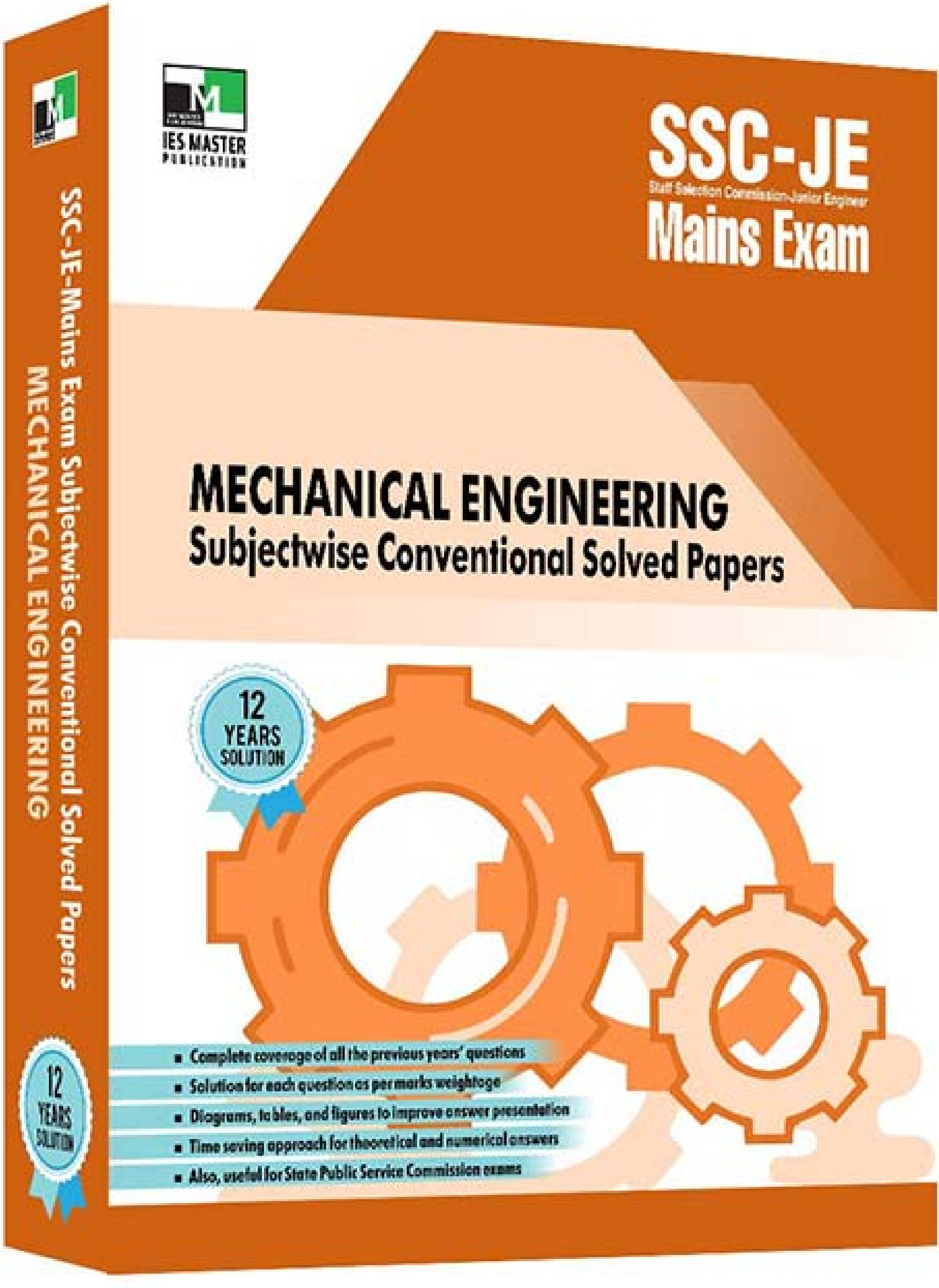
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PREFACE

Thus far, no further… it is one book that covers all the papers, all the questions asked in the SSC-JE Mains exams. If previous years questions give an insight into the mind of examiner, its solutions give you the direction and the distance you need to travel with regard to each and every subject, topic, concept, and numerical. It goes even further in terms of answer writing – giving you language, diagrams, and detail in which you need to answer the questions with regard to the marks allocated to each question.

