Sanjaybhai Rajguru College of Engineering, Rajkot

Department of Electrical Engineering

B.E. (Electrical), Semester-6

Question Bank

Subject : **Computer Aided Analysis and Design for Electrical Engineering**
Subject Code : **2160911**
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Chapter – 1 : Concept of Computer Aided Design and Optimization

Q-1 What is engineering design? and what are the objective of a designer?

ANS. Engineering design is application of science, technology and invention to produce machines to perform specified task with optimum economy and efficiency.

* Main objectives of a designer :-

↳ To design a machine which fulfils a certain set of specifications as economically as possible.

↳ Designer should also ensure that the machine is durable and efficient.

Q-2 What are the three major considerations for a good design?

ANS. The three major consideration to evolve a good design are:

1. cost
2. Durability
3. Compliance with performance criteria as laid down in specifications.

↳ In most of the machines it is difficult to design a machine which satisfy all performance, cost and durability criteria.

↳ It is impossible to design a machine which is cheap and is also durable at the same time.

↳ This is because a machine which is to have a long life span must use high quality material and advanced manufacturing techniques which makes it costly.

↳ A compromise between cost and durability can be made.

↳ A good design is one where the machine has reasonable operating life, and low initial cost.

↳ In most of the design, application, consumer specifications are considered for selection of design criteria between cost and durability.

↳ A machine with better materials has better efficiency and high durability, but the initial cost increases

↳ A single machine can not satisfy both cost & durability criteria.

Q-3 Define:

a. output equation

b. Specific electric loading

c. Specific magnetic loading

ANS: 0

a. Output Equation :-

The output of machine can be expressed in terms of its main dimensions, specific magnetic and specific electric loadings and speed; the equation describing this relationship is known as output equation.

b. Specific Electric Loading (ac)

The number of armature/stator ampere conductors per meter of armature/stator periphery at the airgap is known as specific electric loading.

C. Specific Magnetic Loading

The average flux density over the airgap of a machine is known as specific magnetic loading.

Q-4 Write output equation of DC & AC machine and justify the sentence "It is economical to design a high speed motor compared to a low speed motor"

ANS: Ouput Equation

DC Machine:- $P_a = C_o D^2 L n$

$C_o = \pi^2 B_{av} ac \times 10^{-3}$

AC Machine:- $Q = C_o D^2 L n_s$

$C_o = 11 B_{av} ac K_w \times 10^{-3}$

D = Armature/stator bore diameter, m

L = Stator core length, m

n = Speed in rps,

n_s = Synchronous speed, rps,

C_o = output co-efficient

P_a = Power developed by armature, m

Q = KVA rating of m/c

B_{av} = Specific magnetic loading, wb/m^2

ac = specific electric loading ac/m

K_w = winding factor

↳ The cost of the machine depends upon the volume of active parts of the machine.

↳ The volume of active parts of machine can be reduced by decreasing size of the machine.

↳ The size of the machine can be reduced by increasing speed of machine.

↳ As higher speed of machine is selected then size and active part volume is reduced and hence cost of the machine is reduced.

↳ So it is economical to design a high speed machine.

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Q-5. Write a short note on:

Factors affecting size of rotating electrical machines.

ANS: Output Equation of DC Machine

$$P_a = C_o D^2 L n, \quad C_o = \pi^2 B_{av} ac \times 10^{-3}$$

&

output equation of AC Machine

$$Q = C_o D^2 L n_s, \quad C_o = 11 B_{av} ac k_w \times 10^{-3}$$

↳ From above output equations we can observe that product D^2L will decrease with increase of speed and vice versa.

↳ D^2L will decrease with increment in output co-efficient.

↳ So active part volume of the machine varied with variation in speed or output co-efficient.

* Speed

↳ From the output equation it is clear ~~if~~ that the volume of active parts of the machine varies inversely with the speed.

↳ For same output, machine designed with higher value of speed will have smaller size and hence lesser cost compared with machine having lower speed.

↳ Therefore whenever a choice has to be made, the highest practical speed rating should be selected to decrease size and cost of the machine.

↳ But it is also kept in mind ~~teeth~~ that mechanical stress on armature or rotor depends upon value of speed.

* Output co-efficient

↳ From output co-efficient equation we can observe that the volume of active parts is inversely proportional to the value of output co-efficient.

↳ Thus an increase in the value of Co results in reduction in size and cost of machine.

↳ So it is better to increase output co-efficient if we want to decrease the cost of machine.

↳ But, Co is product of Bav & ac, so if higher value of Co is selected then higher values of Bav & ac should choose.

