European Union energy label

As energy costs rise, the importance of furnace consumption rise as well, whether in natural gas or electricity. However, if we are going to buy a refrigerator or a washing machine, we have EU energy label on it showing that the appliance works in class A +++ -.

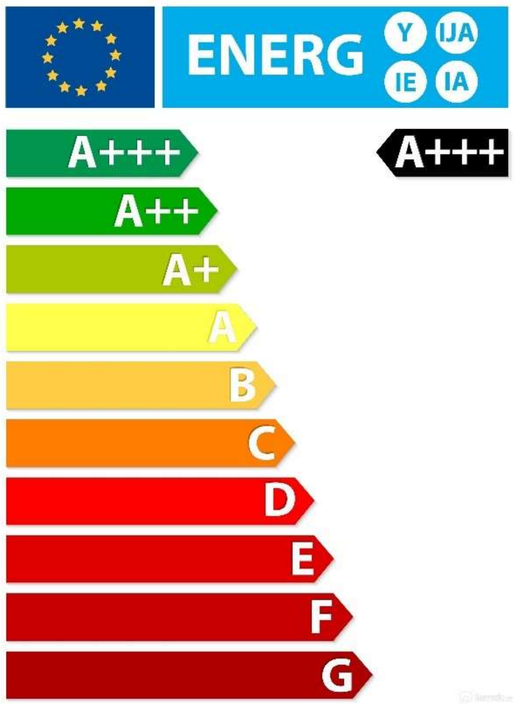


Fig. 1 *- A typical energy label for home appliances.*

But what about heat treatment equipment? When investing in new equipment, we usually find out from the offer what the total input of the furnace is, sometimes added information about the input of the cooling turbine or vacuum pumps, input for oil bath heating etc. However, these are the data we need to dimension the cable or circuit breakers and fuses. However, we usually do not receive any information about the actual consumption. And when we ask about it, we usually get strange information from furnace manufacturers, which usually indicates their detachment from reality. At the same time, for example, in a well-managed heat treatment plant, one of the KPI indicators is the sales per 1 KWh of energy consumed, or to calculate the cost of the quotation process, we must know at least the average equipment consumption so we can calculate cycle costs and then set the quoted price.

Since two new vacuum furnaces from TAV Vacuum Furnaces SPA were installed in CZ last autumn, one for hardening, type TAV H8-S, the other for tempering, type H6-T, I started thinking about how to evaluate them in terms of energy consumption. In energy consumption per 1 hour of operation, per 1 kg of charge, etc.? And if I come to any value, how to compare them with other, similar devices?

The basis of the following analysis is the knowledge of the energy consumption per cycle, from pressing START to STOP cycle, and at the same time the knowledge of the weight of the charge placed for processing in the furnace. The first part of the problem is simple, just have an electric meter or gas meter on the furnace, or both, and the appropriate furnace software will already show us how much energy was consumed in a given cycle time. If I then divide this consumption by the cycle time, I get the approximate average value of the furnace consumption per operating hour.

But since I can have a different batch size in each cycle, we still need to know the weight of the parts in the processing cycle. But furnace software usually can't do that anymore. Therefore, it is necessary to think about the connection of the furnace with the ERP system, with the module for managing sales orders, technological processes and related work cycles. Within this interconnection, we must have the ability to assign the consumed energy to the cycle ID in the virtual world of the ERP system, which does not know the energy consumption, but on the contrary, must know the weight of all production orders placed in the furnace. If subsequently the average consumption of the furnace is divided by the weight of the charge, we get the value of the average energy consumption per 1 kg of goods.

Is it simple enough? I think so, even if we ignore for this method of calculation the fact that within one furnace cycle the consumption changes and is different when heating the furnace and parts to temperature, during holding time, during cooling, hardening or in situations where the furnace only we draw on the necessary vacuum. But because we are looking for average values, then I think that the result obtained in this way is sufficiently representative.

And what is the result?

