IITM GROUP OF INSTITUION , MURTHAL

DEPARTMENT OF ELECTRICAL ENGINEERING

COMPUTER AIDED DESIGN (EE304B)

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Question 1. Describe in detail the step by step the factors which influences the performance of the machine conventional design procedure

Question 2. Explain the different approaches of computer aided design of electrical apparatus

Question 3 . Discuss in detail the limitation of conventional machine design over the computer aided design.

QUESTION 4. Describe in detail the analysis and synthesis method of Design .

QUESTION 5 . Describe about major considerations and limitations in electrical machine design.

QUESTION 6 What is the technique Computer Aided Design-CAD is defined the use of information technology (IT) in the Design process.

QUESTION 7 Objectives and the technique used in cad of electrical engineering.

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QUESTION 16. Discuss in detail the material properties for designing any electrical apparatus .

QUESTION 17. Draw the basic Computer-Aided Design flowchart , and for dc machine ,transformer, non salient pole generator ,salient pole generator,3_ph pole motor 1-ph pole motor .

Question 1. Describe in detail the step by step the factors which influences the performance of the machine conventional design procedure.

Solution. Specific magnetic loading:

Following are the factors which influences the performance of the machine.

(i)Iron loss: A high value of flux density in the air gap leads to higher value of flux in the iron parts of the machine which results in increased iron losses and reduced efficiency.

(ii)Voltage: When the machine is designed for higher voltage space occupied by the insulation becomes more thus making the teeth smaller and hence higher flux density in teeth and core.

(iii) Transient short circuit current: A high value of gap density results in decrease in leakage reactance and hence increased value of armature current under short circuit conditions.

(iv) Stability: The maximum power output of a machine under steady state condition is indirectly proportional to synchronous reactance. If higher value of flux density is used it leads to smaller number of turns per phase in armature winding. This results in reduced value of leakage reactance and hence increased value of power and hence increased steady state stability.

(v) Parallel operation: The satisfactory parallel operation of synchronous generators depends on the synchronizing power. Higher the synchronizing power higher will be the ability of the machine to operate in synchronism. The synchronizing power is inversely proportional to the synchronous reactance and hence the machines designed with higher value air gap flux density will have better ability to operate in parallel with other machines.

Specific Electric Loading:

(i) Copper loss: Higher the value of q larger will be the number of armature of conductors which results in higher copper loss. This will result in higher temperature rise and reduction in efficiency.

(ii)Voltage: A higher value of q can be used for low voltage machines since the space required for the insulation will be smaller.

(iii)Synchronous reactance: High value of q leads to higher value of leakage reactance and armature reaction and hence higher value of synchronous reactance. Such machines will have poor voltage regulation, lower value of current under short circuit condition and low value of steady state stability limit and small value of synchronizing power.

(iv)Stray load losses: With increase of q stray load losses will increase.

Question 2. Explain the different approaches of computer aided design of electrical apparatus.

Solution The process of design approaches by CAD follows:

1. Analysis
2. Synthesis
3. Hybrid Process

ANALYSIS: In this process the dimensions of the machine are estimated by experience selecting suitable volume making use of output equation and thus estimating all the dimensions of the m/c and the performance by known methods. The performance so estimated is compared with the desired result as specified and any divergence is eliminated by successive iterations by making small changes in dimensions. Here computer is used as a calculating aid.

SYNTHESIS: The process of synthesis is the exact opposite of the Analysis. Here the starting point is the desired performance and the computer is required to work backward and determine the optimum machine dimensions. The process involves the formulation of suitable inverted performance equations which are differential equations connecting the performance to the various design parameters like length, diameter, air-gap, current density etc. The designer is also required to feed in the boundary conditions or constraints of the equations. This method makes full use of the logic abilities of the computer and theoretically the most desirable method for design using computer.

HYBRID PROCESS: It is a combination of the Analysis & Synthesis and involves partial synthesis using the standard frames, slots & conductors decided on the basis of availability in the market. It is a practical method because it makes possible the use of standardization which is important for economic and practical design. Since the synthesis methods involve greater cost, the major part of the program is based upon analysis with a limited portion of the program being based upon synthesis. This approach makes the design more practical and economical.

Question 3 . Discuss in detail the limitation of conventional machine design over the computer aided design.

Solution SATURATION : In the designing of the electromagnetic machines we use ferromagnetic material. The flux density of the machine is determined by the saturation of the ferromagnetic material used. Higher flux density results in higher cost.

TEMPERATURE RISE: The most important part of the machine is the insulation. It should be according to the maximum temperature in the machine. If the operating temperature is higher than the allowable temperature its life will be drastically reduced. Proper ventilation techniques are used to keep the temperature rise in the safer limits. The coolant will allow the heat from the machine to dissipate.

INSULATION: The insulation is the most important part as it should with stand the electrical mechanical and thermal stress produced by the machine. Transformers are the machines which should have higher insulation where the large axial and radial forces are produced when the secondary winding of the transformer is short-circuited with primary on. It should withstand high mechanical stress due to secondary winding is short circuited.

EFFICIENCY: Efficiency should be high to reduce the operation cost of the machine. So it requires large amount of materials to design. We can reduce the operating cost by increasing the design cost.

MECHANICAL PARTS: The construction of the mechanical parts should be economical but it should satisfy the requirements of performance, reliability, and durability. For the high speed machines it is very important because it will be having more mechanical stress at the rotor. The length of the air gap is reduced to increase the high power factor.

COMMUTATION: This problem only occurs in the commutator machines As it decreases the maximum output taken from the machine.

POWER FACTOR: Poor power factor results in large amount of current in the same power, therefore large conductor sizes have to be used. It mostly affects the induction motor.

CONSUMER SPECIFICATION: The important in this is it should satisfy the consumer specification with their economic constrains. The design should evolve in this manner.

STANDARD SPECIFICATION: This specification cannot be neglected by both consumer and manufacturer.

QUESTION 4. Describe in detail the analysis and synthesis method of Design .

SOLUTION . ANALYSIS: In this process the dimensions of the machine are estimated by experience selecting suitable volume making use of output equation and thus estimating all the dimensions of the m/c and the performance by known methods. The performance so estimated is compared with the desired result as specified and any divergence is eliminated by successive iterations by making small changes in dimensions. Here computer is used as a calculating aid.

SYNTHESIS: The process of synthesis is the exact opposite of the Analysis. Here the starting point is the desired performance and the computer is required to work backward and determine the optimum machine dimensions. The process involves the formulation of suitable inverted performance equations which are differential equations connecting the performance to the various design parameters like length, diameter, air-gap, current density etc. The designer is also required to feed in the boundary conditions or constraints of the equations.This method makes full use of the logic abilities of the computer and theoretically the most desirable method for design using computer.

QUESTION 5 . Describe about major considerations and limitations in electrical machine design.

