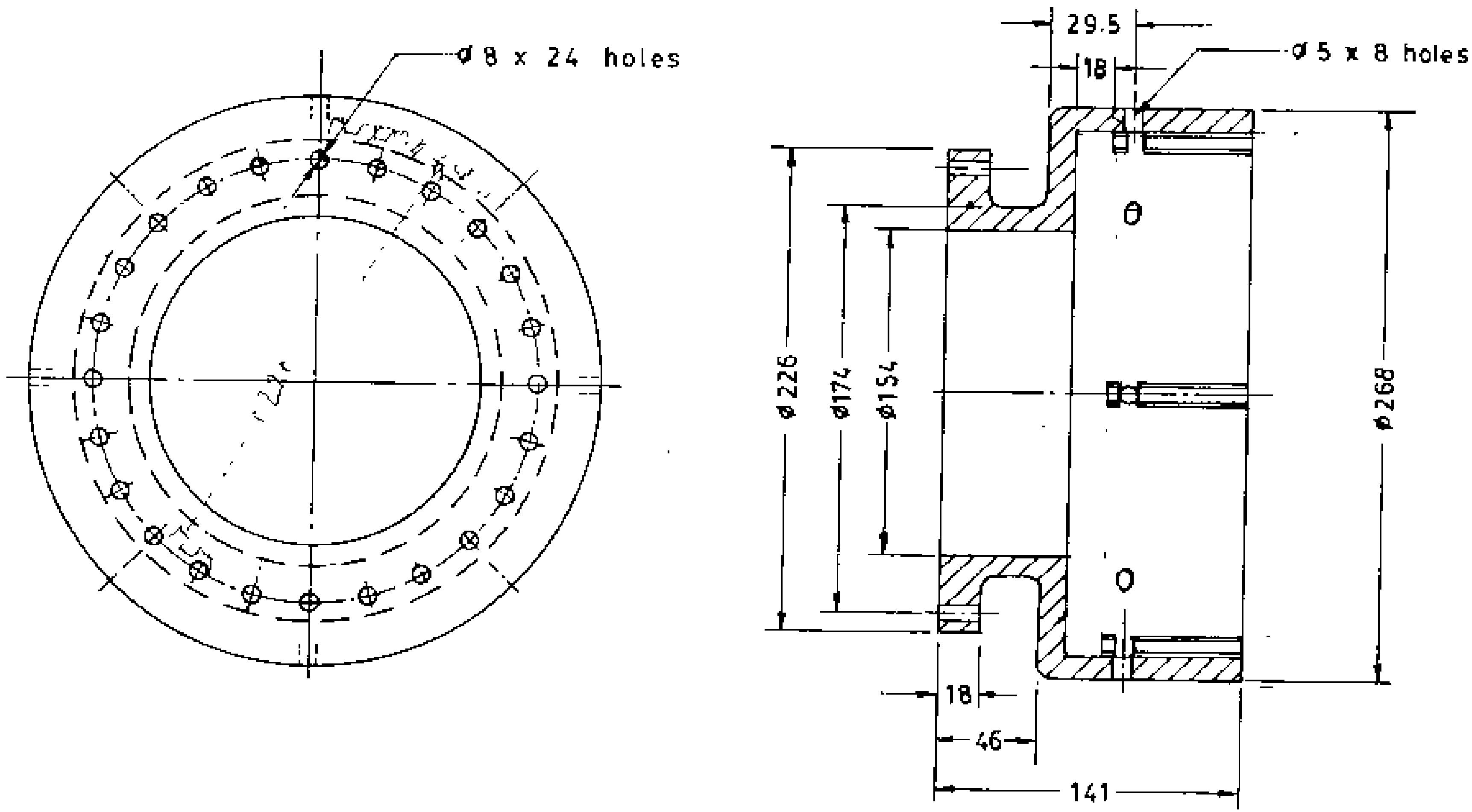
Tolerance is over ± 0.03 and is not shown in the figure

Axial displacement disc



Tolerance is over ± 0.03 and is not shown in the figure.

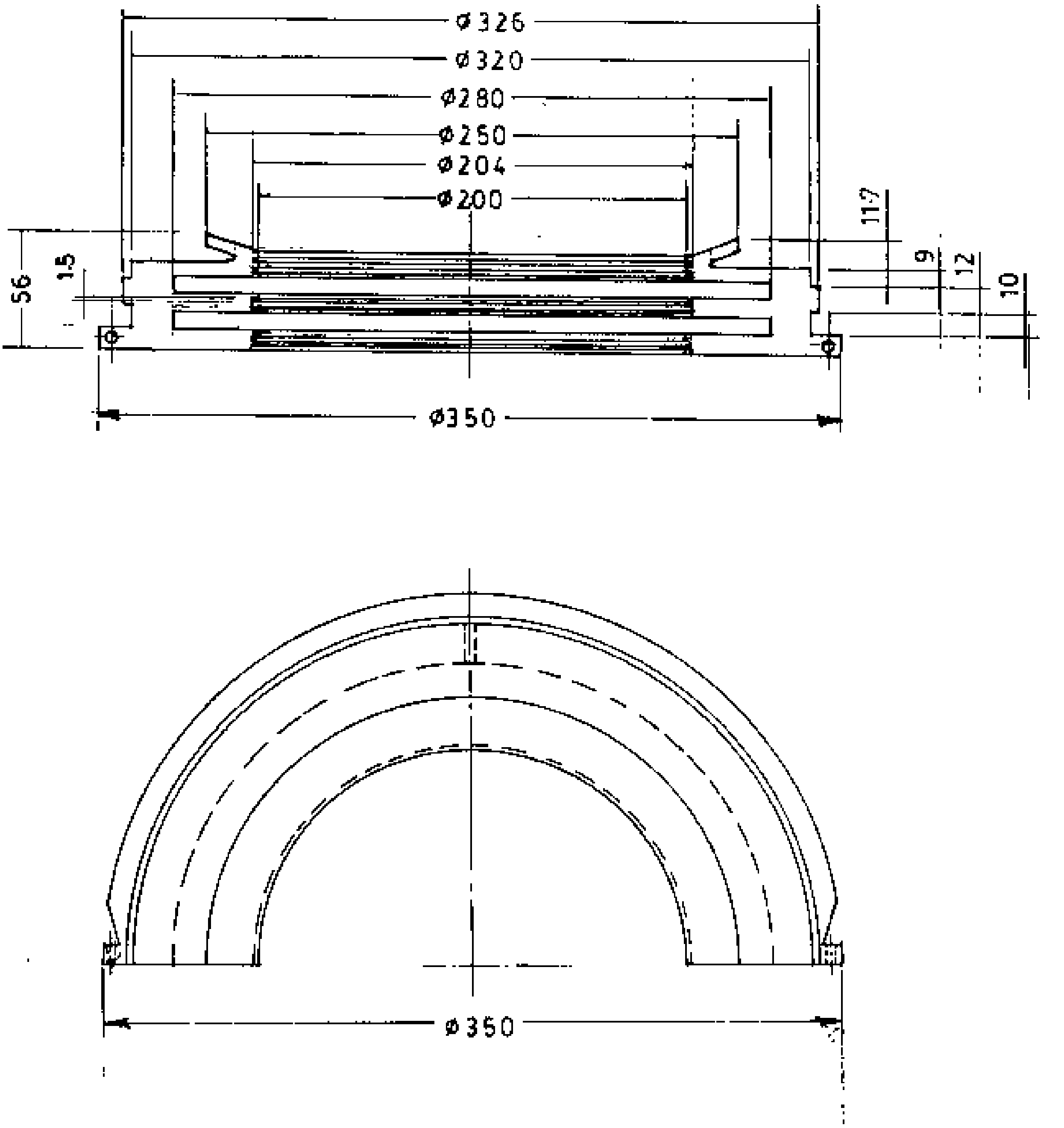
Figure : 2.7 and 2.8 Axial displacement disc and rotor locating ring