All this boils down to save time and energy which in turn relieves you of the pressure, more importantly in the exam hall. The book **"IES Master SSC-JE Subject-wise Conventional Solved Papers"** covers questions from the **past 12 years.** Being subjectwise conventional solutions, it gives you complete line and length on which questions have been asked, or in other words the importance that has been associated with one particular subject, topic or concept.

The best way to make optimum use of this book is to go through the questions, attempt solutions, and then cross-check your solutions with the solutions provided in the book. In fact, this act of self-assessment, if you can do in honesty to yourself, can put you on an auto-pilot mode. This indeed, if achieved, can help you achieve things far beyond than the stated objective.

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EXAM PATTERN

PAPERS	MODE OF EXAMINATION	SUBJECT	NUMBER OF QUESTIONS	MAXIMUM MARKS	DURATION & TIMINGS
Paper-I Objective Type	Computer Based Test	(i) General Intelligence & Reasoning	50	50	2 Hours
		(ii) General Awareness	50	50	Morning Shift
		(iii) General Engineering (Mechanical Engineering)	100	100	Evening Shift
Paper-II Conventional Type	Written Examination	General Engineering (Mechanical Engineering)		300	2 Hours

SYLLABUS

PAPER-I

General Awareness

Questions will be aimed at testing the candidate's general awareness of the environment around him/her and its application to society. Questions will also be designed to test knowledge of current events and of such matters of everyday observations and experience in their scientific aspect as may be expected of any educated person. The test will also include questions relating to India and its neighbouring countries especially pertaining to History, Culture, Geography, Economic Scene, General Polity and Scientific Research, etc. These questions will be such that they do not require a special study of any discipline.

General Intelligence & Reasoning

The Syllabus for General Intelligence would include questions of both verbal and non-verbal type. The test may include questions on analogies, similarities, differences, space visualization, problem solving, analysis, judgement, decision making, visual memory, discrimination, observation, relationship concepts, arithmetical reasoning, verbal and figure classification, arithmetical number series etc. The test will also include questions designed to test the candidate's abilities to deal with abstract ideas and symbols and their relationships, arithmetical computations and other analytical functions.

General Engineering

Mechanical Engineering

Fluid mechanics, Thermodynamics, Heat and Mass Transfer, Refrigeration and Air Conditioning, Power Plant Engineering, IC Engine, Theory of Machine, Strength of Materials, Engineering Mechanics, Machine Design, Production Engineering.

PAPER-II

Fluid mechanics : Properties & Classification of Fluid: ideal & real fluids, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, compressible and incompressible fluids. Fluid Statics: Pressure at a point. Measurement of Fluid Pressure: Manometers, U-tube, Inclined tube. Fluid Kinematics: Stream line, laminar & turbulent flow, external and internal flow, continuity equation. Dynamics of ideal fluids: Bernoulli's equation, Total head; Velocity head; Pressure head; Application of Bernoulli's equation. Measurement of Flow rate Basic Principles: Venturimeter, Pitot tube, orifice meter. Hydraulic Turbines: Classifications, Principles. Centrifugal Pumps: Classifications, Principles, Performance.

Thermodynamics : Properties of pure substances: p-v & P-T diagrams of pure substance like H_2O, Introduction of steam table with respect to steam generation process; definition of saturation, wet & superheated status. Definition of dryness fraction of steam, degree of superheat of steam. H-s chart of steam (Mollier's Chart).

1st Law of Thermodynamics: Definition of stored energy and internal energy, 1st Law of Thermodynamics of cyclic process, Non Flow Energy Equation, Flow Energy & Definition of Enthalpy, Conditions for Steady State Steady Flow; Steady State Steady Flow Energy Equation.