SOLUTION Major considerations in Electrical Machine Design

The basic components of all electromagnetic apparatus are the field and armature windings supported by dielectric or insulation, cooling system and mechanical parts. Therefore, the factors forconsideration in the design are,

Magnetic circuit or the flux path: Should establish required amount of flux using minimum MMF. The core losses should be less.

Electric circuit or windings: Should ensure required EMF is induced with no complexity in winding arrangement. The copper losses should be less.

Insulation: Should ensure trouble free separation of machine parts operating at different potential and confine the current in the prescribed paths.

Cooling system or ventilation: Should ensure that the machine operates at the specified temperature.

Machine parts: Should be robust. The art of successful design lies not only in resolving the conflict for space between iron, copper, insulation and coolant but also in optimization of cost of manufacturing, and operating and maintenance charges.

The factors, apart from the above, that requires consideration are

a. Limitation in design (saturation, current density, insulation, temperature rise etc).

b. Customer's needs.

c. National and international standards.

d. Convenience in production line and transportation.

e. Maintenance and repairs.

QUESTION 6 What is the technique Computer Aided Design-CAD is defined the use of information technology (IT) in the Design process.

SOLUTION. A CAD system consists of IT hardware (H/W), specialised software (S/W) (depending on the particular area of application) and peripherals, which in certain applications are quite specialised. The core of a CAD system is the S/W, which makes use of graphics for product representation; databases for storing the product model and drives the peripherals for product presentation. Its use does not change the nature of the design process but as the name states it aids the product designer. The designer is the main actor in the process, in all phases from problem identification to the implementation phase. The role of the CAD is in aiding him/her by providing:

Accurately generated and easily modifiable graphical representation of the product . The user can nearly view the actual product on screen, make any modifications to it, and present his/her ideas on screen without any prototype, especially during the early stages of the design process.

Perform complex design analysis in short time. Implementing Finite Elements Analysis methods the user can perform:

Static, Dynamic and Natural Frequency analysis, Heat transfer analysis, Plastic analysis, Fluid flow analysis, Motion analysis, Tolerance analysis, Design optimisation .

Record and recall information with consistency and speed. In particular the use of Product Data Management (PDM) systems can store the whole design and processing history of a certain product, for future reuse and upgrade.

The technique initiated in the MIT from Ian Sutherland, when the first system the Sketchpad was created within the SAGE (Semi-Automatic Ground Environment) research project. The automotive and aerospace industries were the first users and the forerunners of development of CAD technology.

The first system were very expensive, the computer graphics technology was not so advanced at that time and using the system required specilised H/W and S/W which was provided mainly by the CAD vendors. The first CAD systems were mainframe computer supported systems, while today the technology is for networked but stand alone operating workstations (UNIX or WINDOWS based systems). AUTODESK was the first vendor to offer a PC based CAD system the AUTOCAD (beginning of 1980). Today WINDOWS is the main operating system for CAD systems.

The first applications were for 2D-Drafting and the systems were also capable of performing only 2D modelling. Even today 2D-drafting is still the main area of application (in terms of number of workplaces). Later, (mid-1980), following the progress in 3D modelling technology and the growth in the IT H/W, 3D modelling systems are becoming very popular. 3D modelling are at the beginning wire frame based. Aerospace and automotive industries were using surface modelling systems for exact representation of the body of the product. At the same time solid modelling was recognised as the only system, which could provide an unambiguous representation of the product, but it was lacking adequate support for complex part representations. Today we are experiencing a merge of solid and surface modelling technology. Most solid modelling systems are capable of modelling most of industrial products. Systems sold today (especially for mechanical applications, which are the majority of systems sold world-wide) The use of CAD systems has also been expanded to all industrial sectors, such AEC, Electronics, Textiles, Packaging, Clothing, Leather and Shoe, etc. Today, numerous CAD systems are offered by several vendors, in various countries.

QUESTION 7 Objectives and the technique used in cad of electrical engineering.

Solution Originally the technique was aiming at automating a number of tasks a designer is performing and in particular the modelling of the product. Today CAD systems are covering most of the activities in the design cycle, they are recording all product data, and they are used as a platform for collaboration between remotely placed design teams. Most of its uses are for manufacturing and the usual name of the application is CAD/CAM. The areas of application of CAD related techniques, such as CAD, CA Engineering and CA Manufacturing is shown in Fig.1. On the left side of the figure we have a simplified representation of the design cycle and on the right side the use of IT systems. Each of the above functions is not accomplished by a single system and it is quite often for a company to use more that one system, especially when we have CAD and CAE applications.

CAD systems can shorten the design time of a product. Therefore the product can be introduced earlier in the market, providing many advantages to the company. In fig.2, there is a representation of the product development time and of the product useful life span. The shortest the development time, the earliest the product is introduced into the market and it may give a longer useful life span, if the built in quality is correct.

As mentioned above, the first applications of CAD were 2D drafting applications, while now most of them are 3D solid and parametric representations of the real part. Complete assemblies can be modelled and a full analysis of a virtual prototype can be performed. The 3D representation can be exported to other platforms and it can be the communication medium between groups of people from various departments of a company-organisation .

CAD systems enable the application of concurrent engineering and can have significant influence on final product cost, functionality, and quality.

QUESTION 8 . Discuss basic Concept of Computer-Aided Design and Optimization .

SOLUTION A design problem has to be fonnulated considering the various constraints, processes, availability of materials, quality aspects. cost aspects etc. Constraints can be from technical, cost or availability aspects. Technical constraints can be from calculation methods, available process systems, skilled labour, manufacturing facilities, machinery, or tools etc. Sometimes transport facilities to site also pose problems. If suitable quality . materials are not available indigenously they may have to be imported, which effects cost and delivery time. In designing -any system, accuracy of prediction, economy, quality and delivery period playa vital role. Basically, a design involves calculating the dimensions of various components and parts of the machine, weights, material specifications, output parameters and perfonnance in accordance with specified international standards. The calculated parameters may not tally with the final tested perfonnance. Hence, design has to be frozen keeping in view the design analysis as well as the previous operating experience of slfch machines. The practical method in case of bigger machines is to establish a computer program for the total design incorporating the constraint parameters and running the program for various alternatives from which final design is selected. Though the final design may meet all the required specifications, it need not be an optimal one as regards the weight and cost of the active materials, and certain perfonnance aspects like efficiency, temperature rise etc.

QUESTION 9 . Discuss of Computer-Aided Design and Optimization .

SOLUTION. Various Objective Parameters or Optimization in an Electrical Machine are

(a) Higher Efficiency

(b) Lower weight for given KVA output (Kg/KVA)

(c) Lower Temperature-Rise

(d) Lower Cost

(e) Any other parameter like higher PF for induction motor, higher reactance etc.

Here we have to understand that if an optimized design is finalized keeping in view of any of the parameters mentioned above, the design may not be optimum for the above parameters. For example, if a design is selected for higher efficiency, it may not be optimum in other parameters, maybe the cost is high. Nonnally this is a case where compromise is to be made. This is because more costly materials like higher grade silicon steel stampings are used for armature core to reduce iron losses and hence efficiency is increased. Similar controversies will exist for other options also. One more practical example in case of bigger machines is that a constraint is imposed in weight or volume of the machine to transport it through any road bridge or tunnel to reach the site where the machine has to finally operate. Hence, it is desirable to define clearly the objective function for optimization to which the design should fulfill.

