BRIAN DENGEL
GENERAL MANAGER • KHK-USA

What, precisely, is my gear made of?

Almost 90 percent of the steel produced is carbon steel, but alloy steel, stainless steel, or tool steel are possibilities as well.

The building blocks for all materials are microstructures known as atoms. Whether the material in question is a plastic, a metal, or even your skin, they each consists of atoms co-existing in a peaceful dance known as bonding. Each atom consists of electrons, protons, and a nucleus. When a group of identical atoms are grouped together, they form an element. Since the late 1600s when the concept of atomic structure was first discussed, a total of 118 unique elements have been identified. It is from these elements that we can manufacture gears.

Researchers have determined that the ten most populous elements on Earth are: oxygen, silicon, aluminum, iron, calcium, sodium, magnesium, potassium, titanium, and hydrogen. Some of these elements exist in their natural state and others join together with other elements to form compounds. It is the compounding of elements that create the materials that we use every day.

Carbon is an element that is the foundation of all cellular life. It has unique properties that allow it to compound with nitrogen, hydrogen, and oxygen to form the building blocks of plant and animal cells. Carbon is also a valuable element for gearing as it can be compounded with iron to form steel.

Steel is an alloy of iron, carbon, and other trace elements. It is generally accepted that there are four basic types of steel: carbon steel, alloy steel, stainless steel, and tool steel. Almost 90 percent of the steel produced is carbon steel. The chart included here details the steel classification system of AISI and SAE. The first two digits of the steel designation are determined by the basic structure of the steel, and the last two digits as represented by the XX in the table represent the percentage of carbon in the steel. For example, a 1020 carbon steel has a 0.20 percent carbon content, whereas a 1045 carbon steel has a 0.45 percent carbon content.

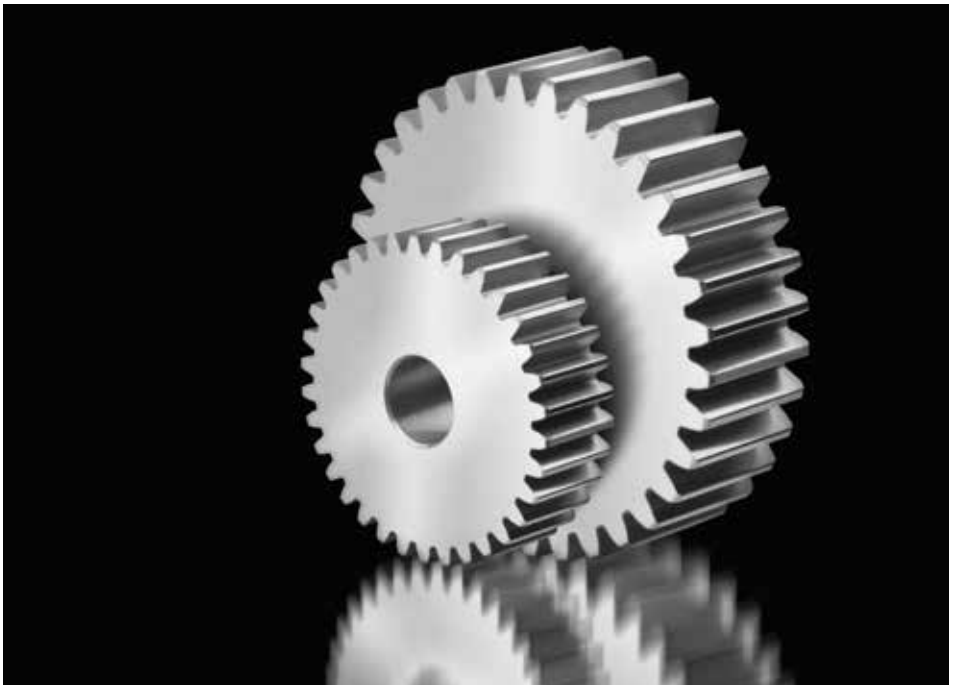
Carbon steels can be further classified into mild steel, medium carbon, and high carbon steel. Mild steel has a less than 0.30 percent carbon content. High carbon steel has a carbon content greater than 0.60 percent, and the medium content steels fall in between.

