Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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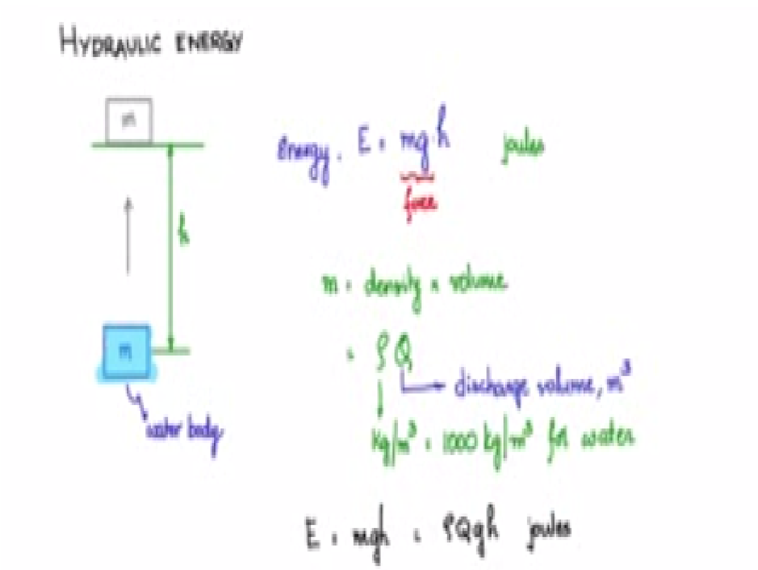

Let us now discuss the hydraulic energy that is required for lifting water from a lower level to a higher level that is for pumping water. Now let us say we have a mass which weighs M, M kgs and you want to lift it to a height H, so we want to bring this mass to this place which is at a height H from the original location.

So you have increased the potential energy in doing so and this energy is given by mgh that is your going to do force against this gravitational acceleration so it has to be lifted against the gravity and your putting energy into it to lift it and that is mass of this body g x h the height to which it is lifted so is in joules so insisted of it is just being some mass jet us say this is a water body so if the water body the mass let us say can expressed as density into volume density of water δ into the volume Q density of water δ into the volume Q density of water in a SI units expressed as kg/m^3 and this is equal to $1000 kg/m^3$ for water and Q is called the discharge volume and this is expressed in m^3 so if you substitute it her for mass as δ into Q you will see that energy is given by m here which is equal to δQgh joules.

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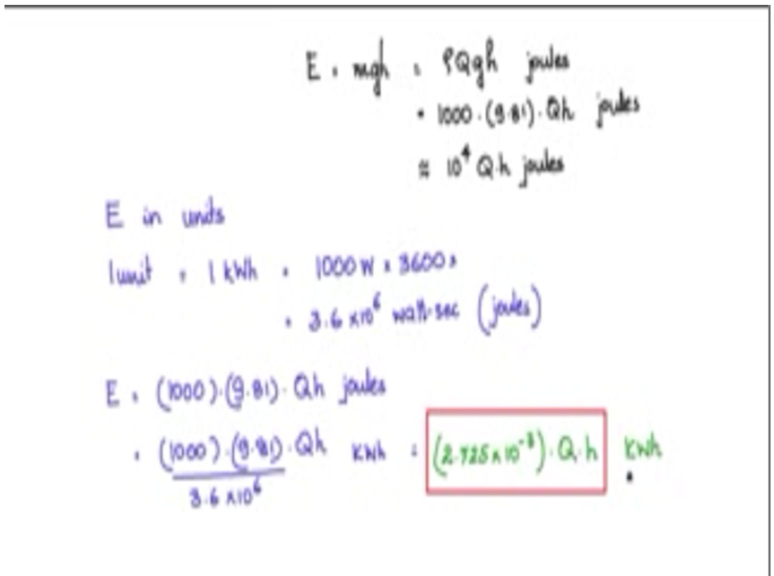

For water δ is the density for water which is 100kg/cubic m so let us put that down Q is a variable g is $9.81m/s^2$ and Q and h or variables this is joules, so if it is a 9.81 approximately 10 you can easily remember it by putting it as 10^4xQ.h joules. Where Q is a m^3 h is in m, so many most of the times you would like to express energy in units one unit is 1kWh which is 1kW is 1000W and 1h is 3600 seconds, so $3.6x10^6$ watt sec or joules.

So you can substitute it here and then you can write it as E=1000*9.81/Qh Joules and 1000*9.81 Qh/3.6 $*10^6$ if you want to express it has kilo watt hours so this because one kilo watt hour is equal to $3.6*10^6$ watts seconds so you can express it in this fashion this will turn out to be $2.725*10^{-3}$ Qh kilo watt hours so this is one way in which you will find it in the literature the hydrogen energy is given as $2.725*10^{-3}$ Qh Q is an meter Q h is in the meters.