QUESTION 10. What is the aim of design.

SOLUTION. Aim of design is to detennine the dimensions of each part of the machine, the material specification, prepare the drawings and furnish to manufacturing units. Design has to be carried out keeping in view the optimizing of the cost, volume and we~ght and at the same time achieving the desired performance as per specification. Knowledge of latest technological trends to supply a competitive product is a mlst. Design should conform to stipulations specified by Internationa lNational standards.

Design is the most important activity. The designer should be familiar with the following aspects:

(a) Thorough knowledge of international/national standards.

(b) Properties of good electrical materials (like copper), magnetic materials (like silicon steels), insulating materials (like Epoxy mica), mechanical and metallurgical properties of all types of steel.

(c) Governing laws of electrical circuits.

(d) Laws ofheat transfer.

(e) Prices of materials used, foreign exchange rates, types of duties levied on products.

(f) Labour rates of both ski lied and un skillied labour .

(g) Knowledge of competitor's products.

QUESTION 11 . What is the output coefficient AND Specific magnetic loading .

Solution output Coefficient Starting point for design is the output coefficient (K) where K = P D- x Lx N

Where P ~ Output of machine in KV A

D ~ Diameter of armature (m)

L ~ Gross length of armature (m)

N ~ Speed of the machine (RPM)

For larger machines, output coefficient is high. By providing a fan and improved cooling, output coefficient can be increased. If output coefficient (K) is higher, product of "D2LN" is lower. i.e. either "D2L" (Volume) is lower or Speed (N) is lower for same KVA output.

That means volume of a better cooled machine is lower for same output and speed.

Importance of Specific Loadings Specific magnetic Loading (Bav) = P x *1[xDxL*

Where

P ~ No of poles ~ Flux per pol

e D ~ Diameter of armature (m)

L ~ Gross length of armature (m)

Specific Electric Loading (q) = fax Za 1[X D

Where

fa ~ Armature Current (A)

Za ~ No of Armature Conductors D ~ Diameter of armature (m)

Considering the above aspects, suitable values of Specific Magnetic and Specific Electrical Loadings are to be selected. In fact by assuming different values of Bav and q falling within the permissible range, many design variants are to be worked out with the help of computer programs and an optimized variant has to be arrived .

QUESTION 12. Describe heating and cooling in electrical matchines .

SOLUTION . Heating and Cooling Heating In electrical machines, heating is the main criterion for design. Electrical machines are designed and manufactured with a selected class of insulation which can withstand a certain temperature. If overheating occurs, insulation will get weakened and results in short circuits leading to the damage of the machine. In general excess temperatures can change the following insulation properties:

(a) Decrease in Resistance

(b) Decrease in Electrical Strength

(c) Increase in Dielectric Loss angle

(d) Increase in Dielectric losses

(e) Decrease in tensile strength.

As result of these, life of the machine reduces.

In all electrical equipments, various losses produce heat which increases the temperature. If this heat produced is not dissipated, temperature goes on increasing resulting in cracking the insulation and failure of the machine. This dissipation of heat occurs in three modes (i.e.) Conduction, Convection and Radiation. If a perfect cooling medium is designed the heat produced is continuously dissipated so that temperature stabilizes at some vallie (Omax) and there will not be further increase at that particular load. "8max " value at rated load is the criterion for deciding class of insulation and further design aspects of the machine.

When a machine is loaded at time t = 0, and when the temp rise is zero (Temp rise = M/c temp - amb temp), the temp-rise gradually increases exponentially with respect to time and and after certain time it attains the steady state value (8max) governed by the equation o = Omax (I_e-t/T), where 8 -? Temperature rise at any time (t) and! -? heating time constant of the machine which is calculated from formula GS / A.

Where

G -? Weight of the machine (Kg) S

Average specific heat (Watt-sec/KgfOC) A

Area of cooling surface (sq.m) A -

Cooling When load is removed and the machine is stopped, temperature-rise gradually decreases and cools down exponentially with respect to time, as governed by the formula

Be = Bh x e-1/TC

where eh -7 Temp-rise of the machine just before stopping and load removed

Oc -7 Temperature rise at any time(t)

rc -7 cooling time constant of the machine Effect ojji-equent healing alld cooling 011 {/ machine If a machine is subjected for loading and un-loading many times in day, thermal expansion and contraction of insulation occurs and results in early cracking down of insulation and reduction in its life period. Hence, design of such machines needs additional care. Specific heat dissipation from the cooling surface (Warts/m2 /°C) .

QUESTION13. What are the modes of head dissipation .

SOLUTION Modes of Heat Dissipation Heat is dissipated by three modes:

I. Conduction

2. Convection and

3. Radiation

Since Transformer is a static device, no rotational losses. Heat produced by core and windings are to be dissipated by tank. In most power transformers watt loss per Kg in the iron and the watt loss per Kg in the copper will be nearly equal. This means that the total losses to be dissipated vary as the weight or volume of the material (L"'), where "L" represents the dimensions of transformer. On the other hand, cooling surface provided by the tank of the transformer varies as (L\ As the size of the transformer is increases, the ratio of heat generation volume to surface for dissipation (L 3/ L 2) becomes large.

For small transformers a smooth case readily dissipates the heat as can be seen from the above by Convection and Radiation. But in case of rotating machines, rotational losses exist and heat transfer takes place by Conduction and Convection with negligible radiation.

QUESTION.14 What is the general design procedure. What are the steps to get optimal design.

SOLUTION. General Design Procedure Sequential steps involved in the design and manufacture of any product:

I. Customer specification as per contract, if available, should be read and salient points of design parameters to be highlighted.

2. Latest National/International standards applicable for this design should be referred.

3. Calculation of main dimensions and subsequently dimensions of each part and Performance parameters, using well-proven computer programs, established with equations, scientific formulae, empirical formulae based on previous experience, curves, tables, charts, etc.

4. Ensuring that the volume and weight of the product do not pose any problem for either manufacture at works or transport to site or erection and commissioning at site. Any foreseen problems should be solved before the related activity begins.

5. Preparation of the specifications of each type of materials used in the product.

6. Preparation of drawings of each part and furnishing to manufacturing shops, Purchase department for purchase of raw materials, tools and sub-contracted items.

7. Writing of process (Sequential steps involved): How to manufacture each part, clearly indicating the types of tools, machines, workmen, etc.

8. Writing of process: How to sequentially assemble each part/component.

9. Writing the process how to carry out tests on each component and fully assembled machine to check the quality as specified by standards.