1. Internal tolerance is over + 0.06 and is not shown in the figure.

2. Tolerance is over ± 0.1 for all other dimension and is not shown in the figure

Figure : 2.9 Gear coupling



1. Internal toleration is over + 0.04 and is not shown in the figure.

2. External toleration is over ± 0.1 and is not shown in the figure.

Figure 2.10 Oil retaining ring

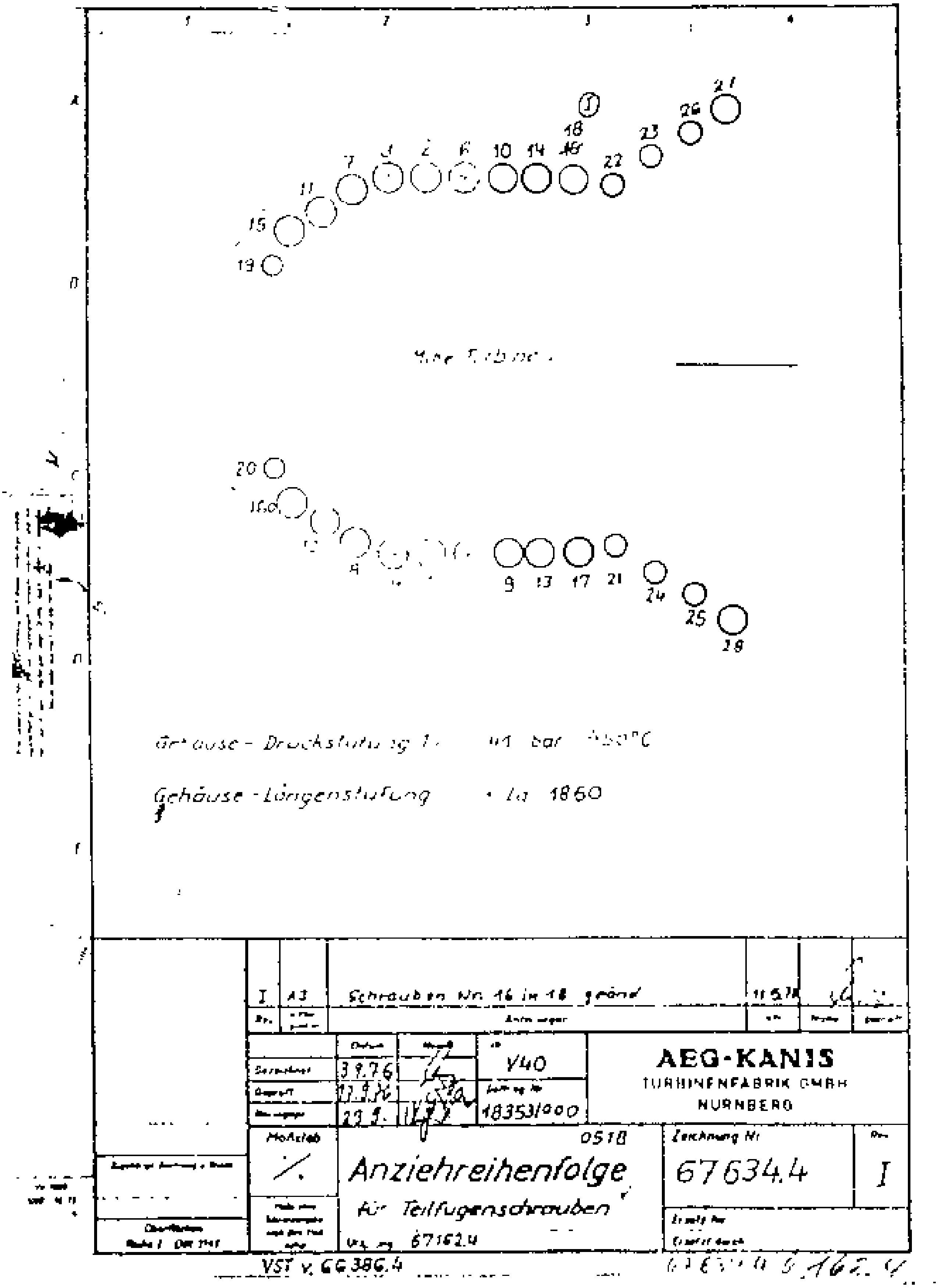


Figure : 2.11 Arrangement of turbine casing bolts

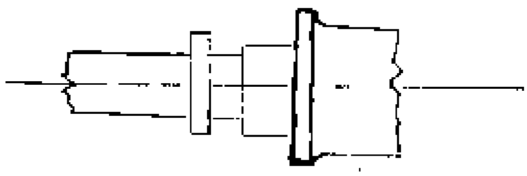


Figure . 2.12 Position of rotor locating ring (bold line)

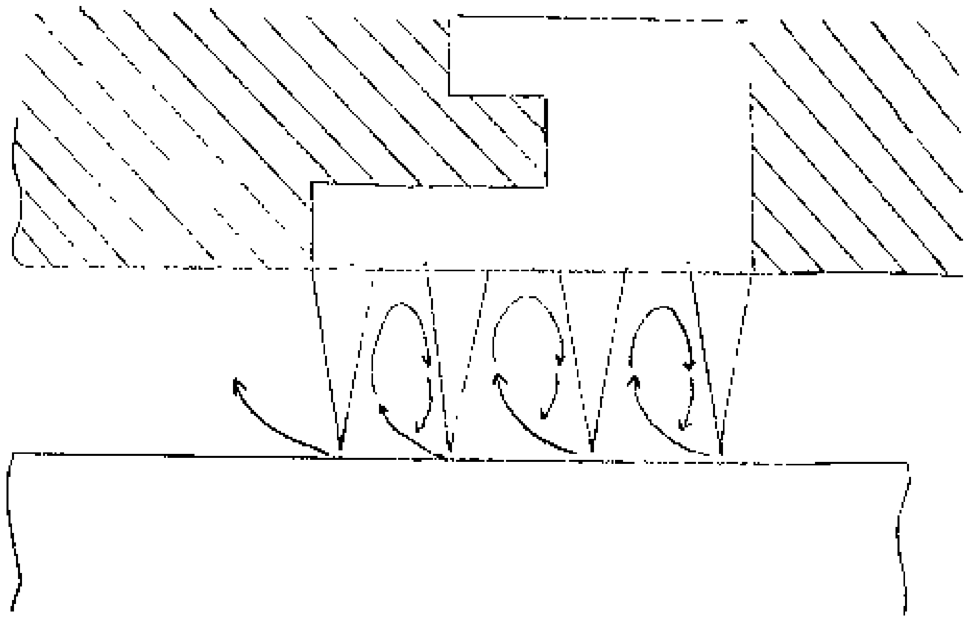


Figure . 2.13 Lube oil sealing system

Oil retaining ring

It can easily be manufactured although with certain deviation of clearances between shaft and ring as well as bearing housing and outside of the ring. If it experiences loose fitting, then it can be minimised by providing with shims. So due to this dimensional inaccuracy it can be identified as non-precision item If failure in certain part of the item occur, it might increase lube oil leakage. This can be easily checked by providing extra high pressure jet of air or steam from outside of the ring and thereby oil leakage will be stopped For this, it can be classified as non-critical item [fig. no. 2.10]

2.3 Lot sizes of the selected spare parts:

The alternator drive turbines are not generally shut as they are very costly in line process equipment. If any valuable machine or equipment remains idle, it would be simply a loss to the owner. But if the turbines malfunction, excessive steam leakage or lube oil or control oil loss occur they are brought under shut instantaneously Otherwise for every two years alternately one turbine has to undergo overhauling and the other to servicing work and vice versa. During these overhaul or emergency shut period, the spare parts which would loss their properties due to wear and tear would be changed and their average consumption rate are recorded for future reference From this analysis the lot sizes of the selected spare parts per anum have been determined on the basis of this consumption record and are shown below in a tabular form

Sl No.	Description of the spare parts	Average annual consumption rate (approx.)
1.	Turbine casing bolts	28
2.	Turbine casing nuts	28
3.	Coupling bolts	48
4	Coupling nuts	48
5	Gear coupling	2
6.	Rotor locating ring	2
7.	Axial displacement disc	2
8	Oil retaining ring	8

Table: 2.1 Lot sizes for the selected spare parts

2.4 Functions of selected spare parts:

According to the location of use and purposes served, the selected items have different functions A brief description of their functions is given below.

i) <u>Turbine casing bolts and nuts.</u>

The bottom casing of the turbine rests on the structure which inturn fixed to the foundation of the turbine. Turbine bolts and nuts firmly hold the top casing with the bottom one, thereby resist thermal expansion of the casing as well as steam leakage [fig. no. 2.11].

ii) <u>Coupling bolts and nuts:</u>

Coupling bolts and nuts are being used to hold the coupling spacer and to couple turbine to gear box for transferring mechanical power [fig no 2 1, part no 185 (bold line)]

iii) <u>Gear coupling:</u>

Its main function is to transmit the mechanical power of turbine to the gear box. There are some limiting value for backlash and certain axial play [fig. no 2.1, part no 185].

iv) <u>Rotor locating ring.</u>

Rotor locating ring is placed after the journal bearing of governor end, the main function of it to locate the rotor at its proper position. This can be ensured by resting the rotor collar to the side face of the rotor locating ring [fig. no 2.12]

v) <u>Axial displacement disc.</u>

The axial displacement disc is fitted at the extreme end of the rotor at governor end. Control oil which is issuing from a fixed nozzle strikes on the flat surface (lapped surface) of the disc. If the rotor moves away from the nozzle the oil pressure decreases and if the rotor moves toward the nozzle then the oil pressure increases By sensing the pressure by an instrumental device the rotor axial play can easily be detected [fig. no. 2.1, part no 267 (bold line)].

vi) <u>Oil retaining ring.</u>

The interior part of bearing housing of governor end and coupling end are provided with 2 no of oil retaining rings. One of the rings is fitted at the inside part of coupling side bearing housing end the other is at the inside of the bearing housing of governor side. Each one is divided as top half and that of bottom half. The both halves are identical and make a complete circular one Since pressurized lube oil enters the bearing housings which have large area, the pressure drops inside the bearing housings. The reduced pressurized lube oil still trys to come out from the housing through small clearance between the shaft and rings strips [fig. no 2.1, part no 55 and 56]. Then again the pressure drops Due to eddy inside the slots of the ring, the pressure again be reduced at a level from which it can not get out thereby sealing bearing housing from leaking out the lube oil [fig. no. 2 13].

