1.4005

X12CrS13

Stainless martensitic, chromium steel with sulphur

C 0.08 – 0.15 **Cr** 12.00 – 14.00 **S** 0.15 – 0.35 **Mo** max. 0.60

General comments

1.4005 is essentially 1.4006 to which sulphur has been added in controlled amounts to improve machinability and allow this steel to be readily used for automated machining purposes. The corrosion resistance and surface finish is however inferior than that of 1.4006 due to the addition of sulphur.

Relevant current and obsolete standards

EN 10088-3	1.4005	X12CrS13
AISI	416	
BS	416S21	
JIS	416	
AFNOR	Z11CF13	
DIN 17440	1.4005	
SIS	2380	

Special grade for particular use

shaft material

General properties

corrosion resistance	low
mechanical properties	average
forgeability	poor
weldability	with care
machinability	good

Special properties

ferromagnetic grade

Physical properties

density (kg/dm^3)	7.70
electrical resistivity at 20 °C (Ω mm^2/m)	0.60
magnetizability	possible
thermal conductivity at 20 °C (W/m K)	30
specific heat capacity at 20 °C (J/kg K)	460
thermal expansion (K^{-1})	20 – 100 °C: 10.5 x 10^{-6}
	20 – 200 °C: 11.0 x 10^{-6}
	20 – 300 °C: 11.5 x 10^{-6}
	20 – 400 °C: 12.0 x 10^{-6}

Typical applications

automotive industry
petrochemical industry
electronic equipment
mechanical engineering

Note: 1.4104 with improved corrosion resistance can be used as an alternative.

Processing properties

automated machining	yes
machinable	yes
hammer and die forging	seldom
cold forming	yes
cold heading	not common
suited to polishing	no

Conditions

annealed, tempered

Demand tendency

decreasing

Corrosion resistance

Although 1.4005 contains a nominal 13 % chromium, its corrosion resistance is compromised by the addition of sulphur. Care should thus be taken when specifying this stainless steel for use in corrosive environments which might promote crevice and/or pitting corrosion. 1.4005, is probably the least resistant to corrosion of all of the stainless steel grades.

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Heat treatment and mechanical properties

1.4005 is usually delivered in the annealed condition. This condition is obtained by heating in the temperature range 745 °C to 825 °C, followed by slow cooling in a furnace. In this condition, the following mechanical properties can be expected:

Property		Specification
tensile strength (N/mm²)	R_m	≤ 730
hardness	HB	≤ 220

Note: the HB values could be 60 units higher and the tensile strengths 150 N/mm² higher due to cold work during straightening of profiles ≤ 35 mm.

This steel may be heat treated by hardening in air or oil after holding at a temperature between 950 °C and 1000 °C. Although a range of mechanical properties may be obtained by tempering at different temperatures, the QT 650 condition is usually specified and may be obtained by tempering in the temperature range 680 °C to 780 °C. In this condition, the following mechanical properties can be expected:

Property		Specification	Typical
yield strength (N/mm²)	$R_{p0.2}$	≥ 450	480
tensile strength (N/mm²)	R_m	650 – 850	710
tensile elongation (%)	A_5	≥ 12	14

The mechanical properties (d ≥ 160 mm) have to be agreed on for thicker dimensions, or the delivered product is based on the values given.

Elevated temperature properties

Due to the possibility of 475 embrittlement, processing or service in the temperature range between 425 °C and 525 °C is to be avoided, or at least minimised. In the QT 650 heat treated condition, the elevated temperature strengths will essentially be the same as for 1.4006.

Welding

In general welding of a steel with high sulphur content should be discouraged especially when autogenous welding is considered, with the exception of friction welding. When welding is unavoidable, then the use of 1.4833 as a filler material should be considered. Tempering at 650 °C after welding is recommended to restore some ductility to the weld and heat affected zone. Care must also be taken to ensure that the shielding gasses used during welding do not contain nitrogen or hydrogen.

Forging

Gradual heating to a temperature of about 800 °C is recommended prior to more rapid heating to a temperature of between 1150 °C and 1180 °C. Forging then generally takes place between 1180 °C – 1000 °C followed by slow cooling in an oven or in dry ash or similar material to promote slow cooling.

Machining

1.4005 displays improved machinability compared with 1.4006 as a result of the sulphur addition. As with all martensitic stainless steels, the machining parameters will depend on the heat treated condition of the steel. Bearing this in mind and using coated hard metal cutting / machining tools, the following machining parameters can be used as a guideline.

1. Turning CNC:

	Depth of cut (mm)	6	3	1
	Feed rate (mm/r)	0.5	0.4	0.2
Annealed	Cutting speed			
R_m 600 – 685 N/mm²	(m/min)	160	200	300
Quenched and tempered	Cutting speed			
R_m 750 – 950 N/mm²	(m/min)	200	250	350

2. Automated machining

	Depth of cut (mm)	6	3	1
	Feed rate (mm/r)	0.5	0.4	0.2
Annealed	Cutting speed			
R_m 600 – 685 N/mm²	(m/min)	155	165	195
Annealed and drawn	Cutting speed			
R_m 695 – 780 N/mm²	(m/min)	140	165	175
Quenched and tempered	Cutting speed			
R_m 750 – 950 N/mm²	(m/min)	175	200	240

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