10. Manufacturing the components and carrying out in-process tests.

II. All components are assembled and testing has to be carried out on full machine

12. If it is a new design, additional tests (type tests) to be done over and above the normal routine tests specified.

13. Dispatching the machine to customer site where it is erected and commissioned to keep ready for normal operation.

14. Loading the machine at rated conditions and checking the performance.

Steps to Get Optimal Design

(a) Input parameters like KW, Voltage, PF, Frequency, and any parameter guaranteed to customer etc., to be kept constant.

(b) Operating range (minimum and maximum values) of various input design parameters to be selected (like Flux densities, Current densities etc.)

(c) Maximum and minimum values of certain output parameters to be incorporated (like number of stator slots, % Regulation etc.)

(d) A well proven computer program is run to print out various possible alternative designs.

(e) Optimization criteria to be identified. (like lower cost, lower weight, lower Kg/KVA, Higher efficiency, lower temp-rise, etc.)

(t) Optimal design is selected to suit the optimization criteria.

QUESTION 15. What are the general type of enclosers used in machine design .

SOLUTION.

Types of Enclosures Electrical machine is protected by a metallic cover called enclosure against ingress of moisture, dust, atmospheric impurities and any foreign material. The degree of protection varies in different environments. If the machine is provided under a roof, it is safe from certain problems like falling of rain, snow etc. But still protection is required from air born dust etc. If the machine is not having a roof, higher degree of protection is required. Ifhigher degree of protection is provided, cooling is lower and vice versa.

Depending upon the required degree of protection, enclosures are classified into following types:

(a) Open Type: Ends of machine are in contact with atmosphere. Cooling is better. Here it is with lowest degree of protection.

(b) Protected type: End covers are provided with holes for ventilation.

(c) Screen protected type: A wire mesh to prevent foreign bodies is additionally provided for protected type (b).

(d) Drip Proof type: In a damp environment hanging bowls are provided, so that condensed moisture does not enter the machine.

QUESTION 16. Discuss in detail the material properties for designing any electrical apparatus .

Electrical Conducting Materials:

Materials serving as electrical conductors can be divided into two main groups, namely,

1. High Conductivity Materials: These materials are used for making all types of winding required in electrical machines, apparatus and devices, as well as for transmission and distribution of electric energy. These materials should have the least possible resistivity.

2. High Resistivity Materials: These materials are used for making resistances and heating devices.

I. High Conductivity Materials: The fundamental requirements to be met by high conductivity materials are

a. Highest possible conductivity and hence least resistivity

b. Least possible temperature coefficient of resistance

c. Adequate mechanical strength, in particular, high tensile strength and elongation characterizing to a certain degree of the flexibility, i.e. absence of brittleness

d. Rollability and drawability which is important in the manufacture of wires of small and intricate sections

e. Good weldability and solderability which ensure high reliability and low electrical resistance of the joints

f. Adequate resistance to corrosion

The following section gives a brief analysis on the values of resistivity, specific weight, density, resistance temperature coefficient, co-efficient of thermal expansion, thermal, conductivity specific heat and tensile strength of conducting materials used in electrical machines.

a. Copper: Copper is the most widely used electrical conductor combining, high electrical conductivity with excellent mechanical properties and relative immunity from oxidation and corrosion. It is highly malleable and ductile metal. It can be cast, forged, rolled, drawn, and machined. Mechanical working hardens it but annealing restores it to soft state.

b.Aluminium: The application of aluminium is increasing due to the high demand for conductor materials which cannot be met by copper product alone. Therefore, aluminium which is the conductor material next to copper is used. Also aluminium is available in abundance on earth’ s surface. Pure aluminium is softer than copper and therefore, can be rolled into thin sheets (foils). Aluminiun cannot be drawn into very fine wires on account of its low mechanical strength. In replacing copper conductors with aluminium ones in electrical machines due account should be taken of their differences in resistivity, density and mechanical strength.

c. Iron and Steel: Steel alloyed with chromium and aluminium is used for making starter rheostats where lightness combined with robustness and good heat dissipation are important considerations. Cast iron is used in the manufacture of resistance grids to be used in the starters of large motors.

Magnetic Material: All magnetic materials possess magnetic properties to a greater or a lesser degree. The magnetic properties of materials are characterized by their relative permeability. In accordance with the value of relative permeability, materials may be divided into three broad classes.

a. Ferromagnetic materials: The relative permeabilities of these materials are much greater than unity and these permeability values are dependent upon the magnetizing force.

b. Paramagnetic materia1s: These materials have their relative permeabilities only slightly greater than unity. The value of susceptibility is thus positive for these materials.

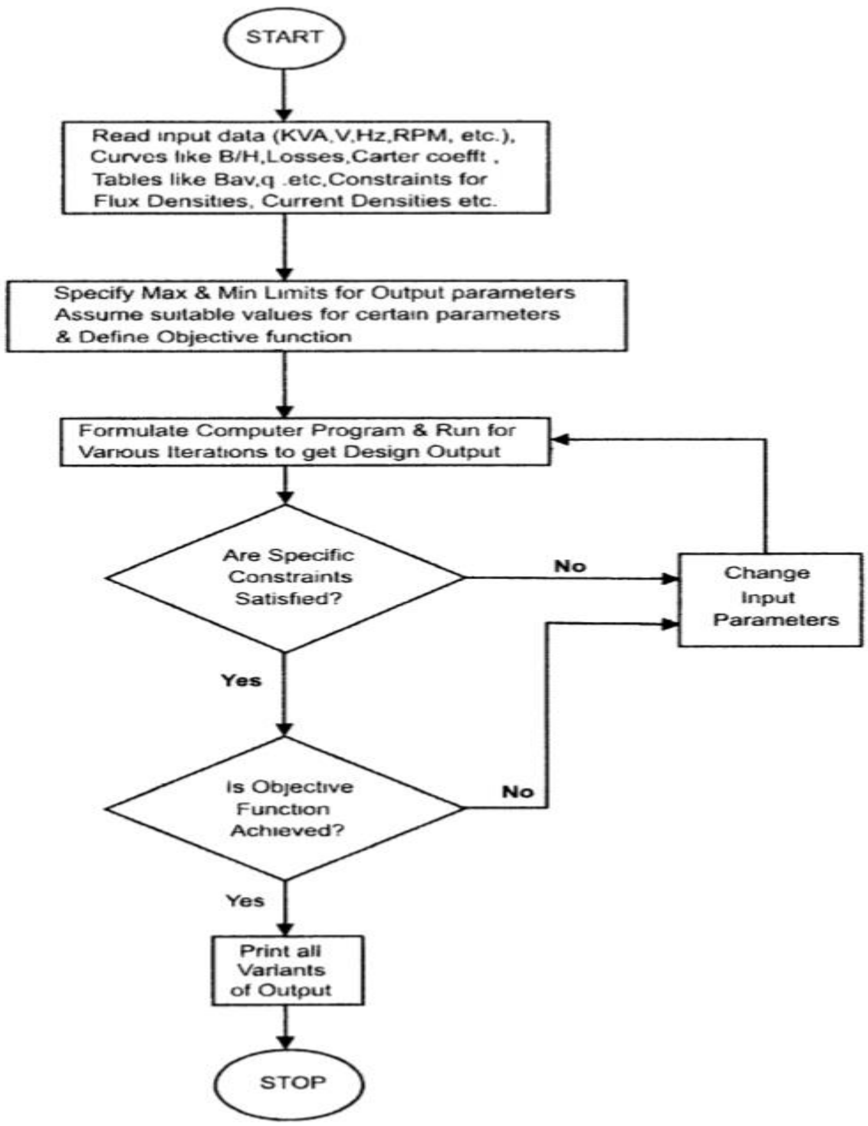
c. Diamagnetic materials: These materials have their relative permeabilities slightly less than unity. In both Paramagnetic and Diamagnetic materials the value of permeability is independent of the magnetizing force.