2.5 Causes for changing /replacing the spare parts :

The spare parts have certain design value for clearances, dimensions etc. After prolong use the dimensions may be changed from their design value . At this stage if they are not replaced then there may arise steam or oil leakage, vibrations, malfunction of instrument devices etc. and hereby reducing turbine's output.

For oil retaining ring the radial clearance (design limit) is 0.17-0 22 mm for both the sides If it exceeds the design limit oil leekage will be apparent.

There are two sizes of bolts for turbine casing .They have specific dimensions. If under prolong tension it elongates more than the design limit then naturally the top half of turbine casing will get space and steam will escape.

The coupling bolts and nuts should have specific threads and concentricity. If it differs from the suggested value then it must be replaced. Otherwise due to presence of unbalance mass, vibration will occur.

The gear coupling should have perfect shape and designed dimension, otherwise due to backlash, noise and tear would deteriote the performance of the turbine.

The axial displacement disc should have a super polished surface as well as the dimension within design limit. Due to prolong use the surface may run out As a result the instrument device can not function properly due to running out of the surface.

The rotor locating ring should have the dimension within design limit. Otherwise rotor can not be fixed to its proper position

2. 6 Recommended material for the spare parts:

Considering the working environment of the selected spare parts of the turbine, materials have been selected for them according to ASME / ASTM standards which have been shown in the table [table no. 2.2].

RECOMMENDED MATERIAL FOR THE SPARE PARTS

NAME OF THE SPARE PARTS	GRADE OF THE MATERIAL	CHEMICAL COMPOSITION %																	HARDNESS	REMARKS
		C	Mn	P	S	Si	Ni	Cr	Mo	V	W	Al	Ti	Sn	Mg	Cu	Fe	OTHERS		
TURBINE BOLTS AND NUTS	A437 B4B B4C	0.2-0.25	0.5-1.0	0.025	0.025	0.2-0.5	0.5-1.0	11.0-12.0	0.9-1.25	0.2-0.3	0.9-1.25	0.05 (max)	0.05	0.04 (max)					331 BHN	Hardness for bolts of B4B
	A 437 B4D	0.36-0.44	0.45-0.70	0.04	0.04	0.02-0.35		0.82-1.15	0.5-0.65	0.25-0.35									302 BHN	Hardness for Bolts of B4D
																			277 BHN 293-341 BHN 229-277 BHN 263-311 BHN	Hardness for bolts of B4C Hardness for nuts of B4B Hardness for nuts of B4C Hardness of nuts of B4D
	A193B7 (Cr – Mo)	0.37-0.47	0.65-1.1	0.035	0.04	0.15-0.35		[illegible]	0.15-0.25										35-40 HRC	
	A193 B16 (Cr Mo-V)	0.36-0.44	0.45-0.7	0.035	0.04	0.15-0.35		0.8-1.15	0.5-0.65	0.25-0.35									35-40 HRC	
COUPLING BOLTS AND NUTS	A193 B5 A193 B6	0.1 0.15	1.0 1.0	0.04 0.04	0.03 0.03	1.0 (max.) 1.0 (max.)		4.0-6.0 11.5-13.5	0.4-0.65										35-40 HRC 35-40 HRC	
GEAR COUPLING	A193 B6	0.15	1.0	0.04	0.03	1.0 (max.)		11.5-13.5											55 HRC	Teeth Hardness
ROTOR LOCATING RING	A412 Type 201 UNS Designation S20100	0.15 (max.)	5.5-7.5	0.060 (max.)	0.030 (max.)	1.0 (max.)	3.5-5.5	16.0-18.0											40 and above	
AXIAL DISPLACEMENT DISC	A412 Type XM-11 UNS Designation S21904	0.04 (max.)	8.0-10.0	0.060	0.03 (max.)	1.0 (max.)	5.5-7.5	19.0-21.5											40 and above	
OIL RETAINING RING	SB-26B 356 0		0.35			6.5-7.5						Remainder	0.25	0.2-0.4	1.25	0.25	0.6	0.05		

Table : 2 2 Recommended material for the spare parts (As per ASME / ASTM standard)

CHAPTER - THREE

PROCEDURE / METHODOLOGY FOR MANUFACTURING PROCESS PLANNING FOR THE SELECTED SPARE PARTS

- Introduction
- Facilities available at the workshop of ZFCL
- Calculation of manufacturing time
- Preparation of process sheets
- Formulating the process planning
- Computerized process planning
- Developing computer algorithm and output of the work

3.1 Introduction:

Process planning has several elements. Material requirement planning, master production scheduling, bill of materials etc are the main elements of process planning In the industrially developed countries they have been using computerized process planning. But in Bangladesh most of the spare parts manufacturing firms have been following traditional system If a few no. of components of process planning could be used in Bangladesh, it would not incur much money but good quality products at low cost could be manufactured.

The manufacturing process of identified spare parts includes calculation of operation time of the spare parts, preparation of process sheets followed by determining the best possible time / minimum time for their manufacturing with the help of computer software of critical path methed (CPM) and a network has been drawn manually as well as the selection of materials for the spare parts have also been made.

The procedure / methodology for manufacturing the spare parts can be briefed as follows:

1. Selection of spare parts for alternator drive turbine using existing workshop facilities.
2. Study the working condition of the spare parts and selection of materials for them.
3. Calculating the operation time for each of the spare parts.
4. Developing master oporation sheets for manufacturing of selected spare parts.
5. Formulating the process planning to determine best possible time / minimum time of manufacturing the spare parts and developing a computer algorithm.

3.2 An introduction to facilities available at the workshop of ZFCL:

Different machines would be used for manufacturing the selected spare parts. These are available at the factory's workshop except gear shaper machine. The selected spare parts can easily be manufactured by the machines available at the workshop. But for the gear coupling, the teeth might be machined by a shapor or by a milling machine But machining time might increase as well as dimensional accuracy might not be attained. Rather it would be easy to machine the teeth by gear shaper machine from BITAC or any other workshops on contract basis.

3.3 Overall condition of the workshop at Zia Fertilizer Co. Ltd.

The workshop is situated at the rear part of MTS (Maintenance and technical services) building. Generally backup services for maintenance works are being provided by the workshop However, annual production / contribution of this workshop is about taka 13 - 14 lacs. Moreover, some difficult jobs of other sister organizations are also carried out at this workshop.

Lathes, milling, drilling, grinding, lapping machines etc. exist at the workshop. Moreover other machines such as shaper, slotting, key-way cutting machines, shearing, bending, rolling machines etc. are also available at the workshop Welding as well as non - destructive testing (NDT) facilities are also available.

About 33 no. of general technicians and 7 no. of engineers have been employed at the workshop. Under the planning and supervision of the engineers the workshop is running smoothly

3.4 Main characteristics of the machines:

3.4.1 Lathe:

There are 11 no. of lathe machines at the workshop. Among them 10 are horizontal and 1 is vertical one. The vertical lathe has maximum capacity for machining the job of 1½ m diameter and ½ m height.

The maximum diameter of job and bed length of the horizontal lathes are 40" and 18' respectively.

3.4.2 Milling:

There is only one milling machine at the workshop with the following parameters:

Maximum longitudinal feed of the table - 1 m.

Maximum cross feed of the table - 400 mm.

Maximum vertical feed of the table - 500 mm.

3.4.3 Grinding:

There are two grinding machines at the workshop. One is surface grinding machine and the other is cylindrical grinding machine which is capable of grinding both external and internal surfaces.

For surface grinding machine, maximum stroke length is 1½ ' and maximum width of the job is 8".

The maximum diameter and length of a job that can be machined on the cylindrical grinding machine are 250 mm and 600 mm respectively.

3.4.4 Drilling:

There are 6 no. of drilling machines - one radial drill, one drilling and boring, one column drill and three no of bench drill are available at the workshop.

For radial drill machine -

Maximum drilled hole size is 70 mm.
Swinging diameter of the machine is 1 m.

3.4.5 Lapping and Tapping:

Lapping can be done either manually or by a machine. Only flat surface can be lapped by the machine but cylindrical surfaces are machined manually
Tapping operation is done manually.

3.5 Calculation of manufacturing time:

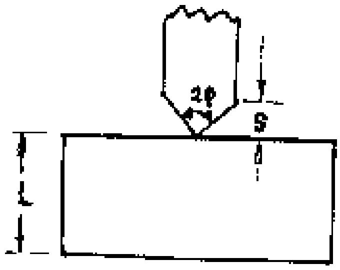
Manufacturing time of any product is the sum of cutting time and handling time. Depending on the lot sizes, cutting time is maximum 20% of total time / manufacturing time for job-shop production, 20-40% for batch production and 90-95% for mass production. In the present work, the cutting time is 40% of total time and it has been calculated using various usual formulae.

Handling time can be determined from the following formula:

Handling time = transfer and changing position time + loading and unloading time + centering time + inspection time + preparation time + tool change time.