2nd Law of Thermodynamics: Definition of Sink, Source Reservoir of Heat, Heat Engine, Heat Pump & Refrigerator; Thermal Efficiency of Heat Engines & co-efficient of performance of Refrigerators. Kelvin – Planck & Clausius Statements of 2nd Law of Thermodynamics, Absolute or Thermodynamics Scale of temperature, Clausius Integral, Entropy, Entropy change calculation of ideal gas processes. Carnot Cycle & Carnot Efficiency, PMM-2; definition & its impossibility.

Refrigeration and Air Conditioning : Refrigeration cycle, principle of a refrigeration plant, VCRS

Power Plant Engineering : Rankine cycle of steam: Simple Rankine cycle plot on P-V, T-S, h-s planes, rankine cycle efficiency with and without pump work. Boilers ; classification, specification; fittings and accessories: Fire tube and water Tube Boilers. Nozzle and steam turbine.

IC Engine : Air standard cycles for IC engines: Otto cycle; plot on P-V, T-S planes; thermal efficiency, Diesel cycle; plot on P-V, T-S planes; thermal efficiency.

IC engine performance, IC engine combustion, IC engine cooling and lubrication.

Theory of Machine : Concept of simple machine, four bar linkage and link motion, flywheel and fluctuation of energy. Gears - Type of gears, gear profile and gear ratio calculation, governors - principle and classification.

Strength of Materials : Concepts of stress and strain, Elastic limit and elastic constants, Bending moments and shear force diagram. Stress in composite bars, Torsion of circular shafts, Buckling of columns – Euler's Rankine's theories, Thin walled pressure vessels.

Engineering Mechanics : Equilibrium of Forces, Law of motion, Friction

Machine Design : Power transmission by belt - V - belts and flat belts, clutches - plate and conical clutch, riveted Joint, Bearings, Friction in Collars and Pivots.

Production Engineering : Classification of Steels: Mild steal and alloy steel, Heat treatment of steel, Welding – Arc Welding, Gas Welding, Resistance Welding, Special Welding Techniques i.e. TIG, MIG, etc. (Brazing & Soldering), Welding Defects and Testing; NDT, Foundry & Casting – methods, defects different casting processes, Forging, Extrusion, etc, Metal cutting principles cutting tools, Basic Principles of machining with (i) Lathe (ii) Milling (iii) Drilling (iv) Shaping (v) Grinding, Machines, tools and manufacturing processes.

CONTENT

UNIT-1 FLUID MECHANICS

SYLLABUS

Properties & Classification of Fluid: ideal & real fluids, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, compressible and incompressible fluids. **Fluid Statics:** Pressure at a point. **Measurement of Fluid Pressure:** Manometers, U-tube, Inclined tube. **Fluid Kinematics:** Stream line, laminar & turbulent flow, external and internal flow, continuity equation. **Dynamics of ideal fluids:** Bernoulli's equation, Total head; Velocity head; Pressure head; Application of Bernoulli's equation. **Measurement of Flow rate Basic Principles:** Venturimeter, Pitot tube, orifice meter. **Hydraulic Turbines:** Classifications, Principles. **Centrifugal Pumps:** Classifications, Principles, Performance.

Q-1: Distinguish between laminar and turbulent flows.

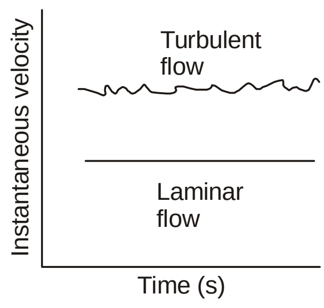
[15 Marks, SSC JE-2004]

Sol: Laminar Flow:

- Laminar flow is sometimes also called as stream line flow.
- Laminar flow is a flow in which liquid moves in layers, one layer sliding over another layer. In this type of flow, there is no mixing between different layers and hence shear force is exclusively due to viscosity.
- Each fluid particles follow a smooth and continuous path. The fluid particles in each layer remain in orderly sequence. e.g. A crude analogy to smilar flow may be soldiers on parade as they march in well defined lines, one behind the other and maintain their order even they turn a corner.
- In Laminar flow, viscous force predominates inertia forces.

