Computer Aided Design and Fabrication of Energy Efficient Single Phase Induction Motor

Project Report 1995 - 96

Submitted by

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In partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Electrical and Electronics Engineering of Bharathiar University, Coimbatore

Department of Electrical and Electronics Engineering

Kumaraguru College of Technology

Coimbatore - 641 006

Department of Electrical & Electronics Engineering

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Certificate

This is to certify that the Project Report entitled

Computer Aided Design and Fabrication of Energy Efficient Single Phase Induction Motor

has been submitted by

Mr. S. RAMAKRISHNAN, R. RAMESWARAN, K.P. THIYAGARAJAN, R.S. RAMKUMAR

In partial fulfilment for the award of the Degree of

Bachelor of Engineering in

Electrical & Electronics Engineering

branch of the Bharathiar University, Coimbatore

during the academic year 1995-96

8/3/96

Guide

PROFESSOR & HEAD
Head of the Department
Dept. of ... Kumaraguru College of Tech., Coimbatore

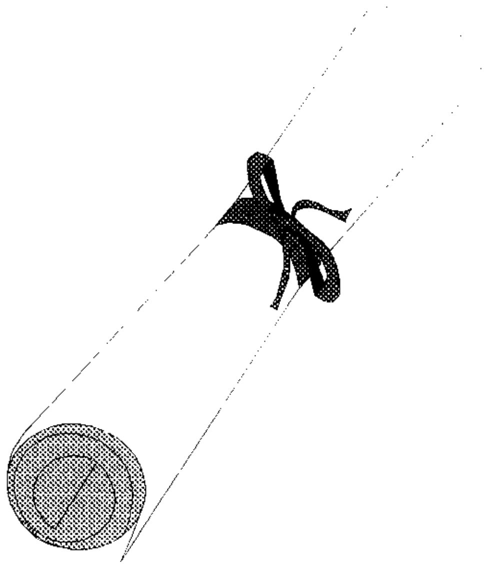
Certified that the candidate with University Reg.No. ____________
was examined in Project Work Viva Voce by us on __________

Internal Examiner

External Examiner

Dedicated to Our

Beloved Parents



Certificate

rk Motors

7.D. Sitra Road, Kalapatti, Coimbatore - 641 035
Phone : 574672 Fax : 0422 - 574612 Grams : STARK MOTOR

Date: 19.03.96

CERTIFICATE

This is to certify that the following final year students of Kumaraguru college of Technology successfully carried out their project in our industry,titled "COMPUTER AIDED DESIGN & FABRICATION OF ENERGY EFFICIENT SINGLE PHASE INDUCTION MOTOR".

	NAME	ROLL NO
1.	S. Ramakrishnan	92EEE21
2.	R. Rameswaran	92EEE23
3.	K.P.Thiyagarajan	92EEE33
4.	R.S.Ramkumar	91EEE20

They had shown keen interest in designing the motor.

We wish them all success in their future career.

C. Muthusami

C.MUTHUSAMI B.E.,AIE.,
Managing Partner.

STARK MOTORS

7-D, SITRA ROAD, KALAPPATTI, COIMBATORE-35.

Stark

ROUTINE TEST REPORT - IS : 996

PLATE DATA

	TYPE	KW	RPM	VOLT	CYS	FLC	INS. CL	RATING	PHASE
	TEFC CS&R	0·185	1440	240	50	1·4	E	S_1	SINGLE PHASE

o.	Winding Resistance	Electrical Specn.
16	incold at 34°C °C 19·2 ohms at 75°C 22·13 ohms	IS : 996

Operation : NOT APPLICABLE

OAD TEST at 240 V 50 Hz

	Current	Watts	Speed
NO LOAD	0·5	40	1470

away Starting Torque

$$W_1 \times \text{Arm Length} = (2 \times 0{\cdot}1) \times \frac{(240)^2}{(220)} = 0{\cdot}24 \text{ kgm.}$$ 200 %

ut Torque $= \frac{(240)^2}{(240)} \times 9 =$ 9 kg. 300 %

o Torque $= \frac{(240)^2}{(240)} \times 5 =$ 5 kg. 200 %

Tested by : R. Ramswamy. S. Ranganathan

Checked by :

Approved by :

STARK MOTORS

7-D, Sitra Road, Kalappatti, Coimbatore - 641 035

TEST REPORT

RFORMANCE CALCULATION

No Load Input (W_0)			=	40	Watts
No Load CU. Loss (CU_0)	=	$I_0^2 \times R_{75}$	=	—	Watts
Fixed Losses	=	$W_0 - CU_0$	=	—	Watts
FL. CU. Loss	=	$I_1^2 \times R_{75}$	=	—	Watts
Total Losses	=	(3) + (4)	=	—	Watts
FL. Input			=	230	Watts
Stator Output	=	(6) – (5)	=	—	Watts
Rotor Output	=	$(7) \times \frac{NA}{NS} \times 0.995$	=	185	Watts
Efficiency	=	$\frac{(8)}{(6)} \times 100$	=	80·4	%
Power Factor	=	$\frac{(6)}{230 \times I_L}$	=	0·7692	
Efficiency X P.F.	=	(9) X (10)	=	0·618	
Slip	=	$\frac{NS - NA}{NS} \times 100$	=	—	%

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Acknowledgement

ACKNOWLEDGEMENT

We express our sincere thanks to our Project Guide, **Mrs.N.KALAIARASI B.E, M.I.S.T.E.**, for her able guidance.

Our sincere thanks are due to our beloved Professor and Head Of The Department **Dr.K.A.PALANISWAMY B.E,M.Sc(ENGG),Ph.D., M.I.S.T.E.,C.ENG(I),F.I.E.**, for his valuable suggestions and immense help in making our project work a success.

We express our thanks to our Principal **Dr.S.SUBRAMANIAM, B.E., M.Sc(ENGG), Ph.D., SMIEEE.**, for providing all facilities in the college.

We whole heartedly express our gratitude and sincere thanks to **Mr.MUTHUSWAMY, B.E.**, Managing Partner,**STARK MOTORS** for sponsoring our project.

We also thank our friends for sparing their time and computer to carry out our Project.

Synopsis

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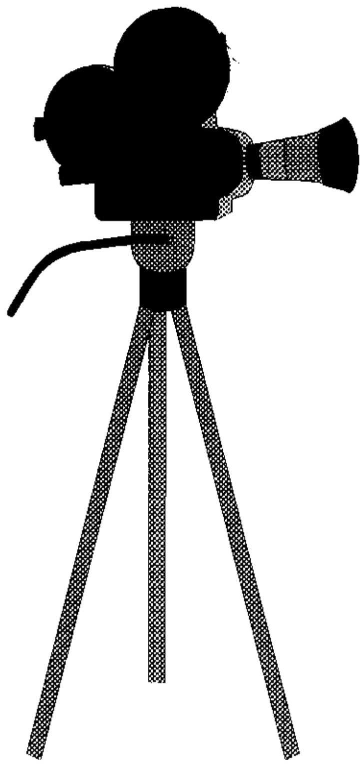


Introduction

CHAPTER - 1

INTRODUCTION

These motors are very widely used in industries especially in the fractional kilowatt range. They are extensively used for electric drives for low power constant speed apparatus such as machine tools, domestic apparatus and agricultural machinery. There is a large demand for single phase induction motors in sizes ranging from a fraction of a kilowatt power upto about 3.7 K.W.

Constructionally this motor is more or less similar to a polyphase induction motor except that

(1) Its stator is provided with a single phase winding.

(2) A centrifugal switch is used in some types of motors in order to cut out a winding used for starting purpose only.

It has a distributed stator winding under squirrel cage rotor.

1.1 TYPES OF SINGLE PHASE MOTORS

Single phase induction motors may be classified as follows depending on their construction and method of starting:

(1) Induction motors(Split Phase, Capacitor and Shaded Pole etc.).

(2) Repulsion motors (also called inductive-series motors).

(3) A.C.Series Motors.

(4) Unexcited Synchronous Motors.

1.2 ADVANTAGES OF CAD

Literally it is a known fact that electrical technology has developed amazingly in the recent past. But recently it has been chipped and shaped attractively to the final stage. The incoming of computers in the field of design is yet another land mark in the field of electrical technology.

The concept of CAD, the modern trend in the design field, has emerged as a boon to the design engineers. It enables creations followed by rigorous testing of graphic models without involving the chores of making physical models.

The design procedure resides as a very general software which is user alterable. The user can alter the design as and when he wanted according to any given specifications. It is also possible for him to emphasis on any part of design according to the needs.

SYNOPSIS

Energy Conservation is the foremost talk of the day and efforts are being made to bring down Power Consumption. In this project an attempt is made to design and fabricate an Energy Efficient Single Phase, 0.25 H.P, 1440 rpm Induction Motor with the help of CAD.

Program is written in C language for the design purposes.

To increase the efficiency the Conductor Area and the Core Area are increased and higher grade of Steel is used. Also higher grade insulation is used to reduce the weight of the motor.

The motor is tested and the test reports are presented in the report.

This vital advantage of flexibility in the design procedure is evident when modifications and alterations are sought after. Apart from the flexibility, the incredible speed with which the complex mathematical manipulations are done adds to the versatility.

1.3 ADVANTAGES OF INDUCTION MOTORS

The Single Phase Induction Motors are useful for small outputs . It has the following main advantages.

(1) Its cost is low and very reliable.

(2) It is very simple and extremely rugged, almost unbreakable in construction.

(3) It requires a minimum of maintenance.

(4) In normal operating conditions no brushes are needed hence frictional losses are reduced.

(5) It starts up from rest and needs no extra starting motor and has not to be synchronised.

1.4 APPLICATIONS OF SINGLE PHASE INDUCTION MOTOR

(A) DOMESTIC APPLICATIONS:

(1) Wet Grinders.

(2) Blowers.

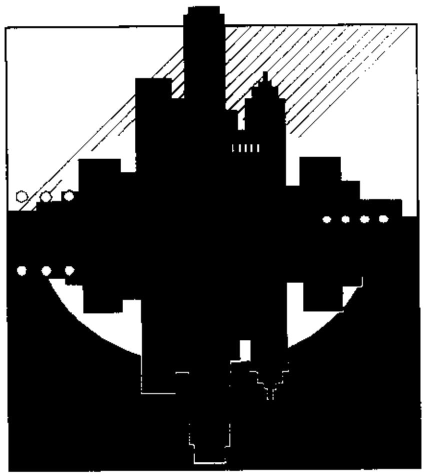
(3) Fans.

(4) Small pumps (Ex: jet pump).

(5) Conveyers.

(B) INDUSTRIAL APPLICATIONS:

Petro-chemical, Cement, Rubber, Textile, Food processing, Sugar-cane Industries use single phase induction motors. In these kind of industries such motors are used for pumping purposes.



Constructional Details

CHAPTER - 2

CONSTRUCTIONAL DETAILS

2.1 INTRODUCTION

The construction of Single phase induction motor is similar to that of a three phase induction motor. However they consist essentially of a stator with running and starting windings, a squirrel cage rotor, an automatic switch to disconnect the starting winding when the motor has picked up speed and a body and end shield to which these parts, and also the terminal box, bearings etc. are fitted.

2.2 STATOR

The stator is the stationary part of the induction motor. It is a cylindrical structure, made up of laminations mounted in a cast iron or die cast aluminium frame. The stator has tapered slots with parallel sided teeth. The slots house the starting and running windings. The centre circles are used for punching rotor laminations. The laminations are either 0.35mm or 0.5mm thick.

The stator laminations are welded at several places around the outer cylindrical surface and the stack is later pushed into a frame for assembly.The segments are held together by axial key bars fitting into dovetailed slots in the outer rim of the core.The total number of segments is chosen in such a way so as to provide an equal number of joints in the core flux paths of alternating poles.

Long cores are divided into a number of stacks with radial ventilating ducts in between in order to facilitate the cooling. The width of a single stack of core should be in between 50mm and 60mm.

2.3 STATOR FRAME

Frames of electrical machines are structures in which stator core is assembled.They serve four distinct purposes:

(1) They enclose the core and windings.

(2) They shield the live and moving machine parts from human contact and from injury caused by intruding objects or weather exposure.

(3) They transmit the torque to the machine supports, and are therefore designed to withstand twisting forces and shocks.

(4) They serve as ventilating housing or means of guiding the coolant into effective channels.

A great variety of designs is employed to meet the above requirements,and to adapt machines to particular service conditions.

Frames of small machines are made as a single unit.They are provided with feet by which they are fixed to the base plate. The frames of totally enclosed machines are provided with axial fins in order to increase the heat dissipating surface.

For induction motors the frame should be strong and rigid both during construction and after assembly of the machine.This is because the length of air gap is small and if the frame is not rigid,the rotor will not remain concentric with stator giving rise to unbalanced magnetic pull.

2.4 STATOR WINDINGS ✓

Single phase induction motors are generally wound with concentric windings.They have two distinct windings.They are:

(1) Main winding (or) Running winding.

(2) Auxillary windings (or) Starting windings.

Each is a single layer winding, with the main winding being at the bottom of the slots. In three phase motors equal slot space is devoted to all phases but in single phase motors considerably more slot space given to main winding and less to auxillary winding. The most popular kinds of single phase windings are the concentric,progressive and skein.

Concentric windings are so named because all the coils for a single pole have a common centre and different pitches for each individual coil. That is the individual coils in the pole group are concentric coils of varying sizes.

2.5 ROTOR

The rotor consists of a block of slotted laminations mounted on a shaft. The slots form a series of tunnels when the rotor is assembled. The tunnels are filled with aluminium poured in the molten state. The bars, end rings and fan blades form one homogeneous casting. In some motors copper bars and copper end rings are used, the former being brazed into the latter. The rotor slots are skewed so that a quieter operation is obtained. In large machines the radial ventilating ducts provided in the rotor are equal to that of the stator.

2.6 SHAFTS AND BEARINGS

The air gap of an induction motor is made as small as possible. Therefore the shaft is made short and stiff in order that the rotor may not have any significant deflection, as even a small deflection would create large irregularities in the air gap which would lead to production of an unbalanced magnetic pull.

Ball and Roller Bearings are generally used for low capacity motors. In single phase motors roller bearings at the driving end and a ball bearing in the non driving end are used.

2.7 STARTING SWITCHES

These switches are required to cut the auxillary winding out of circuit when the motor has attained about 75% of synchronous speed. Starting switches are centrifugally operated whenever possible. For most applications, the centrifugal switch is preferable over the magnetic switch because it is not affected by the line voltage, is more reliable and is less expensive.

2.8 ELECTROLYTIC CAPACITOR

Modern capacitor start motors employ A.C ELECTROLYTIC CAPACITORS. An A.C electrolytic capacitor is formed by winding two sheets of etched aluminium foil, separated by two layers of insulating paper into a cylindrical shape. The unit is impregnated with an electrolyte usually ethylene glycolol or a derivative. An anodic film is later produced on each foil by electro-chemical means.

The voltage rating of a capacitor is not necessarily same as that of the motor, it may be less, the same, or more depending upon how it is used. Power Factor of the electrolytic capacitor is generally of the order of 6 to 8%.

Design Aspects

CHAPTER - 3

DESIGN ASPECTS OF STATOR

3.1 OUTPUT EQUATIONS:

The Output Equation for Single Phase Machine is

KVA Input Q = $C0 \times D^2 \times L$

Output Coefficient = C0 = 11 x KWM x BAV x AC x 10-3

KVA Input = KW / (cos Φ x τ)

D x D x L = Q / C0

But normally the rating of the induction motor is given by the HORSE POWER. Then the KVA Input is

$$Q = HP \times 0.735 / (\tau \times \cos\Phi)$$

The Horse Power, Efficiency, Power factor and Speed of the machine are specified. Therefore in order to calculate the value of D x D x L, we must evaluate Output Coefficient. But the Output Coefficient depends on the choice of the electric and magnetic loadings (i.e) Values of ac and Bav.

3.2 CHOICE OF AVERAGE FLUX DENSITY IN THE AIR GAP :

The choice of average flux density depends upon the following factors.

(i) **Power Factor** :The value of flux density in the air gap should be small as otherwise the machine will draw a large magnetsing current giving a poor power factor.

(ii) **Iron Loss** : An increased value of Bav results in increased iron loss and decreased efficiency.

(iii) **OverLoad Capacity** : An increased Bav value means that flux per is large and if the number of turns is less, the leakage reactance become small. So the diameter of the conductor is large which means that the maximum output or in otherwords the machine has a large OverLoad Capacity.

For 50 Hz single phase machines,the value of Bav normally lies between 0.35 to 0.6 Wb/m}.

3.3 MAIN DIMENSIONS :

The ratio of core length to pole pitch for various design feature is :

(i) Minimum Cost - 1.5 to 2.0

(ii) Good Power Factor - 1.0 to 1.25

(iii) Good Efficiency - 1.5

(iv) Good Overall Design - 1.0

3.4 STATOR WINDINGS :

Single layer concentric windings are generally used for stator. In the concentric windings all coils have a common centre and different pole pitch.

MAIN WINDING TURNS :

Flux per pole mm = $Bav \times \pi \times D \times L / P$

Total Turns Tm = $E / (4.44 \times f \times \Phi_m \times kwm)$

3.5 CHOICE OF AMPERE CONDUCTOR PER METRE :

(i) **Copper Loss** : A large value of ac means that a greater value of copper employed in the machine results in higher copper loss and large temperature rise.

(ii) **VOLTAGE** : A small value of ac should taken for high voltage machines as in this case the space for insulation is large.

(iii)**OVERLOAD CAPACITY**: A large value of ac would result in large number of turns. This would mean the leakage reactance of the machine would become high and will result in reduced value of overload capacity.

For single phase induction motors the value of ampere conductors normally lies between 5000 to 12000 (ac/m).

3.6 NUMBER OF STATOR SLOTS:

The following factors are considered in selecting the number of stator slots.

