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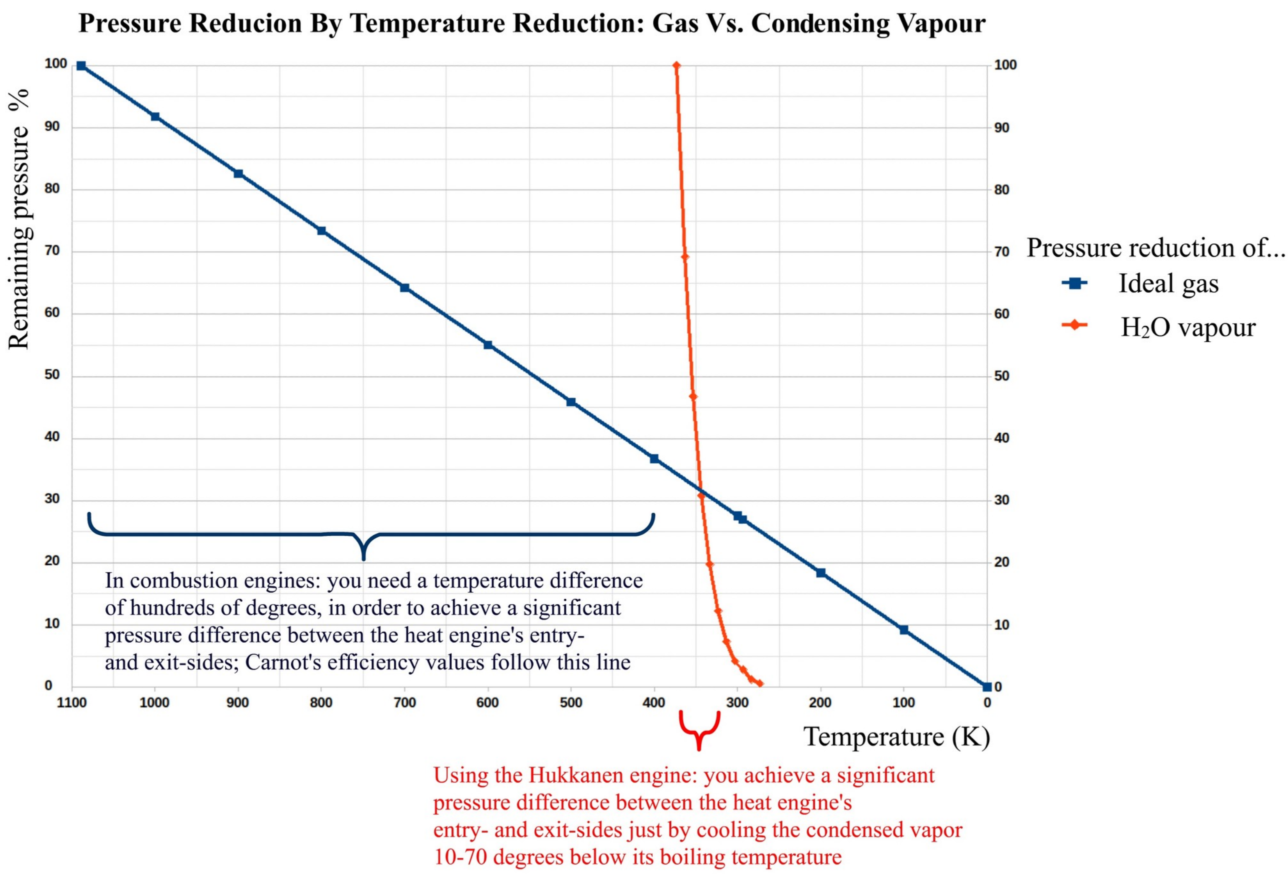
How and why *the Hukkanen engine*'s efficiency can beat the Carnot's maximum efficiency

(written by Vesa J. Hukkanen)

The following picture (picture 1) shows the pressure reduction, induced by the temperature reduction inside a closed container, being very different for the ideal gas (and other gases) Vs. for the condensing water vapor.



Picture 1: Pressure reduction of ideal gas (blue line) and condensing saturated water vapor(red line) as a function of reduced temperature inside a closed container. Calculations of values are shown in tables 1 and 2.

It should be observed that in picture 1, the lowering of the ideal gases pressure(blue line), occurs linearly and over a much wider temperature range than the pressure reduction of the condensing water vapor.