Alloy steels such as 4140 contain additional elements such as aluminum, chromium, copper, and/or nickel. These other elements when alloyed with the iron and carbon create steels which are stronger, easier to machine, and offer more corrosion resistance than plain carbon steel.

Stainless steels have a minimum chromium content of 11 percent and are an alloy of many trace elements including nickel, manganese, silicon, phosphorus, sulfur, and nitrogen. They are subdivided into ferritic stainless steels, which are magnetic, and austenitic stainless steels, which are nonmagnetic. The austenitic stainless steels are designated as 300 series stainless steels, whereas the ferritic stainless steels are designated as the 400 series stainless steels.

Tool steels are the final family of steel. They are steel alloys with traces of cobalt, molybdenum, tungsten and/or vanadium. These elements add heat resistance and durability to the steel.

There is one additional alloy of steel that has yet to be developed. It is frequently requested by customers for use in their gear design. This alloy is known as unobtainium. This material is extremely light-



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weight, has a hardness greater than that of a natural diamond, has a co-efficient of friction of 0.001, is dimensionally stable in all environments, neither corrodes nor rusts, it is easily machinable and a raw material cost of $0.01 per pound. Once invented it will make all other steels obsolete and will greatly improve gear train efficiency.

AISI/SAE Designation	Steel/Alloy	Chemical Composition
10XX	Carbon steels	Plain carbon, Mn 1.00% max
11XX		Resulfurized free machining
12XX		Resulfurized / rephosphorized free machining
15XX		Plain carbon, Mn 1.00-1.65%
13XX	Manganese steel	Mn 1.75%
23XX	Nickel steels	Ni 3.50%
25XX		Ni 5.00%
31XX	Nickel-chromium steels	Ni 1.25%, Cr 0.65-0.80%
32XX		Ni 1.75%, Cr 1.07%
33XX		Ni 3.50%, Cr 1.50-1.57%
34XX		Ni 3.00%, Cr 0.77%
40XX	Molybdenum steels	Mo 0.20-0.25%
44XX		Mo 0.40-0.52%
41XX	Chromium-molybdenum steels	Cr 0.50-0.95%, Mo 0.12-0.30%
43XX	Nickel-chromium-molybdenum steels	Ni 1.82%, Cr 0.50-0.80%, Mo 0.25%
47XX		Ni 1.05%, Cr 0.45%, Mo 0.20-0.35%
46XX	Nickel-molybdenum steels	Ni 0.85-1.82%, Mo 0.20-0.25%
48XX		Ni 3.50%, Mo 0.25%
50XX	Chromium steels	Cr 0.27-0.65%
51XX		Cr 0.80-1.05%
50XXX		Cr 0.50%, C 1.00% min
51XXX		Cr 1.02%, C 1.00% min
52XXX		Cr 1.45%, C 1.00% min
61XX	Chromium-vanadium steels	Cr 0.60-0.95%, V 0.10-0.15%
72XX	Tungsten-chromium steels	W 1.75%, Cr 0.75%
81XX	Nickel-chromium-molybdenum steels	Ni .30%, Cr 0.40%, Mo 0.12%
86XX		Ni .55%, Cr 0.50%, Mo 0.20%
87XX		Ni .55%, Cr 0.50%, Mo 0.25%
88XX		Ni .55%, Cr 0.50%, Mo 0.35%
92XX	Silicon-manganese steels	Si 1.40-2.00%, Mn 0.65-0.85%, Cr 0-0.65%
93XX	Nickel-chromium-molybdenum steels	Ni 3.25%, Cr 1.20%, Mo 0.12%
94XX		Ni 0.45%, Cr 0.40%, Mo 0.12%
97XX		Ni 0.55%, Cr 0.20%, Mo 0.20%
98XX		Ni 1.00%, Cr 0.80%, Mo 0.25%

ABOUT THE AUTHOR

Brian Dengel is general manager of KHK-USA, which is based in Mineola, New York. Go online to www.khkgears.us