The elements of the handling time (right hand side of the equation) can be found out using various charts and tables A training manual on manufacturing technology of Mitsubishi Co. of Japan has been used for finding out the elements of handling time. In the present work the handling time for oil retaining ring has been determined using charts and tables of above mentioned training manual. This has been done to set an example. For rest of the items, manufacturing time has been determined considering as cutting time is 40% of manufacturing time. Machining time for different operations for manufacturing of selected spare parts are as follows:

i) Drilling time, T_{md}



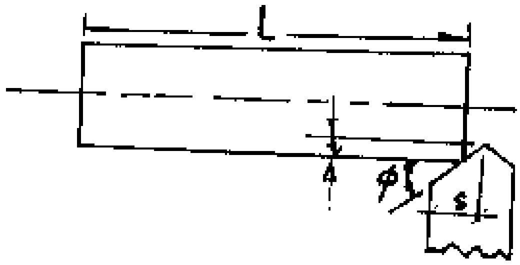
$$T_{md} = \frac{L}{nf}$$

Here, L = total length = l + s + Δ, l = length of the job

n = r.p.m, s = length due to tool geometry

f = feed/rev., Δ = approach and over travel length

ii) Turing time, T_{mt}



$$T_{mt} = \frac{L}{nf} \times i$$

Here, L = total length = l + s + Δ, l = length of the job

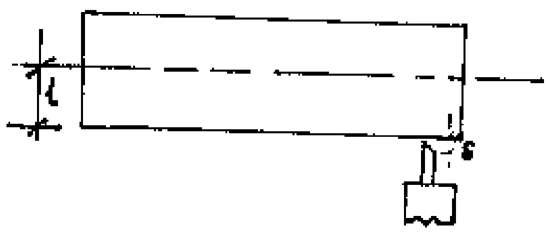
n = r.p.m, s = length due to tool geometry = t cot φ

f = feed/rev.

i = no. of cut, Δ = approach and over travel length

φ = principal cutting angle.

iii) Parting and facing time, T_{mp}



$$T_{mp} = \frac{L}{nf}$$

Here, L = total length = l + s + Δ, l = length of the job [half of the diameter of job]

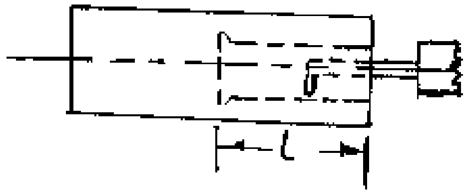
n = r.p.m

f = feed/rev., s = length due to tool geometry

Δ = approach and over travel length

iv) **Grooving and boring time, T_{mg}**

$$Tmg = \frac{L}{nf} \times i$$



Here, L = total length = l + s + Δ, l = length of the job [length of the groove]

n = r.p.m s = length due to tool geometry

f = feed/rev. Δ = approach and over travel length

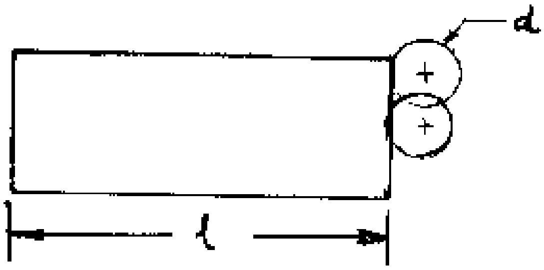
i = no.of cut

v) **Threading time, T_{mth}**

(From machining time of thread cutting table of training manual, page 13/40)

vi) **Milling time by end mill cutter, T_{me}**

$$Tme = \frac{L}{nf} \times i$$



Here, L = total length = l+Δ+s. l = job length

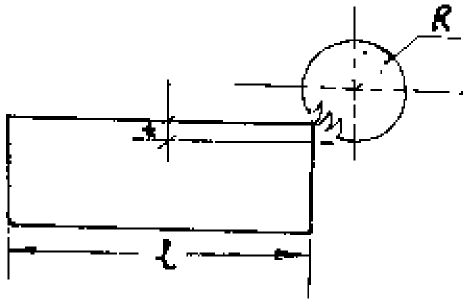
n = r.p.m Δ = approach and over travel length

f = feed/ rev. of the cutter. d = diameter of the cutter

i = no. of passes

vii) **Milling time for surface cutting, T_{mm}**

$$Tmm = \frac{L}{nf} \times i$$



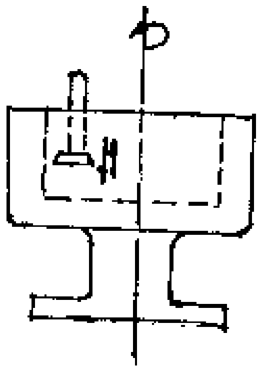
Here, L = total length = l+Δ+s.

l = job length Δ = approach and over travel length

s = length due to tool geometry i = no. of passes

f = feed/ rev. of the cutter. n = r.p.m

viii) <u>Gear shaping time, T_{mG}</u>



$$TmG = \frac{\pi m z}{ns} + \frac{t}{ns_1}$$

Here, m = module

z = no. of teeth

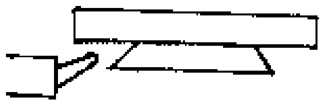
n = no. of double stroke of cutter

t = depth of teeth

s = circular feed /double stroke

s_1 = radial feed /double stroke

ix) <u>Angle cuting time, T_{mA}</u>



$$TmA = \frac{L}{nf}$$

L = total length = l + Δ + s

n = r.p.m

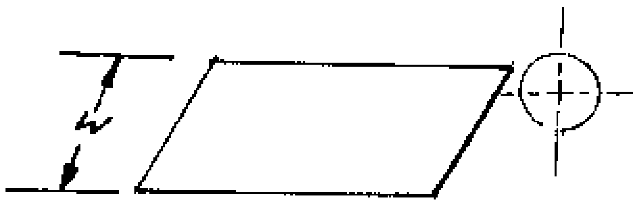
f = feed/rev.

l = cutting length

Δ = approach and over travel length

s = length due to tool geometry

x) <u>Grinding time, T_{mg}</u>



$$Tmg = \frac{W}{nt_1} \times i \times K$$

Here,

W = width of the job

n = stroke/min

t_1 = cross feed

i = no. of passes

$$= \frac{t_1}{f}$$

f = depth of cut

K = co-efficient due to elasticity of material.

xi) **Lapping operatian time**

An estimated value as lapping operation has been performed manually

xii) **Removing bars, sharp corners, edges etc.**

An estimated time

3.6 Preparation of process sheets:

There are 8 no. of spare parts which have been selected for manufacturing them locally. As a part of their manufacturing process, their process sheets have been prepared which are shown below:

Operation sequence for rotor locating ring

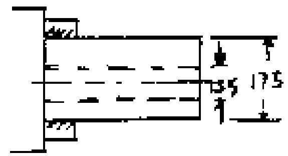
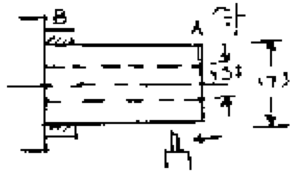
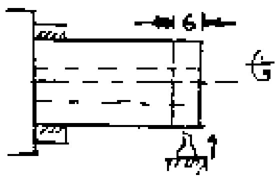
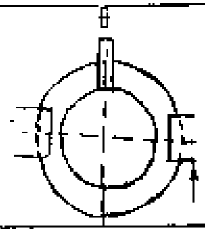
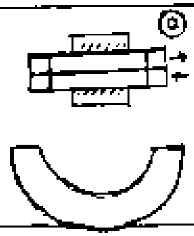
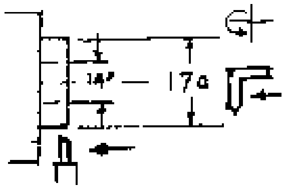
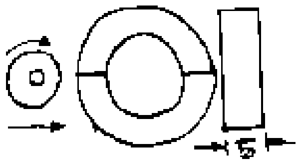
Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures etc.	Cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1.	Cutting stock from shaft		center lathe					
2.	Facing and turning side A. and side B.		center lathe	i) turing tool ii) 4-jaw chuck	220	0.1	0.5	5
3.	Parting		centre lathe	i) 4-jaw chuck. ii) parting tool	220	0.1	0.5	5
4.	Blank slitting by circular saw			metal slitting saw clamps	70	0.3	0.5	10

Table 3.1 Operation sequence for rotor locating ring

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures etc.	Cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
5.	Surface grinding by fixing machine visc.		Do		30 stroke per min.	0.001	0.1	8.25
6.	Turning outside and inside		centre lathe	i) magnetic chuck ii) turning tool iii)clamps.	220	0.1 0.05	0.5	7.5
7.	Grinding		grinding machine	clamping	30 stroke per min.	cross feed = 10 mm. feed = .002	0.1	150

Operation sequence for bolts (coupling)

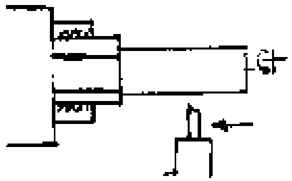
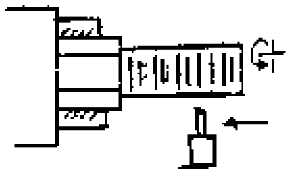
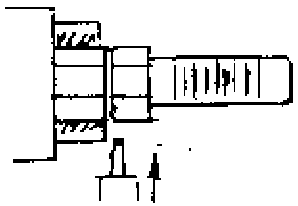
Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures etc. used	Cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1.	Hexagonal Bar/Blank							
2.	Turning		lathe	i)3-jaw chuck ii)turning tool	220	0.1 and 0.05	0.5	3.75
3.	Threading		lathe	3-jaw chuck	12			5.4
4.	Parting		lathe	paring tool	75	0.06	0.5	1.15

