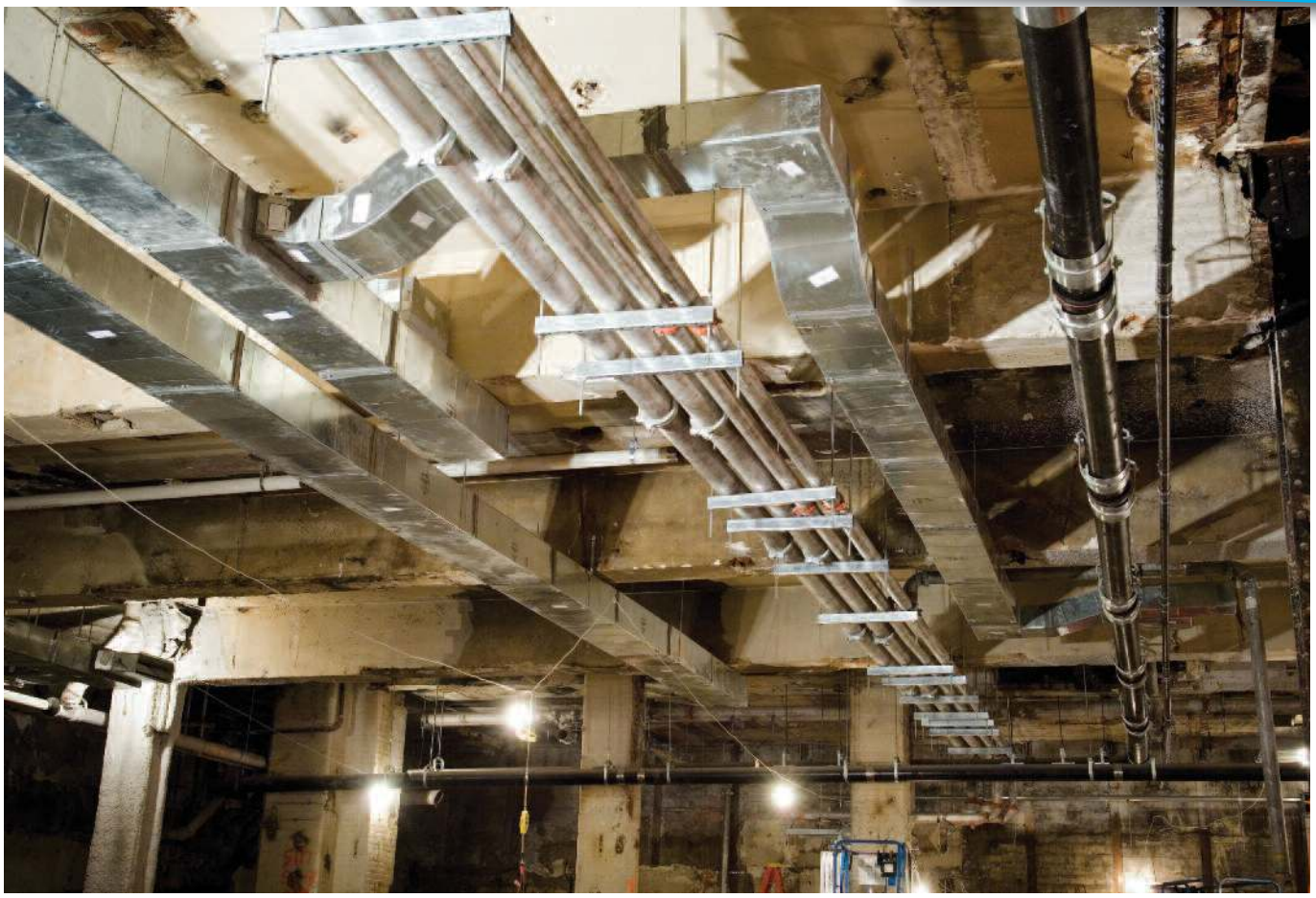

Using stainless steel for transporting drinking water?

There have been several years of international discussions concerning the potential role of stainless steels in replacing copper in the pipes used to supply drinking water. This article pays particular attention to the specific benefits of stainless steel when compared to copper.

Keywords: Copper; Drinking water; Plastics

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What is copper?

Copper is a metal that has been used for years as a means of transporting drinking water to taps in homes and other buildings. Copper is a soft and malleable metal due to its face-centred cubic atomic lattice. In addition, it offers good resistance to corrosion. Nevertheless, it is increasingly coming under fire because of the copper ions released into the drinking water that undermine public health. A detailed study was commissioned by the European Commission to find out the emission values of various metals and plastics in drinking water. The results for copper were rather disappointing whilst stainless steel, on the other hand, was shown to do particularly well.

