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PROJECT: DG/NIR/95/039/11-53/06-4000

FEASIBILITY STUDY
AND
ENGINEERING DESIGN FOR ELECTRIC MOTOR AND TRANSFORMER PILOT PLANT
(PRODA, ENUGU - NIGERIA)

REPORT BY

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JULY/AUGUST/SEPTEMBER - 1997

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CONTENTS

ABBREVIATIONS

1)	TOR	-	Terms of Reference
2)	UNIDO	-	United Nations Industrial Development Organisations.
3)	UNDP	-	United Nations Development Programme
4)	SME	-	Small and Medium Enterprises.
5)	PRODA	-	Project Development Institute
6)	FMST	-	Federal Ministry of Science and Technology
7)	FMI	-	Federal Ministry of Industries
8)	SEDI	-	Scientific Equipment Development Institute
9)	I.S.O.	-	International standard Organisation
10)	IS	-	Indian Standards
11)	IEC	-	International Electro Technical Commission
12)	VDE	-	Verband Deutsche Elektro Teknik (German Standard)
13)	NGEF	-	New Government Electric Factory
14)	H.P.	-	Horse Power
15.	mm	-	Milimeter
16)	kg	-	Kilogramme
17)	^{0}C	-	Degree Celcius
18)	EHC	-	Electrolitic High Conductivity
19)	kv	-	Kilo Volt
20)	dB	-	decibels.
21)	RPM	-	Revolutions Per Minute
22)	CO2	-	Carbon dioxide
23)	NEW	-	Nigeria Engineering Works

PREAMBLE

After the civil war in 1966 - 67, the need for developing Indigenous Product was felt in Nigeria instead of dependency. An Institution by name Project Development Agency was formed by the state Government. PRODA attempted to develop basic needs for construction materials such as Bricks, cement etc Indigenously. However during 1976 the Federal Govt. took over and named it as Project Development Institute, as the Federal Government had number of institutes under them. All the Institutes were merged to develop, local Technologies specially for Food processing. The Institutes developed several food processing machines like, Kasawa processing units, Peanut shellars, Maize & Corn shellers etc.

In 1992 PRODA was informed to develop Power Equipment, Engines and accessories. Till 1995, not much was done in the field of development of Electric Motors, Transformers, Gear systems etc, but slowly PRODA tried to acquire the knowledge in these areas by dismantling the Motor/Transformer & trying to adapt themselves to their requirements. As PRODA thought that every machine requires a motor for driving, they were keen to attempt in this project. The work done by PRODA has been already studied by the National Consultant Alhaji Engr. I.K. INUWA under the Heading "Feasibility study and Enginerring Design for Electrical Motor and Transformer Pilot plant PRODA, ENUGU". This has been released by Federal Ministry of Industry Garki, ABUJA, under UNDP - Assisted SME Development Programme NIR/B1, Sub - Programme 5B.

MISSION

United Nations Industrial Development Organisation VIENNA-AUSTRIA under reference DG/NIR/95/039/11-53/06-4000, offered to the Author under post title "International Consultant in Engineering Design - Electrical Equipment" to study for Two months at Enugu Nigeria. The purpose of this project is to study under the over-programme for small & medium enter prise development & establish ways by which the SME"S can take advance of research and development work carried out in the Institutions. The purpose is also to adapt the activities of R&d to the natural needs of modern small Enterprises in the country & to see how existing institutions (Government Agencies and Private Sector Organistions) can really bring the research to the SME's and make it a commercial success. It is hoped that this type of project will increase linkages between enterprises as well as the flow of Information between Institutions & SME'S

TERMS OF REFERENCE (TOR)

TOR - 1	Identifying the R&D results related to the design and fabrication of Electrical Motor/Transformer with a view to determining their actualisation.
TOR - 2	Assessing the magnitude and cost Implication of the work yet underdone on the R & D results for electrical Motor/Transformer Pilot plant, and recommend ways of remedying the situation.
TOR -3	Reviewing the effectiveness/appropriateness of existing facilities for the production of Electrical Motor/Transformers.
TOR - 4	Identifying Technical defective designed Electrical Motor/Transformer and recommend ways of standardising them.
TOR -5	Designing the most appropriate method of assessing the effective performance of the Implements.
TOR -6	Reviewing the Proposals for commercialisation of the viable R&D results from PRODA (Project development Institute, Enugu) on the development of pilot plant for Electrical Motor/Transformer.
TOR -7	Assessing the effective performance and prospects for commercialisation of existing demonstration plant for electrical Motor/Transformer with a view to streamlining them.
TOR -8	Examining the composite material requirement for the fabrication of Electrical Motor/Transformers with a view to recommending the most suitable one for SME'S.
TOR -9	Identifying the required Production Processes and recommend the most feasible and Economic Process to be used by SME'S .
TOR -10.	Evaluating the manuals of Electric Motor/Transformer Pilot plant and design the appropriate Training Programme for the plant operators.
TOR -11	Examining the R&D capacity of PRODA in electrical Equipment with a view to strengthening it.

ACTIVITIES

1) Collected DATA by meeting people at various levels, right from machine operators to Managing Directors of various Research Institutes and Manufacturing units/Industries.
2) Observed Manufacturing Capabilities and Processes adopted in Enginerring units by visiting the shop floor, of various industries.
3) Visited Research and development Institutes like PRODA and SEDI
4) Delivered lectures to Engineers and Technicians
5) Engineers were taught, the Basic design features of Electric Motors
6) Conducted various SEMINARS and WORKSHOPS using Audio visual Medium to Educate the Engineers, SME'S and others, regarding the manufacturing process.

Lectures Delivered/Seminars Conducted

a)	22 -7- 97	-	Design features of Motors/Transformers - to PRODA Engineers
b)	26-7-97	-	Seminar at PRODA Guest House Audio Visual Programme
c)	12-8-97	-	Basic Design of Electric Motor to PRODA management and staff - Lecture at PRODA old Library
d)	1-9-97	-	Design/production of Electric Motors and Transformers - Enugu
e)	2-9-97	-	Debriefing

Major Companies Visited to Study in detail

a)	Nigerian Foundries	-	Lagos
b)	Nigerian Engineering works	-	Portharcourt
c)	Star Foundries	-	Oko
d)	Pyro product Ltd	-	Enugu.
(e)	Ajaokuta steel Co. Ltd.	-	Ajaokuta

Note: This Report is not yet approved by UNIDO. Hence opinions and views expresed by the author are not necessarily the views and opinions of UNIDO

EXECUTIVE SUMMARY

Constant efforts are made by Federal Ministry of Science and Technology, Federal Ministry of Industries, UNIDO and UNDP to develop and improve small and medium Enterprises in Nigeria from several years.

UNIDO under reference DG/NIR/95/039/11-53/06-4000, assigned the Author of this Report to study for a period of 2 months at ENUGU, under the over programme for small and medium enterprises development, and also to establish ways by which the SME'S can take advance of Research and development work carried out in the country in Investment and other Institutions.

This study is mainly about Commercialisation of Research work done by PRODA on Electric Motors and Transformers. The Report submitted by the Author is highly Technical and it can be very easily understood by Engineers and People with Technical background. However efforts are made to simplify and make the Report understandable by others also. The Report gives the required materials and their specification, the processes to be adopted in the manufacture of Electrical Equipment, the machineries required to adopt special processes and other quality related details.

ACTIVITIES:

Seminars and workshops were conducted to Targeted audience using Audio visual medium which gives highest impact. Lectures and personal discussions with Engineers and Technicians of PRODA, helped in Educating them on the Importance of Technology and at the same time bringing to their notice their present level of knowledge. The seminars and lectures were well attended. Various foundries like Nigerian Foundry at Lagos, star Foundries at Oko were visited. Manufacturing companies like Nigerian Engineering works at PORTHARCOURT and various SME'S works were visited to asses the capacity and technology level available. A seperate visit Report is given as a part of main Report.

It is emphasized that, by production of one PROTOTYPE MOTOR AND TRANSFORMER, using copy technology, there is not much that has been achieved. Entire series of Motors/Transformers of Various speeds, voltages, outputs and mounting, are required to be developed, for various applications in an Engineering Industry.

The Executive Summary is in the order of Terms of Reference.

TOR - 1

The R&D Results obtained by PRODA in the field of Electric Motor is Purely by way of copy Technology and the knowledge gained by PRODA is not sufficient enough for actualisation. There is still a wide gap between understanding the Design features of an Electric Motor/Transformer and actually manufacturing the same. Hence the Results are not Ripe Enough for actualisation. More details are available in chapter 1 of the Report.

TOR - 2

The work done so far in setting up a pilot plant for manufacturing Electric Motors and Transformers, is mainly in the form of Land acquisition and Construction of Building. The Building available is sufficient enough to put up a huge factory. The know how in the form of Drawings, limits, fits and tolerances are totally missing. The importance of certain specific processes to achieve the desired results are not known to the Engineers. The Existing machineries are not suitable for manufacturing Electric Motors, as Motors are precision dynamic Equipments. Machineries, Technical knowledge and Tranining are essential to achieve Results.

Following three proposals are given depending on funding capacity.

a) To set up an Electric Motor/Transformer manufacturing unit of capacity 5000 Motors per year up to 10 HP and 250 Transformers per year up to 100 KVA, in the Existing PRODA Building at a cost of 60 (sixty) Million NAIRA, for the machineries and equipment, excluding Technical co-operation cost with a leading Electrical Equipment manufacturer in the world.

b) To set up a demonstration plant in the existing Building at PRODA with few machines but with a technical co-operation. As per the part processed in the demonstration plant, SME'S can produce part for assembly. Estimated cost of Machinery, excluding Technical co-operation and Training cost is 9 (nine) Million NAIRA.

C) With a proper technical co-operation, to set up an Assembly unit at PRODA Building and Import semifinished part in the beginning. After acquiring the knowledge it can be Expanded as per "b" based on Market demand.

Estimated cost excluding Technical Co-operation Cost and TRAINING is 4.2 (four point two) million NAIRA.

All the above 3 proposals does not include the cost of material and working capital.

TOR - 3

Existing facilities are totally inadequate for the Production of Electrical Motors and Transformers as there is a need for Technology and special purpose machines. Electric Motor being an Electro Dynamic Equipment needs special Technology. The Existing machines at PRODA are very old and not suitable.

TOR - 4

The technically defective designs of Electric Motor and Transformers are identified and various improvements are suggested. The improvements are mainly in the material specification of Housing Body, shaft, key, Rotor winding, stamping, Fan etc.

Complete process is given to manufacture individual parts right from Raw Material stage to machining tolerances. There is a need to change the Design specification in every part and also the process to be adopted. Some of the new unknown processes to PRODA, such as knurling by Milling, pressure die casting, Dynamic Balancing, stamping Notching etc, and the appropriate machines to do that process properly are suggested. The chapter 4 deals in detail the complete manufacturing process of Electric Motor and Transformers. With the help of the processes given, a good Industry can start manufacturing.

TOR - 5

The performance of the Electric Motor and Transformers produced, are far below any National or International standard. An equipment like the one already tested at PRODA may not be a saleable product. Hence the most appropriate method for designing the product and for implementation is as elaborated in chapter - 4, which requires, many tools, jigs, and fixtures. The chapter 2 proposes the method of implementation.

TOR - 6

The Results obtained at PRODA are not Ripe enough for commercialisation. PRODA has to primarily acquire the know how to convert the same into an acceptable product of National or International standard. Then only commercialisation can be thought of. At pressent only few areas like turning, winding etc can be offered to SME'S who can handle certain Repair jobs of failed Motors.

TOR - 7

There is no Prospect for commercialisation of Existing demonstration plant without any investment in Technical co-operation and procurement of some vital machines. The pressent demonstration plant needs total upgradation both in terms of Technology and Machinery.

TOR - 8

The detailed Material specifications are given both in chapter 4 and chapter 8. It is found that most of the Raw materials have got to be imported as the same are not manufactured in Nigeria at Pressent. Hence the most suitable one for SME'S would be to concentrate in the machining and processing activities of imported Raw Materials. The details and Processes will have to be collected by SME's from the demonstration plant after the demonstration plant, acquires the same through a Technical co-operation.

TOR - 9

The production processes like ferrous and Non ferrous casting, Blanking, Notching, centering, cutting, Turning, slitting/shearing, knurling, Grinding, Milling, Drilling, Broaching and welding are identified as the most feasible processes suitable for SME'S to perform.

By Transfering these Technology after acquiring the same at demonstration plant, SME'S can help boost the production of Electric Motors and Transformer with least individual investment. This helps to establish the process in a wider circle.

TOR - 10

A Training Programme has been designed and proposed at Two levels.

(a) Management

(b) Technical

(a) Management level Training is estimated to cost 1.3 million NAIRA

(b) Technical level Training is estimated to cost 12.7 Million NAIRA.

The above Training cost excludes the Technical co-operation cost and any charges demanded for Training by the collaborators.

A suggestion is made to Train the Management level with an investment of approximately 1.3 Million NAIRA, to identify the possibility of a Technical co-operation. This will help to decide the further investment on demonstration plant ranging between 4.2 Million NAIRA to 60 Million NAIRA, depending upon the funding capacity and policy decision.

TOR - 11

For strengthening the R&D capacity of PRODA in Electrical Equipment, the Design and drawing knowledge of the Engineers has got to be enhanced. There is an urgent need to Train the Engineers and Technicians in a large Electrical equipment manufacturing company. They also need many more new machines and Testing equimpment for Raw Materials.

SUMMARY

Summarising, although the Engineers in PRODA should be capable of improving the Design and manufacturing Processes as highlighted and suggested by the Author in chapter 4, which gives complete material specifications and the correct machining process, there is an urgent need to equip PRODA with a demonstration plant. This can be done by entering into a proper Technical co-operation with any of the leading Electrical equipment manufacturers of repute.

Copy Technology without basic knowledge cannot sustain for long, as the world is advancing very fast and there is no need to "INVENT THE WHEEL" again. If the State of Art is not adopted in the pressent day thinking of Globalisation, the country will be left behind, when others march ahead. There is a need for indigenisation with the state of Art.

RECOMMENDATIONS

A. TO PRODA

1) Enter into a Technical Co-operation with any leading Electrical Equipment Manufacturer of repute.
2) Bring the State of Art, otherwise the time spent and Effort put in does not go in tune with the progress made by other countries.
3) TRAIN both management and Technical level at factories manufacturing Electrical Equipment in Asian/European Countries.
4) First acquire Technical "KNOW HOW" and then try to acquire "KNOW WHY" to become self sufficient .
5) Install a demonstration plant to Train SME'S
6) Make Trained people accountable for implementation.
7) Atleast start Assembling the Motors and Transformers by initially importing semi finished parts and later on with the help of SME's by producing every component.