QUESTION 17. Draw the basic Computer-Aided Design flowchart , and for dc machine ,transformer, non salient pole generator ,salient pole generator,3_ph pole motor 1-ph pole motor .

SOLUTION **Computer-Aided Design**

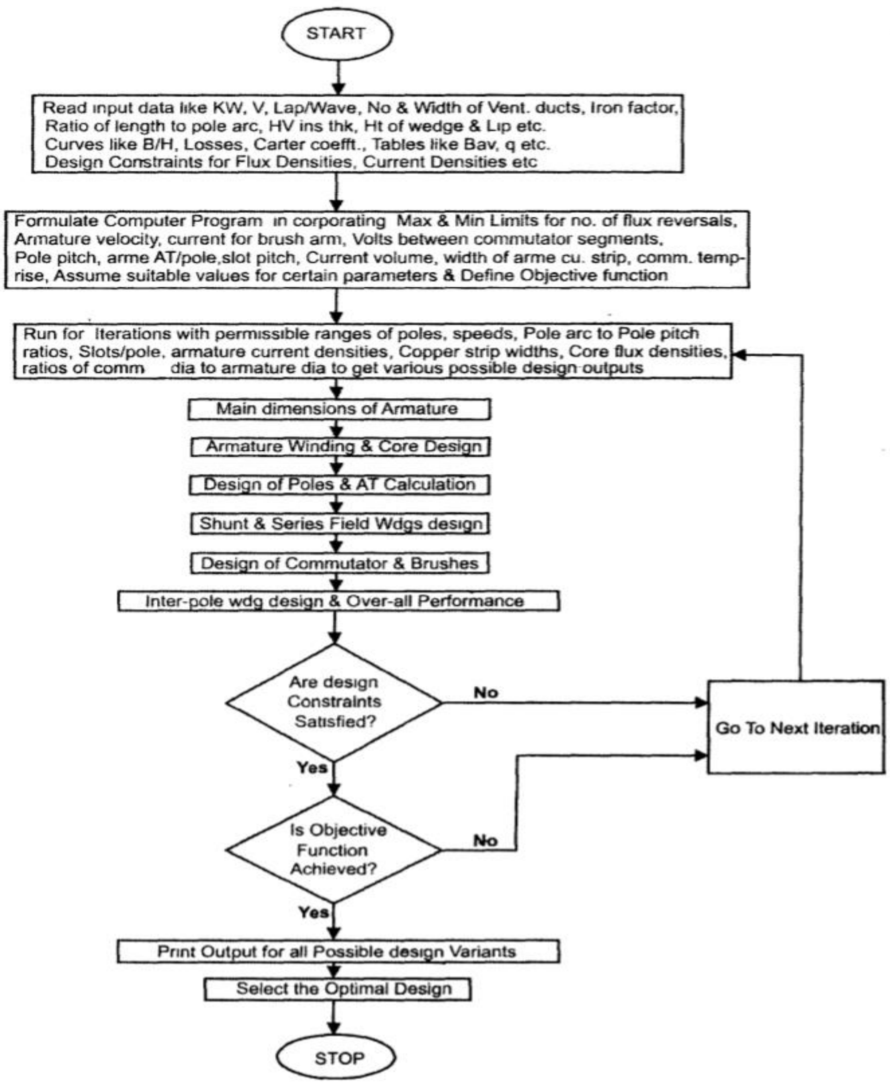
In any practical design the number of variables is so high that hand calculations are impossible. The number of constraints is also large and for these to be satisfied by final design, a lengthy iterative approach is required. This is only possible with the help of computer programs

