Journal of Special Topics

S1_6 Iceman

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November 2, 2009

Abstract

This article investigates the physics behind x-men's Iceman and his ability to produce ice out of the air. Some theoretical ideas to explain the anomaly are suggested. It is concluded that, although he is a genetically advanced human, Iceman is still human and so the energy required to produce any significant amount of ice (being >1kg) is unrealistic and too high to be of any practical use.

Introduction

The film X-men depicts Iceman as a genetically advanced human man with the ability to produce ice out of will [1]. In reality, would he have the energy needed to create even just a tiny amount of ice? How would he create this ice? These questions are investigated in this article.

Investigation

It is assumed that the average size of a man is 80.0kg with a body temperature of 37.5^{o}c and that the water needed to create the ice comes from the air (~15.0^{o}c). It is also assumed that, being a mutant, iceman has some sort of refrigerator-like system within his body which uses his own energy to create ice. A suggestion for how this could work follows. Iceman's body contains organic material that acts as a refrigerant [4].This refrigerant can be compressed in his body and directed into specialised vein-like channels which expand as he pushes the material along his arms. The heat of expansion comes from the water vapour in the atmosphere which turns to ice when it reaches his fingers. Whilst the kinetic energy, which propels the ice from his fingers, comes from electromagnetic pulses associated with the process which accelerate the water vapour as it cools along his arm (because it is heating the expanding organic refrigerant in his arm, which could occupy the whole surface area of his arm in theory). The writer would like to note that this is only one suggestion for the workings of Iceman and although there may be other ways for Iceman to produce ice, due to length restrictions on the article this will be the only one suggested and used for the calculations.

For calculation purposes a 1.00kg mass of water vapour is chosen to be turned into ice. The energy required to change this water into ice is calculated below. The heat needed to cool the water to 0.00^{o}c is

$$Q_c = mc\Delta T = 62.7kJ \quad (1)$$

of energy [3]. Here, m is the mass of water (1.00kg), c the heat capacity of water (4.19kJ/kgK) and ΔT the change in temperature (15.0K). Freezing this water releases a further

$$Q_f = ml_f = 534kJ \quad (2)$$

of energy [3], where l_f is the latent heat of water (534kJ/kg). The total energy released when a 1.00kg mass of water is turned into ice is therefore approximately 597kJ. The work (W) required to transfer heat from the air to his body can now be worked out using equation 3.

$$W = \left(\frac{T_h}{T_c} - 1\right) Q \quad (3)$$

where T_c is the temperature of the air and T_h is the temperature of Iceman's body (both in Kelvin). The work done by Iceman himself is therefore 42.4kJ.

Looking at the recommended daily allowance (RDA) for the average man (2500 calories/10kJ) this would mean that Iceman would have to eat more than four times this recommended amount to turn just 1kg of water into ice by the end of the day. So if Iceman were to instead be put on a very high calorie diet of say 2500 calories (10kJ) per meal (neglecting the fact that this is an enormous amount to eat in one go for anybody!), Iceman would have to eat about 5 of these meals a day at a rate of one meal every 4.8hours in order to produce 1kg of ice at the end of the day. Although 5 meals would give Iceman slightly more energy than he needs to produce the ice the calculation used does not include the energy needed for basic functions such as moving of limbs, eating and breathing. So in reality the energy needed is even larger than that calculated. Thus we will call the calculated work the minimum energy needed by Iceman.

Given that the energy required for 1kg of water is so high, smaller amounts of water were investigated next to find a more reasonable energy requirement for a given mass of ice. The graph below displays these results.

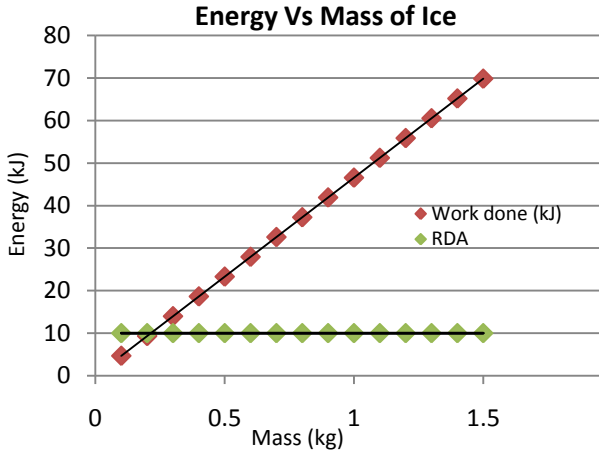

Figure 1

Analysis

As you can see from Figure one, the energy required by Iceman to produce ice quickly becomes much larger than the RDA. The point on Figure 1 where the work done by Iceman to produce the ice is the same as the RDA of a human man equates to 10kJ needed for 0.215kg of ice. Any mass beyond this requires

$$E = (46.6m - 6.00x10^{-15})\text{kJ} \qquad (4)$$

of energy from Iceman (equation was found by line of best fit on Fig 1.) Thus any significant amount (we set this as being >1kg) would need a very large amount of energy from Iceman. Certainly any large amount would not be viable. For example, using equations 1, 2 and 3 we find that 500kg of ice would need an input of ~23300kJ of energy from Iceman. Clearly, this is excessive to say the least.

Conclusion

In answer to the questions we originally asked, if Iceman did exist and could use an organic refrigerator-like system like the one suggested previously, it is not unlikely that he could produce small amounts of ice after a large (e.g. 2500cal) meal. However, in the film x-men, Iceman is able to produce large amounts of ice, including a thick ice wall [2]. We have shown that the energy needed to produce anything like this (estimating the mass to be ~917kg for a $1m^3$ ice wall [5]) would be too much for any human.

References

[1] 20th Century-Fox Film Corporation, 2000, X-men
[2] Marvel Enterprises, 2003, X-men 2
[3] Physics for Scientists and Engineers Fourth Edition Paul A. Tipler
[4] Transport properties of organic liquids by By G. Latini et. Al.
[5] http://hypertextbook.com/facts/2000/AlexDallas.shtml