B. Recommendations to Ministry

1) Encourage Private/Joint sectors to go for special purpose machines by helping them with funds to make components for motors.
2) Encourage foundries to Produce Intricate Castings by adopting CO2 Process.
3) Encourage steel Industries to Produce special purpose steels like, High carbon steel and silicon steel.
4) Till such time, steel Industries gear up to produce special steel, Cut down import duty on Raw materials like, High carbon steels, silicon steels, copper etc.
5) Increase Import duty on finished Motors to help Indigenous Industries once they are set up.
6) Once the Motor manufacturing units are fully set up to Produce a series of Motors in all standard out put, Put a Ban on Importation of Electric Motors.
7) Ban Importation of Motors even in the machineries which come with Motors. This helps to increase local demand for motors so that local manufacturers can survive.

8) Encourage Private/Joint Sectors to acquire state of Art through proper Technical - Co-operation.

The above recommendations help in forcing the people to purchase Indigenously manufactured quality product, and help the country to grow Industrially. Industrial growth leads to self sufficieny and increases the capacity of people to absorb higher grade of Technology further.

CHAPTER - 1

TOR - 1 Identify the R&d results related to the Design and fabrication of Electrical Motor/Transformer with a view to determining their actualisation.

Activity

1.1 DATA COLLECTION

The Author studied in detail the work carried out by PRODA at ENUGU, both at the Research Institute and the Workshop. Discussions were held at various levels such as Director, Senior Research officer, principal Research officer, principal Technology, principal Technologist, senior works superintendent, and senior foreman. Details of names & designations are given at the end.

From the Technical discussions and seeing the workshop containing the machines and tools/equipment, it is infered that the R&D results obtained by PRODA is only basics in Engineering, and they have only made an attempt to acquire basic knowledge in Motor Rewinding. There is no need to "RE INVENT THE WHEEL".

Copy Technology is adopted by dismantling some of the Motors and trying to understand the design. The knowledge of the Engineers met, Specially in the field of Electric Motor Manufacturing is at a very low level. The Author is of the opinion that with the level of knowledge available at PRODA, they will not be in a position to transfer any Technology to SME'S. PRODA is still unaware of the basic Raw material and specifications required for the Manufacture of an Electric Motor or Transformer. They have just learnt the method of assembling & disossembling a Motor. They have also learnt the method of forming, winding formers in wood, to produce coils. Here also they know only to the extent of 4 pole motors and if the Number of poles are changed it is not possible to give the basic detign, by them. It is claimed in Earlier Report, that, they have developed tools and dies for punching of slot in stampings. Actually the Punches made are primitive in nature and are not sutable for mass production technique. Single punch & die are developed without any accuracy of tolerances and fit. This will give very large variations in the size of slot and leading to misalignment. It is made clear in this Report that, Technology transfer for manufacturing Motors cannot be made by only learning how to assemble and disassemble a Motor. There was no clear understanding at the Engineers level about the different class of Insulation that Exists in the Insulation Technology. The knowledge on the tolerances, fits, machining accuracies etc that are required for the manufacture of an Electric Motor is very poor and there is a very large Gap. There are no basic drawings with any sort of standardisation.

As such no PROTOTYPE Motor is manufactured at PRODA, other than winding few Motors and assembling them. By using one of the Existing Housing Body as a Model and by using shell Moulding, a Housing has been cast in Aluminium. As the cast Aluminium is not having the required mechanical strength to with stand the Electro Dynamic forces coming on the Body, it is not suitable for production. Moreover shell Moulding will be expensive and the cost of the Motor will be very high, making the product uncompetivie in the market.

In a Nutshell, the Results obtained by R&d at PRODA ENUGU is not Ripe for actualisation.

1.2 Up gradation of Knowledge

Since there are no proper drawings maintained for the understanding and manufacture of various part of Motor, the Author of this Report Explained with sketches the importance of limits, Fits, tolerances and allowances to all the Engineers and working Technicians. A further upgradation in this area is essential.

1.3 SEMINARS

Lectures and seminars were organised to make the Engineers and Technicians understand the importance of basic Design, Process, Quality Control and consistancy in dimensional accurancy. The Seminars were well attended where Audio visual medium was used for better impact in understanding. The Lectures were attended in large number with keen interest and enthusiasm.

1.4 Personal Discussions

Personal discussions were held at various levels right from Directors of R&D Institution and Managing Directors of companies, up to Engineers and machine operators to know the Real Problem.

CHAPTER - 2

TOR -2

Assessing the magnitude and cost implication of the work yet undone on the R&D results for Electric Motor Transformer Pilot plant and Recommend ways of Remedying the situation.

2.1 The facilities available at PRODA is totally inadequate to consider for the pilot plant. The machines available at pressent are incapable of maintaining accuracies due to poor maintenance. The machines are not capable of producing even Grade 12 tolerance, where as for manufactring Motors it requires Grade 5 and 6 tolerance.

2.2 Land and Building

There is a very big building with permanent structure of approximately 8720 squaremeters of floor area, in PRODA. There is power supply lines and water supply lines available almost up to the Building. The Building is properly designed and provisions are made to accomodate overhead cranes and cable ducts for cabling purposes. The place is ideally suitable to put up a modern Motor/Transformer manufacturing unit. Even by using one fourth of this Building a pilot plant to manufacture about 5000 Motors and 250 Transformers per year can be planned. The Motors canbe up to 10 HP and Transformers up to 100KVA.

The Author proposes strongly a captive foundry to manufacture cast iron component which is required in large quantity. Without a foundry there will be bottlnecks in the production.

It is proposed to procure in addition to the list of machinery & Equipment proposed by prof. Inuwa in his February 1996 Report (Appendix A-4 to chapter-8) a shot blasting Equipment, Two Numbers Dynamic Balancing machines and one No. pressure die casting machine, which is missing in his Report, at a total cost of approximately 750 thousand Naira. The dynamic Balancing machine to balance the Rotors and fans is absolutely necessary other wise, the Motors will have vibration & they just do not function. The pressure die costing machine is also absolutely necessary to get proper charecteristics of the motor.

2.3 Capital Cost Estimate

2.3.1 Land, Building, Road Network, and Water Supply - Available

2.3.2 Power supply - Requires cabling and other Electrical wiring for the supply & Errection of Machines. This needs very detailed working.

2.3.3. Plant and Machinery

			Million NAIRA
A.	Cost of plant & Machinery as per Annexure chapter 2 which includes foundry		47.87
B.	Errection and commissioning Approximately 20% of Cost of Equipment		9.574
C.	Contingency		2.556
		Total	60.000

Total of 60.00 million Naira, is required Excluding cost of furniture, vehicles etc which are considered as available in PRODA. The above does not include the working capital and Raw Material stock for the production. This requires a greater study depending upon the No. of units to be produced.

2.3 Market Demand

At pressent there is no motor manufacturer in NIGERIA and entire requirement of the country is being imported. It is Reported that the country imports about 50,000 motors per year including the motors that come along with the equipment. The average computed value of motors amount to NAIRA 700 million. The price of Motors upto 10HP at international levels converted to NAIRA is given in Annexure II, chapter 2.

Considering the huge amount being spent for importing Motors, it will be worth, putting up a modern plant and develop the know how & Technology in the country. No doubt this will be an investment, but it will definitely pay in the long run.

The level of knowledge, skill and training is not adequate to run a pilot plant of the capacity proposed. Hence the Author strongly Recommends to enter into a Technical co-operation with any of the Motor manufacturers in the world, who can supply, manufacturing drawings, provide tools figs fixtures, supply required machinery & also Train the people totally for Handling the plant. In this way one can acquire the state of Art & not left behind, in the Globalisation being thought of in the entire world.

Even with the establishment of a pilot plant, if the state of Art is not acquired through a proper Technical co-operation with leading manufacturers of Motors, PRODA may not be in a position to produce Motors.

Further once the pilot plant is established with technical co-operation, the trained Engineers can acquire both technical know how & know why. At tis stage SME"s can start supplying the components such as shafts, stampings, machined Housing, Phenolic moulded part etc and help PRODA to increase the No of Motor manufactured per year without any further investment. This will be the stage of real achievement of the objective.

2.4 Alternative I

If the funding does not permit to invest 60 million Naira (Sixty Million Naria) to put up a plant of the capacity proposed above and to produce about 5000 Motors per year, the Author proposes to put up a demonstration plant, which can show the process to be adopted for manufacturing the Motors, in which case we can eliminate the foundry and have fewer machines installed along with the Existing machinery. The details of machines are as per Annexure III to chaper 2. Lay out for machinery is also given in the Annexure.

			Million NAIRA
A.	The machinery cost	=	7.205
B.	Errection & Commissiong 20%	=	1.441
C.	Contingency	=	0.354
	Total		9.0

A total of 9 (Nine) Million Naira will be required to put up a demonstration plant, where foundry is excluded. Further it is important to note that, a Technical co-operation and Training of Engineers in Essential if the Technology is to be Transfered to SME'S. The cost of this is not included in the above, as it requires a detailed study after discussing with leading manufacturers of Motors who are interested to give the state of Art.

2.5 Alternative II

One more alternative is proposed, to start a winding & Assembling unit for the Motor, and procuring the components from any of the leading Motor manufacturers in the world. The parts are, stator core packet, Diecasted Rotor, Housing bodies and End covers. In this proposal the machinery required will be minimum, but the technology can be acquired in stages & once it is perfected the Expansion programme can be thought of.

Machinery required is as per Annexure IV to chapter 2. Layout for machinery is also given.

			Million Naira
A	Cost of machinery	=	3.4
B	Errection & Commisioning 20%	=	0.68
C	Contingency	=	0.12
	Total		4.2 Million Naira

Again this amount does not include the Technology know how and Training cost.

2. 6 COMMENT

All the above three proposals does not include the working capital required to produce the motors. A detailed study taking into cosideration, Technical coperation cost, Training cost, Raw Material and Semi finished part cost etc, is required to be assessed by an International consultant, after deciding the partner with whom Technical co-operation is to be entered into. If the country from which the Technical co-operation to be obtained is decided, in about Two months a final detailed Report will be possible to asses the Extent of expenditure required, which are not covered in this Report. An International consultant will be able to find the most Economical Technical co-operation and also the sources to get, Raw materials at the lowest price.

ANNEXURE I, Chapter 2

A. Machines Required for Production of 5000 Motors per year up to 10 H.P

SL.No	Details	Qty	VALUE IN THOUSAND NAIRA Per Machine	Total
1	Centre lathe	2	1800	3600
2	Shaft cutting machine (Hydraulic Power)	1	350	350
3	Medium Capacity Milling machine	1	450	450
4	Radial drilling machine	1	350	350
5	Gang drilling Machine	1	300	300
6	Hydraulic Press 100 Ton	1	500	500
7	Hydraulic Press 50 Ton	1	300	300
8.	Eccentric Press	2	500	1000
9.	Notching Machine	2	400	800
10.	Baking oven	1	50	50
11	Coil winding machine	6	15	90
12.	Grinding machine	2	70	140
13	Precision lathe (Pittler)	2	300	600
14.	Pressure die casting machine	1	8000	8000
15.	Dynamic Balancing Machine	2	250	500
16	Testfield Equipment	1 Set	500	500
17	Measuring Equipment	1 Set	500	500
18	Spray painting unit	2	50	100
19	500kg chain Hoist Block	2	15	30
20	Accessories	1 Set	100	100
21	Hand Shear	2	20	40
			TOTAL	**18300**
B.	**Machines Required for Transformers**			
1	Gaswelding Equipment	2	25	50
2	Arc welding Equipment	1	1000	1000
3	Vacuum Tank	2	15	30
4	Electric operated winding machine	2	85	170
5	Shearing Machine	1	200	200
6	Paper taping machine	1	10	10
7	Oil Purifer	1	10	10
8	Expansion machine	1	50	50
9	Fork Lift	3	750	2250
10	Guilotine	2	140	280
11	Air Compressor	2	235	470
12	Fly Pres	1	50	50
			TOTAL	**4570**

Foundry

The cost of a ferrous foundry with modern Induction finance for a production of approixmately 20 Tons per year, is estimated to cost 25 million Naira, as it requires moulding machines to operate the match plated patterns.

If the match plated patterns are not used, there will be misalignment and quality of the casting will be bad. There can be more than 40% Rejection. The above estimate includes a shot blasting machine.

<u>ABSTRACT</u>

I. Cost of Machinery in millions of NAIRA

1)	For Motors	-	18.30
2)	For Transformers	-	4.57
3)	Foundry	-	25.00
	Total	**-**	**47.87**

II. Cost of Plant

1)	Land and Building	-	Available
2)	Machinery	-	47.87
3)	Instalation Cost 20%	-	9.574
4)	Containgency	-	2.556
		Total	**60.00**

A Total of 60 million NAIRA

PRICING OF MOTOR

International Price of each Motor on 4 pole basis Converted to Nigerian NAIRA

SL.NO	Out Put H.P.	Frame Size	Price in NAIRA
1.	0.5	AM 71 N4	5150
2.	0.75	AM 80 K4	5760
3.	1.00	AM 80 N4	5830
4.	1.50	AM 90 SZ4	6400
5.	2.00	AM 90 LZ4	7020
6.	3.00	AM 100 LK4	8450
7.	4.00	AM 100 L4	9230
8.	5.00	AM 112 M4	10850
9.	7.50	AM 132 SZ4	15000
10.	10.00	AM 132 MZ4	17520