(i) **Tooth Pulsation Loss:** Tooth pulsation losses and noise can be minimised by using large number of narrow slots.

(ii) **Leakage Reactance** : With a large number of slots, the machine has higher overload capacity.

(iii) **Magnetising Current and Iron Loss** : The use of large number of slots may result in excessive flux density in teeth giving rise to higher magnetising current and higher iron loss. The stator slot pitch,

$$Yss = \text{gap surface / total number of stator slots}$$

$$= \pi \times D / Ss$$

where Ss = number of stator slots

Total number of stator conductors = 2 x Tm

Conductors per stator slot = Zss = 2 x Tm /Ss

The number of slots per pole lies between 9 to 12.

3.7 SIZE OF STATOR SLOTS :

All the stator slots do not have the same number of conductors and some contain both the running and starting winding conductors. Starting winding conductors have small cross sectional area, and its effect upon the size is small.

Generally the running winding coil with a large number of turns will determine the size of the slots. The slot liner is usually 0.3 to 0.4(MM) thick. The ratio of insulated conductor area to the slot area should never exceed 0.5. Actually this ratio should not exceed 0.35 if the winding process is made easy.

Area required for insulated conductors = $Zs \times (\pi / 4) \times d1 \times d1$

where Zs is the total number of the conductors.

d1 is the diameter of the insulated conductor in mm.

The slot area provided in the stamping is calculated by multiplying the mean width by the depthe of the slot.

The average slot width,

$$Ws(av) = \pi \times (D + dss)/Ss - Wts$$

where dss = depth of the stator slots

wts	=	width of the stator tooth
Ss	=	number of the stator slots.

Area of each slot = Ws(av) x dss

3.8 STATOR TEETH :

We should check the flux density in the stator teeth in order to see that it is not excessive. The stator tooth density Bts can generally be from 1.4 to 1.7 Wb/m^2. If the low losses and noise are important or if the motor is totally enclosed, the lower densities should be used. For general purpose machines a flux density of 1.45 Wb/m^2 is taken while for high torque it may go up to 1.8 Wb/m^2.

As stacking factor of 0.95 is taken,

Nett iron length Li = 0.95 x L

Flux density in the stator teeth,

$$Bts = \Phi m/((Ss/p \; xLi \times Wts)$$

3.9 **STATOR CORE** :

The flux density in the stator core should not exceed 1.5 Wb/m}. Generally it lies between 0.9 to 1.4 Wb/m^2.

Flux in the stator core = $\Phi c = \Phi m/2$

Flux density in the stator core,

$$Bcs = \Phi m /(2 \times Li \times dcs)$$

where dcs is the depth of the stator core.

Area of the stator core = $Li \times dcs$

Outer diameter of stator laminations,

$$Do = D + 2(\text{depth of the stator slots} + \text{depth of core})$$

$$Do = D + 2dss + 2dcs.$$

LENGTH OF MEAN TURN :

The length of the mean turn for each of the coils per pole of a concentric winding,

$$Lmt = 8.4 \times (D + dss)/Ss \times \text{Slot span} + 2 \times 1$$

CHAPTER - 4

DESIGN OF AIR GAP

The following factors should be considered when estimating the length of the air gap.

(i) **Power Factor** : If the power factor increases then the length of the air gap reduces.

(ii) **OverLoad Capacity** : The length of air gap affects the value of zig-zag leakage reactance which forms a large part of total leakage reactance in the case of induction motors. If the length of air gap is large, the zig-zag leakage flux is reduced resulting in a reduced value for leakage reactance. So the overload capacity will increase.

(iii) **Pulsation loss** : The pulsation loss is less with larger air gaps.

(iv) **Unbalanced magnetic pull** : If the length of air gap is small even a small deflection or eccentricity of the shaft would produce a large irregularity in the length of air gap and is responsible for the production of large unbalanced magnetic pull.

(v) **Cooling** : If the length of air gap is large the distance between the stator and the rotor is large. This would provide a better ventilation or cooling.

(vi) **Noise** : The noise of the motor is reduced by increasing the length of the air gap.

The following empirical relation gives the value of length of air gap in millimeter.

(i) $lg = 0.007 \times \text{rotor diameter} / \sqrt{p}$

(ii) $lg = 0.2 + 2\sqrt{(D \times L)}$

(iii) $lg = 0.125 + 0.35 \times D + L + 0.015 \times Va$

(iv) $lg = 0.2 + D$

C H A P T E R - 5

D E S I G N   O F   S Q U I R R E L   C A G E   R O T O R

5.1 NUMBER OF ROTOR SLOTS :

The selection of number of rotor slots in squirrel cage motors is very important and a considerable attention should be paid to select a suitable value. This is because with certain combination of stator and rotor slots the machine may refuse to start or may crawl at some ssynchronous speed. In some cases severe vibrations may be set up generating excessive noise. The effects are produced be harmaomic fields. The harmonic fields are due to :

(i) **Windings**

(ii) Slottings

(iii) Saturation

(iv) Irregularities in the air gap.

The difference between the stator and the rotor slots should not be equal to

(i) 0, ± p, ± 2 p, ± 3 p, ± 5 p ------> To avoid synchronous cusps.

(ii) ± 1, ± 2, ± (p ± 1), ± (p ± 2) -------> To avoid noise, vibration.

5.2 AREA OF THE ROTOR BARS :

The cage rotor winding may be either of copper bars and end rings or of cast aluminium. Also techincal advantages lie with copper but manufacture is cheaper with cast aluminium. Also with cast rotors, the joints between bars and end rings are eliminated.

A high rotor resistance is desirable from the stand point of starting torque and current but leads to high slip and poor efficiency. The total rotor copper section is generally 0.5 to 0.8 of total stator copper section.

Total cross section of rotor bars Ar = Sr x ab

where,

ab	=	area of each bar, mm}
Ratio Ar/Am	=	0.5 to 0.8 for copper rotors

Since aluminium, generally used for this purpose,has a resisitivity approximately twice that of copper, total bar area must be two times the area required for copper.

Ratio Ar/Am	=	1.0 to 1.6 for aluminium rotors.

5.3 SHAPE AND SIZE OF ROTOR SLOTS :

The rotor slots for squirrel cage rotor may either be closed or semi -closed types.

Closed slots are preferred for small size machines because the reluctance of air gap is not large owing to absence of slots opening.It reduced magnetising current.as surface of rotor is smooth,the operation of machine is quieter.advantage is that leakage reactance is large therefore the current at starting can be limited,so we can used to start with direct on line starters.But the result in reduced the overload capacity.Buy semi-closed slot gives a better over load capacity.

5.4 ROTOR BARS :

The rectangular shaped bars and slots are generally preferred to circular bars and slots as the higher leakage reactance of the lower part of the rectangular bars,during starting,forces most of the through the top of the bar.It gives increase rotor resistance at starting,so improves the starting torque.The value of resistance depends upon current density used for rotor conductors. Current density of rotor taken as 4 to 7 A/mm^2.

5.5 END RING :

The stator field produces emfs of fundamental frequency in the bar. The magnitude of emf in the bar are assumed to be infinitely distributed, the distribution of emf can be considered as sinusoidal in the bars over a pole pitch. This emf produced in the bars would circulate currents. The resistance of end rings is negligible when compared with that of the bars, the resistance coming in each current path is the resistance of two bars. Thus the current which the bars carry would be proportional to their instantaneous emfs which in turn depend upon the position of the bars in the magnetic field.

The maximum value of the current in the end ring is

Ie(max) = bars per pole/2 x current per bar

= Sr/2 x Ib(max)

5.6 ROTOR TEETH :

The width of the rotor slot should be such that the flux density in the rotor teeth does not exceed about 1.7 Wb/m^2. The maximum flux density occurs at their roots as their section is minimum.

Minimum width of the rotor teeth,

Wtr(min) = mm /(1.7 x (Sr/p) x Li)

Minimum width of tooth actually provided

Wtr = Rotor slot pitch at the root -Rotor slot width.

= π (Dr -2 x dsr)/Sr - Wsr

Where, dsr = Depth of the Rotor slot.

Wsr = Width of stator slot.

5.7 **ROTOR CORE** :

The flux density in the rotor core is generally equal to the Stator core density.

Depth of rotor core = Φ m/(2 x Bcr xLi)

Where, Bcr = Flux density in the Rotor core.

Inner Diameter of Rotor Lamination,

Di = Dr - 2 x (dsr + dcr)

The flux density in rotor teeth and core can be taken slightly higher than those in the stator teeth and core.

Software

CHAPTER - 6

SOFTWARE

6.1 ALGORITHM

STEP :01 :-

For the design of single phase induction motor the input requirements are Rated Voltage, Horse Power, Speed,Efficiency, Power Factor, Specific Magnetic Loadings and Specific Electric Loadings.

STEP :02 :-

Winding factor of the Main winding is calculated by following equation.

Pitch factor of coils = sin (coil span/slots per pole)

winding factor of concentric winding is,

Kwm = Sum of product of pitch factor of each coil to turns in each coil divided by total turns per pole.

STEP :03 :-

The main dimensions are obtained by the following equations.

(1) ns = n /60

(2) c0 = 11 x Bav x ac x kwm x 10^{-3}

(3) Q = op x10^{-3}/(τ x cos Φ)

(4) D^2xL = Q/(c0 x ns)

Core diameter can be obtained upon the Length to Pole pitch ratio.

STEP :04 :-

The flux per pole in stator,

Φ m = Bav x π x D x L/P

STEP :05 :-

Main winding parameters are desinged by the following equations.

(i) Induced voltage, E = 0.95 x V

(ii) Total series turns in main winding is :

Ts = E /(4.44 x Kwm x f x mm)

(iii) Total turns per pole, $Tp = Ts/P$

(iv) StatorRatedcurrent,$Is=op/(vxcos\ \Phi \ x \ \tau)$

(v) Area of the main winding, $Am = Is/Ids$.

Where,

Ids = Current density in Main winding.

Ids is lies between 7 to 9 A/mmxmm

(vi) Diameter of the Main winding is, $dm = \sqrt{(Amx4/\pi)}$

(vii) Length of Mean turn of main winding is

Lmt = 8.4 x (D + dss)/Ss xslot spanned + 2 x l

STEP :06 :-

Winding factor of axillary winding.

pitch factor of aux winding for coils

= sin ((coil span +1)/slots per pole)

$$Kwa = \frac{\text{sum of product of pitch factor of each coil to turns in each coil}}{\text{total turns per pole in aux winding.}}$$

STEP :07 :-

STARTING WINDING DESIGN :

Starting winding parameters are found out by the following equations.

(i) Total no of turns = Ta = k x Ts x Kwm / Kwa

(ii) Total turns per pole = Tpa = Ta / P

(iii) Area of the aux winding,

As = Area of the main winding / 2 to 2.4

(iv) Dia of the aux winding = da = { (As x 4 / π)

(v) Length of mean turn of aux winding is,

Lmts = 8.4 x (D + dss)/Sr x slot spanned + (2 x L)

STEP : 08:-

STATOR SLOT DESIGN:

The stator slot parameter are obtained by the following steps

(i) stator slot pitch = Ssp = π x T / Ss

(ii) Depth of the stator core = dsc = Φ m / (2 x Li x bcs)

where bcs is the flux density in the stator core (0.92 to 1.4 wb/m^2)

(iii) Width of the stator teeth = Wst = Φ m/ ((ss/p)xLixbst

where Li = 0.95 x L

bst = flux density in the stator (1.4 to 1.7 wb/m})

(iv) Slot area = conductor area/ space factor

(Normally the space factor = 0.5)

Conductor area = 2 x Tm x Am

STEP : 09:-

Length of air gap = lg = 0.2 + 2 x $\sqrt{}$ (D x L) mm

where D & L are in metres.

STEP : 10 :-

DESIGN OF SQUIRREL CAGE ROTOR:

Normally Squirrel cage rotors are used in the single phase induction motors.

The values are calculated by the following eqns.

(i) Rotor outer diameter Dr = stator inner dia - 2 x length of the air gap

$$Dr = D - 2 \times lg$$

(ii) Total conductor section in stator,

$$= Tcu = 2 \times Tm \times Am$$

(iii) (a) **Copper rotor**:

Total conductor section in the rotor =0.55xTcu

(b) **Aluminium rotor**:

Total conductor section in the rotor = 1.1 x Tcu

STEP : 11 :-

ROTOR SLOT AND BAR DESIGN :

The rotor slot parameters are obtained from the following equations.

(i) Rotor Slot Pitch = π x dr /Sr

(ii) Width of the Rotor Teeth,

Wtr = Φ m /((Sr/p) x Li x btr)

where btr = flux density in the rotor teeth. Its value is slightly more than the flux density in the Stator Teeth(bts).

(iii) Depth of the Stator Core,

dsc = Φ m /(2 x Li x bcr)

(iv) Bar Current Ib = 2 x i x cos Φ x ts x kwm /Sr

(v) The Bar Width and Depth are equal to the slot dimensions(excluding neckr).

(vi) The Length of each bar = Lb = √ (L} + Ssp})

The Rotor Bars are skewed by one slot pitch in the Rotor slots.

STEP : 12 :-

END RING DESIGN :

The End Ring Parameters are obtained by the following formulae.

(i) Area of the end ring = 0.32 x tcsr /p

where tcsr is total conductor section in the rotor

In this case the current density in bars is assumed to be equal to the current density in the end ring.

The depth and thickness are selected depending upon the area of the end ring(Assign the value of depth in order to find the thickness of the end ring).

(ii) End ring current Ie = Sr x Ib /(π x p)

STEP : 13 :-

(i) Gap Contraction of the Stator Slots,

Kgs = Ys / (Ys - Kcs x Wo)

where Wo is Slot opening of SemiclosedStatorslots

K_{cs} = Carter's Gap Coefficient.

$= 1/(1 + 5 \times (lg / W_s))$

where Ws is the width of the Stator slots

(ii) Gap Contraction Factor of the Rotor Slots(Kgr) are found out in the similar manner as that of the Stator Slots.

(iii) Gap Contraction Factor of the Machine,

$$K_g = K_{gs} \times K_{gr}$$

STEP : 14 :-

RESISTANCES AND REACTANCES OF THE WINDINGS :

(i) Resistance of the Stator Windings, Rotor Bar and End Ring Resistances at 20 degrees and 75 degrees are found out by the standard formulae of the Induction Machines.

(ii) Specific Permeance of Stator, Rotor and Zig-Zag Leak age are found out by using the standard formulae of Semi Closed type slots.

(iii) The Slot Leakage Reactance, Zig-Zag Leakage Reactance,Over-Hang Leakage Reactance and Magnetizing Reactance are found out by standard formulae of the Semi-Closed Slots type Induction machines.

STEP : 15 :-

CAPACITOR DESIGN :

(i) Capacitive Reactance required for maximum starting torque,

Xc = Xla + (Ra + Rm) /(Zm + Xlm)

where Xla = Total Leakage Reactance in terms of Auxillary Winding.

Ra = Total resistance in terms of Aux wdg.

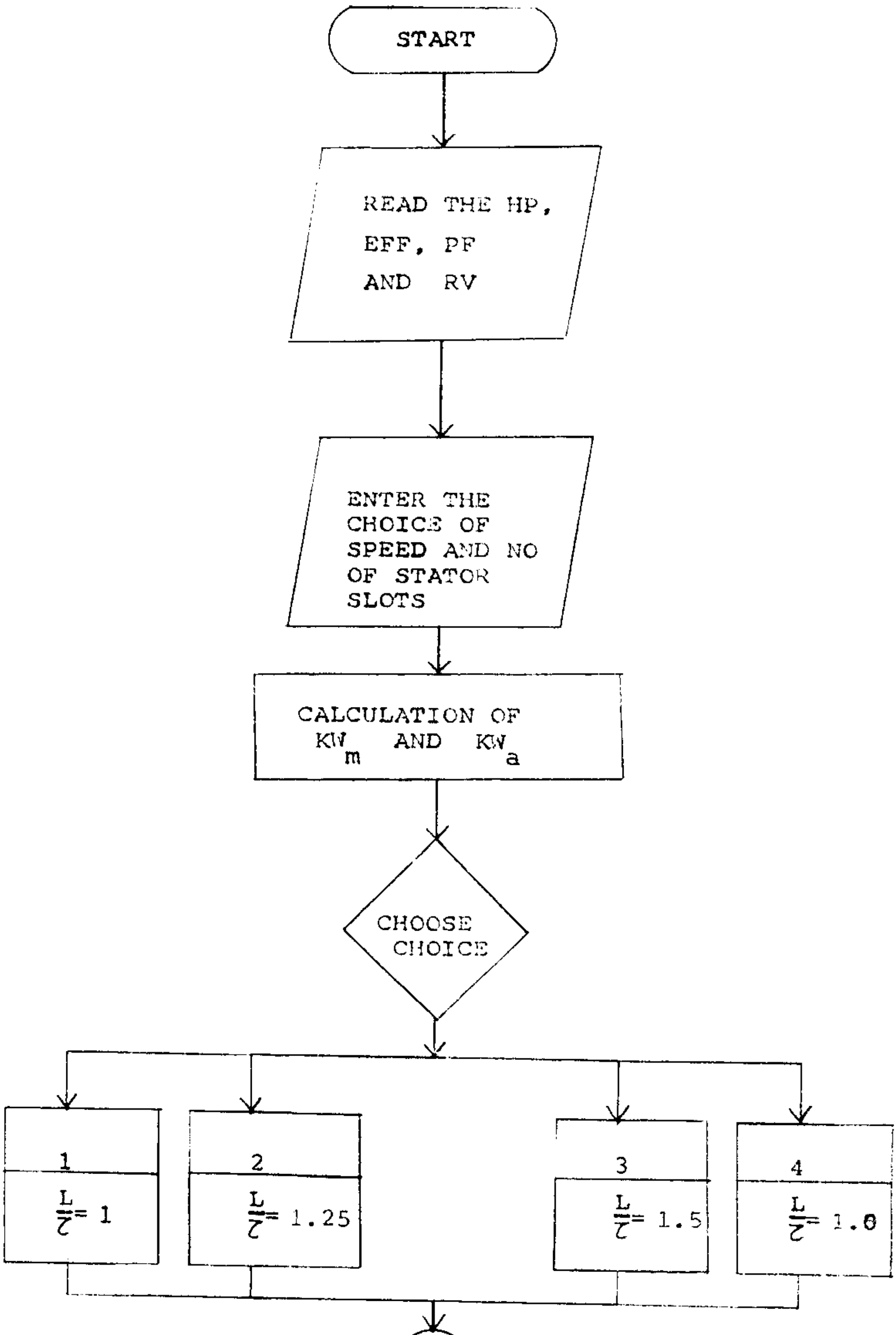
Rm = Total resistance in terms of Mainwdg