1. Comparison of individual technologies

All values need to be taken with caution, because this methodology has no support in any established methodology, yet it seems to me that the results are not only interesting, but also in line with the average reality (Fig. 1)

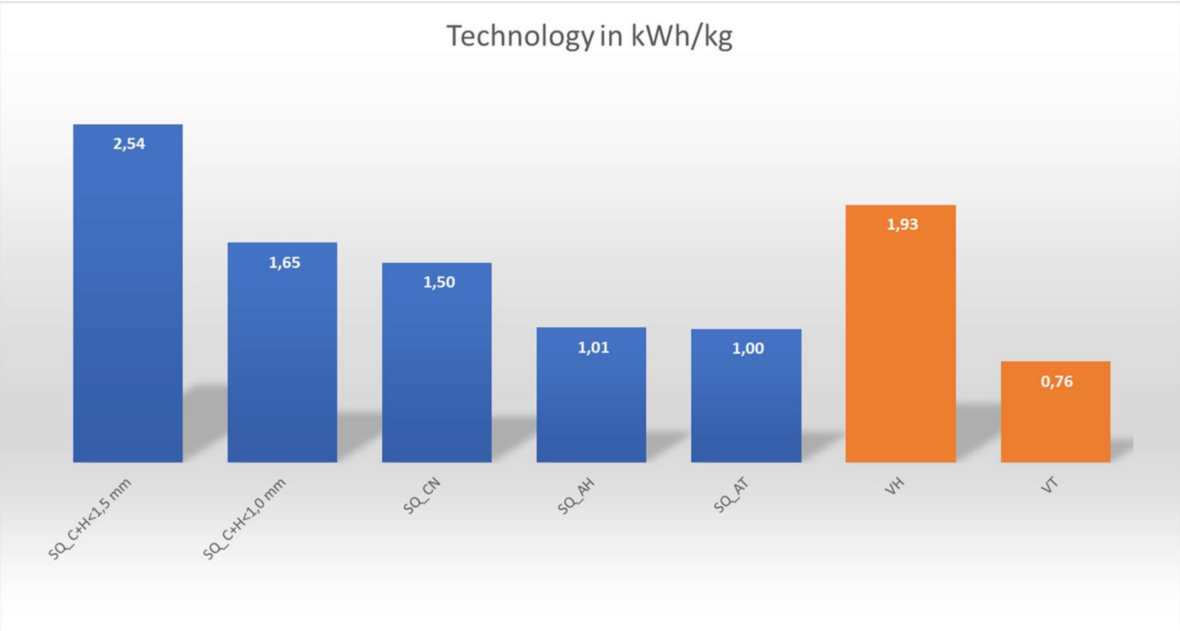


Fig. 2 *– Average energy consumption by technology and type of equipment*

Used shortcuts:

- *SQ - Multipurpose furnaces*
- *V - Vacuum furnaces*
- *C + H <1.5 mm - gas carburizing with CHD <1.5 mm, typical Ipsen TQF7 and 8 furnaces*
- *C + H <1.0 mm - gas carburizing with CHD <1.0 mm, typical Ipsen TQF7 and 8 furnaces*
- *AH - Hardening under protective atmosphere in SQ furnaces, typical Ipsen TQF7 and 8 furnaces*
- *CN – Carbonitriding in gas with CHD <0.5 mmm of typical furnace Ipsen TQF7 and 8*
- *AT - Tempering without or with protective atmosphere, typical Ipsen DAC or DL 7 and 8 furnaces*
- *VH - Vacuum hardening in various vacuum furnaces with different size*
- *VT - Vacuum tempering in various vacuum furnaces with direct heating and different size*

Logically, the highest energy costs are for processes that require long times. It is a carburizing or carbonitriding. It can be seen from Figure 2 that 2.54 kWh / kg falls on carburizing with CHD <1.5 mm. This is followed by carburizing to CHD <1.0 mm and carbonitriding with depths up to 0.5 mm. For direct hardening in multi-purpose furnaces, we need about 1 kWh per 1 kg of goods.

There are also some interesting results, which are logical, but in practice not everyone will notice them. For example, vacuum hardening consumes 2x more energy per kg of charge than multi-purpose hardening. Why? For multi-purpose hardening, we load into a furnace heated to at least 750 C, for a vacuum furnace we always start from zero. From this point of view, if we have SQ furnaces still heated on temperature, this type of hardening is significantly less energy-intensive per 1 kg of charge. Provided that at the same time we ignore the idling costs of heating the furnaces in non-production times.

In order to achieve the same consumption result in vacuum furnaces, we will probably have to think about a two-chamber or multi-chamber solution.