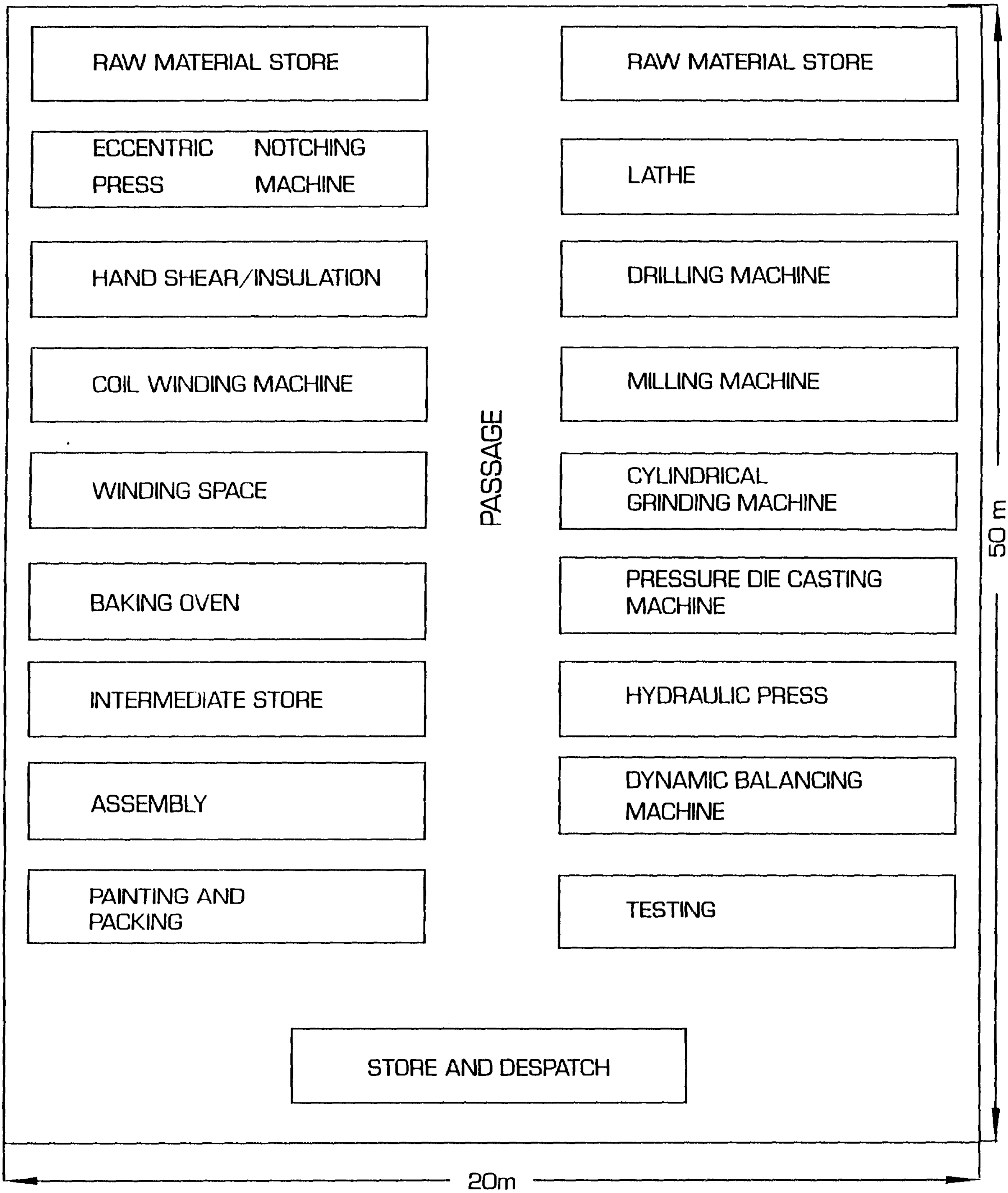
ANNEXURE III - Chapter 2

Machinery required for a demonstration plant

SL. NO.	Details.	Qty	Thousand Naira
1	Center Lathe	1	1800
2	Medium Size Milling Machine	1	450
3.	Radial drilling Machine	1	350
4.	Hydraulic Press 50T	1	300
5.	Eccentric Press	1	500
6.	Notching Machine	1	400
7.	Baking oven	1	50
8.	Coil winding machine	1	15
9.	Cylindrical Grinding	1	70
10.	Pressure die casting Machine	1	2500
11.	Dynamic Balancing Machine	1	250
12.	Hand Shear	1	20
13.	Tools, fixtures and measuring Equipment	one set	500
			7205

A Total of 7.205 Million NAIRA.

LAYOUT FOR DEMONSTRATION PLANT
(REFERRED TO ANNEXURE III, CHAPTER 2)



TOTAL AREA = $1000m^2$

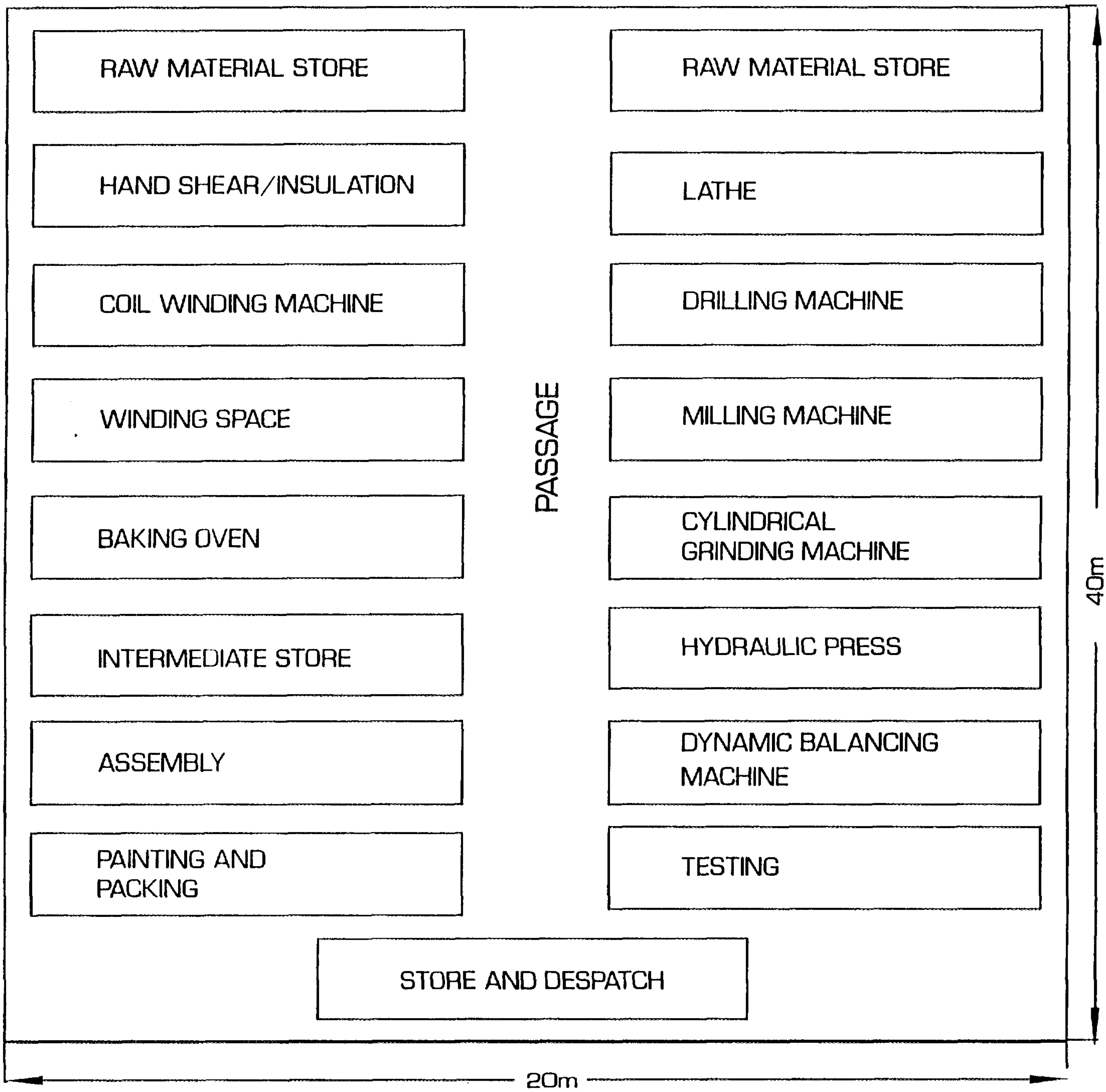
ANNEXURE IV - Chapter - 2

Machinery required for an Assembly unit.

SL. NO.	Details	Qty	THOUSAND NAIRA
1.	Center lathe	1	1800
2.	Milling machine	1	450
3.	Radial drilling Machine	1	350
4.	Hydraulic Press	1	300
5.	Baking oven	1	50
6.	Coil winding Machine	1	15
7.	Cylindrical Grinding Machine	1	70
8.	Dynamic Balancing Machine	1	250
9.	Hand shear	1	20
10.	Tools and Fixtures	one set	95
			3400

A Total of 3.4 Million NAIRA

LAYOUT FOR ASSEMBLY UNIT
(REFERRED TO ANNEXURE IV, CHAPTER 2)



TOTAL AREA = $800m^2$

ANNEXURE V CHAPTER - 2

EMPLOYMENT POTENTIAL

1. For production of 5000 Motors up to 10 H.P. and 250, Transformers up to 100KVA.

a)	General Manager	- 1
b)	Production Manager	- 2
c)	Sales Manager	- 4
d)	Finance Manager	- 2
e)	Quality Control Manager	- 2
f)	Scheduling/planning Manager	- 2
g)	Testing Manager	- 2
h)	Staff/Operators for production	-95
i)	Staff for other disciplines like finance, scheduling, sales and secretaries etc	- 50
	Total	160 Nos

The above No is estimated based on 2 shift working and direct employees. The Turnover will be approximately 35 million NAIRA per year.

By off loading some of the components to SME's and increasing the production to double that of installed capacity the indirect employment potential could be approximately for another 100 persons.

The advantages will be, saving in valuable foreign exchange, development of Technology in the Country, Industrialization and Self Reliance.

2) By Installing a demonstration plant additional employment potential that can be created is as follows

a)	General Manager	- 1
b)	Production Manager	- 1
c)	Quality control Manager	- 1
d)	Planning	- 1
e)	Testing	- 1
f)	Operators and staff	- 20
		25

Apart from the existing employees in proda additional 25 persons can get permanent employment.

The concept is that, this demonstration plant serves as a Training center for SME's and the machinery installed can be used by PRODA for developing higher Horse Power Motors, without further Technical co-operation for self reliance.

The employment potential is very large in this system as number of SME's can be developed by giving the technology. The Technology, thus percolated to SME's at the lower levels can be helpful in not only producing Motors in large number for the Countries requirement, but also can be used to help other Industries where similar process/Technology is required. This gives a very broad base in the Country especially at the SME's level, which helps Industrialization.

In Southern part of India there are large number of Motor manufacturers in UN-organized sector, manufacturing Motors for Agricultural Pumps, small compressors, domestic Grinding Machines Etc which has given an Industrial base.

India also adopted a policy to allow any Small or Medium Scale industry to enter into a collaboration with other Countries to bring the state of Art. Till the recent Globalization policy India had banned importation of equipment that were manufactured in the Country to help indian Industry to grow. Thus the technology level has increased in that Country.

It is also very common that large Motor manufacturers in India help small scale Industries by giving Raw material & asking them to process, to avoid working capital problem for smaller industries.

CHAPTER - 3

TOR 3 Reviewing the effectiveness/Appropriateness of Existing facilities for the production of Electrical Motor/Transformers.

3.1 Technical Knowledge

The Existing facilities at PRODA and other places was reviewed in Detail and it is found that the facilities are totally inadequate to produce a high precision Equipment like an Electric Motor, which is a Dynamic Equipment. It is easier to produce Static Equipments, which does not require closer accuracies, while for a Motor the accuracies required are 5 or 6 Grade tolerances as per ISO, Tolerance limits. Without this kind of Precision, the Rotor and stator will rub with each other, the Bearings will Rotate, and become loose in Bearing Housings. The Motors become inoperable in a few months of Running.

3.2 Drawings

The Basic problem appears to be lack of correct working drawings. The drawing, both for Raw part and machining should be available for proper processing. This facility is not available. Also there is no knowledge regarding the drawings as per International standard. Engineers are working with hand sketches, which cannot be reproduced, and the mating parts are made by trial and error, instead of sticking to one particular dimension as per drawing.

3.3 STANDARDISATION

There is no standardisation of components and there is no Quality control. The facilities lack the equipments on quality control such as measuring Equipments, Gauges & Materials testing laboratory. Unless a well established Testing lab is available, Quality cannot be maintained. The facilities required will be right from production of drawings, standardisation, Process planning, Methods study, production control, Quality control, Reliability studies, Maintenance of machines, painting and packing technology.

3.4 Machines

None of the above enumerated facilities are available, hence Electrical Equipment like Electric Motors cannot be produced. Facility like pressure die casting machine if installed can be useful to produce Rotors, fans, and even Housings out of Aluminium Alloy. Although the cost of Pressure die casting tools are expensive, it is worth investing on a bigger machine, which can dispense with the foundries, as it is learnt that, the sand available in NIGERIA for sand casting of cast iron parts, do not have the temperature with standing capability, to form the intricate Ribs required in the Housing Body.

3.5 SkILLS

The skill required for the production of Electric Motors is lacking, specially in the machining of Parts to close tolerances, maintaining the higher slot fill factors in the slot of the stator, consistancy in achieving the uniform accuracies in every component produced etc. This facility is to be created by Tranining the Engineers in any of the Motor Manufacturing units in the world. This is necessary.

3.6 Foundry and Ovens.

The foundry Existing in PRODA is both ferrous and non ferrous, type. For greater mechanical strength and damping, ferrous foundry with cupola or induction furance is required. The Rotary crucibles do not have the temperature controls, hence there is no possibility of achieving consistancy. The size of the foundry avaialble is also not adequate for any regular production. The type of sand used is not suitable for getting good surface finish, and the castings obtained will be highly porous. Because of the Porosity the spigot will not have the strength to withstand Electro dynamic forces. CO_2 Process is Recommended for the intricate Ribs to be formed in Housing.

It is found that the existing facilities at PRODA are not effective/Appropriate for the production of Electric Motors/Transformers.

3.7 List of Machinery & Status

3.7.1	Double Ended Table Grinding machine	-	Working
3.7.2	Two Nos. centre lathe	-	Working, but cannot give ccuracy as taper is more than 0.5mm permeter
3.7.3	Two more centre lathes and one capston lathe	-	Not working
3.7.4	One Radial drilling machine	-	Can drill up to 25 dia max - Not for accurate working
3.7.5	Power saw	-	Not working
3.7.6	Shaping Machine	-	Not working
3.7.7	Planing Machine	-	Not installed which is procured in 1980
3.7.9	Seam welding machine	-	Not installed since 1980.

CONCLUSION:

None of the machinery available in PRODA are suitable for the manufacture of a precision machine like an Electric Motor. Further there are no Testing Equipment to check the suitability of enamelled copper wire, shaft steel, insulating material etc for maintaining the quality and consistancy. Most of the Existing machines under use, and also the machines which are procured long back and not commissioned, deserve to be scrapped. There is practically no maintenance of machines which are under use & also they have not been oiled. Thick dust has accumulated over the machines. Only few shearing machines and welding equipment can be used to manufacture transformer Tanks.

On the contrary SEDI has presses to produce stampings, and better machinery.

CHAPTER - 4

TOR-4 Identifying Technically defective design, Electrical Motor and Transformer and recommend ways of standardising them.

The Technical defect identified in Design and Process of both Motor and Transformer are as given below. By following the details given below it is possible to produce a quality motor, as it is technically very informative.

STANDARD PRODUCTION PROCESS OF ELECTRIC MOTOR

The production process of Electric Motor can be subdivided into following groups:

4.1 Production of Stator Complete
4.2 Production of Rotor Complete
4.3 Production of Bearing System
4.4 Production of Cooling System
4.5 Production of Terminal Connections
4.6 Assembly Parts.

4.1 Production of Stator Complete

This consists of following components which need detailed machining, punching, casting, winding, slitting, drilling, impregnating etc.

4.1.1. Body of the Motor or Housing with feet

The Body or the Housing is made up of Cast Iron having Tensile strength of 15kg/mm^2 for Rigidity. Aluminium pressure die cast bodies can be used for smaller frames of output range, up to a maximum of 10 Horse Power. Cast Aluminium bodies with sand casting is Not Recommended as they lack the required Mechanical Strength to withstand the Dynamic Load that comes during the operation of the Motor. Further the Cast Iron body dampens the vibrations, making the Motor work very smooth.