Table : 3.2 Operation sequence for bolts (coupling)

Operation sequence for oil retaining ring

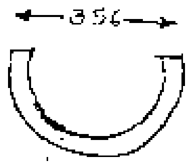
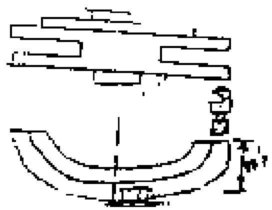
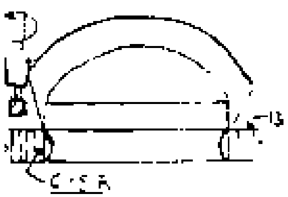
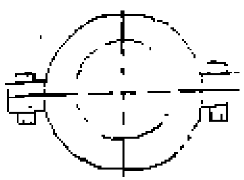
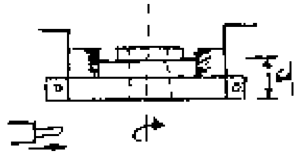
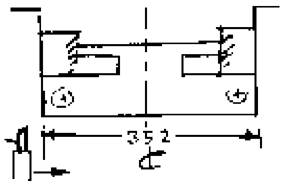
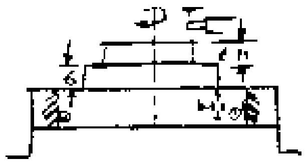
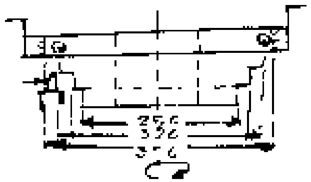
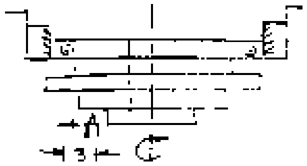
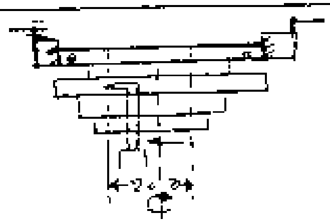
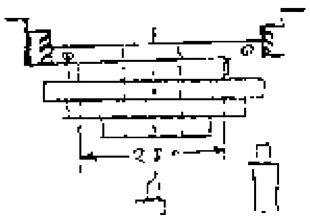
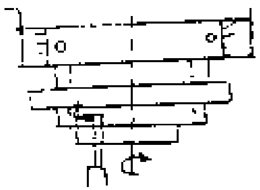
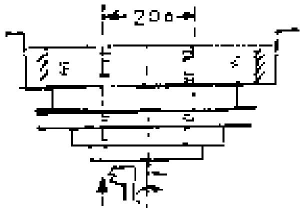
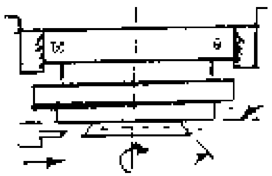
Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures etc.	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1	Die casting with aluminum alloy		die					
2	Milling		milling machine	machine vise	200	0 8	1(no. of cut =1)	23.84 min
3.	Milling and drilling		milling and drilling machine	i) fixture ii) end-mill cutter (13 mm) iii) drill-5.5 mm	220	0.1	1 (no .of cut = 1)	24.23 min.
4.	Clamping two halves				-	-	-	10 min.

Table : 3.3 Operation sequence for oil retaining ring

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
5.	Facing		centre lathe	i) facing tool ii) 4-jaw chuck	200	0.05	1 (no. of cut = 1)	65.74 min.
6.	Turning		centre lathe	turning tool	200	0.05	1 (no. of cut =1)	7.34
7.	Facing		centre lathe	i) facing tool ii) 4-jaw chuck	200	0 05	1+1+1 3 no. of cut	53.12
8.	Turning		centre lathe		200	0.05	1+1÷1 3 no. of cut	36.65

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
9.	External grooving		centre lathe	grooving tool	200	0.05	1+1+1 3 no. of cut	14.45
10.	Internal turning		centre lathe	boring tool	180	0.1 and 0.05	1+1 2 no. of cut	30.79
11.	Internal grooving		centre lathe	i)grooving tool ii)form tool	180	0.1 and 0.05	1+1+1+1 3 no of rough cut and 1 no of finish cut	74
12.	Internal grooving		centre lathe	grooving tool	180	0 0.05	0.5+0.5+0.5+0.5 total 4 no. of cut	23.23

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
13.	Making Strip by form tool		centre lathe	form tool	180	0.1 and 0.05	1 1 no.of cut	24.93
14.	Angle cutting		centre lathe	form tool ,sharp tool (rough work)	180	0.1 and 0.05	1 total 7 no of cut	35.53
15.	Angle cutting		centre lathe	Do	Do	Do	1 total 4 no. of cut (3 rough +1finish cut)	15.73
16.	Removing all bars, sharp edges and chamfering							20
17.	Drilling		milling machine					35
18.	Tapping			by hand				120

Operation sequence for gear coupling (toothed coupling)

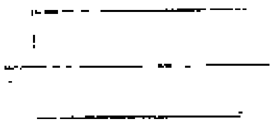
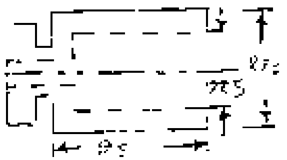
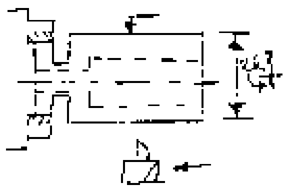
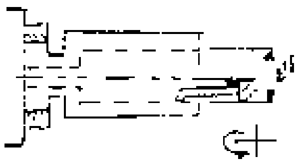
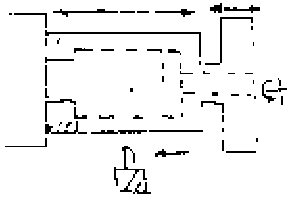
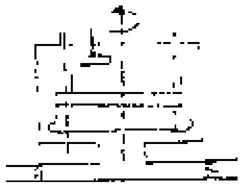
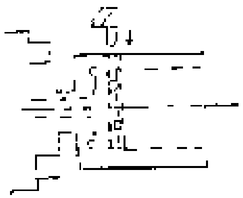
Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1.	Forging blank							
2.	Forged blank		die forging					
3.	Facing and outside turning		centre lathe	i) facing tool ii) turning tool (iii) drill bit iv) 4-jaw chuck	220	0.1 and 0.05	0.5 1+1+1+1= 4 no. of cut	138.2
4.	Boring		Do	i) boring tool ii) 4-jaw chuck	180	0.1 and 0.05	0.75 1 + 1 = 2 no of cut	175.6

Table : 3.4 Operation sequence for gear coupling

SL No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed. V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
5.	Grooving		Do	i) grooving tool ii) 4-jaw chuck	120	0.08	0.75 1 + 1 = 2 no. of cut	25
6.	Facing & turning outside		Do	i) facing tool ii) 4-jaw chuck	220	0.1 0.05	0.5 1+1+1+1= 4 no. of cut	77.85
7.	Teeth cutting		gear shaper	milling cutter	stroke = 20/min.	0.03 mm/stroke		834
8.	Drilling		drill.	i) milling divider head. ii) 3-jaw chuck iii) twist drill bit 8- mm dia.	38	0.08		4

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
9.	Drilling		drill. machine	i)3-jaw chuck ii)drill bit twist drill bit 8 mm.dia. iii)rotary table.	38	0.08		31.1
10.	Remove all bars, sharp edges and necessary chamfering			1				40
11.	Case hardeening (carborising / nitriding) hardness 58-60 HRC.			2.				