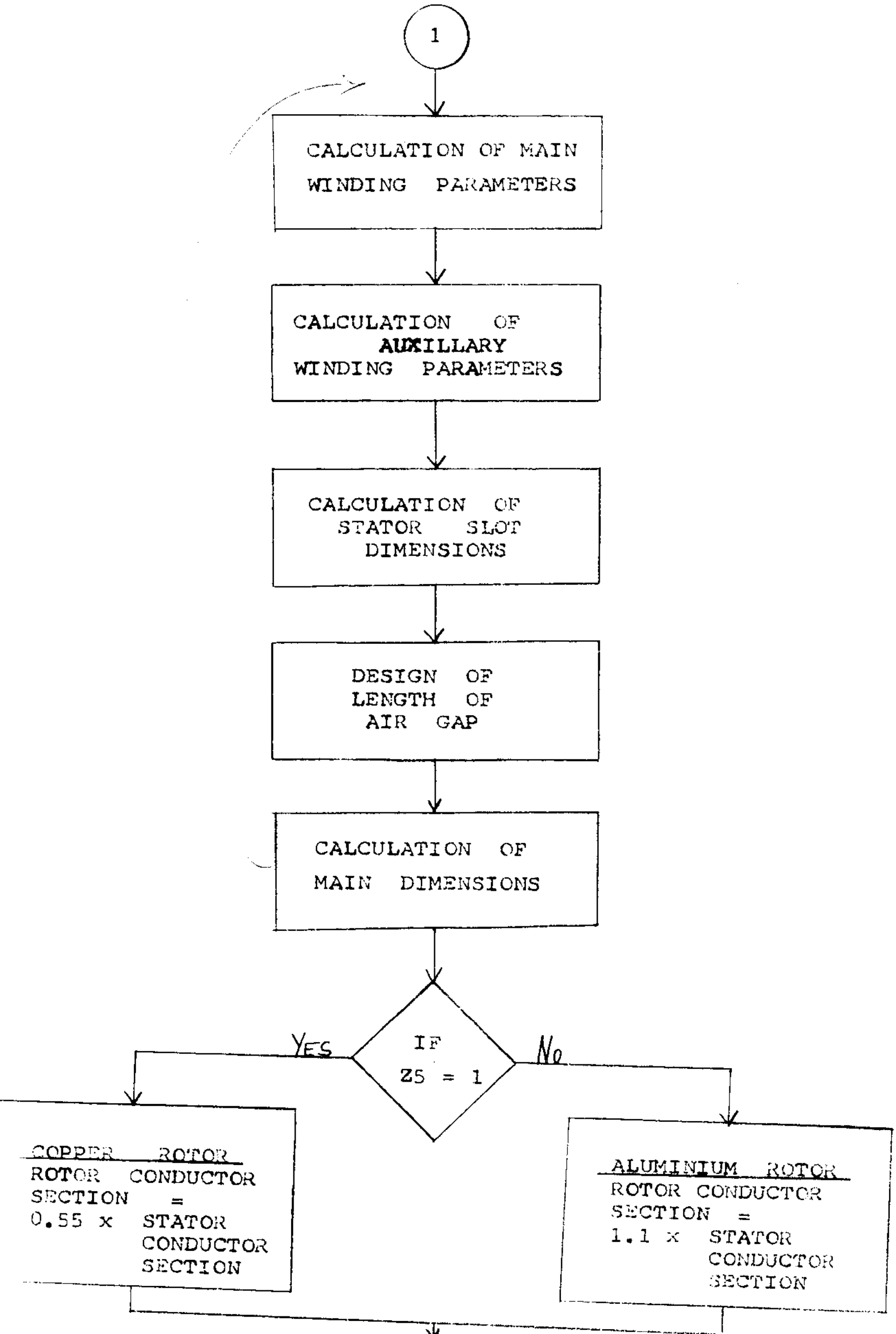
Zm = Locked Impedance of Main winding.

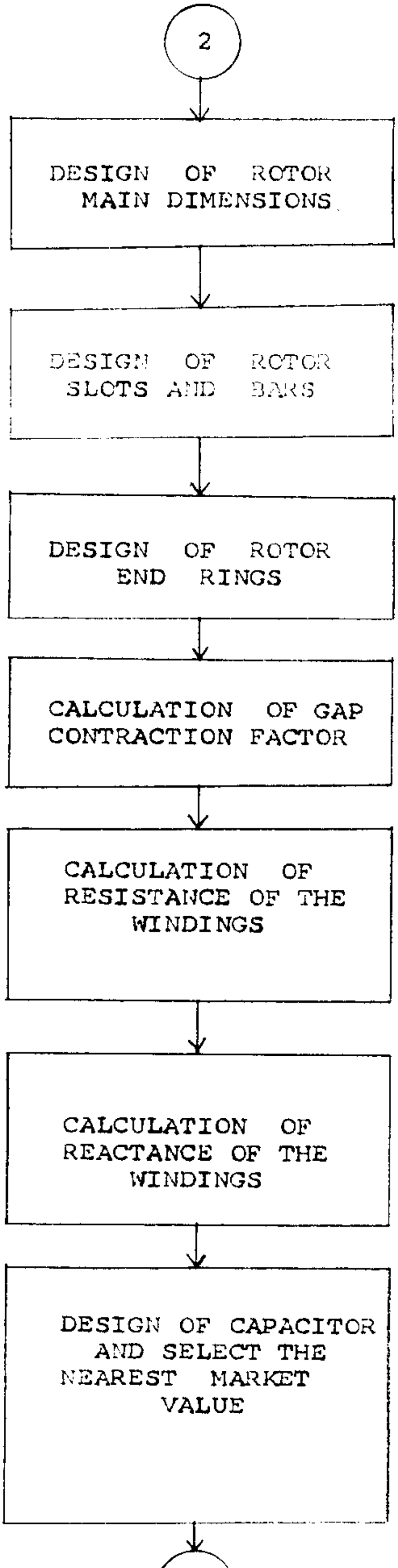
Xlm = Total Leakage Reactance Referred to Main winding

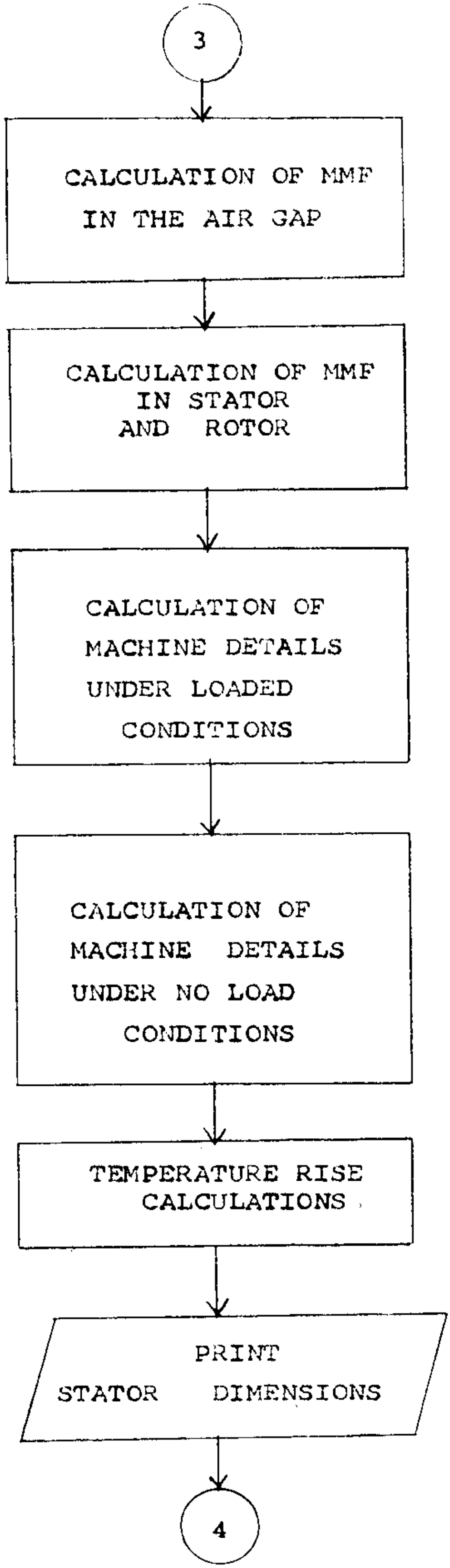
(ii) Capacitance C = 10^6 / (2 x π x f x Xc)

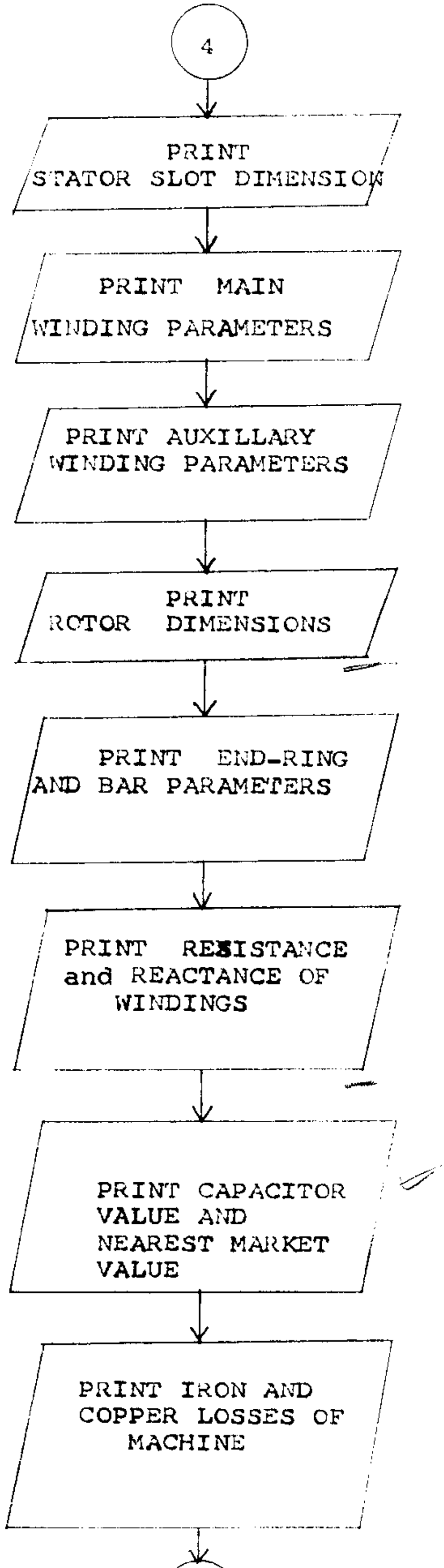
(iii) We should select the nearest and also the smaller value of the Capacitor available in the Market.

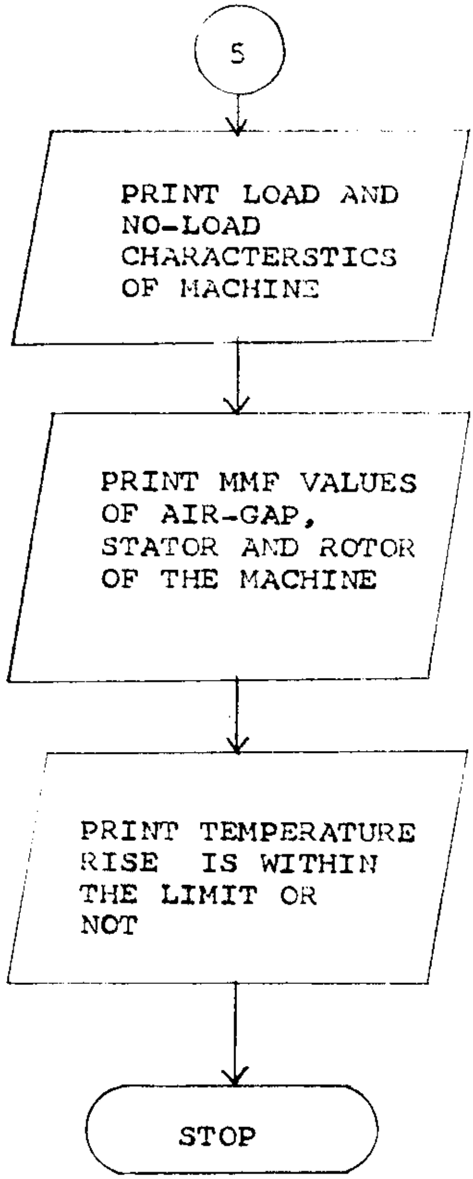

START
READ THE HP,
EFF, PF
AND RV
ENTER THE CHOICE OF SPEED AND NO OF STATOR SLOTS
CALCULATION OF KW_m AND KW_a
CHOOSE CHOICE
1
$\frac{L}{\tau}= 1$
2
$\frac{L}{\tau}= 1.25$
3
$\frac{L}{\tau}= 1.5$
4
$\frac{L}{\tau}= 1.0$


1
CALCULATION OF MAIN WINDING PARAMETERS
CALCULATION OF AUXILLARY WINDING PARAMETERS
CALCULATION OF STATOR SLOT DIMENSIONS
DESIGN OF LENGTH OF AIR GAP
CALCULATION OF MAIN DIMENSIONS
IF Z5 = 1
YES
NO
COPPER ROTOR
ROTOR CONDUCTOR SECTION = 0.55 x STATOR CONDUCTOR SECTION
ALUMINIUM ROTOR
ROTOR CONDUCTOR SECTION = 1.1 x STATOR CONDUCTOR SECTION


2
DESIGN OF ROTOR MAIN DIMENSIONS
DESIGN OF ROTOR SLOTS AND BARS
DESIGN OF ROTOR END RINGS
CALCULATION OF GAP CONTRACTION FACTOR
CALCULATION OF RESISTANCE OF THE WINDINGS
CALCULATION OF REACTANCE OF THE WINDINGS
DESIGN OF CAPACITOR AND SELECT THE NEAREST MARKET VALUE


3
CALCULATION OF MMF IN THE AIR GAP
CALCULATION OF MMF IN STATOR AND ROTOR
CALCULATION OF MACHINE DETAILS UNDER LOADED CONDITIONS
CALCULATION OF MACHINE DETAILS UNDER NO LOAD CONDITIONS
TEMPERATURE RISE CALCULATIONS
PRINT STATOR DIMENSIONS
4


4
PRINT STATOR SLOT DIMENSION
PRINT MAIN WINDING PARAMETERS
PRINT AUXILLARY WINDING PARAMETERS
PRINT ROTOR DIMENSIONS
PRINT END-RING AND BAR PARAMETERS
PRINT RESISTANCE and REACTANCE OF WINDINGS
PRINT CAPACITOR VALUE AND NEAREST MARKET VALUE
PRINT IRON AND COPPER LOSSES OF MACHINE