The Cast Iron body with cooling Ribs on the periphery of the body, should be subjected to shot blasting after receiving it from the foundry, to remove the sand particles and any unfettled parts. This process is also essential to see that the surface takes proper painting.

To protect the casting from rusting, immediately after shot blasting, the Housing should be dipped in Red oxide Primer and Air dried. This coating prevents the body from oxidation throughout the process and up to final Assembly, before final finish painting.

A Machining

A.1 **Turning:** The bore of the Housing with feet should be turned to a diameter equivalent to basic outside diameter of the stamping core with tolerance as per ISO H7 Grade tolerance limit. This tolerance enables a proper fit between core packet and Housing.

Now the two ends of the Housing are to be turned to accommodate the spigot of end covers, which houses the Bearings. The spigots of Housings should be turned to an equivalent diameter in end covers, with ISO H7 Grade tolerance limit.

A.4 **Milling:**

Keeping the spigots of housing as reference, the foot portion of the Housing shall be milled for the correct axle height of the motor, with max allowable tolerance of 0.5mm. Care shall be taken while setting the Housing, for milling the feet, so that, the axis of the Housing is parallel to the milling axis, failing which after assembly of the Motor, the shaft extension will be inclined to feet surface instead of being parallel.

A3 **Drilling and Tapping**

A number of holes are required to be drilled and some of them tapped in the Housing to see that the motor can be fixed on the foundation or on the machine. The tapped holes are used for fixing the end covers to the housing, which houses the bearings. Four numbers of tapped holes are to be made, on either side of Housing, for fixing end covers to the eyes, provided in the Housing.

Similarly tapped holes are to be made on the terminal box platform, to fix the insulated terminal board and cast iron or sheet metal terminal covers.

Four number of holes in the foot portion of the motor shall be drilled, exactly symmetrical to the axes, which are used for fixing the motor to the foundation.

Now the Housing is ready for Assembling the core packet with winding.

4.1.2 **Stator Core Packet with winding**

This consist of the following:

[A] **Stator Stampings**

This is made up of 0.5mm thick, cold or hot rolled non grainoriented silicone steel sheet, of M45 grade as per AISI standards having a loss of 5.31 watt loss per kg.

The sheet shall have a varnish coating as per C4 of AISI standards, which should withstand a voltage of 20 volts. The varnish shall adhere properly, so that, during punching of slot the varnish does not peel off. A Bend test is recommended to ensure this.

Square sheet of required size is to be slit in a slitting machine, and the centre bore with key way for aligning purpose, blanked in an eccentric press using a die and punch. The bore diameter after blanking, shall have the diameter equivalent to shaft diameter, with H7 tolerance as per ISO tolerance limit.

Using this bore as reference, outside diameter of the stator stamping shall be blanked, with diameter equivalent to Housing bore diameter, with plus 0.3mm allowance for turning purposes. In this operation 8 Nos. Rivet holes are also formed.

Now the stator slots are to be punched in a notching machine according to the number of slot. Now the stator stamping and rotor blank are to be seperated out. The stator stamping, is ready to form the core. The left out blank of rotor to be separately notched to get the rotor stamping and kept aside to use it in the manufacture of Rotor core.

[B] **Stator Core**

The stator stamping so obtained as above, shall now be stacked on a mandrel, suitable for the bore of the stamping and aligned.

Rivet made of mild steel of approximately 4mm diameter, suitable for the holes already made in the stampings are to be introduced in the holes. The No. of stampings to be used is approximately equal to, twice the core length for riveting. The ends of the Rivet are to be flared in a Hydraulic Press to get the stator core.

At this stage the core packet which is still on a mandrel should be taken to a lathe, and outside diameter of the stator core packet, turned, equivalent to Housing bore diameter with "r6" tolerance as per ISO tolerance limit. This will ensure tight fit in the Housing so that the packet does not rotate in the Housing during running of motor.

[C] INSULATION

The state of the Art, is only insulation class F having a temperature with standing capacity of 155^{0}C. Different class of insulation and their temperature withstanding capacity is as follows.

Insulation Class	Temperature in ^{0}C Max	
Y	90	
A	105	
E	120	
B	130	
F	155	STATE OF ART
H	160	
C	Above 160	

The size of Motors as per the state of Art, is in accordance with IEC frames. A copy of the standard fixing dimensions, overall dimensions and shaft extension dimensions are given at the end of the report.

Only with the use of insulation class F or B, the dimensions as per IEC can be maintained. By using lower grade of insulation, the size of the motors increases making them unsuitable for replacement in the existing machines. Hence the materials suggested as leatheroid by PRODA is unsuitable. Only NOMEX manufactured by M/S DUPONT United States of America shall be used.

The flexible NOMEX of 0.25mm thick shall be cut to the required size, in a slitting shear, and used as slot insulation. The different slot insulation cut in the rectangular shape shall be as follows. The NOMEX used shall be calendered type.

a] Slot liner

b] Coil separator

c] Top liner

d] Phase separator [cut to required shape]

e] Coil end support

f] Wedge [made of epoxy glass fibre sheet of one to two, mm thick].

g] The sleeving for wire ends shall be of polyurethane varnished glass fibre sleeve.

[D] Winding.

The stator core packet that has been manufactured as per B above, shall be wound using enamelled copper wire of Electrolitic high conductivity grade (EHC) as per IS:4800. The enamel used for coating these conductors, shall be of modified polyester. The enamelled wire shall have flexibility without cracks. The break down voltage at room temperature shall be minimum 500 volts. And at elevated temperatures it shall be minimum of 400 volts. The enamell shall have the compatibility with insulating varnish.

After insertion of enamelled copper winding wire in the slot with proper insulation, the overhangs of the winding beyond the core packet shall be shaped and formed. This shall be braced with Nylon wires to hold them in position. The ends of the six leads coming out of the winding after end connection, shall be covered with polyurethane Glassfibre sleeves before it is terminated to the terminal board.

[E] **Impregnation**

After completion of the stator core packet with winding, the entire core packet with winding shall be impregnated in insulating varnish and baked. The insulating varnish used shall be as per standard IEC:464. This is being manufactured by M/S Doctor Beck and company in both England and INDIA. This shall form a thin coating on the winding and fill up all crevices so that it gets hardened after baking.

This impregnated core with winding shall be cured at 160^{0}C for 8 hours. After curing and removing from oven, the core packet shall be cooled and the cycle repeated. The impregnating varnish used shall have a minimum electrical strength of 50kV per mm.

[F] **Stator Complete**

The core packet with winding after curing as per para E above, should be cleaned on the machined outside diameter of the stamping, and pressed in to the Housing body already prepared as per 4.1.1. using a Hydraulic press and positioned.

A hammer drive screw should be fixed, so that it locks the core packet in housing, by drilling a hole in Housing and core packet. Care shall be taken so that it does not touch the winding. The ends of the winding shall be connected to terminal board fitted on the housing terminal box. A name plate giving details like output, voltage, current etc is to be fixed on the Housing, for identification. NOW THE STATOR COMPLETE IS READY AS PER 4.1

4.2 **Rotor Complete**

Production of Rotor complete consists of the following:

4.2.1 - Shaft

4.2.2 - Rotor core complete

4.2.1 - Shaft

Shaft is the most important part in the motor, as it transmits the mechanical energy to the driven equipment after the electrical energy is converted into mechanical energy in the motor.

The shaft shall be manufactured out of high carbon steel, having a composition of 0.35 to 0.45 percent carbon. The Minimum Breaking tensile strength shall be 58kg per mm^2. This shall have a minimum yield strength of 30 kg/mm^2.

First, the shaft should be cut to the required length and centred in a centering machine. After centering, it should be turned to accommodate core packet and bearing diameters. The shaft extension shall be turned as per IEC dimensions, corresponding to the output. A key way should be cut in the shaft extension to accommodate the key for transmission of Power. The core packet seating area should be straight knurled by milling, using special cutters. At this stage it is highlighted that the diameter will not increase in shaft, if knurling by milling is adopted.

Now the shaft extension, the bearing seatings on driving end and non driving end, and also the fan seating should be ground to correct tolerance for proper fitting of the mating component. The Ball Bearing seating should be ground to k5 tolerance limits. Now the shaft is ready in all respects.

4.2.2 **Rotor Core Complete**

This consists of the following

A. Rotor stamping

This is the left over material of silicone steel at the centre, after the stator stamping is made as per 4.1.2.A. Using the available centre bore with key way, required number of Rotor slots are to be punched in a Notching machine, thereby getting the Rotor stamping.

B. **Rotor Core with windings**

The Rotor stampings manufactured as per "A", above are to be stacked on a mandrel, to the required core length and then it must be fitted in a die, to cast the 99.9 percent pure electrolytic grade aluminium, using a pressure die casting machine. After Pressure die casting the core, the core is to be cooled and removed from the mandrel.

C. **Rotor Complete**

This Rotor with core as per "B" above, shall now be pressed into the shaft and positioned. Now the Rotor complete so formed shall be taken on a lathe, to turn the outside diameter of the Rotor, to form the required Air Gap.

The Rotor complete thus machined shall be dynamically balanced, on two planes, to a G-2.5 grade tolerance limits.

At present in PRODA dynamic balancing is not done. This will create enormous vibrations, Hence this process is a must.

Now the Rotor complete is ready for assembly as per 4.2.2.

4.3 **Bearing System**

The bearing system consists of

4.3.1 End cover, driving end

4.3.2 End cover, non driving end

4.3.3 Bearing

4.3.4 Inner Bearing cover

4.3.5 Wave washer.

4.3.1 The end cover, driving end, shall be made out of cast iron grade 15, having a tensile strength of $15 kg/mm^2$. PRODA is using cast aluminium and it is not recommended, as it does not have the required mechanical strength. Cast Aluminium will have poracity and will be highly brittle. Alternatively, pressure die cast Aluminium can be used. In any case, a cast iron ring shall be inserted at the bearing seating, to avoid bearing becoming loose in the end cover. The spigot for fixing the end cover to Housing Body of stator, shall be machined to h 11 tolerance grade. The bearing bore shall be machined to J6 Tolerance Grade. The length of the Bearing seating shall be 3 to 4mm longer for the Driving end, end cover, to accommodate wave washer. Drive end side shall have free bearing arrangement. Necessary holes shall be drilled for assembly.

4.3.2 **End Cover Non Driving End**

This shall be manufactured similar to the Drive End, Endover as per 4.3.1 except that the Bearing bore width is shorter since wave washer is not used. The Non driving side shall have fixed bearing arrangement. Necessary holes are to be drilled for assembly.

4.3.3 Bearing

Both the Driving end and Non driving end, shall have deep groove ball bearings of 63 series (Medium series). These Bearings will give very long life.

4.3.4 Inner Bearing Cover

This is used, to protect the Bearing from dirt, and at the same time avoid entry of grease to the winding. This is a simple cover, fixed to the end covers, with a bore, which is 0.5mm more than the corresponding shaft diameter for free rotation. This shall also act as a stopper for bearing, to take the axial load coming during operation of the motor. This shall be preferably of cast iron, or at least of Aluminium Pressure die cast.

4.3.5 Wave Washer

The wave washer is a spring material & manufactured by creating waves in a disc of spring steel. This will apply the required pressure to the Bearing, so that the bearing is preloaded. This way of preloading the bearing reduces the noise of the bearing, during the operation of the Motor. This also helps in giving the Bearings longer life.

4.4 Cooling System

The cooling system contains the following

4.4.1 Fan

4.4.2 Fan cover

4.4.1 FAN

The fan profile is the most important shape, as it has to cool the Motor, which gets heated up due to losses such as Iron loss, copper loss and stray losses. Secondly, the profile so selected shall give minimum noise during running of the motor. As per IEC, the noise level shall be limited to 85dB. The fan shall be either of pressure die cast aluminium or cast aluminium of at least A-6-M alloy which should contain 13% Silica. The tensile strength shall be a minimum of $15kg/mm^2$. The hub where it is mounted on the shaft shall be of cast iron, otherwise the fan will loose on the shaft. The thickness of fans shall be doubled for sand casting. The number of blades shall be odd.

The fan must be independently, dynamically, Balanced, failing which the motor will vibrate heavily. The fans made by PRODA does not work, as profile is not proper. Forming of fan blades by deforming the sheet steel gives noise like a siren.

4.4.2 **Fan cover**

Since fan with blade is a rotating part, it is essential that it is guarded by using a fan cover either made of deep drawn steel or cast aluminium. There shall be slits or openings for suction of air. The profile of the fan cover shall be such that, the flow of Air is smooth and is properly guided to the fins on the Housing body, for proper cooling of the motor.

4.5 **TERMINAL CONNECTIONS.**

Terminal connections are made to a terminal board, made out of phenolic Resin and moulded to shape with brass connected studs and Nuts. There shall be six numbers of brass studs with Nut, for obtaining either star or Delta connections.

The terminal Board thus fixed on the stator of the motor, shall be covered with a Terminal Cover made up of either sheet metal or of cast iron, to protect the operating persons from touching the live terminal accidentally. The design of the terminal cover shall be proper with creepage and clearance distances to avoid arcing. The gaps shall be maintained as per VDE 530.

4.6 **Assembly Parts**

The assembly part shall contain

4.6.1 - Key

4.6.2 - Name plate

4.6.1 - **Key**

This shall be Rectangular in cross section, and made up of carbon and Manganese Alloy. Carbon shall be 0.55 percent and Manganese shall be 0.75 percent. The tensile strength shall be 80 kg/mm^2. The tolerance on the width shall be h9 grade as per ISO.

4.6.2 **Name Plate**

The Name plate shall be made of one milimeter thick anodised Aluminium with Logo of the manufacturer etched. The details such as output in HP, speed in RPM, rated current, rated voltage, power factor, efficiency and weight of the motor in kg shall be punched.
This name plate shall be fixed on the stator body.

Now the Assembled Motor shall be painted to required colour and packed after testing.

II Standard Production Process for TRANSFORMERS

Although Transformer Production is not as complicated as in motors because it is a static equipment, care shall be taken to see that the raw materials chosen are of the right type.

A. TANK

The tank shall be made of mild steel sheet properly welded to make it totally leak proof. It may be necessary to test the welded joint for leakage by using dyepenetrant test. The top surface of the tank shall be flat, to take up the cover properly with gasket. For larger transformers, radiators made out of deep drawn steel sheet shall be used for cooling the oil.

B CORE

The core shall be made out of cold rolled grain oriented steel sheet. The sheet of 0.35mm thick material shall be slit and cut to trapezium shapes for stacking. They must be stacked using fixtures to form the core and bolted.

C WINDING

99.9 percent pure electrolytic, high conductivity copper strips are to be covered with paper as insulation before winding. The winding so formed shall be assembled over the core. The leads are to be carefully taken and connected to the terminal fixed in the porcelain bushings mounted on the top plate of the transformer.