Turbulent flow:

- In turbulent flow, due to continuous mixing between different layers momentum transfer occurs which give rise to additional shear.
- Turbulent flow results from the instability of laminar flow.
- The eddies formed in the flow spread over the whole cross-section.
- Due to these eddies, large scale momentum and energy transfer takes place between different layers and hence the various fluid parameters start varying in time and space.
- However for analysis purposes, we will assume that any flow parameter (velocity, pressure, temp etc.) is a combination of average value and fluctuating value.



Instantaneous Velocity in Laminar and Turbulent Flow

- Thus here fluid motion is not orderly and flow resembles a crowd of commuters in a railway station during the rush hours.
- The path of any individual particles is Zig-Zag and irregular, but on a statistical basis, the overall motion of the aggregate of fluid particles is regular and can be predicted.
- Shear stress at the boundary in case of turbulent flow, is much more than that in Laminar flow. This is because at boundary, the shear is primarily due to viscosity.
- It was **Mr. Osborne Reynolds** who confirmed the existence of these two regimes of flow experimentally. He revealed that the nature of fluid flow is governed by non-dimensional number, called later on **Reynolds number,** Re

$$Re = \frac{u_\infty D}{\nu} \text{ for pipe through flow}$$

$$Re = \frac{u_\infty L}{\nu} \text{ for flow over flat plate}$$

where u_∞ = free stream velocity

D or L = characteristics length

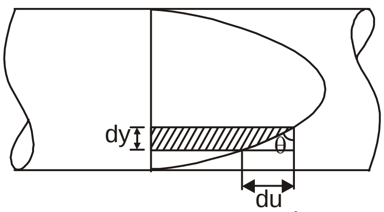
ν = kinematic viscosity of fluid.

Flow flows through pipe, laminar flow exists if Re < 2500. Beyond this value, the flow is regarded as turbulent. In the case of flow over plate, laminar flow exists if Re < 3×10^5. There exists a transition between these two flows.

Note: Additional information for student

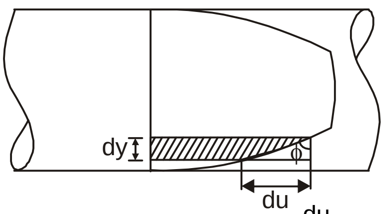
For flow in pipe:

- Flow generally becomes turbulent when Re > 4000. But the value of Reynolds no. at which flow changes from laminar to turbulent is not well defined.
- In between (i.e., generally between Re = 2000 and 4000) flow is in Transition (some times Laminar, some times turbulent).
- As, $\frac{du}{dy}$ i.e. velocity gradient near boundary is large in turbulent flow, hence shear at boundary is large in turbulent flow.



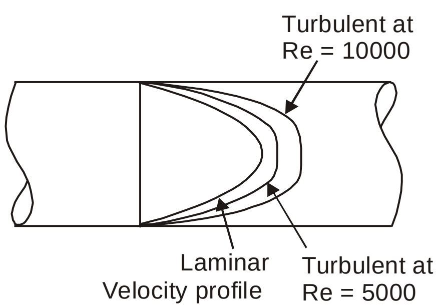
$\tan\theta = \frac{du}{dy}$

Laminar flow profile

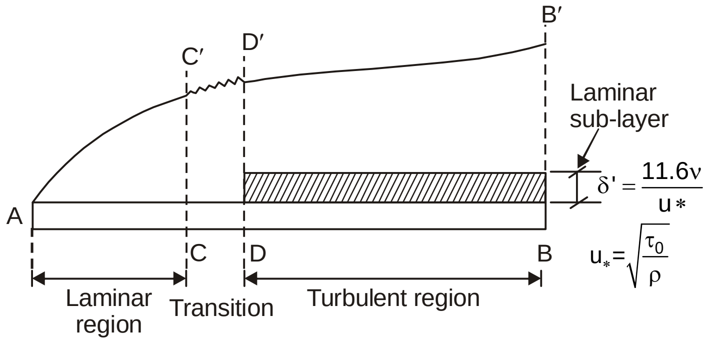


$\tan\phi = \frac{du}{dy}$

Turbulent flow profile



For Flow Between Parallel Plates:



$$Re < 1000, \text{ Laminar}$$

$$1000 < Re < 2000, \text{ Transition}$$

$$Re > 2000, \text{ Turbulent}$$

Q-2: Classify different kinds of hydraulic turbines.