Operation sequence for turbine casing nuts

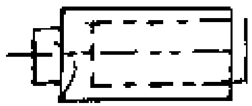
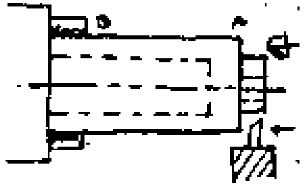
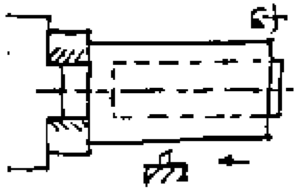
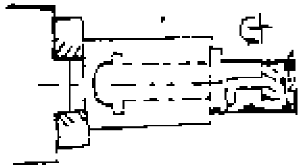
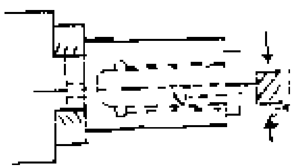
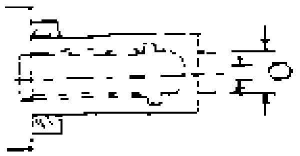
Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting condition V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	Machining Time (min)
1.	Forging blank							
2.	Forged blank							
3.	Stress relieving							
4.	Facing, turning & drilling		centre lathe, drilling machine	i) facing tool ii) turning tool iii) drill bit iv) 4 – jaw chuck	220 75	0.1 0.05 0.2	0.5 3 no. of cut 0.5	17.55 (facing and turning time) 5 (drilling time)
5.	Facing and turning		Do	i) facing tool ii) turning tool iii) 4-jan chuck	220	0.1 0 05	0.5 (2X2)=4 no. of cut	36.2
6.	Boring		Do	i) boring tool ii) 4-jaw chuck	220	0.1 0.05	0.5 , 0.1, 0.1,0.05 and 0.1,0.05	15

Table : 3.5 Operation sequence for turbine casing nuts

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting condition			Machining Time (min)
					V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
7	Threading		centre lathe	threading tool	18	5	0.5, 0.3, 0.2 0 15, 0.1	112.5
8.	Hexagon		milling machine	i) milling cutter ii) dividing head	220	0.1	0.5 3 no. of cut	78.75

Operation sequence for turbine casing bolts

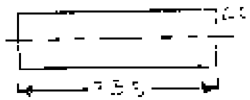
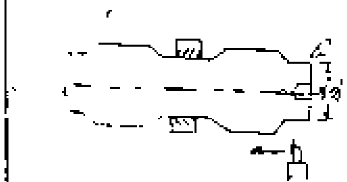
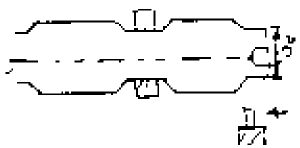
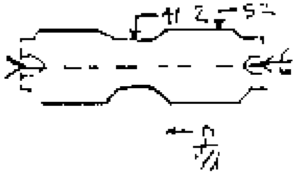
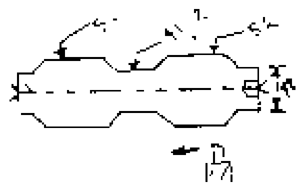
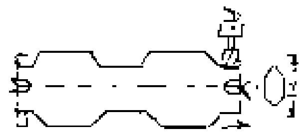
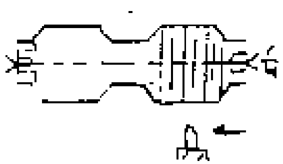
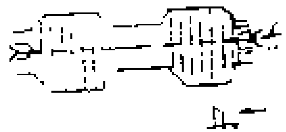
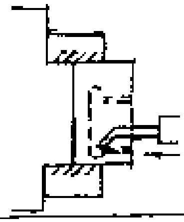
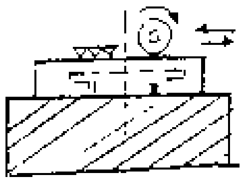
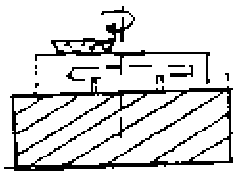
SL. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures etc.	Cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1.	Blank cutting for forging							
2.	Forging							
3.	Facing and centering side A.		centre lathe	i) 4-jaw chuck ii) facing tool iii)centre drill	220	0.1 and 0.05	0.5	4.3
4.	Facing and centering side B.		centre lathe	i) 4-jaw chuck ii) facing tool iii)centre drill	220	0.1 and 0.05	0.5	3.8
5.	Turing side B.		centre lathe	i) 4-jaw chuck ii) turning tool	220	0.1 and 0.05	0.5	67.5

Table : 3.6 Operation sequence for turbine casing bolts

SL No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
6.	Turing side A.		centre lathe	i) facing tool ii) 4-jaw chuck	220	0.1 0.05	0.5	20
7.	Milling side B.		milling machine	milling cutter	60 r.p.m	0.1		10
8.	Grinding external		grinding machine	i) milling divider head. ii) 3- jaw chuck iii) twist drill bit 8-mm diameter.	60 rpm	0.002	0.1	43.75
9.	Thread cutting side A		centre lathe	i)4-jaw chuck ii)threading tool	18	5	0.5, 0.3, 0.2, 0.15, 0.1	112.5

Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures used	Cutting Condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
10	Thread cutting side B		centre lathe		Do	Do	Do	112 5
11.	Remove all sharp edges bars etc							25

Sl. No.	Operations	Sketch	Machine tools used	Tools, Jigs, fixtures used	cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
5.	Threading		centre lathe		18			8.4
6.	Surface grinding		surface grinder	magnetic chuck	30 stroke/min	cross feed =10 mm/stroke	0.002	100
7	Lapping			lapping powder and paste				100

Operation sequence of Axial displacement disc

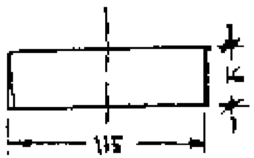
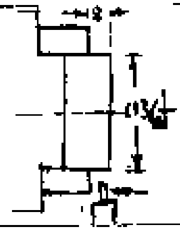
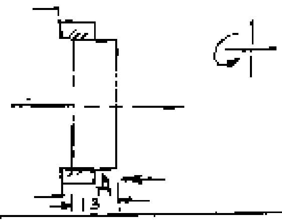
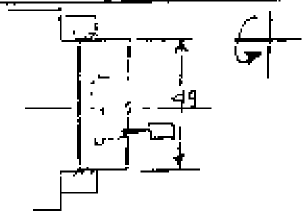
Sl. No.	Operations	Sketch	Machine tools used	Tools, Jigs, fixtures used	cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1.	Sawing from a shaft							
2.	Turning and facing		centre lathe	i) turning facing tool ii) 3-jaw chuck	200	0.1	0.5	13
3.	Turning and facing		centre lathe	Do	220	0.1	0.5	13
4.	Boring		centre lathe	i) boring tool ii) 3-jaw chuck	220	0.1	0.5	27.5

Table : 3.7 Operation sequence of axial displacement disc

Operation sequence for nuts (coupling)

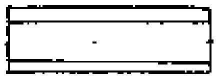
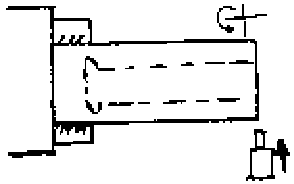
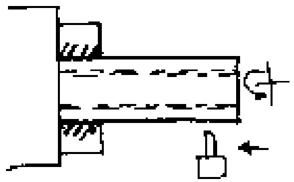
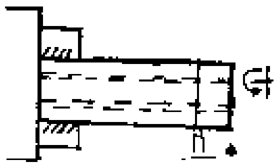
Sl. No.	Operations	Sketch	Machine tools used	Tools, jigs, fixtures etc. used	Cutting condition			Machining time (min)
					Speed, V (ft/min)	Feed (mm/rev.)	Depth of cut (mm)	
1.	Hexagonal Bar/Blank							
2.	Facing and drilling		lathe	i) facing tool ii) drilling bit ii) 3-jaw chuck	200	0.1	0.5	1 (facing) 1(drilling)
3.	Threading		lathe	i) tapping head ii) tapping head	12			1
4.	Parting		Lathe	paring tool	75	0.06	0.5	1

Table . 3.8 Operation sequence for nuts (coupling)

3.7 Formulating the process planning:

Criticality of an activity depends on the total float i.e. the excess of available time over required time for completing an activity. If the total float is zero, the job is critical and no delay is allowable to start it.

If there is any float in the job, it will indicate that there can be some latitude in scheduling in start of a non-critical job.

The operation time and chucking conditions etc. for manufacturing the selected spare parts are given below along with their job code and operation code.

Job code	Operation code	Operation time (minute)	Chucking condition
J1	03	23.84	SPM
"	03	24.23	"
"	04	2.98	SPD
"	01	10 00	SPL
"	01	65.74	"
"	01	7.34	"
"	01	58.14	"
"	01	36.65	"
"	01	14.45	"
"	01	30.79	"
"	01	74.00	"
"	01	23.23	"
"	01	29.93	"
"	01	35.53	"
"	01	15.73	DPL
"	01	20.00	"
"	04	35.00	DPD
"	05	120.00	DPT
J2	01	3.40	SPL
"	01	1 00	"
"	01	2 93	"
"	01	1.00	"
"	01	67.50	"
"	01	20 00	"
"	03	10.00	DPM
"	04	43.75	DPG
"	01	112.50	SPL
"	01	111.50	DPL
"	01	25.60	"
J3	01	9.70	SPL
"	01	7.90	"
"	04	5.00	SPD
"	01	5.93	DPL
"	01	30.60	"
"	01	15.00	"
"	01	112.00	"
"	03	70.75	SPM

Job code	Operation code	Operation time (minute)	Chucking condition
J4	01	21.38	SPL
"	01	26 60	"
"	01	175.70	"
"	01	25 00	"
"	01	60.80	DPL
"	01	17 10	"
"	10	834.00	SPT
"	04	4 00	SPD
"	04	31 10	"
"	01	40 00	SPL
J5	06	2.00	SPS
"	01	7.73	SPL
"	01	3 23	"
"	01	7.73	"
"	01	3.23	DPL
"	01	27.50	SPL
"	01	8.40	"
"	08	100.00	SPG
"	09	100 00	SPLP
J6	01	2.00	SPL
"	01	5.00	"
"	01	5.00	"
"	07	10.00	SPS
"	08	8.25	SPG
"	01	7.50	SPL
"	08	140.00	SPG
J7	01	3 75	SPL
"	01	5 40	"
"	01	1 15	"
J8	01	1.00	SPL
"	04	1.00	SPD
"	01	1.00	SPL