D. DRYING

The entire core with winding shall be dried in vacuum to get the best results. The core with winding shall be heated to 100^0C to drive away the moisture and to see that the moisture absorption is avoided.

E. ASSEMBLY

Immediately after Assembling the core with winding in the tank the transformer shall be filled with mineral oil so that there is no moisture absorption.

F. TESTING

The Transformer shall now be tested as below

a] Routine test

a.1] Measurement of voltage ratio and check of voltage vector relationship.

a.3] Measurement of impedance voltage/short circuit impedance and load loss.

a.4] Measurement of noload loss and current.

a.5] Measurement of insulation resistance

a.6] Power frequency and induced over voltage test.

a.7] Test on load tap change where appropriate

b.] Type test

b.1] Temperature rise test

b.2] Impulse test - full wave.

Regarding production of transformer, since the Author is more or less in agreement with the report submitted by National consultant in February 1996, the manufacturing process is not elaborated, but only salient points are highlighted.

CHAPTER. 5

TOR-5 Designing the most appropriate method of assessing the effective performance of the implement.

It has been elaborated in chapter 2, and also proposed to sellect one of the three alternatives suggested for implementation. The performance of the Electric Motor claimed to have been developed is not effective for implementation.

5.1 The first proposal is to put up a large scale manufacturing unit which can produce up to 5000 motors per year. The advantage of this unit is that, the technology can be absorbed by the country very fast so that the expansion programme to manufacture the entire quantity of motors imported by the country of the order of 70,000 Nos per year, can be implemented in about 2 years of time. Ban on importation of motors at that stage will be effective. This helps in countries approach for self sufficiency.

5.2. The first alternative proposed in chapter 2, requires a little longer time to meet the countries requirement , which may be about 3 to 4 years.

5.3 The second alternative as per chapter 2, requires at least 5 to 6 years, to come to the level of first proposal, as most of the machining operations and pressure diecasting operations will have not been implemented immediately in the country.

5.4 **COMMENT**

Considering the development of SME's, the first alternative as per chapter 2, helps in educating SME's the methodology to be adopted for supplying component required for the assembly of an electric motor. Assistance can be taken from one other institute called SEDI, which is more organised and posseses the required skills in process technology.

The performance of the product developed by PRODA like electric motor, is not up to the mark. The test results obtained by PRODA shows that, they have not been able to achieve the desired output, efficiency, power factor, and R.P.M. to consider them as Models for SME's to adopt the same. The performance of the existing models are assessed as not effective, unless the production technique is changed as per the design and process improvement suggested in chapter 4.

CHAPTER - 6

TOR 6 Reviewing the proposal for commercialisation of the viable R & D results from PRODA on the development of pilot plants for electrical Motors/Transformers.

6.1. So far the work that has been carried out at PRODA regarding Electric Motors and Transformers, is by and large copy technology. There is no original work done. The work so far done is only dismantling of an available electric motor and using the existing body of the motor as a pattern, and formation of moulds in shell moulding technology. This method creates large amount of shrinkage and the final part will not be as per requirement. The Body thus formed is also not of cast Iron but of cast aluminium, which is not desirable.

6.2 The stampings of Rotor, as received from M/S Rutland United Kingdom, are stacked and Aluminium metal poured to form the winding. This technology is not suitable for commercialisation, as the required technology is pressure diecasting of Rotor, which is not still acquired by PRODA due to lack of knowledge and machinery. If the required pressure is not applied while casting, there will be blow holes in the Rotor winding as seen in some of the Rotors. This gives rise to high no load current and high no load losses. This also reduces RPM and increases slip. The net result is a bad motor.

6.3 The shaft machining technology adopted by PRODA can be commericalised only up to the point of turning of shaft. The process of grinding and knurling by milling cannot be commercialised as there are no drawings with international tolerance. Further there are no special milling tools to demonstrate the same. By training some of the Engineers in any of the Motor Manufacturing Unit of Repute, this shaft manufacturing technology can be commercialised.

6.4 Stamping manufacturing technology which is under development by PRODA is in an infant stage. The right word for the die and punch produced by PRODA could be PRIMITIVE. The accuracy to be achieved in the art of tool and die making, requires training of some Engineers, who can learn the art of producing tools and dies and there after offer it for commercialisation to SME's. The material used for tool and die making shall be chrome molybdinum steel, without which there will be breakage of tools leading to expensive Rework.

6.5 The sand casting of fan for the motor with Aluminium was studied. There is a basic problem in the copy technology adopted, as the copying is done without the knowledge and function of the part used. A design which is suitable for pressure diecasting with Aluminium is used for sand casting with Aluminium, thereby leading to blow holes, cold flow etc and weakening the part mechanically. The process of sand casting with Aluminium can be commercialised provided the design of fan is modified as suggested in Chapter 4.

6.6. Winding of Motors is one area which can be tried for commercialisation, by asking SME's to Rewind the failed motors with the help of PRODA Engineers. As the Engineers at PRODA need training to learn the art of winding, higher pole motors and pole changing motors, with different end connections, they will not be able to assist SME's at every stage. Only 4 pole motors of smaller output, up to 5HP, can be rewound with the existing technology.

6.7 The welding transformer manufacturing technology acquired by PRODA can be tried for commercialisation by educating SME's in core manufacturing and winding. However, it may be noted that the quality of work that has been achieved is not at International Level and to acquire the same, on the job training is required. The training required , is in areas like Design, Core making, Winding, and Vacuum impregnation.

6.8 COMMENT

The results obtained so far by PRODA in the Electric Motor and transformer manufacturing is not Ripe for commercialisation. There is still lot of work to be done specially in the areas like, Basic design, Drawing, Process Planning, Production and Quality Control, before commercialisation can take place in a regular way. Under the present scenario if all the components, which are completely finished and ready for assembly are procured from any of the leading motor and transformer manufacturer, they can be assembled with the help of PRODA Engineers. This can save to a great extent the importation cost and at the same time develop the screw driver technology in PRODA immediately.

As proposed in the chapter 2, a demonstration plant is absolutely essential, so that the technology that can be acquired by PRODA, by way of technical co-operation is given out to SME's for commercialisation. With this SME's can learn the process, so that the country can be self sufficient in the area of electric motors up to 10HP and transformers up to 100KVA.

CHAPTER . 7

TOR 7 Assessing the effective performance and prospects for commercialisation of existing demonstration plants for Electric Motor and trnsformers with a view of streamlining them.

7.1 The existing plant at PRODA is totally inadequate to be called as a demonstration plant for commercialisation of results. The existing facility at PRODA workshop is found to be, with very old machines and are not well maintained. The accuracy of machined parts that can be obtained from the existing machines is far from the desired values for the manufacture of electric motors. Hence it cannot be called as a demonstration plant. Further a number of new machines are required to demonstrate in the area of pressure die casting, dynamic balancing, notching of stamping slot, cylindrical grinding etc.

7.2 Most of the machines available in PRODA demonstration plant, are 15 to 20 years old and are not well maintained to give precise dimensions in the component. Some of the machines like Horizontal Boring machine, seam welding machine, planing machine, special purpose milling machine, and surface grinding machine are not even errected and commissioned, although they are procured in 1980 as informed by PRODA. The condition of these new, unerrected and not commissioned machines are very bad and most of them are badly rusted. It may not be possible to even recondition them. The machines, are more or less fit for scrapping.

7.3 Vital machines required in a demonstration plant for manufacture of Electric Motors such as pressure die casting machine, Hydraulic press, Notching machine and dynamic balancing machines are missing.

7.4 The commercialisation of the existing facility is also not possible as the technology is not available. There is a misconception that, by dismantling few motors and transformers it is possible to sell technology, which in the opinion of the Author is totally incorrect.

7.5 Huge investments already made in PRODA in the form of building, roads etc since 1993-94 and procurement of machines in 1980 to 1984, have still not seen the light of the day. Interest cost alone on these investment already made, may be a mind bogling figure.

7.6 COMMENT

For streamlining the existing demonstration plant and for commercialisation of the same, many more machines like, eccentric press, hydraulic press, pressure die casting machine, and dynamic balancing machines are required. Even if further investment is made to purchase the required machines and supplied to PRODA, the technicians and engineers lack the technology for proper errection, commissioning and maintenance of the machine. Hence it is absolutely essential to train the people and make investment in the purchase of technology before the demonstration plant can start functioning and help commercialisation.

There is no prospect for commercialisation of existing demonstration plant, without further investment and monitoring by a joint venture, or technology transfer, from any leading motor/transformer manufacturers of repute.

CHAPTER - 8

TOR-8 Examining the composite material requirement for the fabrication of electrical motor and transformers with a view to recommending the most suitable one for SME'S.

Following are the individual material details recommended to SME'S for the fabrication. If raw material is imported, SME's can at least carryout the machining operations.

I ELECTRIC MOTOR

a] Housing Body and End Covers

Housing body and end covers shall be of Greay cast iron of grade 15 for less than 2okg weight, and grade 25 for more than 20kg weight of castings.

The carbon content is between 3 to 4 percent

melting point	-	1150 to 1250°C.
Grade 15	-	Minimum Tensile strength of $15kg/mm^2$.
		Elongation minimum 0.75 percent
Grade 25	-	Minimum Tensile strenght of $25kg/mm^2$
		Elongation - minimum 0.57 percent

Some of the foundries that are able to maintain above properties are.

i] NIGERIAN FOUNDRIES LTD. LAGOS

ii] Star Precision Foundries, Oko.

To get the intricate ribs of the housing body, the foundries may have to adopt CO_2 process, without witch the surface finish and the quality of castings will not be proper. It is gathered that the quality of sand available in Nigeria is not good to withstand high temperature for green sand moulding.

b] STAMPINGS (Raw material to be imported)

The stamping material shall be of Hot Rolled, non grain oriented, silicon steel sheets of 0.5mm thick and coated on both sides with insulating varnish of 20 microns thick.

i] Electrical property

The grade shall be M-45 as per AISI having a core loss of 5.31 watts.kg. The core loss is measured at 1.5 tesla or 15000 gauss.

ii] Mechanical Property

Density - 7.75 g/cc

Yield strength - 27kg/mm^2

Tensile strength - 38 kg/mm^2

Elongation - 34 percent.

Hardness - 62 Rockwell.

c] **COPPER CONDUCTOR** (Material Imported)

The Round Copper conductor wire used for winding shall be annealed copper.

Density - 8.89 g/cm^3

Tensile strength - 25kg/mm^2

The enamel coating of thes wires shall be polyester based enamel suitable to withstand 155^{0}C. It shall have good bond strength.

d] **INSULATING MATERIAL** (Imported)

i] Nomex - manufactured by M/S DUPONT, U.S.A.

Thickness varying from 0.25 to 0.5mm.

ii] Epoxy Glass fibre sheet of 0.5mm to 2mm thick

e] **Insulating varnish (to be imported)**

CLASS-F, varnish of Dr. Beck and company.

f] **Shaft Steel**

C40 Black Grade having a carbon content of 0.35 to 0.45 percent.

Minimum Tensile Strength - 58kg/mm^2

Elongation - 18 percent, minimum.

g] **ALUMINIUM FOR ROTOR**

99.9 Percent pure aluminium of electrolytic grade.

h] **ALUMINIUM FOR FAN AND FAN COVER**

Grade A-6-M

Tensile Strength - 16.5kg/mm^2

Silica content - 10 to 13 percent

i] **Terminal Board (Raw material imorted)**

Phenolic moulding material (Bakelite)

Density - 1.2 to 1.8 g/cc

Breakdown voltage strength - 10kv/mm

This can be moulded in the plastic injection moulding machine available at SEDI.

j] **BEARINGS** (imported)

To be procured from S.K.F., FAG, RHP, STEYER or from any other reputed make.

k] **KEY** (imported)

Carbon Mangahese Steel Tensile strength - 80kg/mm^2

II **TRANSFORMER**

a] **TANK**

Fabricated out of mild steel sheets and plates of various thicknesses. This can be done at PRODA, SEDI, or by any SME having Infra Structure to weld with gas and Arc welding equipments.

b] **CORE** (Raw material imported)

Stamping steel sheets of grade M36, cold rolled and grain oriented, of thickness 0.35mm. The core loss shall be 3.6 watts/kg measured at 15000 Gauss.

c] **COPPER**

Paper insulated copper strips having following properties

Density - 8.9 g/cc

Tensile Strength - 25kg/mm^2

d] **OIL** - Mineral oil

e] **BUSHINGS** (Ceramic)

Porcelain Bushings having following properties.

Break down voltage - 30kV/mm

Density - 2.5 g/cc.

Max temperature withstanding capacity - 1000^{0}C

III **COMMENT**

From the above material details furnished, it can be seen that, there are very few materials that can be procured from SME'S due to non availability of raw materials in NIGERIA. However, the machining activities can be done by SME'S with the know how acquired by Technology Transfer.

This strongly suggests a pilot plant to be established with technical co-operation for a range of motors and transformers.

CHAPTER. 9

TOR-9 Identifying the required production processes and recommend the most feasible and Economic process to be used by SME'S.

The processes for the manufacture of electric motors and transformers are explained in great detail in the chapter 4.

The processes involved are.

a] Casting, both ferrous and Non ferrous
b] Blanking
c] Notching
d] Cutting
e] Centering
f] Turning
g] Knurling
h] Slitting/Shearing
i] Grinding
j] Pressure Die casting
k] Pressing
l] Milling
m] Dynamic Balancing
n] Winding
o] Impregnating
p] Baking
q] Assembly
r] Welding
s] Drilling
t] Broaching
u] Paper insulation of conductor
v] Spray painting
w] Plastic injection moulding

Out of the above 23 processes identified for the manufacture of electric motor/transformer, about 13 processes can be handled by SME'S and the rest are to be done in the demonstration plant.

The processes that can be handled by SME'S are:

a] Casting, ferrous and Non ferrous

b] Blanking

c] Notching

d] Centering

e] Cutting

f] Turning

g] slitting/shearing

i] Grinding

j] Milling

k] Drilling

l] Broaching

m] Welding

The above 13 operation can be easily handled by SME'S, who can produce some of the parts required for the manufacture of Motors, thereby helping to increase the number of Motors manufactured at the demonstration plant with no further investment.

These are the most feasible and economical processes for SME'S with low investment.

CHAPTER .10

TOR 10 Evaluating the Manuals of electric motor and transformer pilot plant and design the appropriate training progrmme for the plant operators.

10.1 DATA

The data available in the final Report submitted by Techno Konsult Mr. I.K. Inuwa in February 1996 has been studied in detail. This Manual Produced for the establishment of a pilot plant at PRODA, ENUGU and TRAINING Programme suggested, is very exhaustive in nature. The machinery requirement, facilities available in the country for various processes and the training requirement for the plant operators, does not elaborate on the technology available at present in PRODA. This also does not confirm whether it is sufficient for a smooth take off after procurement of required machinery and completion of TRAINING.