2. Comparison of vacuum hardening furnaces

And how are the new furnaces from TAV Vacuum Furnaces? Compared to other similar devices very well. However, it must be said that these similar devices are not age-identical, so I prefer not to mention their names or manufacturers. These are generally devices with an age of 5 and 30 years, different designs and different qualities of furnace insulation (Fig. 3)

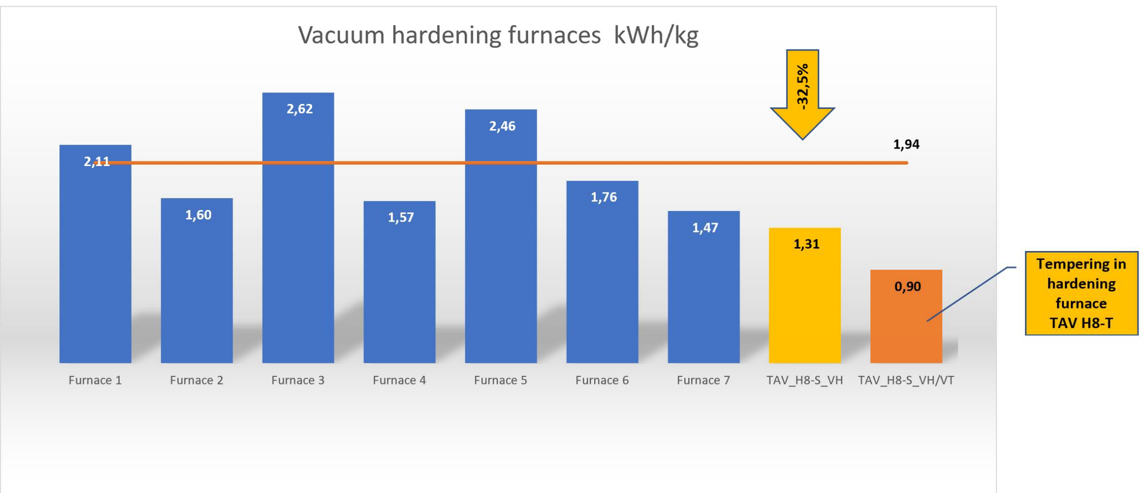


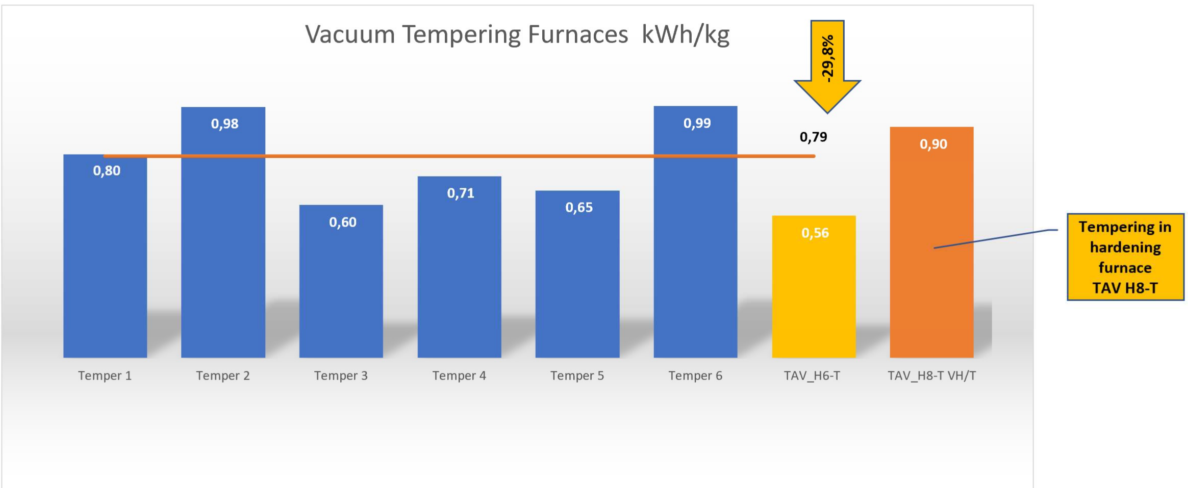
Fig. 3 *– Comparison of vacuum hardening furnaces*

It is a surprise to me that the new TAV H8-S furnace has 32.5% lower consumption per unit charge weight than the average value for other furnaces. With a value of 1.31 kWh/kg of charge, we are slowly approaching the value that came out for multi-purpose hardening, ie 1 kWh/kg. In the last column there is also a value of 0.90 kWh/kg for the situation when we are tempering in the hardening furnace.