[15 Marks, SSC JE-2004]

OR

What are the various considerations, based on which, Turbines are classified?

[15 Marks, SSC JE-2012]

Sol: Classification of modern water Turbines can be made according to the follows:

(i) The action of water on the moving blades.

(ii) The direction of flow of water in the runner.

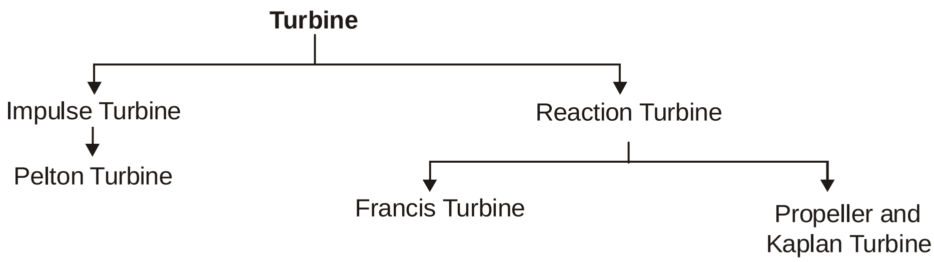
(iii) The head and the quantity of water available.

(iv) The disposition of turbines shaft.

(v) The name of the originator.

(vi) The specific speed N_S.

(i) Classification according to action of water on Moving Blades



Impulse Turbine: In such a turbine, all the available energy of water is converted into kinetic energy or velocity head by passing it through a contracting nozzle provided at the end of the penstock.

- The water coming out of nozzle in the form of a free jet is made to strike only a few of bucket at a time.
- The runner revolve in open air (atmospheric pressure) *i.e.*, there is no difference of pressure in the water at the inlet and outlet.

Example: Pelton wheel, Turgo – Impulse wheel, Girard turbine, Banki turbine and Jonval turbine etc

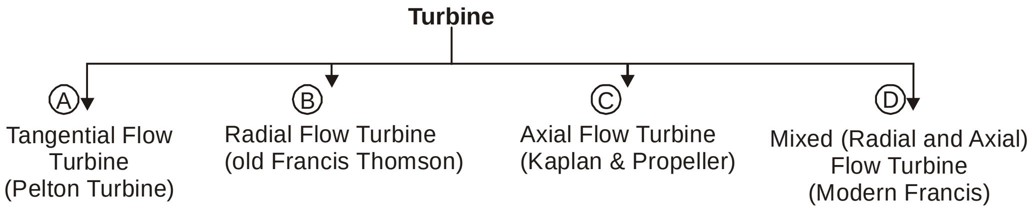
Reaction Turbines: The reaction turbines operates with its wheel submerged in water.

- The water before entering the turbine has pressure as well as kinetic energy.

- All pressure energy is not transformed into kinetic energy.
- The movement on the runner is produced by both kinetic and pressure energies.
- The water leaving the turbine still have the pressure as well as the kinetic energy.
- The pressure at the inlet to the turbine is much greater than pressure at outlet.
- A casing is absolutely essential due to the difference of pressure (or pressure drop) in reaction turbine.

Example: Thomson, Francis, Propeller and Kaplan etc.

(ii) Classification According to direction of flow of water in the runner



A. Tangential Flow Turbine

In tangential flow turbine of pelton type, the water strikes the runner tangential to the path of rotation. This path is the centre line of bucket, which is sometimes, known as pitch circle diameter or means diameter of wheel.

