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ENERGY OF MACHINES

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INTRODUCTION

This concept is applicable mainly to Electrical and Electronic Machines e.g. take Processors of Computers they are often measured by MIPs (Million Instructions Per Second) as a measure or characteristic of its Processing Power. But there is another element than just MIPs what my colleague at IIT Kharagpur (Sumanta Raha BTech Chemical Engg 1987 batch) called as Kinetic Energy of a machine e.g. take a calculator it is measured by how fast or rate at which it performs a certain function such as Random Number generation. He proposed that this can be calculated as follows –

K.E. = 1/2 x $(m)v^2$ = 1/2 x (Avg weight of random numbers generated in time t) x (Rate at which the numbers are generated)^2

m=Avg weight of Random numbers generated in time t is = (n1 + n2 ….nn)/n where n1, n2 … nn are ‘n’ Random numbers generated in time t.

Rate at which the numbers are generated can be calculated as follows –

v = (Range of Random numbers generated)/t = (max(nn) – min(nn))/t

I believe this logic is flawed and the right solution is given in the body of this paper (Energy of Machines) and is followed in the next section.

Energy of Machines

Extrapolating on above concept, we can conclude that the Energy of a machine/device is –

Total Energy of a machine/device = Kinetic Energy + Potential Energy (From common laws of Physics)

Random number generation is an elementary benchmark function which can be used for measuring performance of calculators; of course there might be other Benchmark functions used to measure performance.

The Kinetic Energy can be calculated as follows for a device such as a Electronic Calculator –

Assuming that the Random Number generator is used for benchmarking Electronic Calculators,

The hypothetical mass of the Calculator is m = Avg weight of Random Numbers generated in time t

= (n1 + n2 + n3 …+nn)/n for ‘n’ Random numbers generated in time t

Velocity at any given time t = v = (nj + Δnj – nj)/(Δt) = Δnj/Δt where nj is a Random Number generated at time t and (nj + Δnj) is a Random number generated at time (t + Δt). Therefore,

v = Δnj/Δt .

Hence,

Kinetic Energy = K.E. = 1/2 x $(m)v^2$ = 1/2 x ((n1 + n2 + n3 …+nn)/n) x $(\Delta nj/\Delta t)^2$ …… 1)

There are some implicit assumptions made in calculating the KE as given by above equation 1), namely, we have assumed that the Hypothetical mass of the device is given by a Random Sampling of output given by the Random generator which is a benchmark function for measuring performance of the Electronic Calculator. We presume that the Hypothetical mass of the machine/device is a constant (as presumed in Newtonian mechanics) and is given by a typical output generated by the benchmarking function of the device/machine, in other words, it is the Average of outputs generated in a given Random Sample (here in this case, outputs are n1, n2 …nn and mass = m = (n1+n2 ….)/n). Hence we can safely say that the Hypothetical mass = m = constant, can be derived by Statistical Sampling.

We presume that for other devices/machines including the Electronic Calculator having other defining benchmark functions for measuring performance can be used for calculating the Hypothetical mass of the device/machine (via a single output of the benchmarking function) and for calculating the Hypothetical velocity of the device/machine (via the rate at which the above single output is generated in time).

Now coming to the Potential Energy, P.E. of the device/machine, which can be calculated as follows –

P.E. = m x a x h

Where m = constant = (n1+n2…..+nn)/n as given above in the preceding calculations for the K.E. (given in equation 1)).

Acceleration a = (Rate of change at which these above numbers are generated = ((n1/t1)-(n1 +Δn1)/(t1 + Δt1)) / (Δt1) assuming acceleration/deceleration is a constant for the time being for the benchmarking function (This is the norm in Newtonian mechanics). Here n1 is the Random number generated at time t1, (n1+Δn1) is the Random number generated at time (t1 + Δt1). Hence,

a = ((n1/t1)-(n1 +Δn1)/(t1 + Δt1)) / (Δt1) .

h = n_i = Random number generated at given time t.

Therefore,

P.E. = (n1+n2…..+nn)/n x ((n1/t1)-(n1 +Δn1)/(t1 + Δt1)) / (Δt1) x n_i ………………2)

Therefore,

Total Energy of the machine/device = 1) + 2)

= 1/2 x ((n1 + n2 + n3 …+nn)/n) x $(\Delta nj/\Delta t)^2$ + (n1+n2…..+nn)/n x ((n1/t1)-(n1 +Δn1)/(t1 + Δt1)) / (Δt1) x n_i ………………………………………..3)

We have presumed here that for the Random number generator function Hypothetical mass is a constant and Hypothetical acceleration is a constant, which may not be the case at a given time t. Let us assume instead of the Random number generator any other function such as an exponential function or a logarithmic function or a monotonous sequence etc. is the output of a suitable benchmarking function. Again using the above techniques illustrated and suitable sampling the Hypothetical mass can be determined (e.g. we know from statistics and probability theory that most functions follow the bell shaped curve) as the average or mean of the area under the curve. Also at any given time we could predict the slope or rate of output for such functions and also the rate of change of the output for such functions using Calculus and other techniques at a given time t.

We presumed in the above example that the primary function of a device such as an Electronic Calculator is crunching numbers and generating numbers. Also we presumed that the Random Number generation function can be used as a Benchmark function for performance measurements of the device/machine such as the Calculator. Of course, there might be other defining characteristics of devices/machines and suitable benchmarking functions for performance measurement which could be used as illustrated in equations 1), 2) and 3) for determining the total energy of a machine/device at a given time t for the given defining characteristic and the performance evaluation function.

Other examples of devices/machines, their defining characteristics and performance evaluation functions is given below –

e.g. take a device/machine such as an Oven, here the defining characteristic is the temperature and the performance evaluation function could be used from the rate at which temperature rises and the rate of change of the temperature.

Another example is the Refrigerator, in this case, again the defining characteristic again is the temperature but the performance evaluation function is determined by the rate of cooling and the rate of change of the cooling. If freshness of edible items kept in the refrigerator is its defining characteristic, then rate of decay or losing of freshness of edible food and the rate of change of decay/losing of freshness of food can be used for performance evaluation function

If there are multiple defining characteristics for a device/machine the Total Energy of the device/machine can be calculated by taking the sum of the Total Energies of each of the defining characteristics/variables.

Statistical analysis and the Total Energy function could be used as a yardstick for different classes/species of devices/machines e.g. for Ovens we could say that Oven A has a higher/lower energy value than Oven B which could be good/bad for the device/machine as the case maybe for device/machine type Ovens.