5
PRINT LOAD AND NO-LOAD CHARACTERSTICS OF MACHINE
PRINT MMF VALUES OF AIR-GAP, STATOR AND ROTOR OF THE MACHINE
PRINT TEMPERATURE RISE IS WITHIN THE LIMIT OR NOT
STOP

```
# include <stdio.h>
# include <string.h>
# include <math.h>
# include <conio.h>
# include <graphics.h>
# include <stdlib.h>
# include <dos.h>
# define k 1.53
void   main()
 {
   int ac=10000,c3,c6[10],j,j1,j3,j4,ks1,ks2,ns,n,
   rx,rs,rv,ta,tpm,tppa,tta,ttm,x3,x4,z,z3,z5;

   float a,ab,atg,asw,aer,ab1,add,aos,aa,a1,ats,atr,atcs,atcr,at60,
   atst,atrt,atsc,atrc,aeid,bav=0.4582,bcs=1.2,bcr=1.4,bst=1.45,bb,b60,
   bts1,bts60,btr60,btr1,c0,c[10],c1[10],c2[10],c4[10],c5[10],cap,c7,c8,
   ctr,cs,cus,cur,cue,cc,cx,clsp,ccd,ccis,
   d,d1,dsc,d0,dss,dob,dcr,dr,doe,dors,dero,deri,dem,dss0,
   e,eff=0.9,err,eff1,ermw,fpp,fdt,fwl,fdsc,
   h,he,ist,isc,i,im,il,i0,id=7.5,ib,ie,ip,idr,ics,ldos,
   k1,k2,kr=0.96,kg,kwm,kgss,kgsr,kwa,kcs,kcr,kl,
   l,l1,lb,lg,ln1,ln2,lrcm,lrca,lmt[10],lmtm,lmtn,lmts,lip,lmta[10],ldis,
   lded,lmty,lipr,lcs,lcr,max,msc,m,ntm,nlpf,neck,neckr,
   op,opl,ocs,pf,pac,p1,p,q,q1,r,r1,rr1,rr2,rsp,rsw,rr,rs1,rs2,rrm,
   sa,ssp,spz,scr1,scr2,slht,sps,spr,sar,sct,scpf,st,spp,ss,sr,sd,tr,tlds,
   tou,tld,ttx,tty,tsc,trst,tirs,tcsm,tcsr,tcsb,toe,tts,tim,til,trrs,trsw,tlrs,
   trmw,tl,tcm,tnl,w0,worb,wtr,wsst,wors,wgs,wst,wgt,ws,wo,wrt,wts1,wtr1,
   va,vae,x,x0,xo,xc,xs,xz,xm,xc1,x6,x5,xs1,xlm,xom,y,z1,z2,za,zm;

   int      arr[6]={35,50,70,110,135,225},

            ar[5]={0,3000,1500,1000,750},

            ssa[8]={0,54,36,32,30,28,24,18},

            aw[16]={0,12,18,25,40,46,60,90,120,
                    180,250,370,550,750,1100,1500};

   float    adss[16]={0,0.003,0.004,0.005,0.007,0.008,0.009,
                      0.011,0.013,0.015,0.017,0.019,0.022,0.025,
                      0.028,0.030},

             bt[35]={0,0.3,0.4,0.5,0.6,0.7,0.8,0.9,0.95,1.0,1.05,1.1,
                     1.15,1.2,1.25,1.3,1.35,1.4,1.45,1.5,1.55,1.6,1.65,
                     1.7,1.75,1.8,1.85,1.9,1.95,2.0,2.05,2.1,2.15,2.2,2.25,},

            at[35]={0,170,180,200,210,220,300,330,350,400,410,420,450,
                    500,600,700,900,1100,1450,1700,2400,2900,4000,5000,
                    7000,9000,12000,14000,19000,26000,34000,42500,
                    50000,70000,95000};

int gd =CGA, gm=CGAC1;
initgraph(&gd, &gm, "c:\\tc\\bgi");
```

```
settextstyle(1,0,2);
setcolor(9);
outtextxy(0,0,"ENERGY EFFICIENT MOTOR");
delay(3);
settextstyle(1,0,3);
outtextxy(50,35,"GUIDED BY");
settextstyle(1,0,3);
outtextxy(70,70,"Mrs.N.KALAIARASI B.E");
delay(3);
cleardevice();
outtextxy(10,10,"DONE BY");
settextstyle(1,0,1);
outtextxy(40,40,"    S.RAMAKRISHNAN");
outtextxy(60,70,"    R.RAMESWARAN");
outtextxy(80,100,"  K.P.THIYAGARAJAN");
outtextxy(100,130," R.S.RAM KUMAR");
delay(2);
cleardevice();
settextstyle(1,0,2);
outtextxy(40,40,"SPONSORED ");
outtextxy(70,70," BY");
outtextxy(100,100,"STARK MOTORS");
delay(2);
cleardevice();
settextstyle(1,0,2);
outtextxy(120,40,"DESIGN");
outtextxy(140,70,"OF");
settextstyle(3,0,3);
outtextxy(20,100,"SINGLE PHASE INDUCTION");
outtextxy(110,130," MOTORS");
delay(3);
cleardevice();
settextstyle(1,0,2);
outtextxy(75,75,"INPUT DATAS");
delay(3);
closegraph();
clrscr();

/************************************************************************
                                          STATOR
************************************************************************/
printf("PLEASE ENTER ALL MACHINE PARAMETERS IN SI UNITS\n");
printf("\n ./././././././././././././././././././././././././././");
printf("\n 1.HIGH SPEED MACHINE       [3000 RPM]");
printf("\n 2.MEDIUM SPEED MACHINE     [1500 RPM]");
printf("\n 3.SLOW SPEED MACHINE       [1000 RPM]");
printf("\n 4.VERY SLOW SPEED MACHINE [750  RPM]");
printf("\n ./././././././././././././././././././././././././././");
printf("\n ENTER YOUR MACHINE SPEED :");
scanf("%d",&j3);
n=ar[j3];
p=6000/n;
printf("\nSTANDARD VALUES OF MOTOR OUTPUT IN WATTS");
printf("\n./././././././././././././././././././././././././././");
printf("\n  1: 12,        2: 18,        3: 25,        4: 40,        5: 46,   ");
```

```
printf("\n  6: 60,       7: 90,       8: 120,      9: 180,     10: 250,  ");
printf("\n 11: 370,     12: 550,    13: 750,     14: 1100,     15: 1500.");
printf("\n./././././././././././././././././././././././././././././././");
printf("\n ENTER YOUR REQUIRED OUTPUT POWER (WATTS) CHOICE:");
scanf("%d",&z3);
op=aw[z3];
dss0=adss[z3];
printf("enter the powerfactor :");
scanf("%f",&pf);
printf("enter the rated voltage of machine :");
scanf("%d",&rv);
printf("\n ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~");
printf("\n 1.54, 2.36, 3.32, 4.30, 5.28, 6.24, 7.18 ");
printf("\n ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~");
printf("\nENTER YOUR STATOR SLOT(SS) CHOICE:");
scanf("%d",&j4);
ss=ssa[j4];                                                          /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                      WINDING FACTOR OF THE MAIN WINDING
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */

k2=ss/(2*p);
x4=1;
x3=2*k2;
x5=0;
for(j=1;j<=(int)k2;j++)
{
  tty=(((x3-x4)/(2*k2))*90*(3.141592654/180));
  c[j]=(sin(tty));
  x5=x5+c[j];
  x3--;
  x4++;
  }
  kwm=0;
for(j=1;j<=(int)k2;j++)
  {
       c1[j]=c[j]/x5;
       kwm=kwm+c[j]*c1[j];
  }
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                            MAIN DIMENSIONS CALCULATIONS
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */

ns=n/60;                    /** ns REFEERS TO THE SPEED IN RPS **/
c0=11.0*bav*ac*kwm*1e-3;    /** c0 REFEERS TO OUTPUT CO-EFFICENT**/
m=(op*1e-3)/(c0*eff*pf*ns); /**m REFS TO THE D*D*L VALUE ****/
printf( " MACHINE CHARACTER TABLE \n");
printf("./././././././././././././././././././././\n ");
printf(" 1. minimum cost \n");
printf(" 2. good power factor \n");
printf(" 3. good efficiency \n");
printf(" 4. good overall design \n");
printf("./././././././././././././././././././././\n");
printf("enter your choice :");
scanf("%d",&z);
```

```
switch(z)
{
  case 1:   printf("enter the values between 1.5 to 2.0\n");
            scanf("%f",&x);
            p1=x*22.0/(7.0*p);
            break;
  case 2:   printf("enter the values between 1.0 to 1.5\n");
            scanf("%f",&x);
            p1=x*22.0/(7.0*p);
            break;
  case 3:   x=1.5;
            p1=x*22.0/(7.0*p);
            break;
  case 4:   x=1.0;
            p1=x*22.0/(7.0*p);
  }
   /* p1 REFERS TO THE L/D VALUE */

y=m/p1;
d=pow(y,0.3333333);
tou=(3.142857143*d/p);      /**tou REFEERS TO POLE PITCH OF MACHINE**/
l=tou*x;
l1=0.95*l;
fpp=bav*(3.142857143*d*l/p);

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                          CONDUCTOR  CALCULATIONS
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM      */
e=0.95*rv;                    /* e REFERS TO INDUCED EMF OF THE MACHINE */
ntm=e/(4.44*kwm*50*fpp);/* ntm REFERS TO THE NO OF SERIES TURN MAIN WDG */
tpm=ceil(ntm/p);
ttm=tpm*p;

/* tpm,ttm REFERS TO TURNS IN SERIES/POLE & TOTAL TURNS IN MAIN WDG */

i=op/(rv*pf*eff);
a=i*1e-6/id;                  /**AREA OF MAIN WINDING IN SQUARE METER**/
z1=sqrt(28.0*a/22.0);
c3=0;
for(j=1;j<=(int)k2;j++)
  {
    c2[j]=ceil(c1[j]*tpm);
    c3=c3+c2[j];
  }
x3=2*k2;
x4=1;
for(j=1;j<=(int)k2;j++)
  {
      lmt[j]=(8.4*(d+dss0)/ss)*(x3-x4)+2*l;
      x3--;
      x4++;
  }
lmtn=0;
for(j=1;j<=(int)k2;j++)
lmtn=c2[j]*lmt[j]+lmtn;
```

```
lmtm=lmtn/tpm;            /**lmtm REFEERS TO LENGTH OF MEAN TURN**/

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                    WINDING FACTOR OF STARTING WINDING
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */
x3=2*k2+(int)k2+1;
x4=(int)k2+1;
x6=0;
for(j=1;j<=(int)k2;j++)
  {
    ttx=(x3-x4)/(2*k2)*90*3.14/180;
    c4[j]=sin(ttx);
    x6=x6+c4[j];
    x3--;
    x4++;
   }
kwa=0;
for(j=1;j<=(int)k2;j++)
  {
     c5[j]=c4[j]/x6;
     kwa=kwa+c4[j]*c5[j];
   }
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                              STARTING WINDING DESIGN
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */
ta=ceil(k*ttm*kwm/kwa);
tppa=ceil(ta/p);       /* TPPA REFEERS TO TURNS PER POLE IN AUX.WINDING*/
tta=tppa*p;           /* tta REFEERS TO TOTAL TURNS IN AUX.WINDING***/
a1=a/2.2;             /** a1 REFEERS TO AREA OF THE STARTING WINDING **/
z2=sqrt(28.0*a1/22.0);
lmty=0;
x3=2*k2+(int)k2+1;
x4=(int)k2+1;
for(j=1;j<=(int)k2;j++)
   {
     c6[j]=ceil(c5[j]*tppa);
       lmta[j]=8.4*(d+dss0)/ss*(x3-x4)+2*l;
       x3--;
       x4++;
       lmty=lmty+c6[j]*lmta[j];
      }
lmts=lmty/tppa; /**lmts REFS TO LENGTH OF MEAN TURN OF STARTING WDG**/    /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                         STATOR SLOTS DIMENSIONS
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */
neck=0.7787;          lip=2.228; /**BOTH ARE IN MM***/
/****scr1 REFS TO DIAMETER OF THE BOTTOM SEMI CIRCULAR SLOT*****/
/****scr2 REFS TO DIAMETER OF THE UPPER  SEMI CIRCULAR SLOT*****/

ssp=3.142857143*d/ss;  /**** ssp STATOR SLOT PITCH******/
dsc=fpp/(2*l1*bcs);   /******bcs lies b/w 0.9 to 1.4 wb/sq.m***/
wst=fpp/(ss/p*l1*bst);/*bst REFS TO THE FLUX DENSITY IN THE STATOR TEETH*/
tts=wst*ss*l*0.95;
scr1=(22/7.0*d/ss)-wst;
scr2=(22/7.0*(d+dss0)/ss)-wst;
```

```
max=0;
for(j=(int)k2,j1=2;j>=2,j1<=(int)k2; j--,j1++)
 {
  aa=c2[j]*a+c6[j1]*a1;
  if(aa>max)
 max=aa;
  }
bb=(c6[1]+c6[1])*a1;
if(bb>aa)
max=bb;
cc=c2[1]*a;
if(cc>max)
max=cc;
max=max+0.00002;
sa=(1/0.5)*max;  /****sa REFS TO THE SLOT AREA*******/
asw=(scr1+scr2)/2.0;
ab=sa-((3.142857143*scr1*scr1/8.0)+(3.142857143*scr2*scr2/8.0));
slht=ab/asw;
dss=neck*1e-3+scr1/2.0+slht+scr2/2.0;  /**dss REFEERS TO DEPTH OF STATOR SLOT**/
d0=d+2*dss+2*dsc;      /*** d0 IS THE OUTER DIAMETER OF STATOR LAMINATION**/
/*aws REFERS TO THE AVERAGE WIDTH OF THE STATOR SLOTS*********/

 MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                            LENGTH OF AIR GAP
 MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */

lg=0.2+2*sqrt(d*l);   /***lg REFEERS TO LENGH OF AIR GAP (MM)****/

 /***********************************************************************
                             ROTOR DESIGN
 ***********************************************************************/
dr=d-(2*lg*1e-3); /***dr REFERS TO DIAMETER OF THE ROTOR(M)***/
sr=ss+(2*p); /***sr REFERS TO ROTOR SLOTS ***/
tcsm=2*ttm*a;  /**tcsm REFS TO TOTAL CROSS SECTION IN MAIN WDG******/
printf("\n ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~");
printf("\n 1:COPPER ROTOR ");
printf("\n 2:ALUMINIUM ROTOR ");
printf("\n ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~");
printf("\n ENTER YOUR MOTOR ROTOR CHOICE:");
scanf("%d",&z5);
switch(z5)
 {
  case 1:   tcsr=0.55*tcsm; /**tcsr REFS TO CONDUCTOR SECTION OF ROTOR***/
            break;
  case 2:   tcsr=1.1*tcsm;
  }                                                                          /*
  MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                           ROTOR SLOT DESIGN
  MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */
neckr=1.0668;          lipr=1;  /**BOTH ARE IN MM***/
rsp=3.141592654*dr/sr; /*****rsp REFS TO THE ROTOR SLOT PITCH****/
ib=2*i*pf*ttm*kwm/sr; /****ib REFS TO THE BAR CURRENT***/
wtr=fpp/((sr/p)*l1*1.5);/**btr = SLIGHTLY > THAN  bts(1.5)*****/
wors=rsp-wtr; /***wors REFS TO THE WIDTH OF THE ROTOR SLOT**/
aer=0.32*tcsr/p;   /****aer REFS TO THE AREA OF THE EACH END RING*****/
```

```
aer=aer+0.0001;
tcsb=tcsr-2*aer;  /***tcsb REFS TO AMOUNT OF CONDUCTOR IN BARS****/
if(z5==1)
 {
   worb=wors-1e-3;/**worb REFS TO THE WIDTH OF THE BAR****/
   dob=tcsb/worb; /**dob REFS TO THE DEPTH OF THE BAR*****/
   dors=neckr*1e-3+dob+2e-3;
   }        /**dors REFS TO THE DEPTH OF THE SLOT WITH INSULATION***/
else
   {
        worb=wors;
        dob=tcsb/worb;  /***dob REFS TO THE DEPTH OF THE BARS*****/
        dors=neckr*1e-3+dob;/***dors REFS TO THE DEPTH OF SLOT ****/
        }
dcr=fpp/(2.0*l1*bcr);  /***dcr REFS TO THE DEPTH OF THE ROTOR CORE***/
                       /***bcr REFS TO FLUX DENSITY IN THE CORE ****/
idr=dr-dors-dcr;    /** idr REFEERS TO INNER DIAMETER OF ROTOR***/
ab1=dob*worb;     /****ab1 REFS TO THE AREA OF THE BAR****/
lb=sqrt(l*l+ssp*ssp);/**lb REFS TO THE LENGTH OF EACH BAR***/
sd=idr;                                                                  /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                          END RING DESIGN
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM      */
ie=sr*ib/(3.141592654*p);  /****ie REFS TO THE END RING CURRENT***/
doe=10e-3;       /***doe REFS TO THE DEPTH OF THE END RING*******/
toe=aer/doe; /***toe REFS TO THE THICKNESS OF THE END RING***/
dero=dr-3*1e-3;   /***ders REFS TO THE OUTER DIA OF THE END RING***/
deri=dero-(2*doe); /***deri REFS TO THE INNER DIA OF THE END RING***/
dem=(dero+deri)/2.0; /***dem REFS TO THE MEAN DIA OF THE END RING***/      /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        GAP CONTRACTION FACTOR
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
kcs=1/(1+(5*lg*1e-3/wst));    /**kcs IS CARTER'S CO-EFFICIENT FACTOROF STATOR**/
kgss=ssp/(ssp-kcs*lip*1e-3);/**kgss IS GAP CONTRACTION FACTOR OF STATOR SLOTS**/
kcr=1/(1+(5*lg*1e-3/wtr));   /** kcr IS CARTER'S CO-EFFICIENT FACTOR OF ROTOR**/
kgsr=rsp/(rsp-kcr*lipr*1e-3);/**kgsr IS GAP CONTRACTION FACTOR OF ROTOR SLOTS**/
kg=kgss*kgsr;          /**kg IS GAP CONTRACTION FACTOR OF MOTOR***/

MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                        RESISTANCE AND INDUCTANCES OF WINDINGS
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
/**MULTIPLY FACTOR OF NON UNIFORM CURRENT DISTRI IN ENDRING**/
rs1=0.021*ttm*lmtm/(a*1e6);      /****RESISTANCE AT 75C  OF STATOR WINDING*****/
rs2=0.017*ttm*lmtm/(a*1e6);      /****RESISTANCE AT 20C OF STATOR WINDING***/
rr=0.021*lb/(ab1*1e6);    /*****rr= RESISTANCE OF ROTOR AT 75C***/
err=0.021*dem/(aer*1e6);  /**err=END RING RESISTANCE AT 75C**/
rr1=(8.0*ttm*ttm*kwm*kwm*0.021*((lb/(sr*ab1*1e6))+(2*dem*kr/(3.142857143*p*p*aer*1
rr2=(0.017/0.021)*rr1;
trst=rs1+rr1;   /***trst=TOTAL ROTOR RESIS IN TERMS OF START WDG****/
/*** rr1,rr2 ARE REFEER2S TO RESISTANCE REFERRED MAIN WINDING AT 75C,20C***/
c7=0;
c8=0;
for(j=1;j<=(int)k2;j++)
  {
     c7=c7+c2[j];
```

```
      c8=c8+(c2[j])*(c2[j]);
      }

/*** THE FOLLOWING VALUES ARE SEMI CIRCULAR SLOT VALUES****/
ws=0.145;        h=0.3;
he=0.042;        w0=0.03937;

cx=(c8/(c7*c7))*(1/(kwm*kwm))*(ss/(4.0*p));
sps=4*3.142857143e-7*(0.8+(neck/lip)+(2*scrl)/(lip*1e-3+(2*scrl)));
spr=(h/(3*ws)+(he/w0))*88.0/7.0*1e-7;
xs=16*3.141592654*50*ttm*ttm*kwm*kwm*cx*(sps+spr*ss/sr)*1/ss;

/*** sps,spr ARE SPECIFIC PERMEANCE OF STATOR AND ROTOR SLOTS *****/
/***xs IS SLOT LEAKAGE REACTANCE REFERRED TO MAIN WINDING ********/
wsst=ssp-lip*1e-3;
wrt=rsp-lipr*1e-3;
spz=wsst*wrt*(wsst*wsst+wrt*wrt)*4*3.142857143*1e-7/(12*lg*1e-3*ssp*ssp*rsp);
xz=16*3.141592654*50*ttm*ttm*kwm*kwm*l*spz/ss;
/***spz IS SPECIFIC PERMEANCE OF ZIGZAG LEAKAGE *******/
/***xz IS ZIGZAG LEAKAGE REACTANCE *******************/
x4=1;
x3=2*k2;
r1=0;
for(j=1;j<=(int)k2;j++)
 {
   r1=r1+(x3-x4);
   x4++;
   x3--;
   }
r=r1/(int)k2;             /****r REFEERS TO AVERAG8E COIL SPAN*****/
x0=16*3.142857143*850*ttm*ttm*kwm*kwm*(4*3.142857143e-7/(6.4*ss*p))*3.142857143*(d

/****x0 REFEERS TO OVERHANG LEAKAGE REACTANCE*******/

xm=16*3.142857143*50*ttm*ttm*kwm*kwm*l*4*3.142857143*1e-7*tou/(lg*1e-2*p*kg*1.15);

/****xm REFERS TO MAGNETIZING REACTANCE ********/

aos=(3.142857143/(sr/p))*1*sr/ss; /**aos REFS TO ANGLE OF SKEW**/
xsl=xm*(aos*aos/12.0)*0.95; /*** xsl REFS TO SKEW LEAKAGE REACTANCE**/
xlm=xs+xz+x0+xsl;  /*** xlm REFS TO TOTAL LEAKAGE REACTANCE***/
xom=xm+xlm/2; /*** xom REFS TO OPEN CKT REACTANCE***/
kl=sqrt((xom-xlm)/xom); /** kl REFS TO LEAKAGE FACTOR ***/
add=xs+xz+x0;                                                        /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                          CAPACITOR DESIGN
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
ermw=1.2*rr2;  /*** ermw = EFFECTIVE ROTOR RESIST IN MAIN WINDING***/