5. Apparent Flux density
6. Leakage Coefficients of slots
7. HP vs. output coefficient for 1-ph Ind.Motor

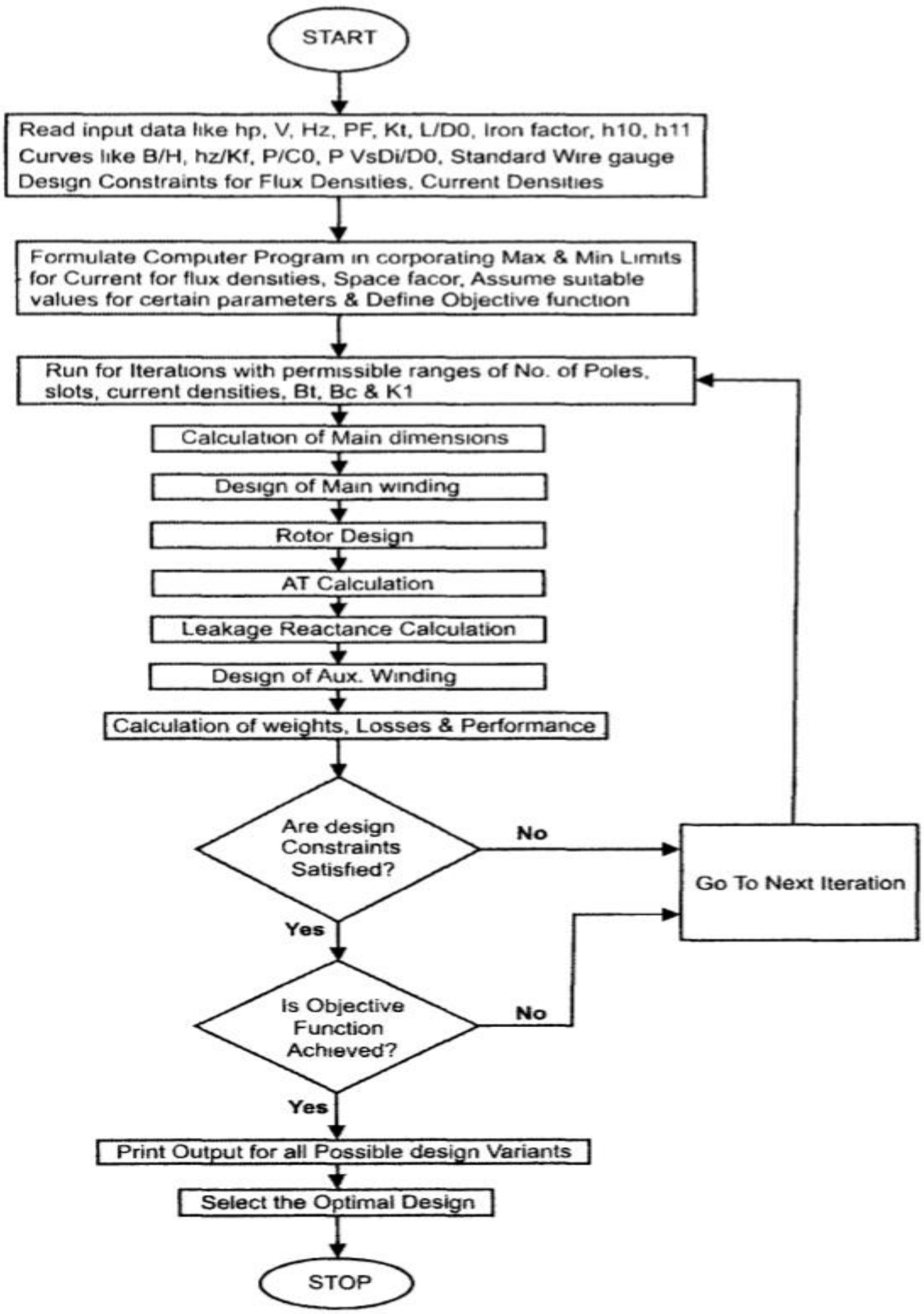


Flowchart 1.1 Computer-aided design.

1.2 to 1.7).

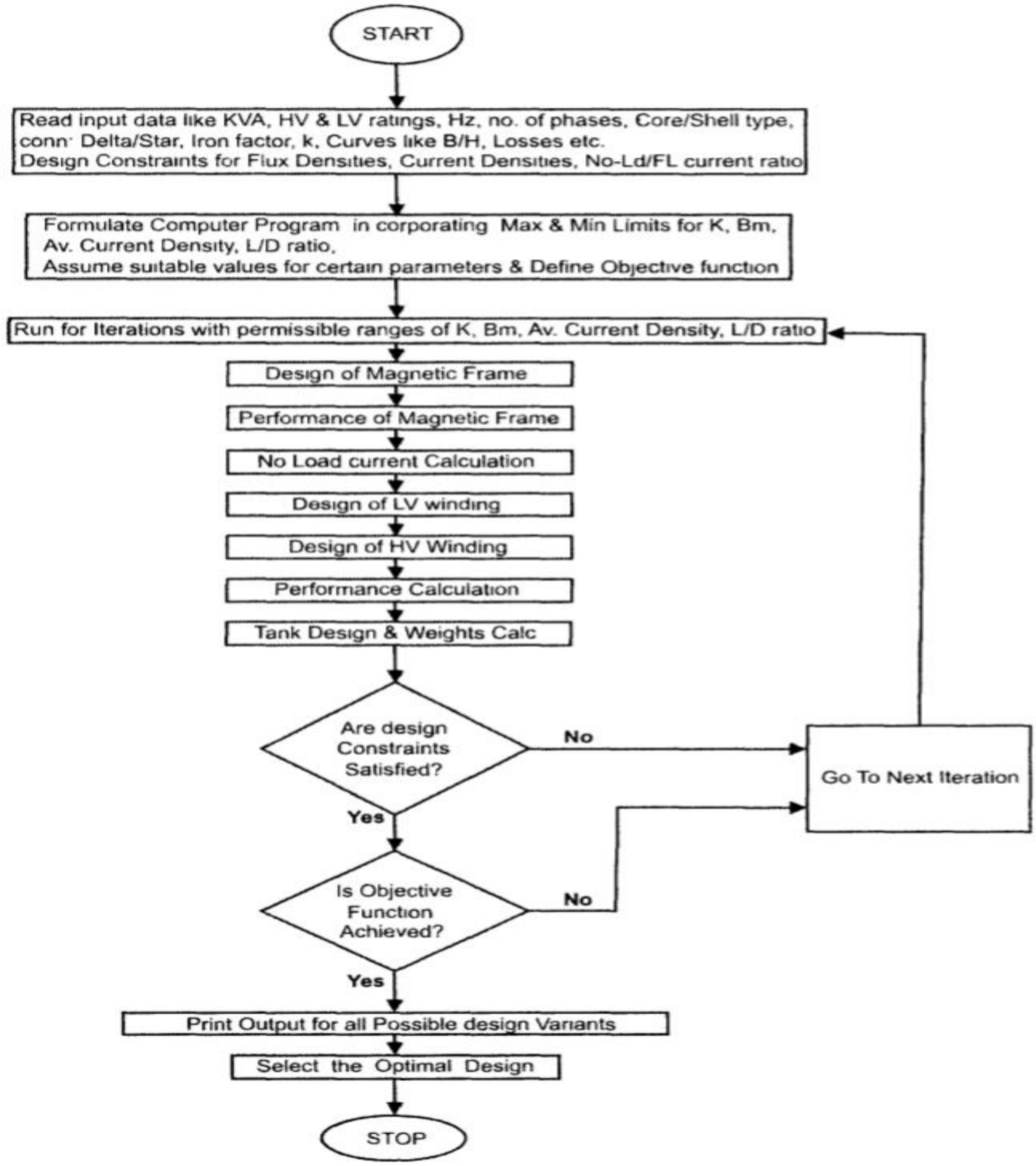


Flowchart 1.2 Flowchart for computer-aided optimal design of DC machine.