Copper and public health

(source: Lenntech b.v.)

Copper can be found in various types of food, drinking water and even in the air. As a result, people involuntarily take in considerable amounts of copper every day just through eating, drinking and breathing. The absorption of a certain amount of copper is necessary as it is a trace element essential for human health. Although humans can absorb reasonably large concentrations without consequences, too much copper can cause significant health problems. People who live in houses with copper plumping are exposed to higher concentrations of copper as copper ions are released into the drinking water through the corrosion of pipes. People

may also come into contact with copper through their work, and in such working environments, contamination with copper may lead to a flu-type condition known as copper fever. According to the WHO (World Health Organization) and guidelines from the EU, the maximum copper content of drinking water must not exceed 2 mg/litre.

Environmental effects of copper

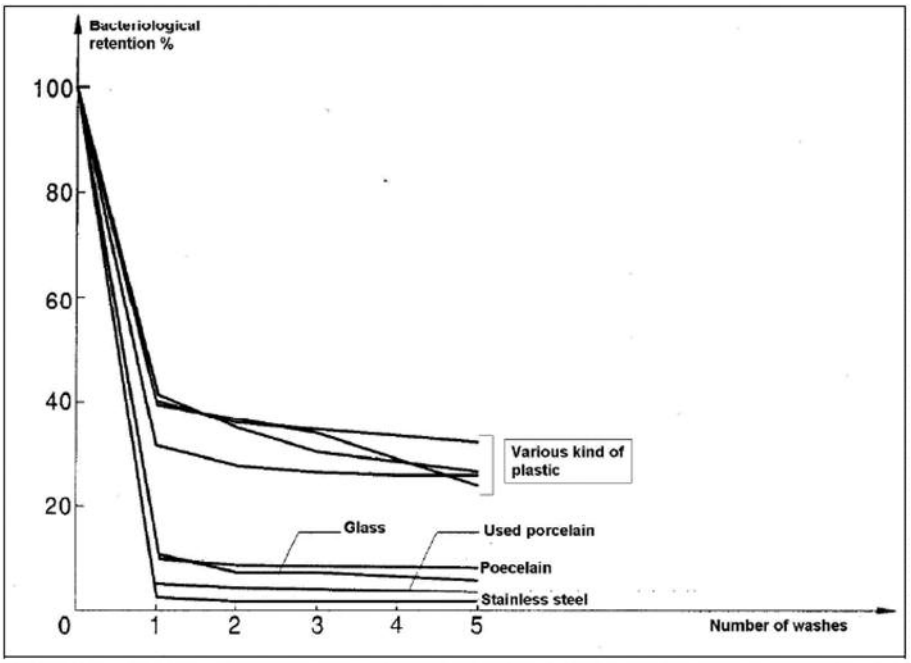
When copper ends up in soil, it attaches strongly to organic matter and minerals. In surface water, copper can travel for great distances, either suspended on sludge particles or as free ions. Copper does not break down in the environment and can therefore accumulate in plants and animals when it is found in soil. Due to the effects of copper on plants, copper poses a serious threat to agriculture.

Sewage treatment plants

More than half of the copper that reaches sewage treatment plants is caused by the corrosion of copper plumbing. In a particular year, 166 tonnes of copper reached sewage treatment plants in The Netherlands (16 million inhabitants) in the form of copper ions. Of these, 94 tonnes originated from copper emissions caused by copper water pipes. After the waste water had been purified, there were still 128 tonnes of copper remaining in the sludge; an amount too high for the sludge to be used in the fertilisation of farmland.

Bacteria

Tap water should not pose a risk to public health and this also applies in connection to bacteria. Bacteria tend to adhere to surfaces where they can form harmful biofilms. To do so, they require a 'shelter' in which to settle. Copper surfaces have been found to offer better 'shelter' than stainless steel, even though one would expect the reverse to be true as copper is somewhat biocidal. However, stainless steel has a smooth, hard oxide layer which offers inferior accommodation to these micro-organisms. On the other hand, the topography of copper surfaces promotes bacterial growth.



Graph 1. Bacteria retention after the water pipes have been cleaned. The best results were obtained by stainless steel. (Source: V. Boneschi and A. Quazzo.)