trmw=ermw+rs2; /*** trmw = TOTAL RESISTANCE IN MAIN WINDING***/
trrs=(1.52*1.52)*ermw; /*** trrs=TOT ROTOR RESIS IN TERMS START WINDING***/
rsw=0.017*tta*lmts/(a1*1e6);
trsw=trrs+rsw;  /*trsw =TOT RESIS IN STARTING WDG****/
tlrs=(1.52*1.52)*xlm;  /*** tlrs = TOT LEAK REACT IN STARTING WINDING***/
zm=sqrt((trmw*trmw)+(xlm*xlm)); /***zm = IMPEDANCE OF MAIN WINDING***/
xc=tlrs+((trmw+trsw)/(zm+xlm)); /***xc REFS TO CAPACITIVE REACTANCE*****/
```

```
cap=1e6/(2.0*3.1428571423*50.0*xc); /***c REFS TO THE VALUE OF CAPACITOR USED***/

for(j=0;j<=5;j++)
 {
   if(cap>arr[j])
   goto xy;
   else
   continue;
  }
xy: pac=arr[j];
xc1=1e6/(2.0*3.142857143*50.0*pac);                                          /*
 MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                              MACHINE  LOSSES
 MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
q1=3.0;                    q=3.0;
wgt=ss*wst*dss*l1*7.6e3;   /***wgt= WEIGHT OF THE STATOR TEETH***/
fdt=(22.0/14.0)*bst;  /***fdt= MAXIMUM FLUX IN THE STATOR TEETH****/
ist=wgt*q;  /**ist=IRON LOSS IN THE STATOR TEETH **/
msc=d0-dss; /**msc=MEAN DIAMETER OF THE STATOR CORE**/
wgs=msc*3.142857143*dsc*l1*7.6e3; /**wgs= WEIGHT OF THE STATOR CORE**/
isc=wgs*q1;    /**isc=IRON LOSS IN THE STATOR CORE**/
til=ist+isc;  /**til= TOTAL IRON LOSS IN THE STATOR**/
tim=2*til;   /**tim= TOTAL IRON LOSS IN MACHINE**/
cus=i*i*rs1; /**cus= TOTAL COPPER LOSS IN THE STATOR**/
cur=ib*ib*rr*sr; /**cur=TOTAL COPPER LOSS IN ROTOR**/
cue=2*ie*ie*err; /**cue=COPPER LOSS IN THE ENDRING**/
tcm=cus+cur+cue;/**tcm= TOTAL COPPER LOSS IN THE MACHINE**/
fwl=1.0*op/100.0; /**fwl= FRICTIONAL AND WINDAGE LOSSES**/
tl=tim+tcm+fwl;  /**tl=TOTAL LOSSES IN THE MACHINE**/
 MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                    MACHINE CHARACTERSTIC DETAILS
 MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
za=sqrt(trsw*trsw+(tlrs-xc1)*(tlrs-xc1));
/**za=IMPED OF START WDG WITH CAPACITOR IN SERIES*************/
lrcm=(float)(rv/zm); /**lrcm=LOCKED ROTOR CURRENT IN MAIN WDG*************/
lrca=(float)(rv/za); /**lrca=LOCKED ROTOR CURRENT IN AUX WDG**************/
tsc=lrcm*(zm+za)/za;  /**tsc=TOTAL STARTING CURRENT**************/
st=(float)((p*0.952*rv*rv*ermw/314.2857143)*((trsw*xlm-(trmw*(tlrs-xc1)))/(zm*zm*z
            /***st REFS TO STARTING TORQUE**********/
tirs=sqrt(trst*trst+add*add);
        /**tirs=TOTAL IMPEDANCE OF ROTOR AT STANDSTILL*****/
sct=(float)(rv/tirs);   /***sct=SHORT CKT CURRENT******/
scpf=(float)(trst/tirs);/***scpf=SHORT CKT POWER FACTOR******/
ip=(float)(rv*i*scpf);
opl=ip-tl;
effl=(opl*1e2)/ip;                                                       /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                             MMF IN THE AIR GAP
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM  */
b60=1.57*bav;
atg=800000*b60*kg*lg*1e-3;  /** atg MMF IN THE AIR GAP**/                  /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                             MMF IN THE STATOR
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */
wts1=(22/7*(d+2*dss/3.0))/ss-asw;
```

```
bts1=fpp/((ss/p)*l1*wts1); /* bts1 FLUX DENSITY AT 1/3 HEIGHT OF TOOTH*/
bts60=1.36*bts1;
for(j=34;j>=1;j--)
  {
    if(bts60>bt[j])
    {
     atst=at[j];
     break;
    }
else
       continue;
  }
ats=atst*dss;                  /** ats MMF IN STATOR TOOTH **/
lcs=3.14*(d+2*dss+dsc)/(3*p);/** lcs LENGTH OF FLUX PATH IN STATOR CORE*/
for(j=34;j>=1;j--)
  {
    if(bcs>bt[j])
    {
      atsc=at[j];
      break;
     }
else
      continue;}
atcs=atsc*lcs;                  /** atcs MMF IN THE STATOR CORE **/        /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                              MMF IN THE ROTOR
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM   */
wtr1=(22/7*(dr+4*dors/3.0))/sr- wors;
btr1=fpp/((sr/p)*l1*wtr1); /* bts1 FLUX DENSITY AT 1/3 HEIGHT OF TOOTH*/
btr60=1.36*btr1;
for(j=34;j>=1;j--)
  {
    if(btr60>bt[j])
    {
     atrt=at[j];
     break;
     }
else
      continue;
   }
atr=atrt*dors;               /** atr MMF IN ROTOR TEETH **/
lcr=3.14*(dr-2*dors-2*dcr)/(3*p);/*lcs LENGTH OF FLUX PATH IN ROTOR CORE*/
for(j=34;j>=1;j--)
  {
    if(bcr>bt[j])
    {
      atrc=at[j];
      break;
    }
else
       continue;
    }
atcr=atrc*lcr;                /** MMF IN THE ROTOR CORE **/
at60=atg+ats+atr+atcs+atcr;   /** at60 TOTAL MMF OF MACHINE **/
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
```

```
                                NO LOAD PARAMETERS
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM      */
im=0.427*p*at60/(kwm*ttm);
tnl=tim+fwl;
il=tnl/rv;
i0=sqrt(im*im+il*il);
nlpf=il/im;                                                                    /*
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
                               TEMPERATURE RISE
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
clsp=2*l/lmtm*cus; /** clsp REFS TO COPPER LOSS IN STATOR PORTION **/
tlds=til+clsp;     /** tlds REFS TO TOTAL LOSS TO BE DIS BY STATOR **/
ocs=22/7*d0*l; /** ocs REFS TO OUTER CYLINDRICAL SURFACE OF STATOR **/
ics=22/7*d*l;  /** ics REFS TO INNER CYLINDRICAL SURFACE OF STATOR **/
va=22/7*d*ns;  /** va REFS PERIPHERAL SPEED OF MACHINE ***/
ldos=ocs/0.043;   /** ldos REFS LOSS DISSIPATED FROM OUTER SURFACE **/
ccis=0.043/(1+0.1*va);/** ccis REFS TO COOLING CO-EFF INNER SURFACE **/
ldis=ics/ccis;  /** idis REFS TO LOSS DISSIPATED FROM INNER SURFACE **/
aeid=22/28*(d0-d)*2; /** aeid REFS TO AREA OF END SURFACE INC DUCTS**/
vae=0.1*va;        /** vae VELOCITY OF AIR AT TWO END SURFACE **/
ccd=0.15/vae;      /** ccd COOLING CO-EFF FOR DUCTS **/
lded=aeid/ccd;   /** lded REFS TO LOSS DISSIPATED FROM END SURFACE **/
tld=ldos+ldis+lded;/** tld REFS TO TOTAL LOSS DISSIPATION **/
tr=tlds/tld;        /** tr REFS TO TEMP RISE IN MACHINE **/
clrscr();
initgraph(&gd, &gm, "c:\\tc\\bgi");
settextstyle(1,0,3);
outtextxy(75,75,"RESULTS");
delay(1599);
cleardevice();
settextstyle(1,0,3);
outtextxy(75,75,"STATOR");
delay(2);
cleardevice();
closegraph();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n                    STATOR PARAMETERS  ");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE SYNCHRONOUS SPEED OF THE MACHINE :%d RPM",n);
printf("\nTHE NUMBER OF THE POLES OF THE MACHINE :%f ",p);
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n       THE STATOR DIMENSIONS");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE DIAMETER OF THE MACHINE :%f METERS",d);
printf("\nTHE CORE LENGTH OF THE MACHINE :%f METERS",l);
printf("\nTHE POLE PITCH OF THE MACHINE :%f METERS",tou);
printf("\nTHE NET IRON LENGTH OF THE MACHINE :%f METERS",l1);
printf("\nTHE FLUX PER POLE : %f WEBERS",fpp);
printf("\nTHE OUTER DIAMETER OF THE CORE :%f METERS",d0);
getch();          clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n       THE STATOR SLOT PARAMETERS");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE DIAMETER OF THE BOTTOM SEMI CIRCULAR SLOT :%f METERS",scr1);
printf("\nTHE DIAMETER OF THE UPPER  SEMI CIRCULAR SLOT :%f METERS",scr2);
```

```
printf("\nTHE NECK OF THE STATOR SLOT :%f MM",neck);
printf("\nTHE SLOT OPENING :%f MM",lip);
printf("\nTHE TOOTH WIDTH OF STATOR :%f METERS",wst);
printf("\nTHE TOTAL TOOTH SECTION :%f",tts);
printf("\nTHE AVERAGE SLOT WIDTH :%f METERS",asw);
printf("\nTHE DEPTH OF THE STATOR CORE :%f METERS",dsc);
printf("\nTHE DEPTH OF THE STATOR SLOT:%f METERS",dss);
getch();           clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n        THE MAIN WINDING PARAMETERS");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE WINDING FACTOR OF MAIN WINDING:%f",kwm);
printf("\nTHE INDUCED EMF IS:%f",e);
printf("\nTHE NUMBER OF TURNS IN SERIES PER PO8LE :%d",tpm);
printf("\nTHE TOTAL TURNS IN SERIES FOR THE MAIN WINDING :%d",ttm);
printf("\nTHE RATED CURRENT OF THE MACHINE :%f AMPS",i);
printf("\nTHE AREA OF THE MAIN WINDING IS:%e SQ.METERS",a);
printf("\nTHE DIAMETER OF THE CONDUCTOR :%f METERS",z1);
printf("\n*****THIS DIAMETER IS NOT CONSIDER THE ENAMEL THICKNESS*******");
x3=2*k2;
x4=1;
for(j=1;j<=(int)k2;j++)
{
   rx=ceil(c2[j]);
   printf("\nTHE TURNS OF THE COIL (%d,%d)=%d",x3,x4,rx);
   x3--;
   x4++;
 }
x3=2*k2;
x4=1;
for (j=1;j<=(int)k2;j++)
 {
   printf("\nLENGTH OF MEAN TURN OF COIL (%d,%d)=%f",x3,x4,lmt[j]);
   x3--;
   x4++;
      }
printf("\nLENGTH OF THE MEAN TURN OF THE MAIN WINDING =%f",lmtm);
getch();                  clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n      STARTING WINDING PARAMETERS  ");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE AREA OF THE STARTING WINDING IS :%e SQ.METERS",a1);
printf("\nTHE DIAMETER OF THE STARTING WINDING IS:%f METERS",z2);
printf("\n*****THIS DIAMETER IS NOT CONSIDER THE ENAMEL THICKNESS****");
printf("\nWINDING FACTOR OF STARTING WINDING:%f",kwa);
printf("\nTHE TURNS PER POLE IN STARTING WINDING:%d",tppa);
printf("\nTHE TOTAL TURNS IN STARTING WINDING:%d",tta);
x3=2*k2+(int)k2+1;
x4=(int)k2+1;
for(j=1;j<=(int)k2;j++)
{
   printf("\nTHE  TURNS OF THE COIL(%d,%d)=%d",x3,x4,c6[j]);
   x3--;
   x4++;
 }
```

```
x3=2*k2+(int)k2+1;
x4=(int)k2+1;
for(j=1;j<=(int)k2;j++)
 {
   printf("\nTHE LENGTH OF MEAN TURN OF COIL(%d,%d)=%f",x3,x4,lmta[j]);
   x3--;
   x4++;
 }
printf("\nLENTH OF MEAN TURN OF STARTING WINDING :%f",lmts);
printf("\nTHE LENTH OF AIR GAP OF THE MACHINE IS :%f MILLIMETERS",lg);
getch();                    clrscr();
initgraph(&gd, &gm, "c:\\tc\\bgi");
settextstyle(1,0,3);
outtextxy(75,75,"ROTOR");
delay(2);
cleardevice();
closegraph();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n                    ROTOR DIMENSIONS" );
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM        ");
if(z5==1) {
   printf("\n    THE COPPER ROTOR PARAMETERS ARE ");
   printf("\n    ------------------------------- "); }
else {
   printf("\n    THE ALUMINIUM ROTOR PARAMETERS ARE ");
   printf("\n    ---------------------------------- "); }
printf("\nTHE NUMBER OF THE ROTOR SLOTS IS:%f ",sr);
printf("\nTHE OUTER DIAMETER OF THE ROTOR IS:%f METERS",dr);
printf("\nTHE WIDTH  OF THE ROTOR SLOT IS:%f METERS",wors);
printf("\nTHE DEPTH OF THE ROTOR SLOT IS:%f METERS",dors);
printf("\nTHE WIDTH OF THE BAR IS :%f METERS", worb);
printf("\nTHE DEPTH OF THE BAR IS :%f METERS",dob);
printf("\nTHE AREA OF THE BAR IS :%f SQ.METERS",ab1);
printf("\nTHE LENGTH OF EACH BAR IS :%f METERS",lb);
printf("\nTHE WIDTH OF THE ROTOR TOOTH IS :%f METERS",wtr);
printf("\nTHE DEPTH OF THE ROTOR CORE IS : %f METERS",dcr);
printf("\nTHE NECK OF THE ROTOR SLOT IS : %f MM",neckr);
printf("\nTHE LIP OF THE ROTOR  SLOT IS : %f MM",lipr);
printf("\nTHE INNER DIAMETER OF ROTOR IS: %f METERS",idr);
printf("\nTHE BAR CURRENT IS:%f AMPS",ib);
getch();                   clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n                    END RING");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE DEPTH OF THE END RING IS:%f METERS",doe);
printf("\nTHE THICKNESS OF THE END RING IS :%f METERS",toe);
printf("\nTHE OUTER DIAMETER OF THE END RING IS:%f METERS",dero);
printf("\nTHE INNER DIAMETER OF THE END RING IS:%f METERS",deri);
printf("\nTHE MEAN  DIAMETER OF THE END RING IS:%f METERS",dem);
printf("\nTHE AREA OF THE END RING IS :%f",aer);
printf("\nTHE END RING CURRENT IS :%f AMPS",ie);
printf("\nTHE DIAMETER OF THE SHAFT IS:%f METERS ",sd);
getch();          clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n             RESISTANCE AND REACTANCE OF WINDINGS ");
```

```
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE GAP CONTRACTION FACTOR IS GOT TO BE :%f ",kg);
printf("\nTHE RESISTANCE OF MAIN WINDING AT 20C IS :%f OHMS",rs2);
printf("\nTHE RESISTANCE OF MAIN WINDING AT 75C IS :%f OHMS",rs1);
printf("\nTHE RESISTANCE OF ROTOR AT 75C IS :%f OHMS",rr);
printf("\nTHE RESISTANCE OF EACH END RING AT 75C IS :%f OHMS",err);
printf("\nTHE RESISTANCE OF ROTOR REFERRED TO MAIN WINDING AT 20C IS :%f OHMS",rr2
printf("\nTHE RESISTANCE OF ROTOR REFERRED TO MAIN WINDING AT 75C IS :%f OHMS",rr1
printf("\nTHE SLOT LEKEAGE REACTANCE IN TERMS OF MAIN WINDING IS :%f OHMS",xs);
printf("\nTHE ZIGZAG LEAKAGE REACTANCE IS :%f OHMS",xz);
printf("\nTHE OVERHANG REACTANCE IS :%f OHMS",x0);
printf("\nTHE MAGNETIZING REACTANCE IS :%f OHMS",xm);
printf("\nTHE SKEW LEAKAGE REACTANCE IS :%f OHMS",xsl);
printf("\nTHE TOTAL LEAKAGE REACTANCE REFERRED TO MAIN WINDING IS :%f OHMS",xlm);
printf("\nTHE OPEN CKT REACTANCE IS :%f OHMS",xom);
printf("\nTHE LEAKAGE FACTOR IS :%f",kl);
getch();                    clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n                    CAPACITOR DESIGN VALUES");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE CALCULATED VALUE OF CAPACITIVE REACTANCE :%f OHMS",xc);
printf("\nTHE CALCULATED CAPACITANCE:%f MICROF",cap);
printf("\nTHE NEAREST STANDARD VALUE IS :%f MICROF",pac);
printf("\nTHE STANDARD VALUE OF CAPACITIVE REACTANCE IS :%f OHMS",xc1);
getch();              clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n                        MACHINE LOSSES              ");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n MAXIMUM FLUX IN THE STATOR TEETH IS:%f WEBERS",fdt);
printf("\n TOTAL IRON LOSS IN THE STATOR :%f WATTS",til);
printf("\n TOTAL IRON LOSS IN THE ROTOR :%f WATTS",til);
printf("\n TOTAL COPPER LOSS IN THE STATOR:%f WATTS",cus);
printf("\n TOTAL COPPER LOSS IN THE ROTOR:%f WATTS",cur);
printf("\n TOTAL COPPER LOSS IN THE END RING IS :%f WATTS",cue);
printf("\n TOTAL IRON LOSS IN THE MACHINE:%f WATTS",tim);
printf("\n TOTAL COPPER LOSS IN THE MACHINE:%f WATTS",tcm);
printf("\n TOTAL FRICTION AND WINDAGE LOSSES IN THE MACHINE:%f WATTS",fwl);
printf("\n TOTAL LOSSES IN THE MACHINE IS:%f WATTS",tl);
getch();                   clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\n                    MACHINE CHARACTERSTIC DETAILS    ");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM    ");
printf("\nTHE IMPED OF START WDG WITH CAPACITOR IN SERIES IS:%f OHMS",za);
printf("\nTHE LOCKED ROTOR CURRENT IN MAIN WDG IS:%f AMPS",lrcm);
printf("\nTHE LOCKED ROTOR CURRENT IN AUXI WDG IS:%f AMPS",lrca);
printf("\nTHE TOTAL STARTING CURRENT IS:%f AMPS",tsc);
printf("\nTHE STARTING TORQUE IS:%f NEWTON-METER",st);
printf("\nTHE SHORT CKT CURRENT IS:%f AMPS",sct);
printf("\nTHE SHORT CKT POWER FACTOR IS:%f ",scpf);
printf("\nTHE INPUT IS GIVEN BY:%f",ip);
printf("\nTHE CALCULATED OUTPUT OF THE MACHINE IS :%f",op1);
printf("\nTHE CALCULATED EFFICIENCY OF MACHINE IS:%f\n\n\n",eff1);
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM");
printf("\n            NO LOAD CHARACTERSTICS          ");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM");
```

```
printf("\nTHE MAGNETISING CURRENT IS :%f AMPS",im);
printf("\nTHE NO LOAD LOSS IS :%f WATTS",tnl);
printf("\nTHE NO LOAD CURRENT IS :%f AMPS",i0);
printf("\nTHE NO LOAD POWER FACTOR IS :%f ",nlpf);
getch();          clrscr();
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM");
printf("\n          MMF VALUES OF MACHINE");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM");
printf("\nTHE MMF IN THE AIR GAP IS:%f AMPS",atg);
printf("\nTHE MMF IN THE STATOR TEETH IS:%f AMPS",ats);
printf("\nTHE MMF IN THE ROTOR TEETH IS :%f AMPS",atr);
printf("\nTHE MMF IN THE STATOR CORE IS :%f AMPS",atcs);
printf("\nTHE MMF IN THE ROTOR CORE IS :%f AMPS",atcr);
printf("\nTHE TOTAL MMF IN THE MACHINE IS:%f AMPS",at60);
printf("\n slht is :%f",slht);
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM");
printf("\n               TEMPERATURE RISE ");
printf("\nMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM");
printf("\nTOTAL LOSS DISSIPATED BY STATOR SURFACE IS :%f WATTS",tlds);
printf("\nTOTAL LOSS DISSIPATION :%f WATTS", tld);
printf("\nTEMPERATURE RISE OF MACHINE IS :%f DEGREE ",tr);
if(tr<50)
printf("\nTHE TEMPERATURE RISE IS WITHIN THE LIMIT");
else
printf("\nTHE TEMPERATURE RISE BEYOND IN LIMIT");
printf("\n**** COMPLETED ALL PARAMETER VALUES *******");
getch();
initgraph(&gd, &gm, "c:\\tc\\bgi");
settextstyle(1,0,3);
outtextxy(75,75,"THANK YOU");
delay(3);
cleardevice();
closegraph();
  }
```