↳ If higher values of Bav & ac are selected then some performance characteristics like temperature rise, efficiency, power factor & commutation conditions are adversely affected.

Q-6 How computer aided design is advantageous in electrical machine design process? Describe in briefs.

ANS.

↳ The design of electrical machine consists essentially solution of many complex and diverse engineering problems.

↳ It is mathematically indeterminate problem with many solutions, as the number of unknowns are greater than the number of equations.

↳ Role of a designer is to design the machine that will suit to the specification as well as would be economical.

↳ To achive this a designer has to solve so many equation with many iterations to get desired design of the machine.

↳ To solve many complex problems with more number of iterations lots of time is required.

↳ So manual design process is time consuming and tedious.

↳ By the use of computers the design process will take very less time.

↳ The computer can solve problems and equations with many iteration within a minutes, where a human will take hours or days to calculate.

↳ Moreover if some decision making programs are developed for computers to solve design process then it will be very helpful for a designer to get solution of design problem very accurate and fast.

↳ In this manner lots of time and man power can be saved by using computer for electrical machine design process.

Q-7 Write a short note on Flowchart with suitable exeample.

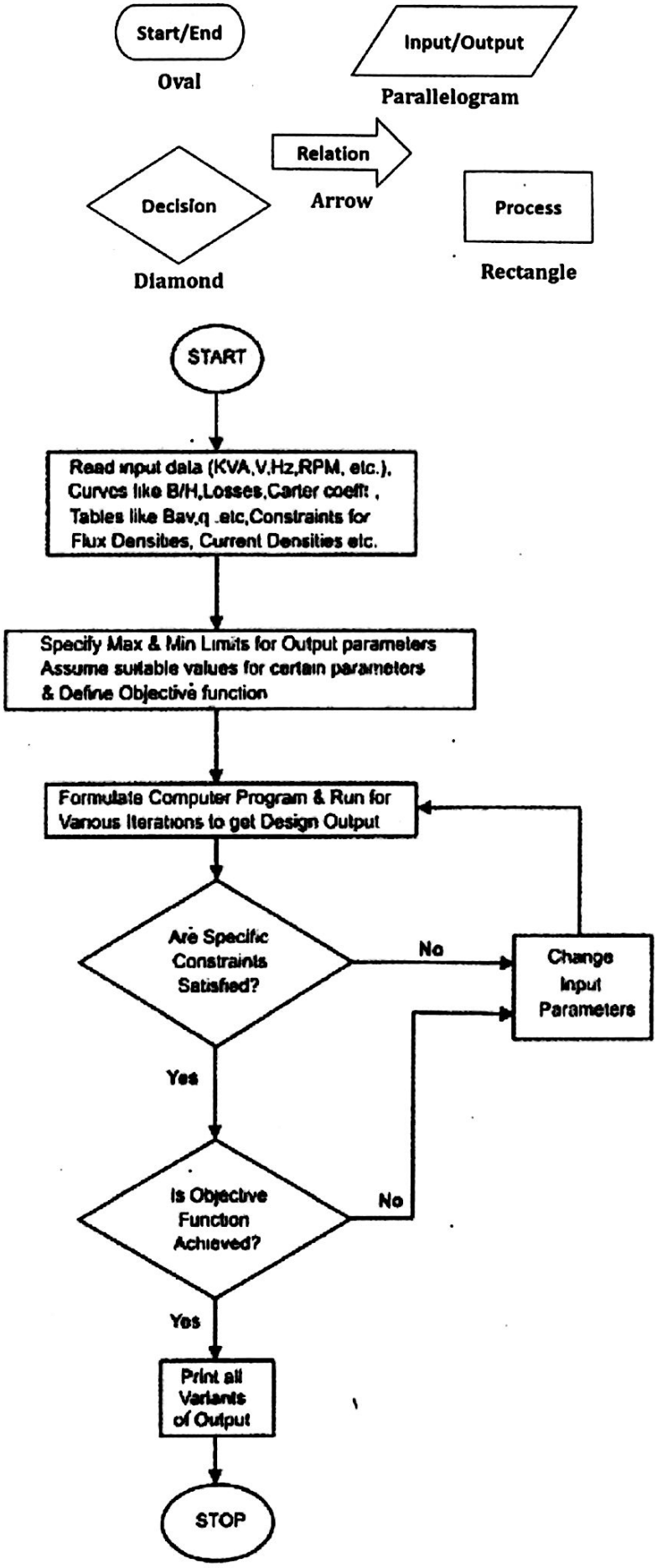
ANS: A Flowchart is a visual representation of the sequence of steps and decisions needed to perform a process.