Plastics

Due to the harmful effects of copper, people are increasingly looking at plastics as a material for transporting drinking water and these materials are now being used on a regular basis. Increasingly, plastic water pipes are installed but these have been shown to leak questionable substances. According to scientists, plastic water pipes can emit various harmful phenols into drinking water. This has been proven by different studies recently conducted in European laboratories. The concentrations encountered in pipes, which are currently being installed in homes on a large scale, are high enough to pose a threat to public health.

In an article published by the Legionella Communication Platform entitled 'Formation of biofilms and growth of legionella bacteria in pipe installations', it was explained that in an experimental hot tap system (37 ºC) with a pattern of domestic tap use, Legionella bacteria multiply in biofilms found in pipes made of stainless steel, copper and plastic (PE-xa). The formation of biofilms on PE-xa was more pronounced than on stainless steel or copper.

Graph 1 shows the effect of cleaning on a range of materials used for drinking water. Various types of plastic were found to give particularly poor results. Porcelain and glass fared significantly better, but stainless steel was found to be the clear winner.

According to experts, the use of plastics in this type of application is not made easier by the fact that they deteriorate faster than stainless steel. Plastics are therefore treated with additive agents which do not easily dissolve in water but which do dissolve in polymers. These agents must prevent the degradation of plastics. These additives can, however, dissociate; a process which releases miniscule particles into the drinking water and which is therefore undesirable.

The question therefore is whether these types of additives will still be permitted to be used in plastics in the future. Certain types of plastics may well be banned by the government in the not too distant future.

Conclusion

Based on the facts described above, it seems highly logical that it will not take long before stainless steel replaces even copper. Actually, this is just history

repeating itself as who would ever have thought in the past that copper would replace lead? Indeed, lead was eventually banned by the governments of several countries and this may well happen with copper. The question, however, is which type of stainless steel would be suitable for this purpose and how should it be processed.

titanium and the grades 1.4435 and 1.4436 have an increased molybdenum content which provides better resistance against pitting. From a practical point of view, grades 1.4401 and 1.4404 are more than adequate. Nor does it matter which of the two is used as, under the right processing conditions, neither are susceptible to inter-crystalline corrosion. Table 1 lists the chemical composition of the various types mentioned. This table does not include the contamination amounts permitted.

Table 1
Chemical composition of various types of stainless steel containing molybdenum

RVS type	C max. %	Cr %	Ni %	Mo %	Ti %	Mn %
1.4401	0.07	16.5-18.5	10.5-13.5	2.0-2.5	--	2.0
1.4404	0.03	16.5-18.5	11.0-14.0	2.0-2.5	--	2.0
1.4571	0.08	16.0-18.5	10.5-13.5	2.0-2.5	5xC<=0.8	2.0
1.4435	0.03	17.0-18.5	12.5-15.0	2.5-3.0	--	2.0
1.4436	0.07	16.5-18.5	12.0-14.0	2.5-3.0	--	2.0

Suitable types of stainless steel

The DVGW (Deutsche Verein Gas und Wasserwerke) in Germany has only permitted the use of molybdenum-bearing stainless steel grades for domestic applications and this was recorded in the GW541 worksheet which was published in 2003 and which specifies the following material numbers: 1.4401 (AISI316), 1.4571, 1.4404 (AISI316L), 1.4435 and 1.4436. Material number 1.4571 is an AISI316 alloy that has been stabilised with

Difference between processing stainless steel and copper

Copper is a metal that is easy to manufacture and process. After all, it is a relatively soft and ductile material that can easily be connected to attachments and fittings with compression fittings or by soft soldering. This is not quite as simple with stainless steel as accountable soldering of stainless steel may only be carried out by specialist companies. This is why special compression fittings have been designed which can create perfect connections in a few seconds with the help of a pair of tongs (Fig. 1).

Fig. 1. Special compression fittings made from stainless steel.

Fig. 2. Special tongs to connect pipes and fittings.