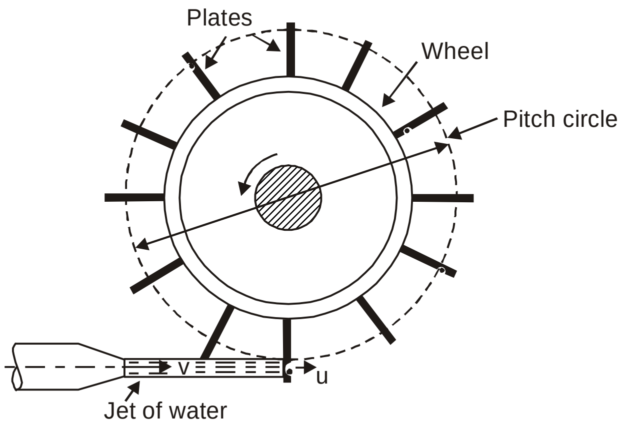


Figure: Jet striking a series of vanes

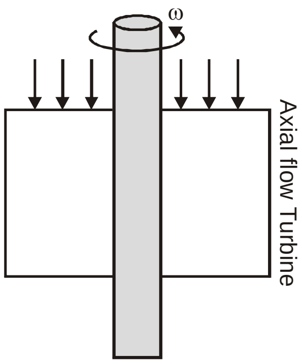
B. Radial Flow Turbine

In radial flow turbine the water flows along the radial direction and remains in the plane normal to the axis of rotation, as it passes through the runner.

C. Axial Flow Turbine

The flow of the water through the runner is along the direction parallel to the axis of rotation of the runner.

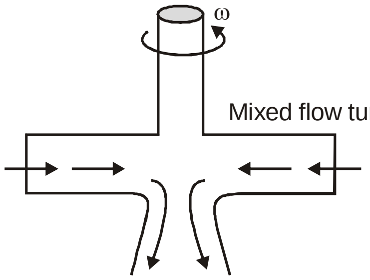
Example: Propeller, Kaplan turbine etc.



D. Mixed Flow Turbine

In this type of turbine water enters the runner at the outer periphery in the radial direction and leaves it at the centre in the direction parallel to the axis of rotation of the runner.

Example: Modern Francis turbine.



(iii) Classification of Turbines Depending upon the Head and the Quantity of Water Available

(a) **Impulse turbine:** Requires high head (H > 400 m) and small quantity of flow.

(b) **Reaction turbine:** Requires low head and high rate of flow.

(iv) Classification According to Disposition of Turbine

Turbine shaft may be either vertical or horizontal. Pelton turbines having number of jets $\leq$ 2, horizontal shaft arrangement may be employed where as for number of jets $\geq$ 4. but $\not>$ 6, vertical shaft arrangement is used. For other turbine (reaction turbine) vertical shaft is used.

(v) Classification According to Specific Speed

The specific speed of a turbine is the speed of geometrically similar turbine that would develop one Brake Horse Power (BHP) in kW under a head of 1 m.

$$\text{Specific Speed } N_s = \frac{N\sqrt{P_t}}{H^{5/4}}$$

where N = Normal working speed in RPM

P_t = Turbine (output) in KW

H = Effective head in meters

(a) Pelton wheel for N_s = 8 to 30 has single jet. (Calculated on per jet basis)

(b) Francis Turbine N_s = 40 to 450

(c) Kaplan Turbine N_s = 300 to 900

(vi) Classification after the names of originators

(a) **Pelton Turbine:** Named in honour of Lester Allen Pelton of USA is an impulse type of turbine, used for high head and low discharge.

(b) **Francis Turbine:** Named after James B.Francis of England is a reaction type turbine for medium head and medium flow.

(c) **Kaplan Turbine:** Named in honour of Dr. V. Kaplan of Germany is a reaction type of turbine for low head and large discharges.

Note: For 5-Marks only different type of consideration shall be written in exam

Q-3: Describe about Francis turbine with respect to its component parts, construction and operation.

[20 Marks, SSC JE-2007]

Sol: **Francis Turbine:** It works on the principle of reaction. i.e. newtons 3rd law

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