The Author of this Report firmly emphasises that the Technology has got to be purchased from a reputed manufacturer of motors and transformers and train the people at their works as per the training programme designed and given below.

10.2 TRAINING PROGRAMME

The training programme is subdivided into two parts namely management and technical.

a] **Management**

Three senior persons [at Director level] from FMST, FMI and PRODA, need a visit to any leading motor manufacturer in the world. Preferably they can visit an Asian country which may be cost effective and the technology transfer could be easier.

Considering a total duration of 15 days visit including travel, the expenses will have to be worked out for a total of 45 Mandays, taking into consideration the daily allowances and class of travel which may be a matter of policy. However, a minimum level of operation as thought necessary by the Author, is given in this chapter, provided the visit is to India.

The duties of these three management level would be, to select the partner for the technical co-operation and enter into an agreement. The level of participants visiting shall be empowered to take spot decisions.

The countries in Asia that are recommended for the visit, to enter into a Technical co-opertion are India and China. However, before visit to these places, the concurrence for the technical co-opertion, from the companies are to be obtained through correspondence. Only after a fair amount of correspondence and concurrence, the visit is to be organised.

b] **Technical**

It is proposed to Train Engineers and Technicians in the following discipline.

SL.NO	DISCIPLINE	ENGINEER	OPERATOR	DURATION
1.	**DESIGN**			
	Electrical	1	-	12 weeks
	Mechanical	1	-	12 weeks
2.	**PRODUCTION**			
	Machine Shop	1	1	12 weeks
	Winding & Impregnation	1	1	12 weeks
	Balancing/Assembly	1	1	12 weeks
3.	**MAINTENANCE**			
	Errection & Commissioning	1	1	12 weeks
4.	Foundry	1	1	12 weeks
5.	Planning/Process	1	-	8 weeks
6	Quality control/testing	1	1	8 weeks
7.	Marketing	1	-	8 weeks

It is proposed and designed to train as above, at least 16 Engineers and 6 operators, in various disciplines. The duties and responsibilities of these Engineers and operators trained will be, to put into practice the knowledge gained during the training period and bring out the product in the least possible time. A reasonable target of bringing out the first ten motors in **six months** time after the installation of the minimum machinery should be fixed. Without a target for the implementation and to bring out the product, it is the apprehension of the Author of this Report that there may be little success after a huge investment. This suggestion is made in view of number of machines still not errected and commissioned as an August 1997 at PRODA, although, these machines are procured during 1980.

The above trained engineers and operators will have to run regular training classes at PRODA after their return, to train other engineers/operators to spread the knowledge to a wider circle. Thus the technology will be absorbed at various levels in the plant, for future expansion. Further it takes care of the plant even if some trained people choose to leave the organisation.

10.3 **COMMENT**

Although it may not be appropriate, it is still felt by the Author to mention that the selection process for the training shall be purely on merit and capability of the person selected. These selected persons will be the Backbone of PRODA in the furture activities.

If the training is arrnged in INDIA, the cost will be approximately a minimum of 200 U.S. dollars per day, per person, excluding travel cost for management level, and 100 US dollars per day per person for engineer/operator level excluding the travel cost.

ESTIMATE [MINIMUM VALUE]

1.	**Management Level**	U.S. Dollars
	3 Persons	
	[a] Travel cost at 2000 U.S dollars per person, up and down.	6,000
	[b] Subsistance cost at 200 U.S. dollars per day for 45 Mandays	9,000
2.	**Technical Level**	
	22 Persons	
	[a] Travel cost at 2000 US dollars per person up and down.	44,000
	[b] Subsistance cost at 100 U.S. dollars per day for a total of 1092 Mandays.	109,200
	Total U.S. Dollars	168,200

At he existing exchange rate of 82 naira per dollar the cost works out to NAIRA 13,792,400.

Say 14 million NAIRA

The above estimate does not include the cost of technical co-operation that will be charged by the collaborators, which needs a detailed study and negotiation. However, with an expenditure of Approximately 1.3 million Naira at management level, one can find out the cost involved for technical co-operation, so that, the remaining 12.7 million Naira to be spent on training the Engineers and operators can be reviewed.

10.4 **Abstract**

[a] Minimum Expenditure to identity Technical co-operation cost - 1.3 Million Naira

[b] Minimum Training Cost of Engineers and Operators - 12.7 Million Naira

The above excludes Technical co-operation cost.

CHAPTER. 11

TOR-11 Examining the R & D capacity of PRODA in electrical equipment with a view to strengthening it .

The R & D capacity in PRODA regarding development of Electrical equipment specially Electric Motors and Transformers is totally inadequate. The present capacity/facilities available are not even sufficient for copy technology, as many new machines and designing knowledge are missing. Naturally it is ill equipped for any original Research and developmental work.

PRODA requires Basic Designers and computers for quick calculations and Programming. Engineers and Technicians need training in Basic Designing, Drawing and standardisation. Lot of work and contributions is expected in this area by the Nigerian standards organisation. This organisation can first train the Engineers on the International Standards, limits, fits and tolerances to give them a base to understand the know how, which generally comes in the form of drawings and process plan. Once the Designers and Technicians understand "KNOW HOW", they can make an attempt to understand "KNOW WHY". At this stage any institution will be self sufficient to do original Research and development. At this new level of knowledge, copy technology will be very easy and they can improve upon the Design further, to suit the countries requirement.

PRODA requires immediately a pilot plant or demonstration plant as proposed in chapter 2. Any proposal out of the three suggestions depending upon the funds, will be useful at this stage. Various testing equipments are required for testing Basic Raw Materials, like ferrous and Non ferrous metals, insulating materials, Thermoplastic and Thermosetting Materials; etc.

Exposure of Engineers to quality assurance, acceptance criterion and testing the Raw Materials in a systematic way, according to the International Standards, is absolutely essential. The pilot plant with a capacity to manufacture motors and transformers, will become a Base for further development of bigger size motors, without the assistance of any additional technical co-operation. The basic knowledge of "KNOW HOW" will surely give the engineers, back up support to know the "KNOW WHY" for further achievement.

It is too early to estimate the funding requirement for strengthening PRODA, in Research and development activities of Electrical Equipment, as their immediate need is a Technical co-operation or joint venture to acquire know how.

Hence as a first phase to strengthen the R & D capacity of PRODA, the Author of this report strongly recommends acquisition of "Technical Know How" in the field of Electric Motor and Transformer manufacturing right from the Design stage.

SUMMARY AND RECOMMENDATIONS

Summarising, it is felt that there is an urgent need for the technology transfer through a technical co-operation with a good Electrical Equipment Manufacturer, otherwise in the Globalisation principle, one may be left behind. The Technical gap goes on increasing between original Research and Copy Technology. More so in the absence of Machinery, Equipment and Training . Hence the Author recommends the following:

I. **Recommendations to PRODA**

1] Enter into a Technical co-operation with the state of Art. Any Motor and Transformer Manufacturer of Repute may be approached, for this purpose.

2] Train the management and Engineers/Technicians level to acquire "KNOW HOW".

3] Make the Trained Persons Responsible for the implementation of Project.

4] Keep a Target of Producing at least first 10 Motors in six months and first 100 motors in one year.

5] With the Technical co-operation, start manufacturing motors up to 10HP, and Transformers up to 100kVA for sale within the country.

6] Establish a demonstration plant.

7] Allow Engineers to develop and acquire "KNOW WHY" so that they can develop motors of higher rating without any further technical co-operation.

II. **Recommendation to Government/Ministry**

1] Insist on a committed production with the incorporation of state of art and huge investment. A minimum production level of 1000 Nos in the second year and 3000 Nos in the Third year, shall be the target.

2] During the period of manufacture of these motors, impose a Ban on importation to the extent of No. of motors manufactured in standard outputs. This Ban shall be applicable even for the motors coming along with machines imported, to create a market for the indegenous make.

3] Encourage steel industries to produce High Carbon steel and silicon steels.

4] Make a study with the help of a good consultant to establish Repair/Rewinding and service centres for motors which becomes necessary once the country starts producing motors.

5] Establish at least one large Rewinding/Servicing centres for motors, in each city where refineries are located.

6] Cut down import duty on Raw Materials like special steels, silicon steels and copper so that, the indigenously manufactured product is competitive. Further increase the import duty on the finished motor in addition to banning importation up to certain output of motor/transformers. This helps the local manufacturing units get a demand for selling their product.

The above Recommendations help in forcing the people to purchase indigenously manufactured quality product. This helps the country to grow industrially. Industrial growth leads to self sufficiency and increases the Technology absorption capacity to achieve higher goals.

VISIT REPORTS

1] NIGERIAN FOUNDRIES - LAGOS

Date - 18-7-97

Persons met

Mr. John Barberopoulos - Managing Director

Mr. Romeo Barberopoulos - Chairman

The foundry is basically a ferrous foundry manufacturing big cast iron pipes and other fittings required for water supply and sewarage systems. The capacity is 6000 tons per month. They can handle single piece of maximum 2 tons capacity.

So far they have not manufactured any intricate castings with ribs. According to the Managing Director of the Company the sand available in Nigeria is not suitable for high temperature moulding. There will be sand fall and sand inclusions. Hence they do not make intricate castings with Green sand moulding. If they adopt CO2 process, they will be able to make intricate castings, but it will be expensive.

2] NIGERIAN ENGINEERING WORKS [NEW]

PORTHARCOURT.

Date - 4-8-97 and 5-8-97

Persons Met

Mr. S. KOTHARI - Managing Director

Mr. T.M. VIJAYAN - Technical Manager

This is a very large joint sector company manufacturing various products like

a] Transformers up to 500kVA both 11kV and 33kV mainly for Distribution.

b] Ceiling Fans

c] Air Conditioners

d] Deep Freezers

e] Tube light fittings

f] Compressors and evaporators for cars

g] Steel furniture and cabinets

h] Cookers

i] Parts for passenger cars.

This company has been established in early 1964 and they have all the infrastructure to manufacture good industrial product. The facilities in "NEW" Portharcourt can be utilised to manufacture stampings, core packet etc. To begin with, the skilled labour available with them can be used for winding the motor. They will be able to establish a demonstration plant at PRODA with proper technical co-operation. Since they are already a joint sector, they can be considered to help PRODA. Since they are manufacturing ceiling fans, they know something about motors and they know quite a lot in Transformers.

During the discussion with the Managing Director, he evinced keen interest to participate in the Industrial Growth of Nigeria, if UNDP/UNIDO can help them in acquiring some special purpose machines. An investment in such places in Nigeria can result in better achievement.

3] Scientific Equipment Development Institute [SEDI]

ENUGU

Date - 14-7-97 and 8-8-97

Persons met

Mr. I.I. Nnadi - Director

Mr. C.O. Eneh - Manufacturing Co-ordinator.

This Institute has well maintained machines of various types and capacities. Most of the machines in the machine shop and tool room are suitable for manufacturing motors. The machines suitable for some of the processes in manufacturing the motors up to 10HP and transformers up to 100KVA are

a] Lathes

Centre lathes -	4 Nos
Turret lathes -	2 Nos
Small lathes -	3 No

b] Milling Machines

Copy Milling -	1 No
Universal Milling -	3 Nos

c] Eccentric Press

100 Ton Press -	1 No
40 Ton Press -	2 No

25 Ton Press - 2 No

d] Drilling Machine

Pillar drilling machine - up to 20 dia - 1 No

Bench drill - up to 15 dia - 4 No.

e] Grinding Machine

Cylindrical Grinding - 1 No

Surface Grinding - 1 No

f] Sheet Bending machine - 1 No

g] Welding Machines

Arc welding - 1 No

Gas welding - 1 No

Spot welding - 1 No

h] Shearing machine - up to 3mm - 1 No

i] Plastic injection moulding machine - 1 No

Additional facilities required:

a] Pressure die casting machine

b] Dynamic Balancing Machine

c] Notching machine

d] Horizontal boring machine

With the facilities available in SEDI, they can supply many semi finished components for the manufacture of Electric Motors and Transformers, if proper drawings are supplied. They are reasonably knowledgeable in limits, fits and tolerances.

PERSONS AND INSTITUTIONS CONTACTED

1 **UNIDO VIENNA** Tel/Fax 431211316817

1.1 MR. V. GOLNIAKOV - Project Personal Officer

1.2 MR. IVAN DE PIERPONT - Project Manager

2. **UNIDO LAGOS TEL**

2.1 Mr. A. Sarbu, - UNIDO Country Director

2.2 Miss Joke Van der ven - UNIDO Programme Officer

3. **FEDERAL MINISTRY OF INDUSTRIES**

3.1 Mr. Nnamdi Ekweogwa - Programme Finance Officer

3.2 Prof Mike Kwanashie - Progrnme Management Advisor UNDP SMI Programme

4. **FEDERAL MINISTRY OF SCIENCE AND TECHNOLOGY**

4.1 Mr. Alh Muhammed Tukur Ahmed - Director
Technology Acquisition and Assessement

4.2 Mr. Emeka Chinalu Orji - Desk Officer
Technology Business Incubator

4.3 Mr. Abdul Shittu - Centre Manager/CEO

5. **UNIDO CONSULTANTS**

5.1 Mr. Pierre Gyss - UNIDO CONSULTANT - FRANCE

5.2 Mr. Stewart Barton - UNIDO CONSULTANT - AUSTRALIA

6. **NATIONAL CONSULTANT**

6.1 Dr. G.O. CHIGBO - Managing Director
CERACAN COMPANY LIMITED

7. **PROJECTS DEVELOPMENT INSTITUTE [PRODA]**

7.1 Mr. NWOSU L . K. Ag DIRECTOR (PRODA)

7.2 Mrs AKAGU I.C.

7.3 Mr OKAFO O.C. Senior Research Officer

7.4 Mr. ACHEBE J.C. Principal Technology

7.5 Mr. IFEZUE D.I. Principal Research, Officer Metalurgy

7.6 Mr. OKONKWO F.C. - Technologist.

7.7 Mr. OZONGWU S.C. - Principal Technologist

7.8 Mrs. KESANDU UCHE NYI O.I. - Senior Research Officer

7.9 Mr. ONOH PETER E. - Principal Technical Officer

7.10 Mr. AGBAKURU E. - Senior Works Superintendant

7.11 Mr. UZOANYA G. - Senior Works Superintendant

7.12 Mr. CHUKWU L. - Higher works superintendant

7.13 Mr. ADELABU F. - Senior Foreman

7.14 Mr. ANOSIKE C. - Principal Technical Officer

7.15 Mr. AGULANNA C.N. - Asst. Chief Research Officer

7.16 Mr. JUSTUS C. IROEGBU - Asst. Chief Technical Officer

7.17 MR. OJI. S.O. - Asst. Chief Technologist

7.18 Mr. IKEJIOFOR I.D. - Principal Research Officer

7.19 Mr. NNEBE E. U. - Asst Chief Technologist

7.20 Mr. OJUNJOBI S. ABIOLA - Research Officer I

7.21 Mr. OPARA R.O. - PTO Electrical Division

7.22 Mr. OSEFOH OSETOH CHUKWUDEBE - Research Engineer.

8. NIGERIA ASSOCIATION OF SMALL SCALE INDUSTRIALISTS [NASSI]

8.1 Mr. Dayo Azeez - Public Relations Sec.

9. SCIENTIFIC EQUIPMENT DEVELOPMENT INSTITUTE (SEDI)

9.1 Mr. I.I. Nnadi - Director

9.2 Mr. C.O. Eneh - Manufacturing Co-ordinator

10. PRIVATE SECTOR - INDUSTRIALISTS/BUSINESSMEN

10.1 NIGERIAN FOUNDRIES LIMITED - LAGOS

MR. JOHN BARBEROPOLOUS - Managing Director

MR. ROMEO BARBEROPOLOUS - Chairman

10.2 Spectra Nigeria Ltd.

MR. D.O. KUTEYI - Managing Director

10.3 EDIK ENTERPRISES [NIG]

MR. EDDY IYIEGBU - Business Consultant

10.4 OLATEJU ANTENNAS LIMITED

MR. ISOLA O. OLATEJU - Executive Chairman

10.5 Nigerian Engineering Works - Portharcourt.

MR. S. KOTHRI - Managing Director

MR. T.M. VIJAYAN - Technical Manager

0.6 Star Precision Foundries - OKO

Mr. ABADOM EMMANUEL - ENGINEER CHIEF

REFERENCE DOCUMENTS

1) Final Report by TECHNO KONSULT, Engineering and Management Consultant, 47 Aminu Kano Way, Gadan Kaya, KANO on "Feasibility Study and Engineering Design for Electrical Motor and Transformer Pilot Plant, PRODA, ENUGU, NIGERIA.