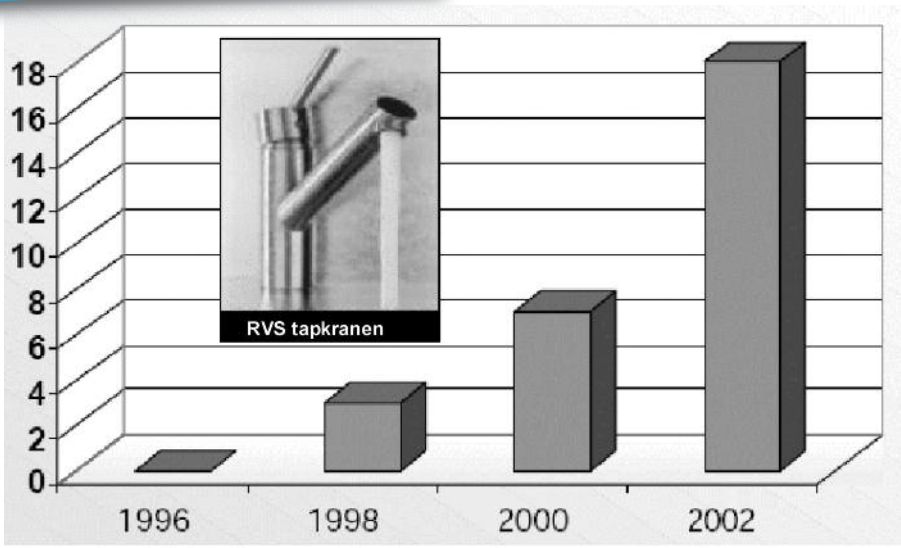
These fittings are connected with a special pair of tongs that creates a perfect connection in a few seconds at the press of a button (Fig. 2).

One advantage of this is that the process is considerably quicker than soldering copper; partly as there is no need to wait for the connection to cool down. In addition, this method of connection eliminates the risk of leakage due to incomplete soldering. In other words, from a technical perspective, it is an improvement as it eliminates human errors.

Although stainless steel is fairly malleable, it is still somewhat more difficult to bend than copper. Another potential problem is strain hardening which can soon lead to the appearance of dents. One solution for this is soft annealed stainless steel pipe materials which can be achieved by annealing the material at 1065°C for a certain amount of time followed by sudden cooling. The pipe manufacturer can carry out this annealing process on request.

Current situation

The use of stainless steel in this market segment is still quite uncommon in many countries even though it is used prolifically in Switzerland, Italy, Germany



Graph 2. The number of manufacturers in Italy that produce stainless steel taps. (Source: V. Boneschi and A. Quazzo.)

and Denmark. Graph 2 shows the huge increase in only a few years' time in the number of Italian manufacturers producing stainless steel taps. There is an increasing call on governments to make stainless steel compulsory. It would also appear that force of habit reigns supreme and it therefore seems like a huge step to switch from copper to stainless steel. If you look at the cost aspect alone, it immediately becomes apparent how expensive copper has become.

Fig. 3. Stainless steel tubes used for drinking water.

Although stainless steel is not a cheap material either, if you take everything into account, the final cost price will not be that much different. Certainly when you take into consideration the financial consequences of all kinds of disorders and other negative effects resulting from the use of copper.

JMC

Quite a few changes have been made in the international drinking water industry in recent years. Europe now has the JMC (Joint Management Centre), an organisation set up by water experts in Germany, France, the UK and The Netherlands. This committee includes representatives from Ministries of Health, the Comité Européen de Normalisation (CEN), and various specialists from water inspection institutes. The JMC is concerned with the standardisation of national guidelines, particularly those covering hygienic aspect of drinking water. However, they also take a critical look at the metals and plastics to be used. The JMC will shortly admit stainless steel to the list of accepted materials for the drinking water industry.

Conclusion

An analysis of all facts and figures will firmly dispel any preconceptions of stainless steel being a difficult and expensive option as a material for drinking water pipes. It is just a matter of time and awareness before this material will be permanently implemented in this market.

Facts concerning public health, in particular, will give a significant boost to the use of stainless steel. People should also not be surprised if the use of stainless steel is eventually made mandatory by governments.

In addition, pipe fitters will learn that the high price of copper and the time saved in processing stainless steel are good reasons for focusing much more attention on the latter material.

About Ko Buijs

Ko Buijs is a metallurgist who has many years of experience dealing with stainless steels, explosion welding, and special metals such as nickel alloys, zirconium and titanium. He provides technical lectures on a wide variety of topics at Technical Centres of Higher Education and Knowledge Centres. He also helps companies in their materials selection and advises them how to avoid corrosion. Ko is also the author of "The Corrosion Wizard" a cd-rom helping the reader with:

- optimising metal selection
- avoiding and combating corrosion
- limiting chemical attack on a metal
- achieving trouble-free service
- finding answers to specific metallurgical questions

It contains information about the following metals:

- stainless steels; subdivided into ferritic chromium steels, austenitic stainless steels, duplex and super duplex stainless steels, and high performance stainless steels
- nickel and nickel alloys
- titanium and titanium-Pd
- copper and copper alloys such as brass, bronze, copper/nickel and aluminium bronze carbon steel

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