

## Gear materials and Heat treatment

It's essential to select proper material and heat treatments in accordance with the intended application of the gear. Here we lay out few common gear materials for your reference.

### No.1 Material selection

#### 1. AISI 1045 / S45C

S45C is one of the most commonly used steel, containing moderate amounts of carbon (0.45% ). S45C / 1045 is easily obtainable and is used in the production of spur gears, helical gears, racks, bevel gears and worms.

Heat Treatment and Hardness

Heat treatment	Hardness
None	≤ 194 HB
Thermal refining	225 - 260 HB
Induction hardening	45 - 55 HRC

#### 2. AISI 4140 / 42CrMo4 / 1.7225 / SCM440

An alloy steel containing moderate amounts of carbon (0.40% ). It also contains chrome / molybdenum. 4140 / 42CrMo4 / SCM440 has more strength than 1045 / S45C and is used with thermal-refining or induction-hardening treatment for producing gears.

Heat Treatment and Hardness

Heat treatment	Hardness
Thermal refining	225 - 260 HB
Induction hardening	45 - 60 HRC

#### 3. AISI 4115 / 15CrMo5 / 1.7262 / SCM 415

4115 / 15CrMo5 / SCM415 is one of the most commonly used low-carbon alloy steel (C = 0.15%). Generally, it is carburized for use. It has more strength than 1045 / S45C or 4140 / 42CrMo4 / SCM440. Surface hardness should be between 55 and 60HRC for use.

#### 4. AISI 303 / X10CrNiS18-9 / 1.4305 / SUS303

Since it is called "stainless steel", it is a rust-resistant steel. This authentic stainless steel is basically non-magnetic. Most commonly used for gears in applications where rust contamination is undesirable, such as in food-processing machinery. There is a similar stainless steel called AISI 304 / SUS304 which has more corrosion resistance than AISI 303 / SUS303

## 5. Copper Alloy Casting

Frequently used as a material for worm wheels. Phosphor bronze casting (CAC502) or aluminum-bronze casting (CAC702) are commonly used. For mating worms, iron metals such as 1045 / S45C, 4140 / SCM44, 4115 / SCM415 are used. To prevent galling / seizure by slippage, different materials are used for each of the paired worm and worm wheel.

## No.2 Heat treatments

### What is Quenching ?

Quenching is a treatment performed on steel, applying rapid cooling after heating at high temperature (Approximate 800C). Quenching is applied to adjust the hardness of steel. There are several types of quenching in accordance with cooling conditions; oil quenching, water quenching, and spray quenching. After quenching, tempering must be applied to give toughness back to the steel, that might become brittle. Quenching cannot harden genuine steel, however, quenching can work for steel containing more than 0.35% carbon.

### What is Thermal Refining ?

Thermal Refining is a heat treatment applied to adjust hardness / strength / toughness of steel. This treatment involves quenching and tempering. Since machining is applied to products after thermal refining, the hardness should not be raised too high in quenching.

### What is Induction Hardening ?

Induction Hardening is a heat treatment performed to harden the surface of the steel containing carbon more than 0.35%, such as 1045 / S45C or 4140 / 42CrMo4 / SCM440. For gear products, induction hardening is effective to harden tooth areas including tooth surface and the tip, however, the root may not be hardened in some cases. The precision of gears declines by induction hardening. To encourage the gear accuracy, grinding must be applied.

### What is Carburizing ?

Carburizing is a heat treatment performed to harden only the surface of low-carbon steel. The surface, in which carbon is present and penetrated the surface, gets especially hardened. Inner material structure (with low-carbon C=0.15%) is also hardened by some level of carburizing, however, it is not as hard as the surface. The precision of carburized gears declines by 1 grade or so, due to deformation (dimensional change) or distortion. To encourage the gear accuracy, grinding is essential.

### What is Nitriding ?

Nitriding is a heat treatment performed to harden the surface by introducing nitrogen into the surface of steel. If the steel alloy includes aluminum, chrome, and molybdenum, it enhances nitriding and hardness can be obtained. A representative nitride steel is AISI 7140 / DIN 1.8550 / 34CrAlNi7 SACM645 (Aluminum chromium molybdenum steel).