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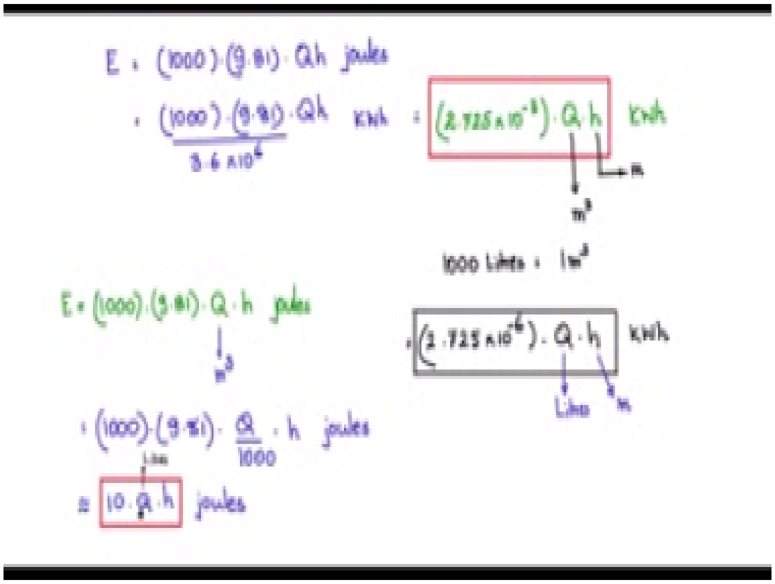

In this expression Q is an expressed in meter cube however the much more general and common as a unit of Q is the liters and it is much easier to imagine in liters than in meter cube the relationship between liters and meter cube is 1000 liters is 1 meter cube and therefore if you want to express this equation where Q is an expressed in liters so all we have to do is $2.725*10^{-6}$.

Instead of -3 we make it as -6 Q/1000 basically so and Q*h kilo watt hours were now Q is expressed in liters h is in meters as you show so this is another expression which people use because there are able to imagine much better in liters they would like to have an expression Q the discharged volumes in liters rather than cubic meter. Another common and very popular method of popular expression for expressing this hydraulic energy is as follows, 1000 x 9.81 that is ρ density x g $9.8m/sec^2$ and Qm^3 hmj. Q is m^3 now we would like to express this Q in liters rather than m^3. So 1000 will come into the picture if you want to express in liters.

So 1000 9.81 m^2 gravity now liters/ 1000 will make it m^3 so the very nice thing about this expression is 1000 and 1000 will cancel of, so you have 9.81 x h and if you take this approximately = 10, you will get a very nice relationship to remember 10 x ^{3} x h j where Q is expressed in units of liters that is nice relationship to remember the hydraulic energy.

Hydraulic energy we can now estimate the hydraulic power is needed to rate the pumps and the motors and the power electronics downstream up to the PV panel. So Ph is nothing but d/dt of the hydraulic energy and this is d/dt of ρ Qgh which is the hydraulic energy. Now ρ which is the density 1000kg/m g is the observation due to gravity 9.81 m/sec their constants, h for a given application the total dynamic head is the constant fixed, the only variable would be Q. So we can bring them out and then d Q/dt. Now d Q/dt is called the discharge rate is the volume.

That is moved out that is flowing through the pipes or the water pumping system per unit time so this discharge rate are the flow rate is the quantity that is measurable and quantity that is also is a requirement from the user perspective when you designing a water pumping system so this is the expression watt so σg.gh watt we can so now we know that σ is 100 we will put that down 9.81 for g Q.h watts.

Now here Q is in meter cube or second units this is the volume discard second h is usual expressed in meters and if you want to express Q. liters per second than divide by 1000 for the liters conversion will get cancelled so you will land up with 9.81 Q.h watts where Q is expressed in liters per second how much wave would be 10.liter watts approximate but the very elegant way of expressing the hydraulic power.

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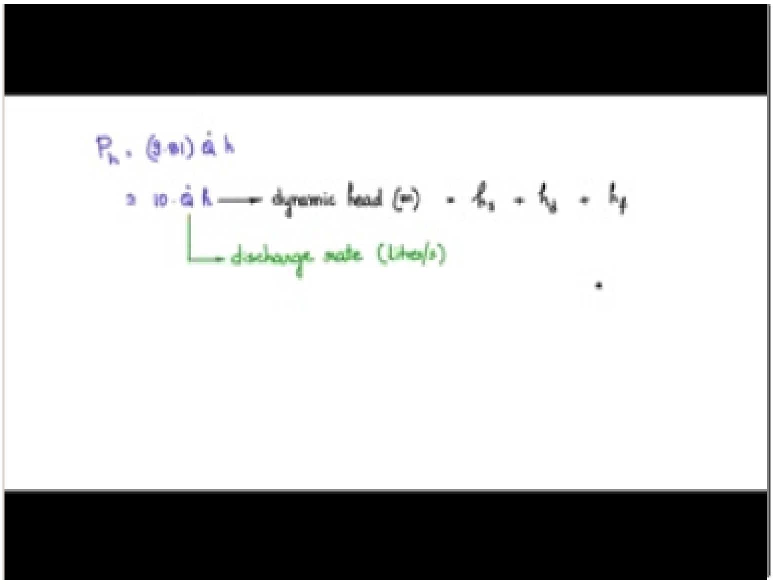

So hydraulic power you know it is approximately 10q.h q. the discharge rate are the flow rate is obtained from the application liters per second and this depends upon how liters of water you want to transfer from the lower level to the higher level or how much liters of water you need for aggregating given piece of land so this spec this value comes from the user requirement H as we know is the dynamic head in meters which is the combination of the succession head addition of succession head the discharge head or the delivery head and also another component which is an equivalent head representing the friction loss in the pipe now how do we estimate this these heads then only you will be able to calculate the hour requirement for that application.