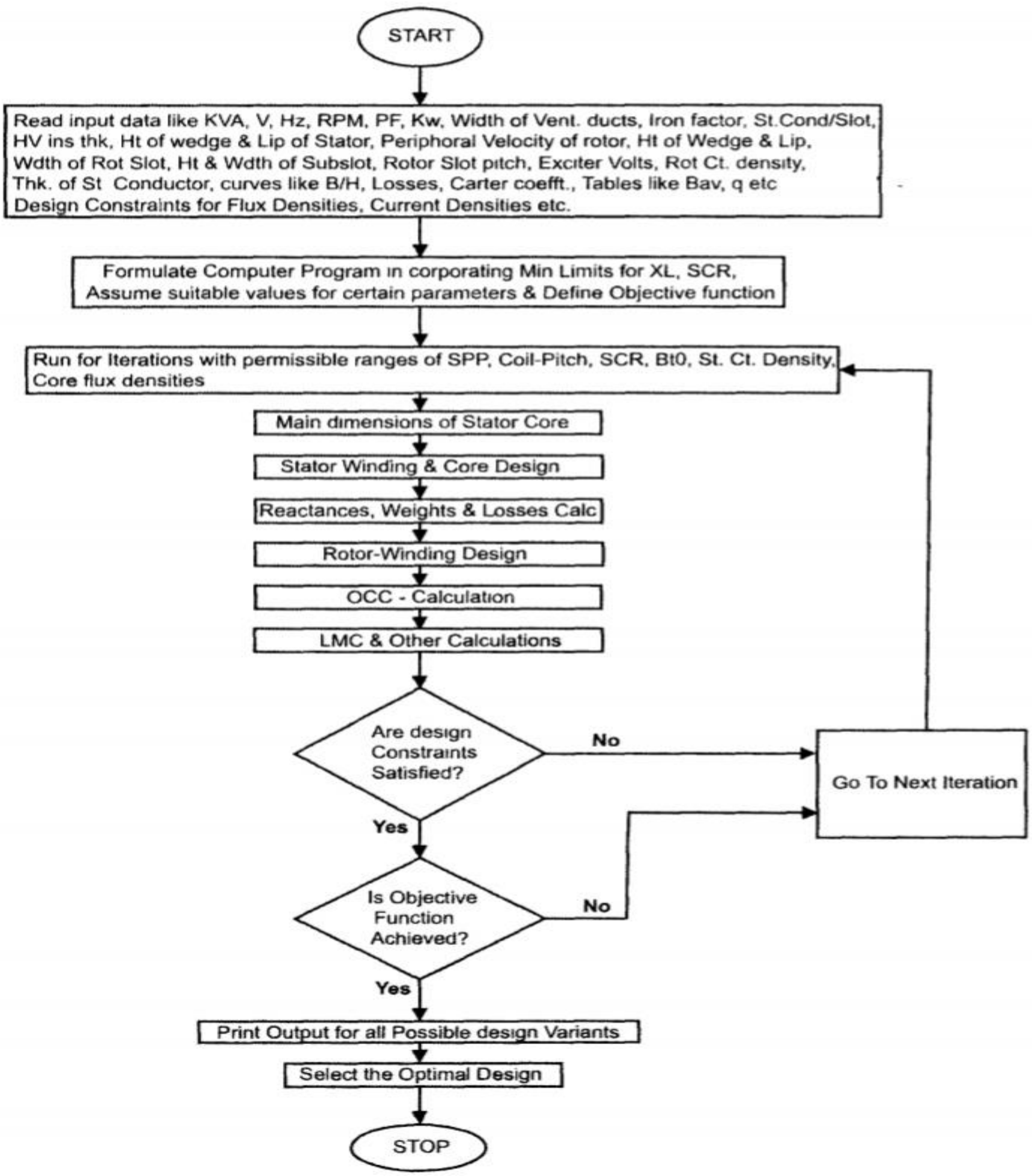


Flowchart 1.7 Flowchart for computer-aided optimal design of 1-ph induction motor.

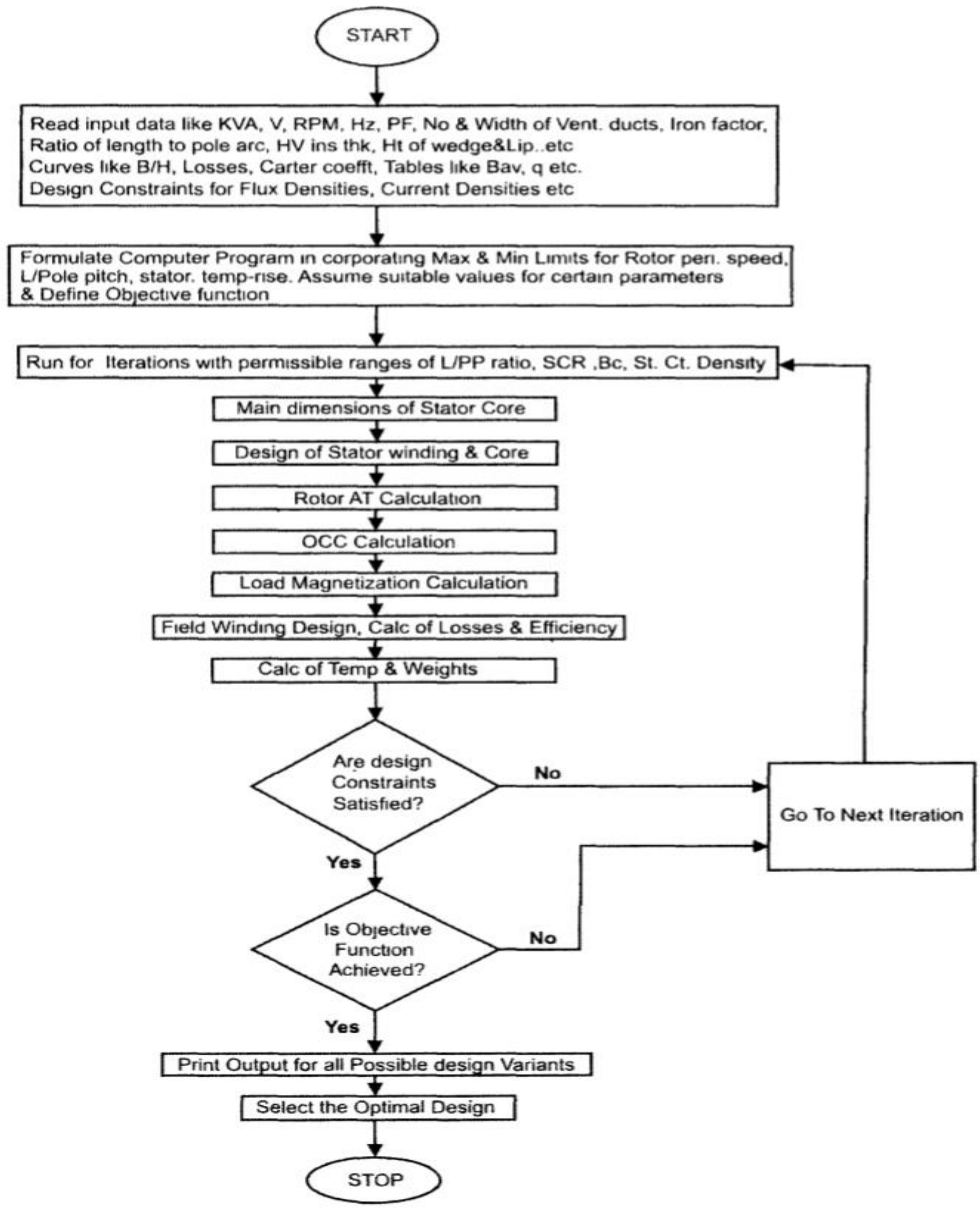
Flowchart 1.2 Flowchart for computer-aided optimal design of DC machine.