The following table (table1) shows the origin of the blue line’s values shown in picture 1. Basically, the values in table 1 demonstrate the Carnot’s maximum efficiency (η_{Carnot}) values being intimately linked to the ideal gases linear pressure reduction as a function of the temperature reduction inside a closed container.

Container's temperature (K)	Pressure (kPa) inside a $1m^3$ container containing 41.418 moles of ideal gas	How many percentages is this pressure of the ideal gases pressure that would exist in that container at 1089K	Calculated Carnot's maximum efficiency: assuming a hot-side temperature 1089K $\eta_{Carnot} = 1 - (T_{(cold)} / T_{(hot)})$	100% - calculated Carnot's maximum efficiency $x = 100\% - \eta_{Carnot}$
1089	374.1122 =>	**100.00%**	0.00% =>	**100.00%**
1000	343.5373 =>	**91.83%**	8.17% =>	**91.83%**
900	309.1836 =>	**82.64%**	17.36% =>	**82.64%**
800	274.8299 =>	**73.46%**	26.53% =>	**73.46%**
700	240.4762 =>	**64.28%**	35.72% =>	**64.28%**
600	206.1224 =>	**55.10%**	44.90% =>	**55.10%**
500	171.7686 =>	**45.91%**	54.09% =>	**45.91%**
400	137.4150 =>	**36.73%**	63.27% =>	**36.73%**
300	103.0612 =>	**27.55%**	72.45% =>	**27.55%**
294	101.0000 =>	**27.00%**	73.00% =>	**27.00%**
200	68.7075 =>	**18.37%**	81.63% =>	**18.37%**
100	34.3537 =>	**9.18%**	90.82% =>	**9.18%**
0	0 =>	**0.00%**	100.00% =>	**0.00%**

Table1: Calculations that show the connection between the Carnot's maximum efficiency values and the pressure reduction inside an ideal gas containing closed container upon cooling the container.

It should be observed that in picture 1, the ideal gases pressure reduction (blue line), indicates the pressure reduction being linear and heading towards zero pressure at zero degrees Kelvin (273.15°C).

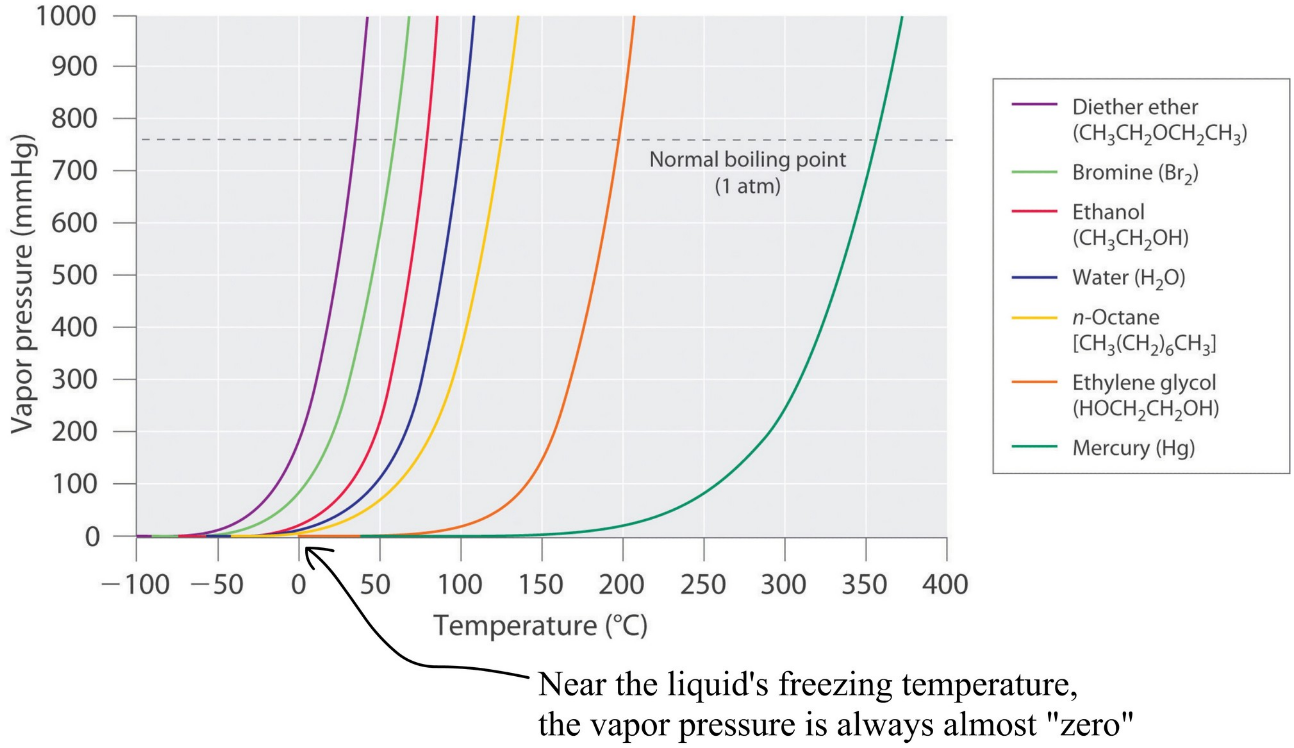
The following table (table2) shows the origin of the (red line) values shown in picture 1. Basically the values in table2 show that the pressure reduction of the condensing water vapor, as a function of reduced temperature inside a closed container, occurs non-linearly.