3. Comparison of vacuum tempering furnaces

If we compare vacuum tempering furnaces with direct heating design, the TAV H6-T tempering furnace works very well here and its consumption shows the lowest values of all analyzed furnaces. The difference compared to the average is also almost 30%. The last column also shows the consumption value when tempering the charge in the hardening furnace. This is just to get a picture of the effectiveness of this type of tempering (Fig. 4)

The fact that the energy consumption for tempering in the hardening furnace is by 79% higher than when we are tempering in the tempering furnace is only part of the problem. In addition, the second problem is that the tempering cycle time in the hardening furnace will be 1 to 3 hours longer than in the tempering furnace (Fig. 5)



***<u>Fig. 4</u>** – Comparison of vacuum tempering furnaces in kWh/kg*

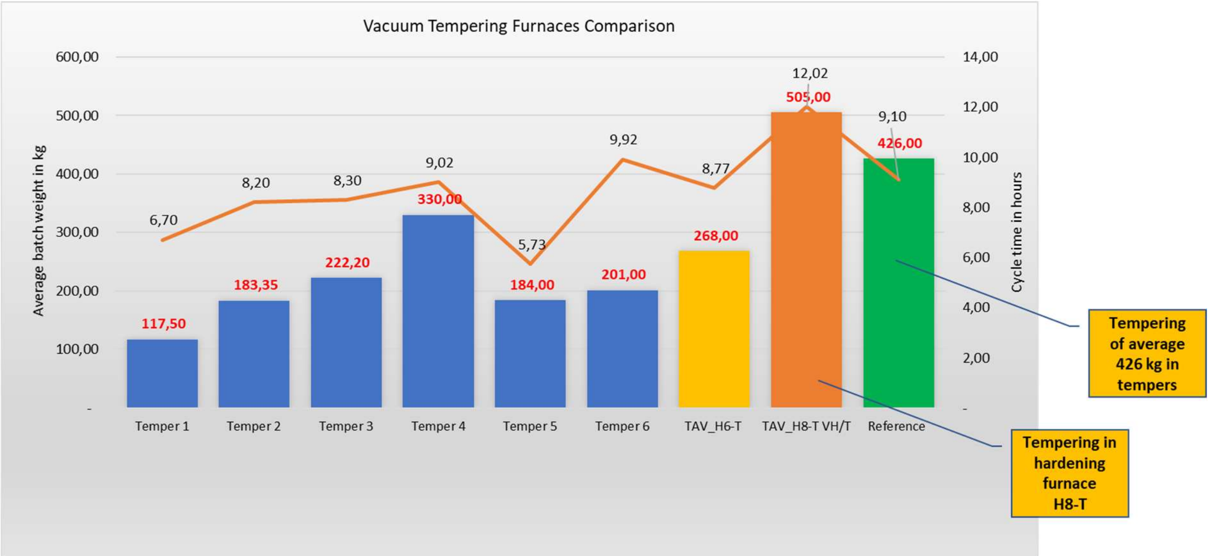


Fig. 5 *– Comparison of vacuum tempering furnaces in terms of time and batch weight and data for tempering in the hardening furnace (orange), and for tempering of AVG gross charge of 426 kg in tempers (green)*

The above analysis does not make any claims in terms of accuracy. But because every appliance, every new car has to account for its share of the carbon footprint, I believe that furnace manufacturers also need to change their minds. It doesn't matter which methodology they choose, but if we invest in equipment worth hundreds of thousands of euros, we have the right to know that in advance. It's a lot of money.

If we take into account 70% utilization of the furnace, ie 6132 Nh, for hardening furnace average consumption 70 kW/hour, for tempering 20 kW/hour, then this is an annual consumption of 551 880 kWh (= (70 + 20) * 6132). With an energy saving of 30%, this is an annual saving of 165,564 kWh. That's a lot. And if we have to use the furnace for 20 years, then this is a very significant cost item.

February 22, 2022

Jiří Stanislav