6.4 LIST OF VARIABLES USED FOR SINGLE PHASE MOTOR

a = Area of Main Winding (square metre)

a1 = Area of Secondary Winding(square metre)

aa = Conductor area for two windings in same slot.

ab = Sum of area of two semi circles in stator slots.

ac = Ampere conductors per meter.

ab1 = Area of the bar (square metre).

add = Sum of the slot,zig-zag & overhang leakage reactances.

aer = Area of the End ring(squre meter).

asw = Average slot width of stator slots(meter).

atg = MMF in the air gap.

ats = MMF in the Stator teeth.

atr = MMF in the Rotor teeth.

aos = Angle of skew in rotor bars.

aeid	=	Area of end surfaces.
atcs	=	MMF in the stator core.
atcr	=	MMf in the rotor core.
at60	=	Total MMF in the Machine.
atcr	=	MMF in the stator core.
bb	=	Conductor area, only for the aux wdg in slots.
bav	=	Flux density in the Air Gap.
bcs	=	Flux density in the Stator core.
bcr	=	Flux density in the Rotor core.
bst	=	Flux density in the Stator core.
b60	=	max flux density in air gap.
c7	=	Sum of main winding coils.
c8	=	Sum of square of the main winding coils.
cc	=	Conductor area, only for the main wdg in slots.

co	=	Output co-efficient of the machine.
cx	=	Arbitrary correction factor
cap	=	Calculated capacitor value.
ccd	=	Cooling co-efficient of ducts.
cus	=	Total copper loss in the Stator.
cur	=	Total copper loss in the Rotor.
cue	=	Total copper loss in the end ring.
c[J]	=	Pitch factor of each coils in Main winding.
ccis	=	Cooling co-efficient of Inner surface.
clsp	=	Total copper Loss in stator portion.
c1[J]	=	% of turns per pole in each coils in Main wdg.
c2[J]	=	Total series turns in each coil in Main wdg.
c4[J]	=	Pitch factor of Auxillary Winding.
c5[J]	=	% of turns per pole in each coils in Aux-wdg.

c6[J]	=	Total Series turns in each coils for Aux-wdg.
d	=	Diameter of the stator core.
d1	=	Nearest Standard Diameter of the Stator Core.
dr	=	Outer Diameter of the Rotor.
do	=	Outer Diameter of the Stator Core.
dcr	=	Depth of the Rotor Core.
dem	=	Mean Diameter of the End Ring.
dob	=	Depth of the Bar.
doe	=	Depth of the End Ring.
dsc	=	Depth of the Stator Core.
dss	=	Depth of the Stator Slot.
ds1	=	Calculated depth of stator slot
deri	=	Inner Diameter of the End Ring.
dero	=	Outer Diameter of the End Ring.

dors	=	Depth of the Rotor Slot.
e	=	Induced EMF in the machine.
eff	=	Input (or) Required Efficiency.
err	=	End ring resistance at 75 degree.
effl	=	Desinged Efficiency.
ermw	=	Effective Rotor Resistance in terms of Main Wdg.
fdt	=	Maximum flux density in the Stator teeth.
fpp	=	Flux per Pole.
fwl	=	Total Friction and Windage Losses.
hp	=	Horse of the Machine.
i	=	Rated Current of the Machine.
ib	=	Rotor Bar Current.
id	=	Current Density(Amps/sq.mm).
ie	=	End Ring Current.

il = No load Losses.

im = Magnetising current.

io = No load current.

ip = Input of the machine.

ics = Inner cylintrical surface of stator.

idr = Inner diameter of the rotor.

isc = Short Ckt Current.

kl = Leakage Factor.

kg = Gap Contraction factor.

kwa = Winding Factor of the Auxillary Winding.

kwm = Winding Factor of the Main Winding.

kcs = Carter's Co-efficient Factor of Stator Slots.

kcr = Carter's Co-efficient Factor of Rotor Slots.

kgss = Gap Contraction Factor of Stator Slots.

kgsr	=	Gap Contraction Factor of Rotor Slots.
l	=	Length of the Stator Core.
l1	=	Nett Iron Length of Stator Core.
lb	=	Length of each bar in the Rotor.
lg	=	Length of the Air Gap.
lip	=	Slot Opening of the Stator Slot.
ldos	=	Loss dissipated from outer surface
ldis	=	Loss dissipated from inner surface.
lded	=	Loss dissipated from outer surface.
lipr	=	Slot Opening of the Rotor Slot.
lrca	=	Locked Rotor Current in Auxillary Wdg.
lrcm	=	Locked Rotor Current in Main Winding.
lmtm	=	Length of mean turn of Main Winding.
lmts	=	Length of mean turn of Starting Winding.

lmt[j]	=	Length of mean turn of each coil for Main Winding.
lmta[j]	=	Length of mean turn of each coil of Starting Wdg.
m	=	d^2 x l value.
max	=	Total Conductor Area in the Stator Windings.
n	=	Synchronous Speed in RPM.
ns	=	Synchronous Speed in RPS.
ntm	=	Calculated number of series turns in Main Wdg.
neck	=	Neck of the Stator Slots.
nlpf	=	No-Load Power Factor.
neckr	=	Neck of the Rotor Slots.
op	=	Motor Output in Watts.
opl	=	Desinged motor output.
ocs	=	Outer cylintrical surface of stator.
p	=	Number of poles of the machine.

p1	=	Length to diameter value.
pf	=	Input Power Factor.
pac	=	Nearest Standard Capacitor.
q	=	Iron Loss per Kilogram in tooth section.
q1	=	Iron Loss per Kilogram in core section.
r	=	Average coil span.
r1	=	Sum of the coil span.
rv	=	Rated Voltage of the machine.
rr	=	Resistance of the Rotor at 75 Degrees.
rr1	=	Resistance of Rotor referred to Main Wdg at 75 Deg.
rr2	=	Resistance of Rotor referred to Main Wdg at 20 Deg.
rs1	=	Resistance of Main Winding at 75 Degrees.
rs2	=	Resistance of Main Winding at 20 Degrees.
rsp	=	Rotor slot pitch.

rsw	=	Rotor slot width.
sa	=	Area of the Stator Slots.
sd	=	Shaft diameter.
sr	=	Number of Rotor slots.
ss	=	Number of Stator slots.
st	=	Starting torque of the machine.
ssp	=	Stator slot pitch.
spp	=	Stator Pole Pitch.
spr	=	Specific permeance of rotor slots.
sps	=	Specific permeance of stator slots.
spz	=	Specific permance of zig-zag leakage.
scr1	=	Lower semi-circle diameter of stator slots.
scr2	=	Upper semi-circle diameter of stator slots.
scpf	=	Short circuit Power factor

ta	=	Calculated total series turns in Aux-Wdg.
tl	=	Total loss in the Machine.
tr	=	Temperature Rise in machine.
tcm	=	Total Copper Loss in the Machine.
tid	=	Total Loss dissipation.
til	=	Total Iron Loss in the Stator.
tim	=	Total Iron Loss in the Machine.
tnl	=	Total no load losses.
tpm	=	Total series turns per pole.
tta	=	Total series turns in Auxillary Wdg.
ttm	=	Actual series turns in the Main Wdg.
tou	=	Pole Pitch of the Machine.
tsc	=	Total Starting current.
tts	=	Total tooth section in Stator.

tcsm	=	Total Copper Section in Main Wdg.
tcsr	=	Total Conductor Section in Rotor Bar.
trrs	=	Total rotar resistance in terms of starting wdg
trsw	=	Total resistance in starting winding
tlrs	=	Total leakage reactance in starting winding.
tlds	=	Total Loss to be dissipated by stator.
trmw	=	Total resistance in terms of main winding
tppa	=	Total series turns per pole in Auxillary wdg
tirs	=	Total impedance of rotor at Standstill.
trst	=	Total rotor resistance in terms of Starting wdg.
va	=	Peripheral speed of Machine.
vae	=	Velocity of air at two End surface.
wtr	=	Width of the Rotor Teeth.
wgs	=	Weight of Stator Core.

wgt = Weight of Stator teeth.

wrt = Width of the Rotor teeth at Slot opening.

worb = Width of the Rotor Bar.

wors = Width of the Rotor Slot.

wsst = Width of the Stator teeth at Slot opening.

x = Length to pole pitch ratio.

xc = Calculated Capacitive Reactance.

xs = Slot Leakage Reactance.

xm = Magnetic Reactance.

xz = Zig-Zag Leakage Reactance.

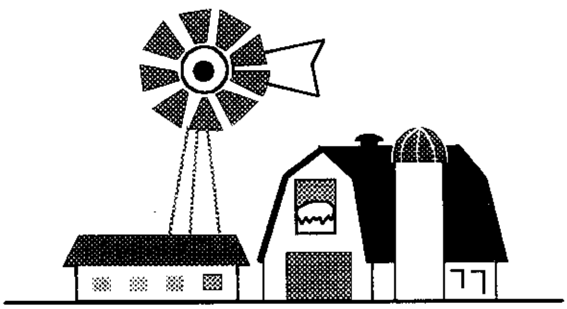
xc1 = Standard Capacitive Reactance.

xsl = Skew Leakage Reactance.

xlm = Total Leakage Reactance.

xom = Open Circuit Reactance.

z1	=	Diameter of the Main winding.
z2	=	Diameter of the Auxillary winding.
za	=	Impedance of Starting Wdg with Capacitor in series.
zm	=	Impedance of Main Winding(locked).



Energy Efficient Motor

CHAPTER-7

ENERGY EFFICIENT MOTORS

7.1 ENERGY EFFICIENT DRIVES

Energy conservation is the foremost task of the day and efforts are being made all over to bring down the power consumption in the walk of present supply/demand position of power with a high cost added to it. Efficient generation, transmission, and distribution are no doubt the important factors to increase the available power. But for a given power, it's efficient usage plays the most important role.

A conventional motor made these days has a high output to weight ratio and reduced material cost thereby compromising on factors like efficiency and power factor. It is interesting to note that the cost of operating a motor is 4 to 6 times it's original cost. Also the general trend is to employ over sized motor and provide a safe service factor.

Under reduced load conditions controlled energy saving plays a significant role. In addition to providing a soft starting,it reduces the power absorbed by the motor at low loads and improves the power factor and hence this controller in conjunction with an energy efficient motor(which has a higher efficiency even at low loads) would give tremendous energy saving.

An incremental improvement in efficiency of these motors can have significant effect in reducing the energy bills.

7.2 ENERGY EFFICIENT MOTOR

Though electric motors are one of the most efficient means of converting electrical energy into mechanical, yet some losses do occur in this conversion process.The losses that occur are comprised of five components namely:

	LOSS COMPONENT	APPROX %
1.	Primary	40
2.	Iron	25
3.	Secondary	20
4.	Friction & Windage	10
5.	Stray load	05
	Total	100

The primary/secondary losses are due to the passage of the current in the windings.Increasing the cross-sectional area of copper/aluminium to reduce the resistance is the only effective means to reduce the losses.Of course,this will add to the copper/aluminium weight and subsequently the cost of motor will increase. Also reduction in secondary resistance will reduce the starting torque of the motor.

The iron losses occur in the machine due to the combined effect of hysteresis and eddy current losses.These losses are a result of the magnetic field in the machine core which oscillate at line frequency.These losses can be reduced by reducing the flux density and this can be achieved by adding length to the stator core.Further reduction is achieved by using a better grade of steel and reducing the thickness of lamination.Increasing silicon watt loss per kg and reducing the thickness effects a reduction in eddy current losses.

The friction and windage losses are those associated with the cooling fans and rotor fins.The stray load losses are the most elusive and are caused by imperfections in and around the air gap length.This includes stator/rotor slotting,nonuniform air gaps,rough surfaces and bulging of stampings.A combination of design and careful manufacturing practices can reduce the stray load losses.

ENERGY FACTORS IN THE SELECTION OF ELECTRIC MOTORS

Choosing a motor most suitable for a particular application is based on many factors,including the requirements of the driven equipments,service conditions,motor efficiency and motor power factor.Good energy management is the application of the motor and its components that results in the least consumption energy.