Temperature (K)	Saturated water vapor pressure (kPa)		How many percentages is this water vapor pressure of the pressure that existed at 373K
373	101.42	==>	**100.00%**
372	97.85	==>	**96.50%**
371	94.39	==>	**93.10%**
370	91.03	==>	**89.80%**
369	87.77	==>	**86.50%**
368	84.61	==>	**83.40%**
363	70.18	==>	**69.20%**
358	57.87	==>	**57.10%**
353	47.41	==>	**46.80%**
343	31.20	==>	**30.80%**
333	19.95	==>	**19.70%**
323	12.35	==>	**12.20%**
313	7.38	==>	**7.30%**
303	4.25	==>	**4.20%**
293	2.81	==>	**2.80%**
283	1.23	==>	**1.20%**
273	0.61	==>	**0.60%**

Table 2: pressure reduction of water vapor as it gets cooled below its boiling temperature inside a closed container

The values in table2 and in picture 1 show a forceful drop of the water vapor's pressure to a vacuum pressure level as the water vapor gets cooled towards water's freezing temperature. For example at the temperature of 323K (50.15°C) the water vapor's pressure is only 12.2% of the pressure that existed at 373K (100.15°C).

Picture 2 shows that the nature of the water vapor's pressure reduction is not an exception among vaporized liquids. In fact, many different vaporized liquids have quite similar and strong pressure drop over a relatively narrow temperature range; as those liquids get cooled below their boiling temperatures.



Picture 2: vapor pressure reduction of various other liquids as they get cooled below their boiling temperatures. Picture slightly modified from the original picture provided by the Howard University's (CC3.0,SA,NC)

Using *the Hukkanen engine*, vaporized liquids get cooled below their boiling temperature at the heat engines exit-side. The fact that the condensing vapor's pressure is reduced more, as a function of the temperature reduction, than the ideal gases pressure reduction suggests a different and a higher maximum efficiency value for *the Hukkanen engine* than for the traditional Carnot's heat engine. This is a result of the maximum efficiencies of the heat engines being a result of the pressures at the heat engines entry- and exit-sides; as is shown by the author's article "Heat engines are powered by pressure – not heat"[1]. Simply put, when the condensing vapor gets cooled below the boiling temperature, its pressure decreases and the more the heat engine's exit-sides pressure drops, the higher will be the heat engines maximum efficiency that can be calculated from the equation:
$\eta_{max}=1-(P_{(exit\text{-}side)} / P_{(entry\text{-}side)})$

Thus, an example calculation of the heat engines maximum efficiency using that equation $\eta_{max}=1-(P_{(exit\text{-}side)} / P_{(entry\text{-}side)})$ can be dome as follows. Let's assume a heat engine's entry-side's vapor pressure being 100kPa. In addition let's assume that the heat engine's exit-side's vapor's temperature gets reduced to near the liquid's that fluid's freezing temperature. Thus, a partial vacuum will be formed at the heat engine's exit-side; lets say the vapor's pressure being 10kPa. Thus, we can then calculate the heat engine's maximum efficiency as follows:

$\eta_{max}=1-(P_{(exit\text{-}side)} / P_{(entry\text{-}side)})$
$\implies \eta_{max}=1-(10kPa / 100kPa)$
$\implies \eta_{max}=1-0.1$
$\implies \eta_{max}=1-0.1$
$\implies \eta_{max}=0.9$
$\implies \eta_{max}= 90\%$

[1] Hukkanen, V. (2021). Heat engines are powered by pressure – not heat. Available from https://web.archive.org/web/20211214100753/https://blog.hotbenefits.com/wp-content/uploads/2021/12/article_14_12_2021.pdf