Table : 3.9 Operation time for the selected spare parts

Maintaining the operation sequence and combining the succeeding operations of same machine, the following table can be prepared :

Job code	Operation code	Operation time (minute)	Operation time (whole no in minute)
J1	03	48.07	48
"	04	2.98	3
"	01	416.53	417
"	04	35.00	35
"	05	120.00	120
J2	01	95.83	96
"	03	10.00	10
"	08	43.75	44
"	01	249.00	249
J3	01	17.60	18
"	04	5 00	5
"	01	163.73	164
"	03	78.75	79
J4	01	326.58	327
"	10	834.00	834
"	04	35.10	35
"	01	40.00	40
J5	06	2.00	2
"	01	57.82	58
"	08	100.00	100
"	09	100.00	100
J6	01	12 00	12
"	07	10.00	10
"	08	8 25	8
"	01	7 50	8
"	08	140.00	140
J7	01	10 00	10
J8	01	1.00	1
"	04	1.00	1
"	01	2.00	2

Legend: SPM - Same position for milling
DPM - Different position for milling
DPD - Different position for drilling
DPL - Different position for lathe operation
DPG - Different position for grinding
DPT - Different position for teeth cutting
SPLP - Same position for lapping.
SPT - Same position for teeth cutting.
SPG - Same position for grinding.
SPS - Same position for sawing
SPD - Same position for drilling.
SPL - Same position for lathe operation

Legend:			
J1	- Oil retaining ring	01 - Lathe operation	
J2	- Turbine casing bolt	03 - Milling	"
J3	- Turbine casing nut	04 - Drilling	"
J4	- Gear coupling	05 - Tapping	"
J5	- Axial displacement disc	06 - Sawing	"
J6	- Rotor locating ring	07 - Slitting	"
J7	- Coupling bolt	08 - Grinding	"
J8	- Coupling nut	09 - Lapping	"
		10 - Teeth cutting	"

Now to fit the problem with CPM the job operation time can be termed as activity. From the preceding table it is observed that the total number of activities is 30. The software used to solve the problem can deal with maximum 25 no of activities. Considering this limitation only job no. J1, J2, J3, J4, and J5 have been selected and the total no. of their activities stand 21.

It is observed from the table for above mentioned selected jobs, that the first operation (activity) for job no. J1 is milling, for job no. J2, J3 and J4 is lathe operation and for job no J5, it is sawing operation. Other activities such as drilling, lapping, teeth cutting etc. are at some intermediate positions of respective job. As the sequence of operations (activities) should have to be maintained strictly so only 3 no. of machines out of 8 no could be assigned simultaneously i.e. lathe machine, milling and sawing machines would be operated parallely. But job no J2, J3 and J4 each has begun with lathe operation. But job no. J4 occupies maximum time with lathe machine. So to get best possible assignment job no. J4 has been selected to be machined first along with job no J1 and J5.

3.8 Computerized process planning:

3.8.1 Introduction:

computer technology has been introduced not only in manufacturing field but also in business function. From material procurement to finished products as well as marketing of the products and managerial activities - everything are being carried out with the help of the computer software

3.8.2 A brief introduction on CPM:

Critical path method (CPM) techniques was developed in the late 1950's to answer the basic need of project management. It was originally conceived as computer oriented planning technique.

A project is defined as a series of related jobs usually directed toward some major output and requiring a period of time to perform. The total project time is the shortest time in which the project can be completed and this is determined by calculating the duration of the longest chain of activities form the first event to the last event This longest chain of activities or path is known as critical path.

The basic objective of network analysis is to find out the critical path. The network is a model of the project as a whole created by linking together by arrows representing specific jobs. The time required to perform each job is used to find the critical path, which is the longest chain from a project beginning to its completion. In otherwise the critical path in a project signifies the total time (duration) requires for its completion.

Critical path analysis (C P. A) is the organized application of systematic reasoning for planning, scheduling and controlling practical situation where many separate jobs, which make up the whole project, can happen simultaneously or in sequence such that it is difficult intuitively to establish the relationship between separate jobs

C. P A. identifies three separate phases.

a. planning phase This phase concentrates on getting logic of the individual jobs into correct parallel and series sequence.

b scheduling phase: This develops from the planning phase and converts the plan into a feasible and implementable schedule having analysis the plan with reference to optimum use of available resources e.g. time, man-power and equipment.

c. control phase: This develops from the scheduling phase and allows actual progress to be monitored and corrections made to ensure adherence to the schedule or modified schedule.

CPM is a powerful diagnostic weapon which pinpoints the important sub-sections of a project for careful attention so that the project is completed in scheduled time. Critical path identifies that important small sub-section of a plan and focuses most of its attention on it and convert, need pay less attention to the rest of the plan.

The rest of the plan must receive some attention which have different amount of surplus time (known as floats or slacks) as it is the whole plan that matters in the long run. The activities lying along the critical path are critical in the sense that their occurrence can't be delayed if the scheduled completion time is to be met. That is, the critical activities have no surplus time or float available.

Ultimate aim of the project is to find out the criticality of any job and the critical path which is the connected chain of critical jobs. There may be more than one critical path in a project.

The following characteristics of the network diagram are evident:

i) The project duration is the sum of the duration along the critical path from project start to project finish.

ii) A delay in the start or finish of a critical job will delay the project completion by an equal amount.

iii) If more resources are applied (crashing) to reduce the project duration, then jobs must be selected among those that are critical.

iv) Priority of resource allocation must be given to jobs. If resources i.e. money, machine, man-power etc. are unlimited, then the critical jobs are rigidly scheduled by their earliest possible start.

Above are the characteristics of CPM and by following this, it is easy to reach the objectives of the present work.

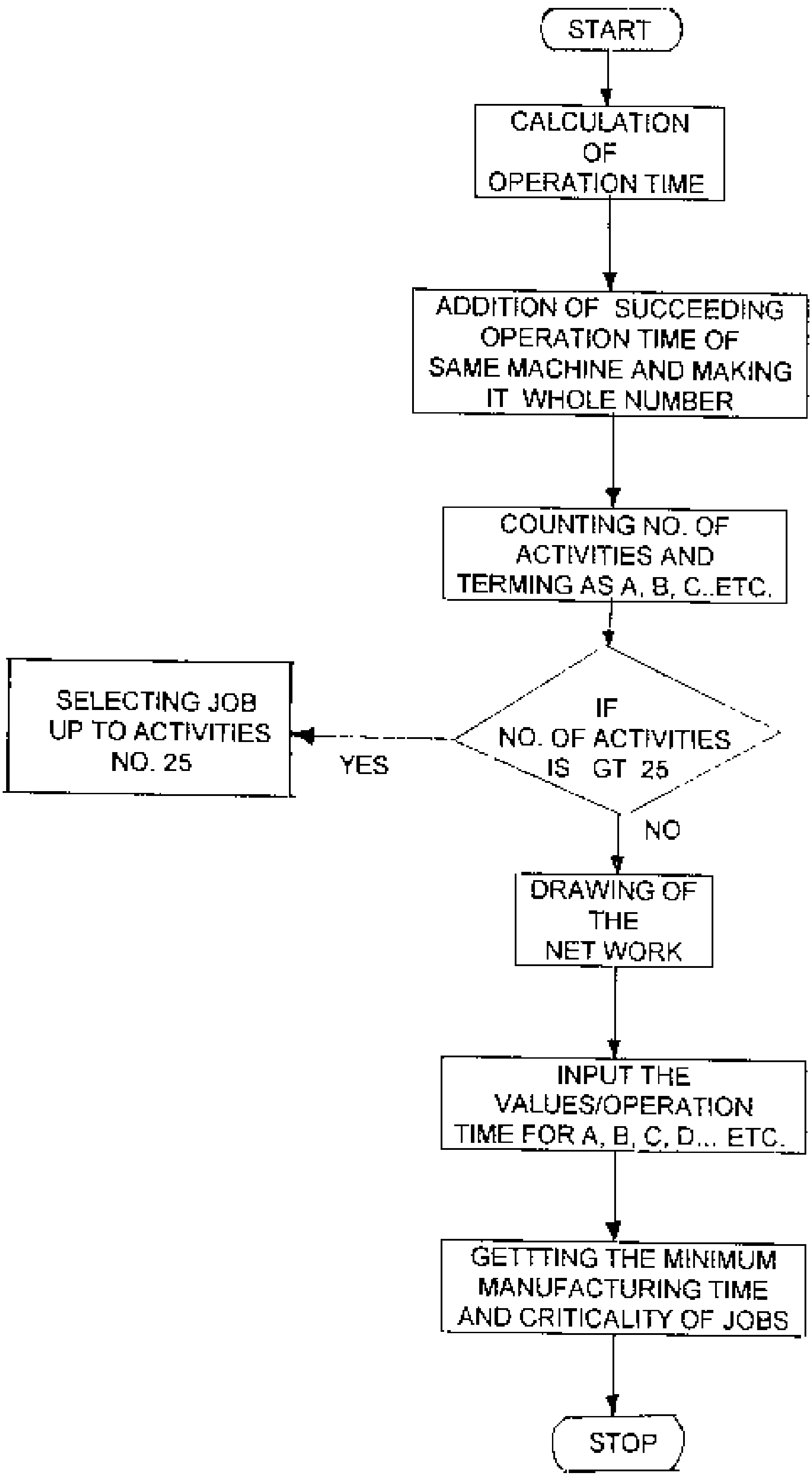
3.9 Developing computer algorithm and output of the work :