7.3 MOTOR EFFICIENCY

Motor efficiency is measure of the effectiveness with which a motor converts electrical energy into mechanical energy to perform work.It is input or interms of electrical power, watts output to watts output plus watt losses. Watt losses are electrical energy that is not converted into useful mechanical energy, but is converted into heat and dissipated through the motor frame.watt losses are electrical losses,friction and windage.

Thus, motor efficiency is a function of watts losses. The lower the watt losses of a given motor,the higher the efficiency. Even in higher horse power motors that typically have higher efficiency percentage than lower horse power motors, watt losses are significant and cannot be ignored.

A.C.motors has five components of watt losses that contribute to motor in efficiency :

1. Iron loss.
2. Stator copper loss
3. Rotor copper loss.
4. Friction and windage loss.
5. Stray load loss.

The losses are associated with three common elements of motor construction :

1. losses in the circuits which carry current(I*I)

2. losses in the circuits that carry magnetic flux (Iron)

3. losses in those parts which help support and ventilate or cool motor parts.(friction and windage loss).

4. Stray losses can occur in any or all of the above elements.

Improvements in motor efficiency is the result of reducing watt losses.Simply stated :

REDUCED LOSSES - IMPROVED EFFICIENCY.

In terms of existing state of electric motor technology, a reduction in watt losses can be in various ways.

1. Increasing the cross sectional area of the winding using a greater number of conductors, or large conductor crossection, increasing slot fill and reducing stator and rotor copper losses ;

2. Adding more core steel to reduce operating flux density ;

3. Utilize low loss, core steel for stator and rotor laminations to improve magnetic properties ;

4. Using low loss motor cooling fans to reduce winding losses;

5. Using trial and error method find out good combination of core diameter and core length to have a reduced loss of machine.

All of these changes to reduce watt loss are also possible with existing motor design and manufacturing technology.They do, however,require additional materials and for the use of higher quality material resulting in increased motor cost.

7.4 FACTORS AFFECTING EFFICIENCY OF INDUCTION MOTORS

VOLTAGE IMBALANCE : A voltage unbalance of 3.5% can increase the motor losses by 20%.

LOAD : Motor efficiency changes as the load changes. Operation at loads substantially different from rate load may also result in a change in efficiency.

HORSE POWER : The efficiency of the motor operating at rated load increases as the motor horsepower rating increases. High horsepower motors are more efficient.

DUTY CYCLE: Motors that operate continuously and for long periods of time provide energy reducing opportunities. A small change in motor efficiency will make a significant change in total energy consumed. Examples: PUMPS, FANS, BLOWERS.

SLIP: Slip is measure of the losses in the rotor winding of poly phase induction motor. Therefore the higher the slip, the lower the efficiency.For applications involving pulsating interia pumping the overall efficiency of motors with high slip may be higher than of motors having a slip of less than 5 percentage.

7.5 ADVANTAGES OF ENERGY EFFICIENT MOTOR

The advantages of an energy efficient motor are:

1. Reduced power consumption.
2. Lower temperature rise and compartively increased service life.
3. Broader band of constant efficiency thereby operating at light loads without appreciable drop in efficiency.

OUTPUT PARAMETERS OF 0.25 H.P SINGLE PHASE INDUCTION MOTOR

Bav=0.52 Wb/m², ac=9000, N=1440rpm, f=50 Hz)

STATOR

HE SYNCHRONOUS SPEED OF THE MACHINE :1500 RPM
HE NUMBER OF THE POLES OF THE MACHINE :4.000000

THE STATOR DIMENSIONS

HE CALCULATED DIAMETER OF THE MACHINE :0.062124 METRES
HE NEAREST STANDRISED DIAMETER IS :0.058000 METRES
HE CORE LENGTH OF THE MACHINE :0.073218 METRES
HE POLE PITCH OF THE MACHINE :0.048812 METRES
HE NET IRON LENGTH OF THE MACHINE :0.069557 METRES
HE FLUX PER POLE : 0.001858 WEBERS
HE OUTER DIAMETER OF THE CORE :0.105000 METRES

THE STATOR SLOT PARAMETRES

HE DIAMETER OF THE BOTTOM SEMI CIRCULAR SLOT :0.005064 METRES
HE DIAMETER OF THE UPPER SEMI CIRCULAR SLOT :0.006414 METRES
HE NECK OF THE STATOR SLOT :0.778700 MM
HE SLOT OPENING :2.228000 MM
HE TOOTH WIDTH OF STATOR,:0.003071 METRES
HE TOTAL TOOTH SECTION :0.005127
HE AVERAGE SLOT WIDTH :0.005739 METRES
HE DEPTH OF THE STATOR CORE :0.011133 METRES
HE DEPTH OF THE STATOR SLOT:0.010305 METRES

THE MAIN WINDING PARAMETERS

HE WINDING FACTOR OF MAIN WINDING:0.776457
HE INDUCED EMF IS:218.500000
HE NUMBER OF TURNS IN SERIES PER POLE :171
HE TOTAL TURNS IN SERIES FOR THE MAIN WINDING :684
HE RATED CURRENT OF THE MACHINE :1.249151 AMPS
HE AREA OF THE MAIN WINDING IS :1.665534e-07 SQ.METRES
HE DIAMETER OF THE CONDUCTOR :0.000460 METRES
****THIS DIAMETER IS NOT CONSIDER THE ENAMEL THICKNESS*******
HE TURNS OF THE COIL (6,1)=86
HE TURNS OF THE COIL (5,2)=63
HE TURNS OF THE COIL (4,3)=23
ENGTH OF MEAN TURN OF COIL (6,1)=0.273187
ENGTH OF MEAN TURN OF COIL (5,2)=0.222487
ENGTH OF MEAN TURN OF COIL (4,3)=0.171786
ENGTH OF THE MEAN TURN OF THE MAIN WINDING =0.242467

STARTING WINDING PARAMETERS

HE AREA OF THE STARTING WINDING IS :7.570610e-08 SQ.METRES
HE DIAMETER OF THE STARTING WINDING IS:0.000310 METRES
****THIS DIAMETER IS NOT CONSIDER THE ENAMEL THICKNESS****
INDING FACTOR OF STARTING WINDING:0.845185
HE TURNS PER POLE IN STARTING WINDING:241
HE TOTAL TURNS IN STARTING WINDING:964
HE TURNS OF THE COIL(10,4)=102
HE TURNS OF THE COIL(9,5)=89
HE TURNS OF THE COIL(8,6)=51
HE LENGTH OF MEAN TURN OF COIL(10,4)=0.298538
HE LENGTH OF MEAN TURN OF COIL(9,5)=0.247837
HE LENGTH OF MEAN TURN OF COIL(8,6)=0.197136
LENTH OF MEAN TURN OF STARTING WINDING :0.259594
THE LENTH OF AIR GAP OF THE MACHINE IS :0.334886 MILLIMETRES

ROTOR DIMENSIONS

THE ALUMINIUM ROTOR PARAMETERS ARE :

E NUMBER OF THE ROTOR SLOTS IS:18.000000
E OUTER DIAMETER OF THE ROTOR IS:0.061454 METRES
E WIDTH OF THE ROTOR SLOT IS:0.006768 METRES
E DEPTH OF THE ROTOR SLOT IS:0.002623 METRES
E TOTAL CONDUCTOR AREA IN ROTOR IS :0.000251 M^2
E WIDTH OF THE BAR IS :0.006768 METRES
E DEPTH OF THE BAR IS :0.001556 METRES
E AREA OF THE BAR IS :0.000011 SQ.METRES
E LENGTH OF EACH BAR IS :0.073668 METRES
E WIDTH OF THE ROTOR TOOTH IS :0.003958 METRES
E DEPTH OF THE ROTOR CORE IS : 0.008349 METRES
E NECK OF THE ROTOR SLOT IS : 1.066800 MM
E LIP OF THE ROTOR SLOT IS : 1.000000 MM
E INNER DIAMETER OF ROTOR IS: 0.039510 METRES
E BAR CURRENT IS:58.970650 AMPS

END RING

HE DEPTH OF THE END RING IS:0.010000 METRES
HE THICKNESS OF THE END RING IS :0.012005 METRES
HE OUTER DIAMETER OF THE END RING IS:0.058454 METRES
HE INNER DIAMETER OF THE END RING IS:0.038454 METRES
HE MEAN DIAMETER OF THE END RING IS:0.048454 METRES
HE AREA OF THE EACH END RING IS :0.000120 M^2
HE END RING CURRENT IS :84.469231 AMPS
HE DIAMETER OF THE SHAFT IS:0.039510 METRES

RESISTANCE AND REACTANCE OF WINDINGS

E GAP CONTRACTION FACTOR IS GOT TO BE :1.300626
E RESISTANCE OF MAIN WINDING AT 20C IS :16.927927 OHMS
E RESISTANCE OF MAIN WINDING AT 75C IS :20.910969 OHMS
E RESISTANCE OF ROTOR AT 75C IS :0.000147 OHMS
E RESISTANCE OF EACH END RING AT 75C IS :0.000008 OHMS
E RESISTANCE OF ROTOR REFERRED TO MAIN WINDING AT 20C IS :15.502359 OH
E RESISTANCE OF ROTOR REFERRED TO MAIN WINDING AT 75C IS :17.149973 OH
E SLOT LEKEAGE REACTANCE IN TERMS OF MAIN WINDING IS :11.724553 OHMS
E ZIGZAG LEAKAGE REACTANCE IS :7.090288 OHMS
E OVERHANG REACTANCE IS :16.846352 OHMS
E MAGNETIZING REACTANCE IS :159.030350 OHMS
E SKEW LEAKAGE REACTANCE IS :3.454373 OHMS
E TOTAL LEAKAGE REACTANCE REFERRED TO MAIN WINDING IS :39.115566 OHMS
E OPEN CKT REACTANCE IS :178.588135 OHMS
E LEAKAGE FACTOR IS :0.883727

CAPACITOR DESIGN VALUES

E CALCULATED VALUE OF CAPACITIVE REACTANCE :91.837433 OHMS
E CALCULATED CAPACITANCE:34.646202 MICROF
E NEAREST STANDARD VALUE IS :25.000000 MICROF *
E STANDARD VALUE OF CAPACITIVE REACTANCE IS :127.272728 OHMS

MACHINE LOSSES

AXIMUM FLUX IN THE STATOR TEETH IS:2.278572 WEBERS
OTAL IRON LOSS IN THE STATOR :7.535411 WATTS
OTAL IRON LOSS IN THE ROTOR :7.535411 WATTS
OTAL COPPER LOSS IN THE STATOR:32.629009 WATTS
OTAL COPPER LOSS IN THE ROTOR:9.197342 WATTS
OTAL COPPER LOSS IN THE END RING IS :0.120953 WATTS
OTAL IRON LOSS IN THE MACHINE:15.070823 WATTS
TAL COPPER LOSS IN THE MACHINE:41.947304 WATTS
TAL FRICTION AND WINDAGE LOSSES IN THE MACHINE:0.919375 WATTS
TAL LOSSES IN THE MACHINE IS:57.937500 WATTS

MACHINE CHARACTERSTIC DETAILS

[illegible] OF START WDG WITH CAPACITOR IN SERIES IS:10[illegible]
[illegible] ROTOR CURRENT IN MAIN WDG IS:4.552[illegible]4 AMPS
[illegible] ROTOR CURRENT IN AUXI WDG IS:2.173576 AMPS
[illegible] STARTING CURRENT IS:6.526030 AMPS
[illegible] TORQUE IS:1.979790 NEWTON-METER
[illegible] CURRENT IS:4.288329 AMPS
[illegible] POWER FACTOR IS:0.746933
[illegible] IS GIVEN BY:214.597229
[illegible]ATED OUTPUT OF THE MACHINE IS :[illegible].6597[illegible]
[illegible]ATED EFFICIENCY OF MACHINE IS:73.001[illegible]4

NO LOAD CHARACTERSTICS

[illegible]STARTING CURRENT IS :2.317287 AMPS
[illegible] LOSS IS :15.990198 WATTS
[illegible] CURRENT IS :2.318330 AMPS
[illegible] POWER FACTOR IS :0.030002

MMF VALUES OF MACHINE

THE [illegible] IN THE AIR GAP IS:284.474365 AMPS
[illegible] IN THE STATOR TEETH IS:350.383514 AMPS
[illegible] IN THE ROTOR TEETH IS :49.829044 AMPS
[illegible] IN THE STATOR CORE IS :11.052895 AMPS
[illegible] IN THE ROTOR CORE IS :24.812551 AMPS
[illegible] MMF IN THE MACHINE IS:720.552368 AMPS

TEMPERATURE RISE

[illegible] LOSS DISSIPATED BY STATOR SURFACE IS :27.[illegible]41389 WATTS
[illegible] LOSS DISSIPATION :1.001567 WATTS
[illegible]TURE RISE OF MACHINE IS :27.198780 DEGREE
[illegible]TEMPERATURE RISE IS WITHIN THE LIMIT
[illegible] ALL PARAMETER VALUES MOTOR******

[illegible] FOR USING SOFTWARE******

[illegible] PARAMETERS OF 0.5 H.P SINGLE PHASE INDUCTION MOTOR

[illegible]=0.57 Wb/m2, ac=9000,N=1440rpm, f=50 Hz)

STATOR

[illegible]NCHRONOUS SPEED OF THE MACHINE :1500 RPM
[illegible] NUMBER OF THE POLES OF THE MACHINE :4.000000

THE STATOR DIMENSIONS

[illegible]CULATED DIAMETER OF THE MACHINE :0.078272 METRES
[illegible]EAREST STANDRISED DIAMETER IS :0.077900 METRES
[illegible] LENGTH OF THE MACHINE :0.092249 METRES
[illegible]LE PITCH OF THE MACHINE :0.061499 METRES
[illegible] IRON LENGTH OF THE MACHINE :0.087636 METRES
[illegible] PER POLE : 0.002950 WEBERS
[illegible]ER DIAMETER OF THE CORE :0.139000 METRES

THE STATOR SLOT PARAMETRES

[illegible]IAMETER OF THE BOTTOM SEMI CIRCULAR SLOT :0.004785 METRES
[illegible]METER OF THE UPPER SEMI CIRCULAR SLOT :0.006390 METRES
[illegible] OF THE STATOR SLOT :0.778700 MM
[illegible] OPENING :2.228000 MM
[illegible]TH WIDTH OF STATOR :0.002902 METRES
[illegible] TOOTH SECTION :0.008138
[illegible]RAGE SLOT WIDTH :0.005588 METRES
[illegible] OF THE STATOR CORE :0.014026 METRES
[illegible] OF THE STATOR SLOT:0.016338 METRES

```
MAIN WINDING PARAMETERS
--------------------------------------------------------------------------------
... FACTOR OF MAIN WINDING:0.78[illegible]
... EMF IS:218.500000
... OF TURNS IN SERIES PER POLE :107
... TURNS IN SERIES FOR THE MAIN WINDING :428
... CURRENT OF THE MACHINE :[illegible] AMPS
... OF THE MAIN WINDING IS :3.33106[illegible]e-07 SQ.METRES
... METER OF THE CONDUCTOR :0.000651 METRES
... DIAMETER IS NOT CONSIDER THE ENAMEL THICKNES*****
... OF THE COIL (8,1)=31
... OF THE COIL (7,2)=35
... OF THE COIL (6,3)=24
... OF THE COIL (5,4)=[illegible]
... MEAN TURN OF COIL (8,1)=0.358342
... MEAN TURN OF COIL (7,2)=0.308672
... MEAN TURN OF COIL (6,3)=0.259002
... MEAN TURN OF COIL (5,4)=0.209332
... OF THE MEAN TURN OF THE MAIN WINDING =0.313978
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--------------------------------------------------------------------------------
STARTING WINDING PARAMETERS
--------------------------------------------------------------------------------
... OF THE STARTING WINDING IS :1.514122e-07 SQ.METRES
... METER OF THE STARTING WINDING IS:0.000439 METRES
... DIAMETER IS NOT CONSIDER THE ENAMEL THICKNES ****
... FACTOR OF STARTING WINDING:0.829425
... TURNS PER POLE IN STARTING WINDING:155
... TURNS IN STARTING WINDING:620
... TURNS OF THE COIL(13,5)=52
... TURNS OF THE COIL(12,6)=48
... TURNS OF THE COIL(11,7)=37
... TURNS OF THE COIL(10,8)=20
... LENGTH OF MEAN TURN OF COIL(13,5)=0.383177
... LENGTH OF MEAN TURN OF COIL(12,6)=0.333507
... LENGTH OF MEAN TURN OF COIL(11,7)=0.283837
... LENGTH OF MEAN TURN OF COIL(10,8)=0.234167
... MEAN TURN OF STARTING WINDING :0.329779
... LENGTH OF AIR GAP OF THE MACHINE IS :0.[illegible]9946 MILLIMETRES
```

ROTOR DIMENSIONS

[illegible] ALUMINIUM ROTOR PARAMETERS ARE :

[illegible] OF THE ROTOR SLOTS IS:44.000000
[illegible] DIAMETER OF THE ROTOR IS:0.077532 METRES
[illegible] OF THE ROTOR SLOT IS:0.003496 METRES
[illegible] OF THE ROTOR SLOT IS:0.019224 METRES
[illegible] CONDUCTOR AREA IN ROTOR IS :0.000314 M2
[illegible] OF THE BAR IS :0.003496 METRES
[illegible] OF THE BAR IS :0.018157 METRES
[illegible] OF THE BAR IS :0.000063 SQ.METRES
[illegible] OF EACH BAR IS :0.092568 METRES
[illegible] OF THE ROTOR TOOTH IS :0.002040 METRES
[illegible] OF THE ROTOR CORE IS : 0.010520 METRES
[illegible] OF THE ROTOR SLOT IS : 1.066800 MM
[illegible] OF THE ROTOR SLOT IS : 1.000000 MM
[illegible] INNER DIAMETER OF ROTOR IS: 0.018045 METRES
[illegible] CURRENT IS:30.342520 AMPS