↳ Each step in the sequence is noted within a diagram shape.

↳ Steps are linked by connecting lines and directional arrows.

↳ This allows anyone to view the flowchart and logically follow the process from beginning to end.

↳ Each diagram shape represents perticular process in the flowchart as shown below.


Start/End
Oval
Input/Output
Parallelogram
Relation
Arrow
Decision
Diamond
Process
Rectangle
START
Read input data (KVA,V,Hz,RPM, etc.), Curves like B/H,Losses,Carter coeff! , Tables like Bav,q .etc,Constraints for Flux Densibes, Current Densities etc.
Specify Max & Min Limits for Output parameters Assume suitable values for certain parameters & Define Objective function
Formulate Computer Program & Run for Various Iterations to get Design Output
Are Specific Constraints Satisfied?
No
Change Input Parameters
Yes
Is Objective Function Achieved?
No
Yes
Print all Variants of Output
STOP

Q-8 List various applicable constraints in design and explain any two in detail.

ANS: Various applicable constraints in design are as follows.

- ↳ flux density in core, tooth, yoke
- ↳ current densities in all windings
- ↳ Ratio of pole arc to pole pitch
- ↳ Ratio of length to pole arc
- ↳ current volume per slot of DC armature
- ↳ Peripheral velocity of rotor
- ↳ frequency of flux reversal in DC armature
- ↳ current per brush arm in DC armature
- ↳ voltage between commutator segments in armature
- ↳ Pole pitch

↳ Temperature Rises

↳ Power factor in I.M.

↳ No load current in I.M.

↳ Starting torque in I.M.

↳ Number of slots in armature

↳ Rotor slots in I.M.

↳ Eddy current loss factor in AC machine

↳ short circuit ratio of Alternator

↳ Leakage reactance of AC machine

↳ Regulation

↳ saturation factor

* Flux density in core/Tooth/yoke

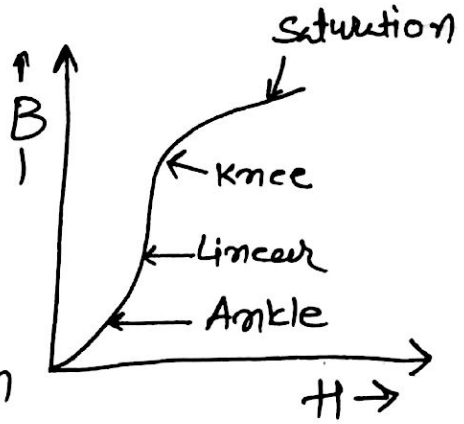
↳ The magnetizing current of a machine is directly proportional to the mmf required to force the flux through the airgap and iron part of the machine.

↳ The mmf required for airgap is directly proportional to the gap flux density (Bav).

↳ In iron parts the value of flux density in them depends upon the value of specific magnetic loading.

↳ If a small value of specific magnetic loading is chosen, the flux density in the iron part is low.

$$B = \frac{\phi}{A} = \frac{\text{Flux}}{\text{Area}}$$



↳ As large value of specific magnetic loading results in increased value of magnetizing mmf and hence more magnetizing current.

* Peripheral velocity of rotor

↳ Peripheral speed V_a,

$$V_a = \pi D n$$

D = diameter of armature, m

n = speed in rps

↳ The peripheral speed is sometimes a limiting factor for the diameter.

↳ As the higher diameter is selected for same speed of the machine peripheral speed increases.

↳ The value of peripheral speed should not normally exceed 30 m/s.

↳ This speed does not require any special rotor construction.

↳ If peripheral speed exceed 30 m/s, then the bands of binding wire for the overhang will have to be made extra strong, otherwise overhang will fly out due to excessive centrifugal force.

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↳ Q-9 List various objective parameters for optimization in an electrical machine design and explain in brief.

ANS. Objective parameters for optimization are:

- ↳ Higher efficiency
- ↳ Lower weight for given kVA output
- ↳ Lower temperature rise
- ↳ Lower cost
- ↳ High Power factor

↳ The optimization is to choose the best solution for a given problem from multiple possible solution.

↳ The optimization process involves the choice of various variables in such a manner that the design in regend a particular feather (mentioned above) is the best and satisfies all limitation imposed on its performance.

↳ Hence optimization is the collective process of finding a set of conditions required to achive the best results from a given solution.