2) Hand Book on Westermann Tables - METAL

3) Engineers data book - 1988 of NGEF

4) Company profile and product Brochures of NEW

5) Product profile of PRODA.

Lecture Notes on Electric Motors

1) There are different types of Electric Motors

   a) A.C. Motors

   b) D.C. Motors

A.C. Motors are for General Industrial purpose, where as D.C. Motors are for Specific Industries like Steel Mills and other Industries where speed regulation is required.

2) In A.C. Motors there are two varieties

   a) Squirrel Cage Induction Motor

   b) Slipring Induction Motor

Further in A.C. Motors, there are two types of protection like, totally enclosed and screen protected, depending upon whether the usage is outdoor or indoor. Both the types are self ventilated.

3) The out puts of various sizes of Motors are internationally standardised.

4) The fixing dimensions, axle height and shaft extension details are internationally standarised.

5) The Main dimensions that are standardised are A, B, C, H, D, F, G, & GA.

6) The different type of Mounting of motor is also standardised, like, B3, B5 etc.

7) The stator stamping outside dia to be selected, is approximately 1.6 x H, where H is axle height. By way of better Housing design, if stator stamping dia can be increased, the core length can be reduced, by arriving at some savings.

8) Fix the length of core packet by considering D^2L requirement, by using outside dia as per 7.

9) Fix the inside diameter of the stator stamping by selecting a smaller dia for 2 pole, and bigger dia for 8 pole, as the peripheral speeds will be higher in 2 pole. Further due to low speed in 8 pole and lower cooling power of fan, we need longer core length. For similar reasons for 2 pole motors, smaller core length is sufficient.

10) Based on shaft extension details, select a proper ball bearing to mount on both driving and non driving, end. Always select wherever possible, the same size of bearings for both drive and non drive end to achieve lower inventory.

11) Check the life of the Bearing based on the load and speed. The load coming on the Bearing is half the weight of the rotor.

a) Let speed = n, of the motor

b) Find speed factor fn, from bearing catalogue.

c) Find also dynamic load carrying capacity of the Bearing "C" from catalogue.

d) If P = Load on Bearing.

$$LH = \frac{C}{P} .fn$$

Based on LH look for the life in Hours in bearing catalogue. The minimum life should be 40,000 hours.

12) Using the weight of Rotor and fixing a diameter of the shaft, slightly higher than the Bearing bore, calculate the deflection of the shaft.

$$YI = \frac{Wa^2b^2}{3EI(a+b)}$$

Y_1	=	Deflection of shaft in cm
W	=	Weight of Rotor in kg
a	=	Distance from Bearing to Load Point on Non drive end, in cm.
b	=	Distance from Bearing to Load Point on Drive End, in cm.
E	=	Modulus of elasticity = 2.2×10^6
I	=	Moment of Inertia in cm4

13) The deflection so calculated shall not exceed 10% of Air Gap.

14) Air Gap can be fixed as per following formula

No. of Pole	Rotor Dia Less than 75 mm	Rotor dia above 75 but less than 750mm
2	0.25mm	$0.25 + \frac{D-75}{300}$
4	0.20mm	$0.20 + \frac{D-75}{500}$
6 and above	0.20mm	$0.20 + \frac{D-75}{800}$

15) Calculate the shaft for any bending loads due to Pulley drive and also for shear force.

16) Fix The Slot size and use class F insulating materials, work out slot fill factor up to 55% and fix up the number of copper wire and size of copper wire.

17) Fix over hang lengths based on the pitch.

18) Design the end covers by keeping at least 5 mm gap from winding to the metalic surface to avoid flash over.

19) The fan shall have proper shape to avoid noise and at the same time to give very high efficiency.

20) The number of blades shall be always an odd number.

21) The fan cover shall have same profile as per the fan blade, to avoid whirling of air and creating pressure loss.

22) The entry of air shall have 8 x 8mm perforation as fixed by international standards.

23) The number of slots preferd for stator and rotor stampings are as follows

STATOR

4 Pole - 24, 36, 48, 60, 72, 84

6 Pole - 24, 36, 48, 72, 96.

ROTOR

4 Pole - 22, 28, 38, 50, 58, 96.

6 Pole - 22, 28, 50, 96

24) The slot selected shall have a shape to give parallel tooth, for uniform tooth induction.

25) The induction level shall be as follows:

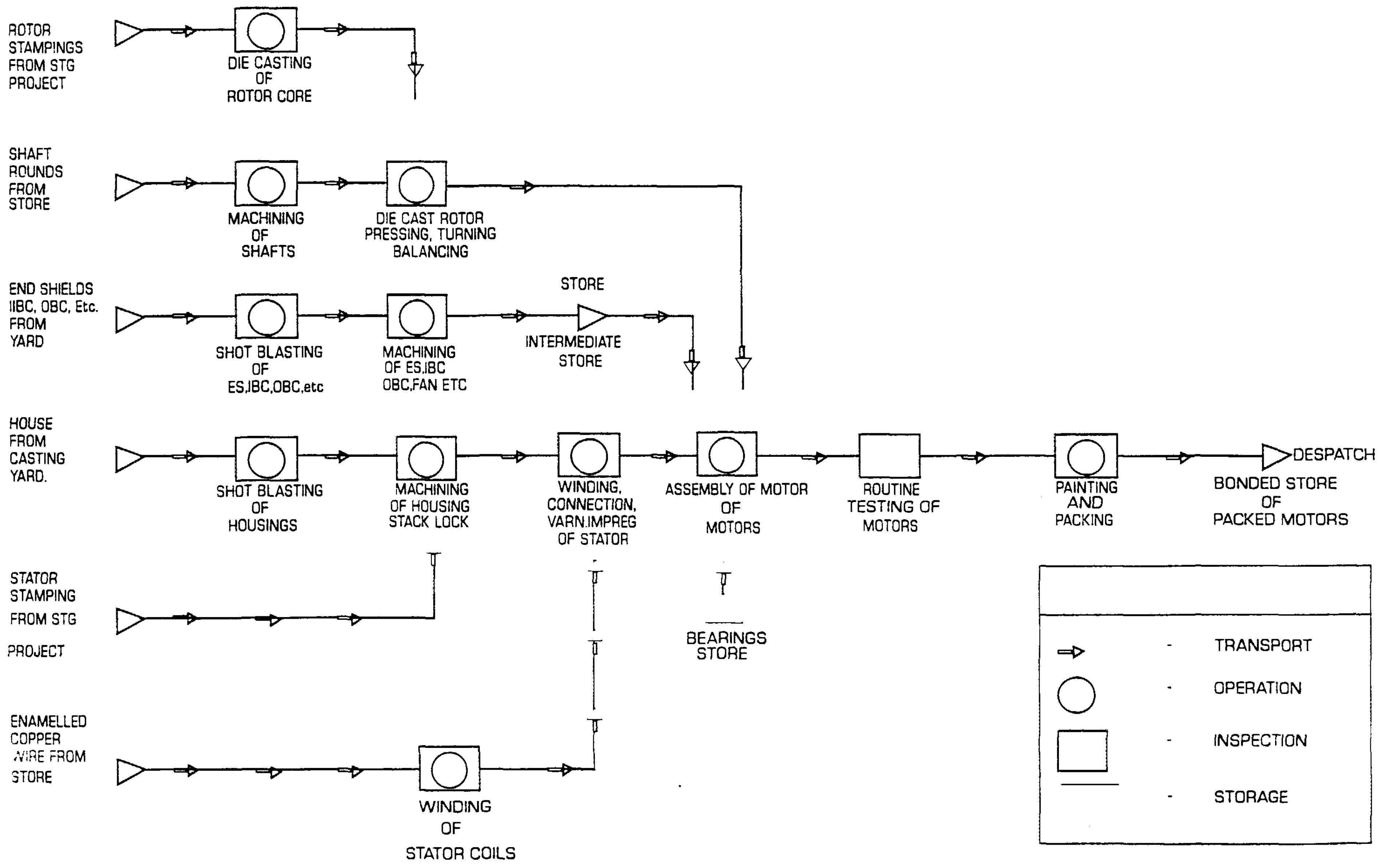
a) Air Gap Induction - 5000 line/cm^2

b) Tooth Induction - 15000 lines/cm^2

26) While selecting the copper cross section the density shall not exceed 2.5 amps/mm^2

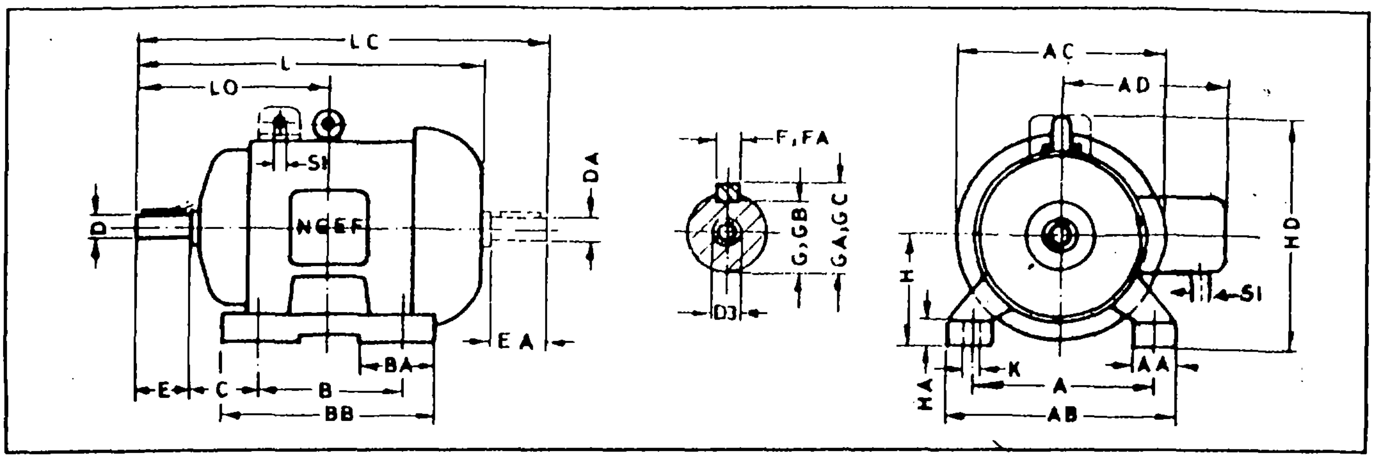
By following the above Basic Design Principles, a fairly efficient Motor can be designed.

FLOW DIAGRAM OF PRODUCTION LINE OF MOTORS



TYPE AM - FOOT MOUNTED (IM-B3)