As a computer software has been used in this work, the data have been arranged in such a way that they (data) could be used in accordance with the requirement of the software. A table has been prepared showing activities, no of predecessors, immediate predecessors and with opreration time as well as with the help of the table, a network has been developed. The whole process of manufacturing the spare parts has been presented by a block diagram (fig. no 3.1)

Activity List :

Activity	No. Of Predecessors	Predecessors	Duration (in min)
A	0	-	48
B	0	-	327
C	1	A	3
D	0	-	2
E	2	B,C	834
F	2	B,C	417
G	1	E	35
H	1	F	35
I	1	F	96
J	1	H	120
K	1	I	10
L	1	I	18
M	2	L,D	58
N	2	L,D	5
O	1	K	44
P	2	N,M	164
Q	2	N,M	100
R	2	O,P	79
S	1	Q	100
T	2	O,P	249
U	2	G,T	40

Figure : 3.1: A block diagram showing the sequence of operation to find out the minimum manufacturing time for the spare parts and the critical spare parts during manufacturing process.



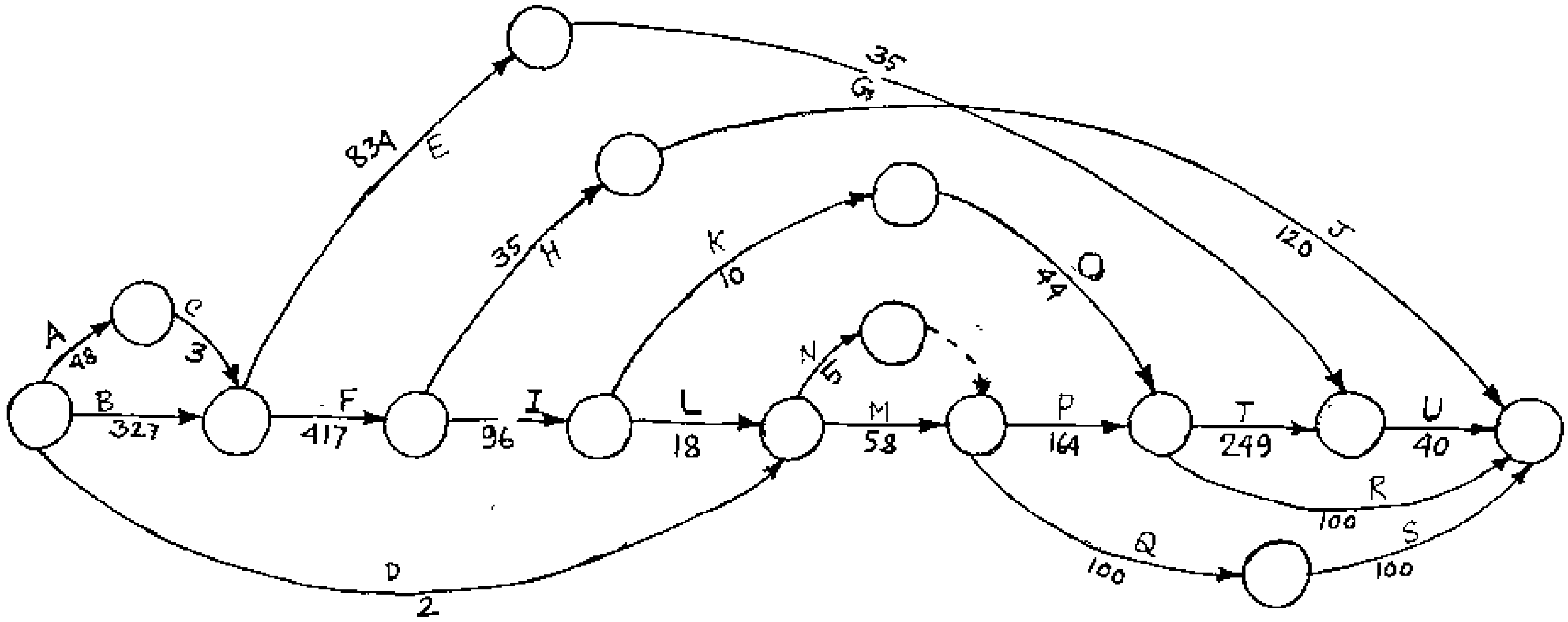


Figure : 3.2 Network for minimizing through put time of spare parts manufacturing for alternator drive turbine.

PROJECT SCHEDULING WITH PERT/CPM
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*** PROJECT ACTIVITY LIST ***

ACTIVITY	IMMEDIATE PREDECESSORS	EXPECTED TIME
A	-	48
B	-	327
C	A	1
D	-	2
E	B,C	834
F	B,C	417
G	F	36
H	F	35
I	F	26
J	H	120
K	I	10
L	I	18
M	L,D	58
N	L,D	5
O	K	44
P	N,M	164
Q	N,M	120
R	O,P	78
S	Q	100
T	J,P	249
U	T,G	40

*** ACTIVITY SCHEDULE ***

ITY	EARLIEST START	LATEST START	EARLIEST FINISH	LATEST FINISH	SLACK	CRITICAL ACTIVITY
	0	276	48	324	276	
	0	0	327	327	0	YES
	48	324	51	327	276	
	0	856	3	859	856	
	327	460	1161	1294	133	
	327	327	744	744	0	YES
	1161	1294	1196	1329	133	
	744	1214	779	1249	470	
	744	744	840	840	0	YES
	779	1249	899	1369	470	
	840	1026	850	1036	186	
	840	840	858	858	0	YES
	858	858	916	916	0	YES
	858	911	863	916	53	
	850	1036	894	1080	186	
	916	916	1080	1080	0	YES
	916	1169	1016	1269	253	
	1080	1290	1139	1369	210	
	1016	1269	1116	1369	253	
	1080	1080	1329	1329	0	YES
	1329	1329	1369	1369	0	YES

CRITICAL PATH: B-F-I-L-M-P-T-U

PROJECT COMPLETION TIME = 1369

CHAPTER - FOUR

CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

- Results and discussion
- Conclusion and recommendation for future work

4.1 Results and discussion:

The present work, minimization of through-put time of spare parts manufacturing for alternator drive turbine of a fertilizer factory involves in selecting non-critical and non-precision spare parts commonly used for alternator drive turbine considering the factors discussed in chapter-2.

To calculate machining time and thereby manufacturing time various charts, tables and formulae have been employed. The master operation sheets have been prepared which are shown in chapter-3.

The software used to determine the minimum time to manufacture the selected spare parts has some limitations. It can not draw network as well as can not deal more than 25 no. of activities. Therefore, as a model only 5 no. of jobs have been selected confined with 21 no. of activities and a network been drawn manually abiding by the rules of constructing network.

With a view to adopting the work with the software the manufecturing process planning has been formulated and an algorithm been developed and used for calculating best possible or minimum manufacturing time. This can not be attained without using computer software particularly when the number of operations i.e. activities are large.

It has also been endeavoured to recommend about the material of the spare parts. No where either in the operation or maintenance manual, it was mentioned regarding the material of those items. Moreover, metallurgical test has not been carried out. But considering their working environment and functions, a table has been prepared suggesting the material according to ASME and ASTM code which is included with material compositions as well as some engineering properties.

Though it is a mere task to estimate the cost involvement for manufacturing the spare parts locally but it has not been done. However this can easily and efficiently be performed by using computer software.

4.2 Conclusion and recommendation for future work:

From the present work the following conclusion can be drawn.

i) Spare parts which are commonly used for alternator drive turbine have been studied precisely. Their engineering properties, working condition, geometric shape etc. have also been observed

ii) The spare parts have been classified as critical and non-critical as well as precision and non-precision items considering several factors mentioned in chapter-2. Their functional properties also been carefully studied.

iii) For manufacturing the selected spare parts, various calculation associated with manufacturing processes as well as master operation sheets and other drawings of them have been prepared

iv) At different stages of manufacturing processes, the operation time for each of the jobs has been calculated.

v) By using computer software of CPM, minimization of manufacturing time for the selected spare parts has been determined

In a conventional way, the jobs are assigned to the machines arbitrarily i.e not in a systematic way This is particularly evident in case of a large group of machines with various jobs with numerous operations. Some machines or jobs might remain idle for a long time due to improper job assignment to the machines which would increase machine down time as well as number of tardy jobs. Which in turn would increase production cost but computerized manufacturing process planning will eliminate these drawbacks.

Moreover, if other computer packages and computer applications could be implemented for manufacturing field it would be a mile stone in manufacturing technology in Bangladesh. If technology develops further, trained and experienced personnel would engage themselves with this area and the country would be able to produce precision and precious items locally saving a lot of foreign currency thereby serving the nation as a whole.

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