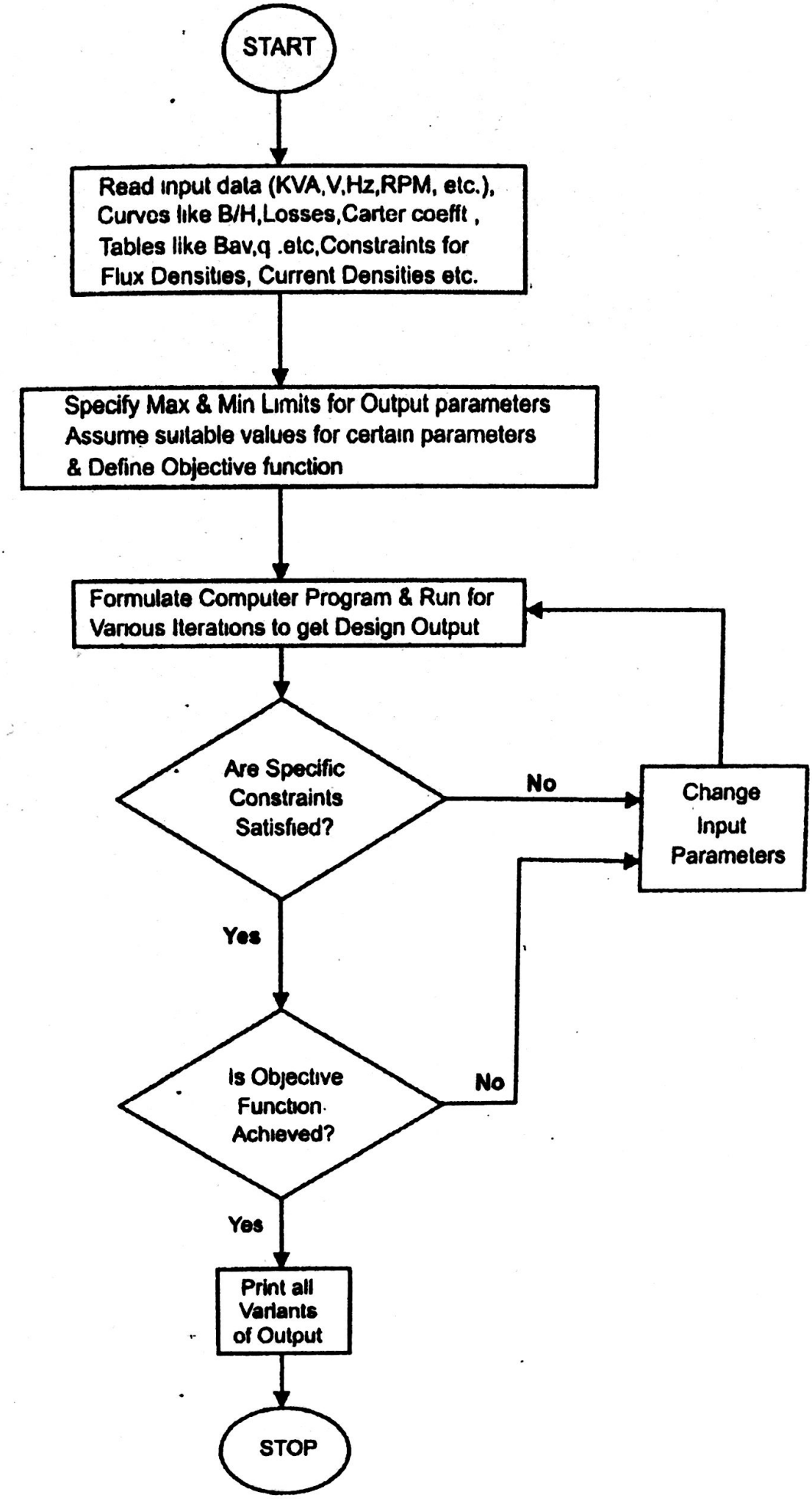
↳ A characteristic feature of optimization in design of electrical machine is the presense of conflicting/opposing influenced.

↳ For example cost of active materials can be reduced by using higher values of specific loadings, which will results in unsatisfactory performance like low efficiency.

↳ Thus, the best design will be obtained by the compromise of two main factors cost & performance.

Q-10 Draw a flowchart for generalized computer aided design.

ANS: The flowchart is as shown below:


START
Read input data (KVA,V,Hz,RPM, etc.), Curves like B/H,Losses,Carter coefft , Tables like Bav,q .etc,Constraints for Flux Densities, Current Densities etc.
Specify Max & Min Limits for Output parameters Assume suitable values for certain parameters & Define Objective function
Formulate Computer Program & Run for Various Iterations to get Design Output
Are Specific Constraints Satisfied?
No
Change Input Parameters
Yes
Is Objective Function Achieved?
No
Yes
Print all Variants of Output
STOP