DIMENSION DRAWING

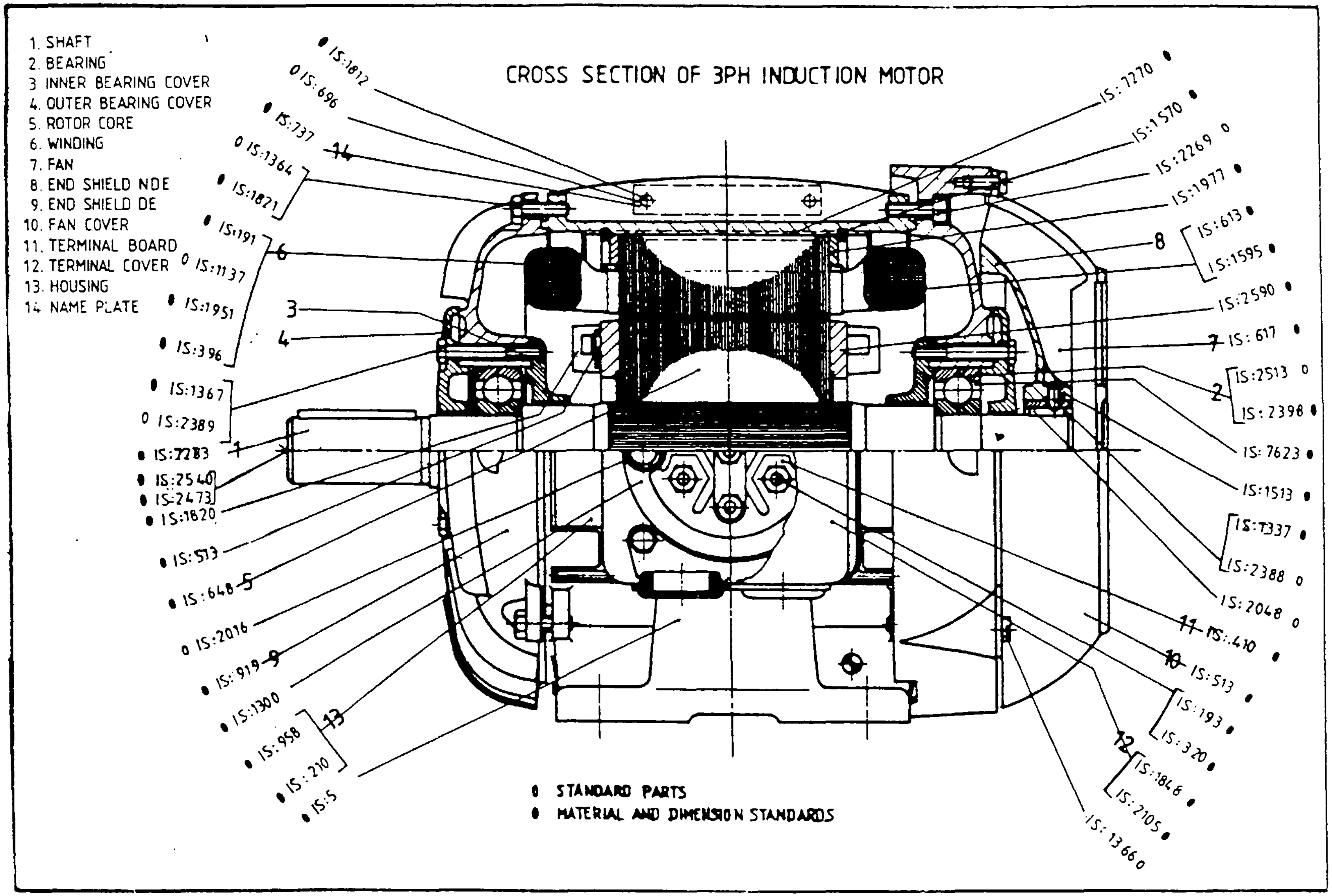


Drg. No. 34 9910 0092

Dimensions in mm

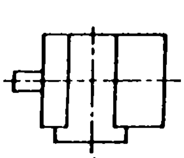
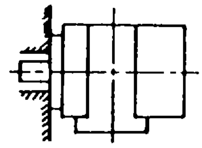
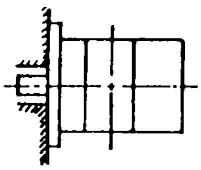
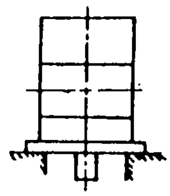
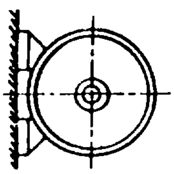
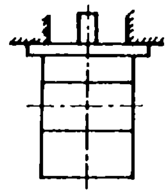
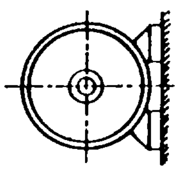
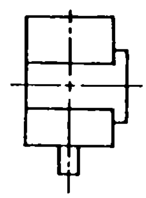
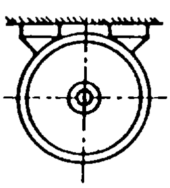
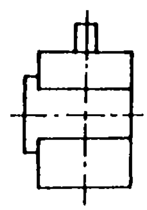
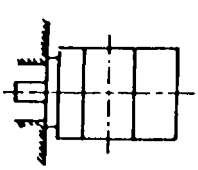
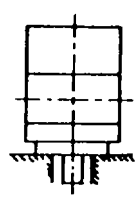
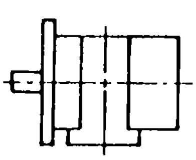
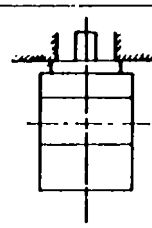
FRAME SIZE	A	B	C	H - 0.5	K	SHAFT EXTENSION D,DA	E,EA	F,FA	G,GB	GA, GC	D3	L	LC	LO
63 K,N	100	80	40	63	7	11j6	23	4	8.5	12.5	—	224	252	103
71 K,N	112	90	45	71	7	14j6	30	5	11	16	—	235	270	120
80 K,N	125	100	50	80	10	19j6	40	6	15.5	21.5	—	270	314	140
90 S	140	100	56	90	10	24j6	50	8	20	27	—	290	347.5	156
L		125										315	372.5	168.5
100 L	160	140	63	100	12	28j6	60	8	24	31	—	358	429	193
112 M	190	140	70	112	12	28j6	60	8	24	31	—	378	448	200
132 S	216	140	89	132	12	38k6	80	10	33	41	M12x28	440	535	239
M		178										478	573	258
160 M	254	210	108	160	15	42k6	110	12	37	45	M16x36	582	708	323
L		254										626	752	345
180 M	279	241	121	180	15	48k6	110	14	42.5	51.5	M16x36	644	772	351.5
L		279										682	810	370.5
200 L	318	305	133	200	19	55m6	110	16	49	59	M20x42	740	870	395.5

Frame Size	AA	AB	AC	BA	BB	HA	HD	IP 54/55 AD	SI	HD	Remarks
63 K,N	39	130	124	30	110	10	165	—	1 X CP 16	177	
71 K,N	35	142	140	40	130	10	181	—	1 X CP 16	193	
80 K,N	38	155	156	40	130	13	158	140	1 X CP 19	—	
90 S	35	170	176	48	130	13	178	151	1 X CP 19	—	
L					155						
100 L	43	195	212	50	170	15	234	164	1 X CP 19	—	
112 M	55	230	234	55	175	15	268	189	1 X CP 25.4	—	
132 S	62	265	274	70	185	20	304	215	1 X CP 25.4	—	
M					225						
160 M	72	320	335	78	260	25	370	257	1 X CP 31.8	—	
L					305						
180 M	82	360	372	95	300	30	420	292	1 X CP 38	—	
L					340						
200 L	92	400	410	105	375	35	463	310	1 X CP 38	—	


CROSS SECTION OF 3PH INDUCTION MOTOR
1. SHAFT
2. BEARING
3 INNER BEARING COVER
4. OUTER BEARING COVER
5. ROTOR CORE
6. WINDING
7. FAN
8. END SHIELD NDE
9. END SHIELD DE
10. FAN COVER
11. TERMINAL BOARD
12. TERMINAL COVER
13. HOUSING
14. NAME PLATE
IS:1812
IS:696
IS:737
IS:1364
IS:1821
IS:191
IS:1137
IS:1951
IS:396
IS:1367
IS:2389
IS:2283
IS:2540
IS:2473
IS:1820
IS:513
IS:648
IS:2016
IS:919
IS:1300
IS:958
IS:210
IS:5
IS:7270
IS:1570
IS:2269
IS:1977
IS:613
IS:1595
IS:2590
IS:617
IS:2513
IS:2398
IS:7623
IS:1513
IS:1337
IS:2388
IS:2048
IS:410
IS:513
IS:193
IS:320
IS:1848
IS:2105
IS:1366
STANDARD PARTS
MATERIAL AND DIMENSION STANDARDS

2. MECHANICAL FEATURES

2.1 Forms of Construction of Electrical Machines

Symbol as per IS: 2253	Design Figure	DETAILS	Symbol as per IS: 2253	Design Figure	DETAILS
IM B3		Foot Mounting	IM B34		Foot/Face Mounting
IM B5		Flange type 'B' according to IS : 2223 Flange Mounting. Shaft extension at flange end.	IM V1		Flange type 'B' according to IS : 2223 Flange Mounting. Shaft extension at flange end.
IM B6		Foot Mounting	IM V3		Flange type 'B' according to IS : 2223 Flange Mounting. Shaft extension at flange end.
IM B7		Foot Mounting	IM V5		Foot Mounting
IM B8		Foot Mounting	IM V6		Foot Mouting
IM B14		Flange type 'C' according to IS : 2223. Flange Mounting. Shaft extension at flange end.	IM V18		Flange type 'C' according to IS : 2223. Flange Mounting. Shaft extension at flange end.
IM B35		Flange type 'B' according to IS : 2223 Foot cum flange Mounting. Shaft extension at flange end.	IM V19		Flange type 'C' according to IS : 2223. Flange Mounting. Shaft extension at flange end.

ELECTRICAL DATA AND APPROXIMATE WEIGHTS

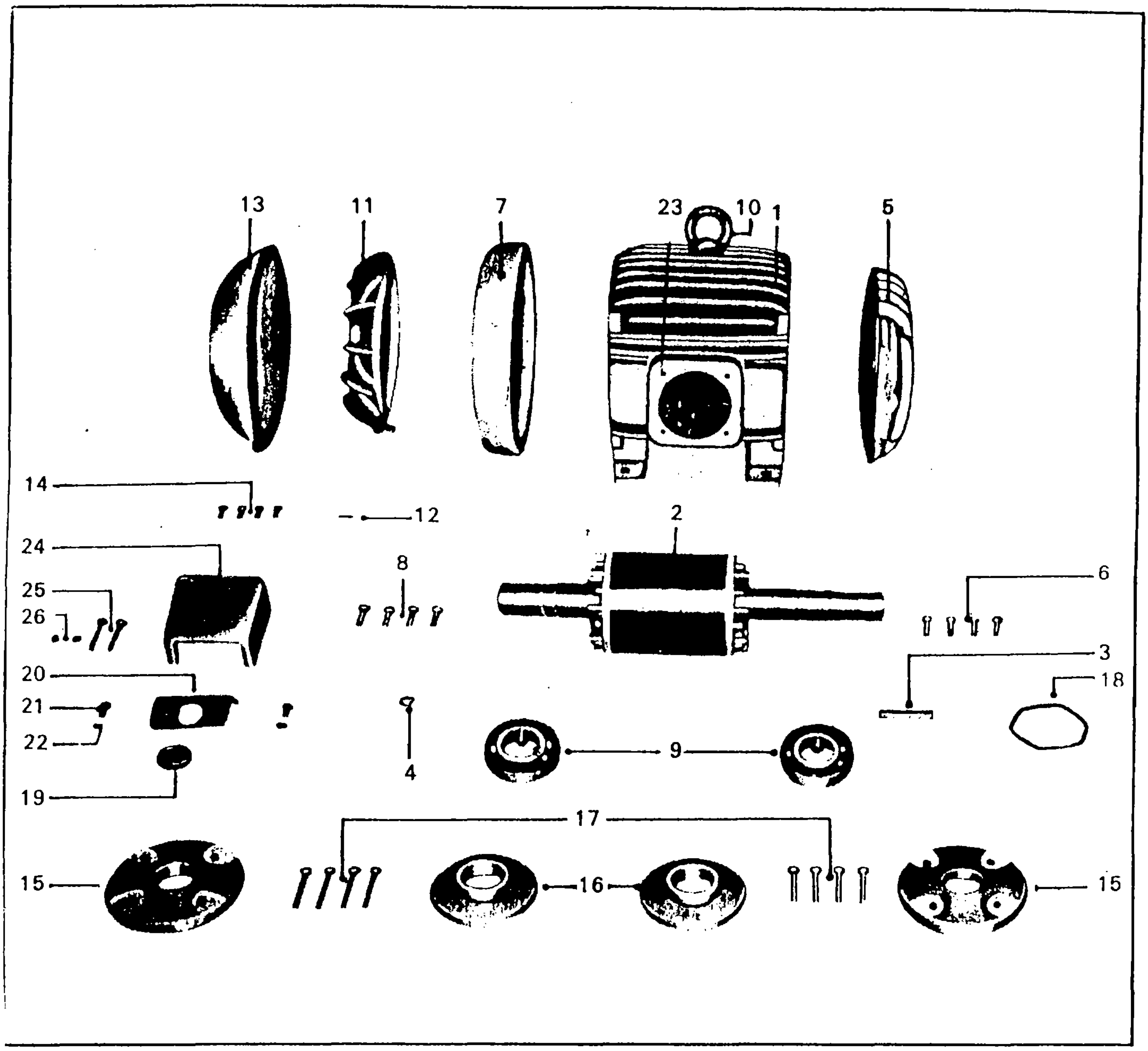
3.5.2. TYPE AM – SQUIRREL CAGE – 1500 rpm

Type	Output		Rated Current at 415V (A)	Speed rpm	Cos Ø	Eff.%	Ist / IR	Tst / TR	Tpo / TR	GD² kgm²	Weight kg.
	kW	hp									
AM63N4	0.18	0.25	0.59	1330	0.71	61	3.0	2.5	2.3	.0013	6
AM71K4	0.25	0.33	0.88	1370	0.72	58	3.5	2.0	2.2	.0027	8
AM71N4	0.37	0.50	1.05	1370	0.76	68	4.0	2.0	2.5	.0034	9
AM80K4	0.55	0.75	1.5	1400	0.78	70	4.5	2.0	2.4	.0058	12
AM80N4	0.75	1.0	1.8	1400	0.80	73	4.5	2.5	2.4	.0073	14
AM90SZ4	1.10	1.5	2.5	1400	0.81	75	5.0	2.5	2.5	.0112	16
AM90LZ4	1.50	2.0	3.4	1400	0.80	76	5.0	2.5	2.7	.012	20
AM100LK4	2.20	3.0	4.6	1400	0.82	79	5.0	2.3	2.6	.0236	30
AM100L4 *	3.00	4.0	7.0	1420	0.78	80	5.5	2.5	2.8	.0283	32
AM112MZ4	3.7	5.0	7.3	1440	0.82	84	6.8	2.8	2.8	.071	45
AM112MZ4 *	4.0	5.5	8.0	1440	0.82	84	6.8	2.8	2.8	.071	45
AM132SZ4	5.5	7.5	10.5	1440	0.86	87	6.5	2.5	2.8	.126	63
AM132SFZ4 *	6.5	8.8	12.5	1435	0.85	87	6.5	2.5	3.0	.147	68
AM132MZ4	7.5	10.0	13.7	1440	0.86	87	6.8	2.5	2.7	.161	75
AM132MFZ4 *	8.8	12	16.5	1440	0.86	87	7.0	2.4	2.8	.181	79
AM160M4	11	15	20.6	1460	0.84	88	5.5	2.5	2.3	.36	117
AM160MF4 *	13	17.5	24.5	1460	0.83	89	6.0	2.7	2.2	0.49	133
AM160L4	15	20	28	1460	0.84	89	6.0	2.7	2.3	0.496	140
AM160LF4 *	17	23	32	1465	0.83	89	7.0	3.0	2.6	0.596	152
AM180M4	18.5	25	33	1465	0.85	90	6.0	2.5	2.2	0.635	160
AM180L4	22	30	40	1465	0.85	91	6.0	2.5	2.4	0.75	190
AM200L4	30	40	53	1470	0.86	92	6.0	2.7	2.6	1.33	257

*. Non Standared Outputs

LIST OF SPARE PARTS

TOTALLY ENCLOSED, FAN COOLED, SQUIRREL CAGE MOTOR
TYPE AM



1. STATOR COMPLETE
2. S.C. ROTOR COMPLETE
3. KEY FOR SHAFT EXTENSION
4. KEY FOR FAN
5. END SHIELD-DE
6. SCREWS FOR FIXING END SHIELD
7. END SHIELD-NDE
8. SCREWS FOR FIXING END SHIELD
9. BEARING
10. EYE BOLT
11. FAN
12. SCREWS FOR FIXING FAN
13. FAN COVER
14. SCREWS FOR FAN COVER
15. OUTER BEARING COVER DE/NDE
16. INNER BEARING COVER
17. BOLTS FOR BEARING COVERS
18. WAVE WASHER
19. RUBBER BUSHING
20. CABLE ENTRY PLATE
21. SCREWS FOR CABLE ENTRY PLATE
22. SPRING WASHER
23. TERMINAL BOARD
24. TERMINAL COVER
25. BOLTS FOR TERMINAL COVER
26. SPRING WASHER