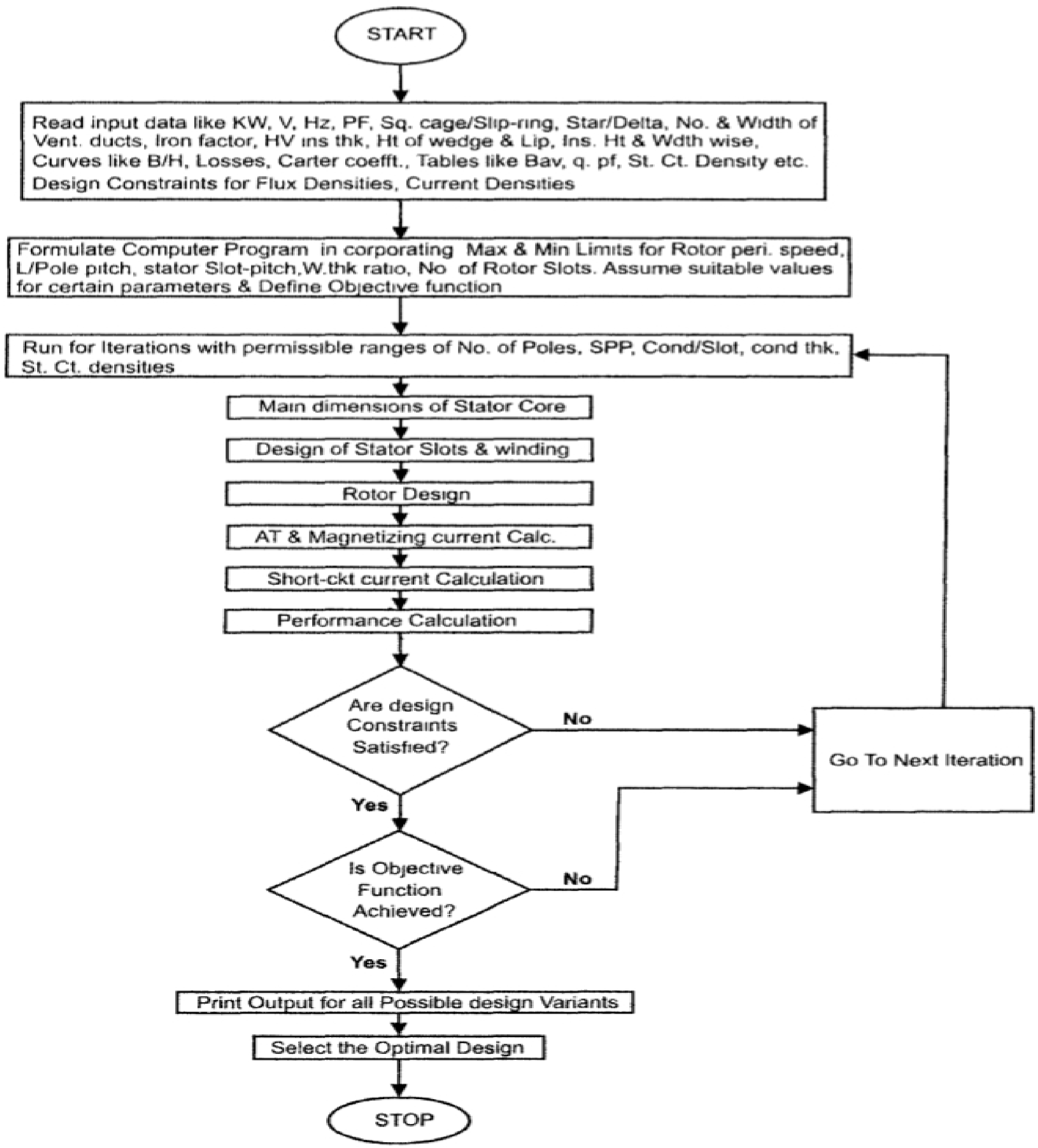
Flowchart 1.3 Flowchart for computer-aided optimal design of transformer.



Flowchart 1.4 Flowchart for computer-aided optimal design of non-salient pole generator.



Flowchart 1.5 Flowchart for computer-aided optimal design of salient pole generator.



Flowchart 1.6 Flowchart for computer-aided optimal design of 3-ph induction motor.

Explanation of Details of Flowch

Input Data to be Fed into the Program

(a) Data

1. Rating of the machine (KW/KVA)

2. Rated Voltage

3. Rated Frequency (for AC only)

4. Rated Speed (RPM)

5. Type of Connection of Phases (Star/Delta) for 3 ph AC only

6. Type of Winding (Lap/Wave)

7. Number of Parallel Paths

8. Shunt/Compound in case of DC Machine

9. Squirrel Cage/Slip Ring type for 3-ph Ind.Motor

10. Rated Slip /Rotor speed for Ind.Motor

11 J. Salient Pole/Round rotor type for 3-ph Alternators J

12. Rated power factor for 3-ph Alternators

13. Core/Shell type for Transformers

14. Ratings of HV /L V for Transformers

(b) Applicable curves in array format like,

1. B/H for magnetic materials used for Core, Poles,

2. Loss Cuves for magnetic materials

3. Hysteresis loss vs. frequency

4. Carters coefficients for slots and vent ducts

5. Apparent Flux density

6. Leakage Coefficien~ of slots

7. HP ys. output coefficient for I-ph Ind.Motor

(b) Applicable tables in array format like,

I. Output vs. Specific Electric Loading(q)

2. Output vs. Specific Magnetic Loading(Bav)

3. Output vs. AT/pole

4. No. of poles vs. Pole pitch

5. Depth of Shunt field winding vs. Arm Dia

6. Standard sizes of brushes

7. Power f·-Factor and Efficiency at different ratings of Ind. Motor

8. Frequency vs. Frequency constant of I-ph lnd. Motor

9. No. of poles vs. DiiDe ratio for I-ph Ind. Motor

10. Efficiency and PF vs. output for I-ph In9._ Motor

11. Thickness of Stator winding ins vs. Voltage for Rotating machines

12. Window space Factor vs. K V A for transformers.

Applicable Constraints I Maximum or Minimum Permissible Limits

I. Flux density in core, tooth, yoke

2. Curr~nt densities in all windings ofthe machine

3. RatiO' of Pole arc to pole pitch

4. Ratio of Length to pole arc

5. Current Volume per slot of DC armature

6. Peripheral velocity of rotor

7. Freq~lency of flux reversal in DC armature

8. Current per Brush arm in DC armature

9. Voltage between Commutator segments in DC armature

10. Current per Brush arm in DC· armature

11. Polepitch .

12. Temperature Rises

13. Power factor in Ind. Motor

14. No load current in Ind. Motor

15. Starting T~rque in Ind. Motor

16. Number of Slots in Armature

17. Space mctor of the slot in I-ph Ind. Motor

18. Rotor slo.ts in Ind. Motor

19. Eddy current loss factor in AC machine

20. Short Circuit Ratio of Alternator

21. Leakage reactance on AC Machine

22. Regulation

23. Saturation factor.

Output Data to be Printed after Execution of Program

(a) Applicable Data

I. Main Dimensions and Internal dimensions of the machine

2. No. of slots

3. Turns in all windings

4. Copper sizes in all windings

5. Weights

6. Losses

7. Efficiency

8. Reactances

9. Full load Field current

10. Temperature rise

11. No. of cooling tubes for a transformer

12. Diameter and number of segments in Commutator

13. Full load slip of Ind. Motor.

(b) Applicable Curves

1. Open Circuit, Short Circuit and Load magnetization characteristics of Alternator

2. Slip vs. Torque curves of Ind. Motor.