END RING

[illegible] DEPTH OF THE END RING IS:0.010000 METRES
[illegible] THICKNESS OF THE END RING IS :0.012509 METRES
[illegible] OUTER DIAMETER OF THE END RING IS:0.074532 METRES
[illegible] INNER DIAMETER OF THE END RING IS:0.054532 METRES
[illegible] MEAN DIAMETER OF THE END RING IS:0.064532 METRES
[illegible] OF THE EACH END RING IS :0.000125 M2
[illegible] END RING CURRENT IS :106.241562 AMPS
[illegible] DIAMETER OF THE SHAFT IS:0.018045 METRES

RESISTANCE AND REACTANCE OF WINDINGS

[illegible]ACTION FACTOR IS GOT TO BE :1.342239
[illegible]STANCE OF MAIN WINDING AT 20C IS :6.958156 OHMS
[illegible]TANCE OF MAIN WINDING AT 75C IS :8.471851 OHMS
[illegible]STANCE OF ROTOR AT 75C IS :0.000031 OHMS
[illegible]STANCE OF EACH END RING AT 75C IS :0.00001[illegible] OHMS
[illegible]STANCE OF ROTOR REFERRED TO MAIN WINDING AT 20C IS :[illegible] OHMS
[illegible]STANCE OF ROTOR REFERRED TO MAIN WINDING AT 75C IS :[illegible] OHMS
[illegible] LEKEAGE REACTANCE IN TERMS OF MAIN WINDING IS :[illegible] OHMS
[illegible] LEAKAGE REACTANCE IS :0.872754 OHMS
[illegible]HANG REACTANCE IS :8.702767 OHMS
[illegible]NETIZING REACTANCE IS :87.574959 OHMS
[illegible] LEAKAGE REACTANCE IS :1.070019 OHMS
[illegible] LEAKAGE REACTANCE REFERRED TO MAIN WINDING IS :1[illegible] OHMS
[illegible] CKT REACTANCE IS :94.517952 OHMS
[illegible] FACTOR IS :0.923627

CAPACITOR DESIGN VALUES

[illegible]CULATED VALUE OF CAPACITIVE REACTANCE :33.188747 OHMS
[illegible]CULATED CAPACITANCE:95.870392 MICROF
[illegible] NEAREST STANDARD VALUE IS :25.000000 MICROF
[illegible]NDARD VALUE OF CAPACITIVE REACTANCE IS :127.272728 OHMS

MACHINE LOSSES

[illegible]MUM FLUX IN THE STATOR TEETH IS:2.278572 WEBERS
[illegible] IRON LOSS IN THE STATOR :16.141581 WATTS
[illegible] IRON LOSS IN THE ROTOR :16.141581 WATTS
[illegible] COPPER LOSS IN THE STATOR:52.877148 WATTS
[illegible] COPPER LOSS IN THE ROTOR:1.240729 WATTS
[illegible] COPPER LOSS IN THE END RING IS :0.24455[illegible] WATTS
[illegible] IRON LOSS IN THE MACHINE:32.283161 WATTS
[illegible] COPPER LOSS IN THE MACHINE:54.362434 WATTS
TOTAL FRICTION AND WINDAGE LOSSES IN THE MACHINE:1.838750 WATTS
TOTAL LOSSES IN THE MACHINE IS:88.484344 WATTS

MACHINE CHARACTERSTIC DETAILS

[illegible] START WDG WITH CAPACITOR IN SERIES IS:9[illegible]
[illegible]ED ROTOR CURRENT IN MAIN WDG IS:14.432[illegible] AMPS
[illegible]ED ROTOR CURRENT IN AUXI WDG IS:2.3358[illegible]3 AMPS
[illegible] STARTING CURRENT IS:16.768017 AMPS
[illegible] TORQUE IS:0.273977 NEWTON-METER
[illegible] CURRENT IS:14.437675 AMPS
[illegible] POWER FACTOR IS:0.593966
[illegible] GIVEN BY:341.298279
[illegible]ATED OUTPUT OF THE MACHINE IS :252.813934
[illegible]ED EFFICIENCY OF MACHINE IS:74.074188

NO LOAD CHARACTERSTICS

[illegible]NETISING CURRENT IS :4.676652 AMPS
[illegible]LOAD LOSS IS :34.121910 WATTS
[illegible]LOAD CURRENT IS :4.679005 AMPS
[illegible]LOAD POWER FACTOR IS :0.031723

MMF VALUES OF MACHINE

[illegible] IN THE AIR GAP IS:324.310974 AMPS
[illegible] IN THE STATOR TEETH IS:555.496582 AMPS
[illegible] IN THE ROTOR TEETH IS :8.650649 AMPS
[illegible] IN THE STATOR CORE IS :14.715676 AMPS
[illegible] IN THE ROTOR CORE IS :11.332358 AMPS
[illegible]AL MMF IN THE MACHINE IS:914.506226 AMPS

TEMPERATURE RISE

[illegible]OSS DISSIPATED BY STATOR SURFACE IS :47.212841 WATTS
[illegible]OSS DISSIPATION :1.694069 WATTS
[illegible]ATURE RISE OF MACHINE IS :27.869497 DEGREE
[illegible] TEMPERATURE RISE IS WITHIN THE LIMIT
[illegible] COMPLETE ALL PARAMETER VALUES MOTOR*******

[illegible]ANK YOU FOR USING SOFTWARE*******

PARAMETERS OF 1.0 H.P SINGLE PHASE INDUCTION MOTOR

... AB/MD, ac=9000, N=1440rpm, f=50 Hz)

STATOR

...RONOUS SPEED OF THE MACHINE :1500 RPM
...BER OF THE POLES OF THE MACHINE :4.000000

THE STATOR DIMENSIONS

...ATED DIAMETER OF THE MACHINE :0.094819 METRES
... STANDARDISED DIAMETER IS :0.093500 METRES
... LENGTH OF THE MACHINE :0.111751 METRES
... PITCH OF THE MACHINE :0.074501 METRES
... IRON LENGTH OF THE MACHINE :0.106164 METRES
... PER POLE : 0.004329 WEBERS
...UTER DIAMETER OF THE CORE :0.156000 METRES

THE STATOR SLOT PARAMETRES

...AMETER OF THE BOTTOM SEMI CIRCULAR SLOT :0.005797 METRES
...AMETER OF THE UPPER SEMI CIRCULAR SLOT :0.0071... METRES
... OF THE STATOR SLOT :0.778700 MM
... OPENING :2.228000 MM
...OTH WIDTH OF STATOR :0.003515 METRES
... TOOTH SECTION :0.011943
...ERAGE SLOT WIDTH :0.006465 METRES
...PTH OF THE STATOR CORE :0.016991 METRES
... DEPTH OF THE STATOR SLOT:0.013599 METRES

THE MAIN WINDING PARAMETERS

WINDING FACTOR OF MAIN WINDING:0.780361
INDUCED EMF IS:218.500000
NUMBER OF TURNS IN SERIES PER POLE :73
TOTAL TURNS IN SERIES FOR THE MAIN WINDING :292
RATED CURRENT OF THE MACHINE :4.441425 AMPS
AREA OF THE MAIN WINDING IS :5.921900e-07 SQ.METRES
DIAMETER OF THE CONDUCTOR :0.000868 METRES
THIS DIAMETER IS NOT CONSIDER THE ENAMEL THICKNESS****
TURNS OF THE COIL (8,1)=28
TURNS OF THE COIL (7,2)=24
TURNS OF THE COIL (6,3)=16
TURNS OF THE COIL (5,4)=6
LENGTH OF MEAN TURN OF COIL (8,1)=0.422721
LENGTH OF MEAN TURN OF COIL (7,2)=0.365801
LENGTH OF MEAN TURN OF COIL (6,3)=0.308882
LENGTH OF MEAN TURN OF COIL (5,4)=0.251962
LENGTH OF THE MEAN TURN OF THE MAIN WINDING =0.370812

STARTING WINDING PARAMETERS

THE AREA OF THE STARTING WINDING IS :2.691773e-07 SQ.METRES
THE DIAMETER OF THE STARTING WINDING IS:0.000585 METRES
THIS DIAMETER IS NOT CONSIDER THE ENAMEL THICKNESS*
WINDING FACTOR OF STARTING WINDING:0.829425
THE TURNS PER POLE IN STARTING WINDING:106
THE TOTAL TURNS IN STARTING WINDING:424
THE TURNS OF THE COIL(13,5)=36
THE TURNS OF THE COIL(12,6)=33
THE TURNS OF THE COIL(11,7)=25
THE TURNS OF THE COIL(10,8)=14
THE LENGTH OF MEAN TURN OF COIL(13,5)=0.451181
THE LENGTH OF MEAN TURN OF COIL(12,6)=0.394261
THE LENGTH OF MEAN TURN OF COIL(11,7)=0.337342
THE LENGTH OF MEAN TURN OF COIL(10,8)=0.280422
LENGTH OF MEAN TURN OF STARTING WINDING :0.392571
THE LENGTH OF AIR GAP OF THE MACHINE IS :0.405873 MILLIMETRES

ROTOR DIMENSIONS

HE ALUMINIUM ROTOR PARAMETERS ARE :

NUMBER OF THE ROTOR SLOTS IS:44.000000
OUTER DIAMETER OF THE ROTOR IS:0.094007 METRES
WIDTH OF THE ROTOR SLOT IS:0.004243 METRES
DEPTH OF THE ROTOR SLOT IS:0.029260 METRES
TOTAL CONDUCTOR AREA IN ROTOR IS :0.000380 M□
WIDTH OF THE BAR IS :0.004241 METRES
DEPTH OF THE BAR IS :0.028193 METRES
AREA OF THE BAR IS :0.000120 SQ.METRES
LENGTH OF EACH BAR IS :0.112139 METRES
WIDTH OF THE ROTOR TOOTH IS :0.002471 METRES
DEPTH OF THE ROTOR CORE IS : 0.012744 METRES
WIDTH OF THE ROTOR SLOT IS : 1.066800 MM
DEPTH OF THE ROTOR SLOT IS : 1.000000 MM
INNER DIAMETER OF ROTOR IS: 0.010001 METRES
BAR CURRENT IS:36.801731 AMPS

END RING

DEPTH OF THE END RING IS:0.010000 METRES
THICKNESS OF THE END RING IS :0.013043 METRES
OUTER DIAMETER OF THE END RING IS:0.091007 METRES
INNER DIAMETER OF THE END RING IS:0.071007 METRES
MEAN DIAMETER OF THE END RING IS:0.081007 METRES
AREA OF THE EACH END RING IS :0.000130 M□
END RING CURRENT IS :128.857910 AMPS
DIAMETER OF THE SHAFT IS:0.010001 METRES

RESISTANCE AND REACTANCE OF WINDINGS

CONTRACTION FACTOR IS GOT TO BE :1.283335
[illegible]ESISTANCE OF MAIN WINDING AT 20C IS :3.108314 OHMS
[illegible]ESISTANCE OF MAIN WINDING AT 75C IS :3.839681 OHMS
RESISTANCE OF ROTOR AT 75C IS :0.000020 OHMS
RESISTANCE OF EACH END RING AT 75C IS :0.000013 OHMS
RESISTANCE OF ROTOR REFERRED TO MAIN WINDING AT 20C IS :[illegible] OH[illegible]
RESISTANCE OF ROTOR REFERRED TO MAIN WINDING AT 75C IS :[illegible] OH[illegible]
[illegible] LEKEAGE REACTANCE IN TERMS OF MAIN WINDING IS :1.85[illegible] OHMS
[illegible] LEAKAGE REACTANCE IS :0.677260 OHMS
[illegible]HANG REACTANCE IS :4.641968 OHMS
[illegible]NETIZING REACTANCE IS :57.004620 OHMS
[illegible] LEAKAGE REACTANCE IS :0.696501 OHMS
[illegible] LEAKAGE REACTANCE REFERRED TO MAIN WINDING IS :7.[illegible] OHMS
[illegible] REACTANCE IS :60.939358 OHMS
[illegible] FACTOR IS :0.933201

CAPACITOR DESIGN VALUES

[illegible]CULATED VALUE OF CAPACITIVE REACTANCE :19.084885 OHMS
[illegible]CULATED CAPACITANCE:166.719284 MICROF
NEAREST STANDARD VALUE IS :25.000000 MICROF
STANDARD VALUE OF CAPACITIVE REACTANCE IS :127.272728 OHMS

MACHINE LOSSES

[illegible]MUM FLUX IN THE STATOR TEETH IS:2.278572 WEBERS
[illegible] IRON LOSS IN THE STATOR :22.109751 WATTS
[illegible] IRON LOSS IN THE ROTOR :22.109751 WATTS
[illegible] COPPER LOSS IN THE STATOR:75.742546 WATTS
[illegible] COPPER LOSS IN THE ROTOR:1.173802 WATTS
[illegible] COPPER LOSS IN THE END RING IS :0.433118 WATTS
[illegible] IRON LOSS IN THE MACHINE:44.219501 WATTS
[illegible] COPPER LOSS IN THE MACHINE:77.349464 WATTS
[illegible] FRICTION AND WINDAGE LOSSES IN THE MACHINE:3.677500 WATTS
[illegible] LOSSES IN THE MACHINE IS:125.246468 WATTS

MACHINE CHARACTERSTIC DETAILS

... OF START WDG WITH CAPACITOR IN SERIES IS:109.684... OHMS
...KED ROTOR CURRENT IN MAIN WDG IS:26.717461 AMPS
...KED ROTOR CURRENT IN AUX1 WDG IS:2.096924 AMPS
...AL STARTING CURRENT IS:28.814384 AMPS
...TING TORQUE IS:0.129035 NEWTON-METER
...ORT CKT CURRENT IS:27.615698 AMPS
...ORT CKT POWER FACTOR IS:0.508187
... IS GIVEN BY:519.127136
... RATED OUTPUT OF THE MACHINE IS :393.880676
...CULATED EFFICIENCY OF MACHINE IS:75.873642

NO LOAD CHARACTERSTICS

...GNETISING CURRENT IS :7.140621 AMPS
... LOAD LOSS IS :47.897003 WATTS
... LOAD CURRENT IS :7.143657 AMPS
... NO LOAD POWER FACTOR IS :0.029164

MMF VALUES OF MACHINE

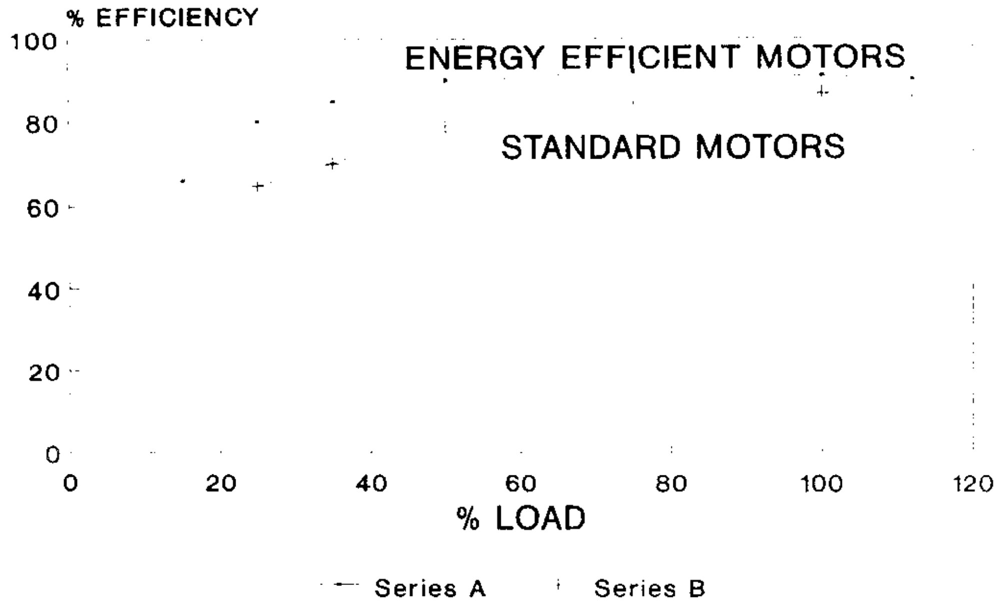
... MMF IN THE AIR GAP IS:340.325684 AMPS
... MMF IN THE STATOR TEETH IS:577.956848 AMPS
... MMF IN THE ROTOR TEETH IS :11.703815 AMPS
... MMF IN THE STATOR CORE IS :16.368261 AMPS
... MMF IN THE ROTOR CORE IS :6.280798 AMPS
... TOTAL MMF IN THE MACHINE IS:952.635376 AMPS

TEMPERATURE RISE

...AL LOSS DISSIPATED BY STATOR SURFACE IS :67.762611 WATTS
... LOSS DISSIPATION :2.481262 WATTS
...ERATURE RISE OF MACHINE IS :27.309740 DEGREE
... TEMPERATURE RISE IS WITHIN THE LIMIT
*** COMPLETE ALL PARAMETER VALUES MOTOR*******

*** THANK YOU FOR USING SOFTWARE*******

COMP OF E.EFF MOTORS WITH STD MOTORS
LOAD Vs EFFICIENCY CURVE



Conclusion

CHAPTER - 8

CONCLUSION

In this project, an energy efficient 0.25 H.P,1440 rpm single phase squirrel cage induction motor has been designed, fabricated and tested successfully.

A computer program in C language has been developed for the design of the motor.

The motor is made energy efficient by reducing the losses. The losses were reduced by increasing the conductor area and core area and using better grade steel laminations. An increase of 10% in efficiency has been achieved.

These energy efficient motors can be widely used in domestic appliances like

(1) Wet Grinders

(2) Small pumps

(3) Fans, etc.,

Appendix