Aug. 10, 1971 TETSURO ITO ET AL 3,598,574

FREE CUTTING STAINLESS STEELS

Filed Nov. 5, 1968 4 Sheets-Sheet 1

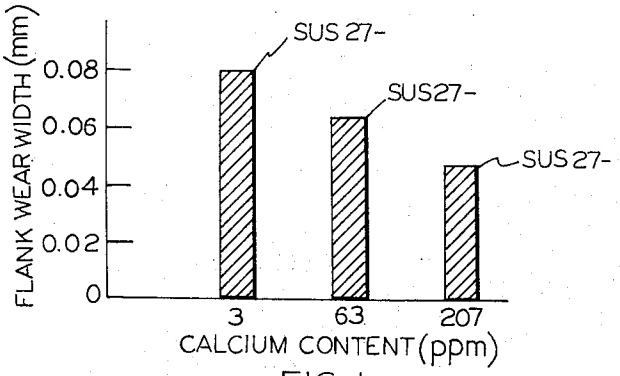


FIG. 1

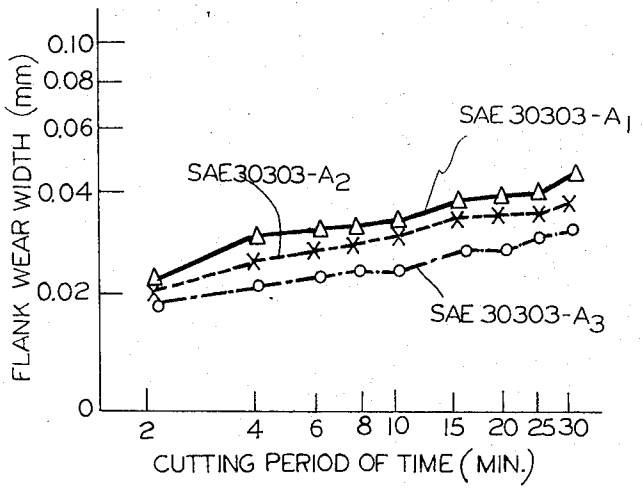


FIG. 2

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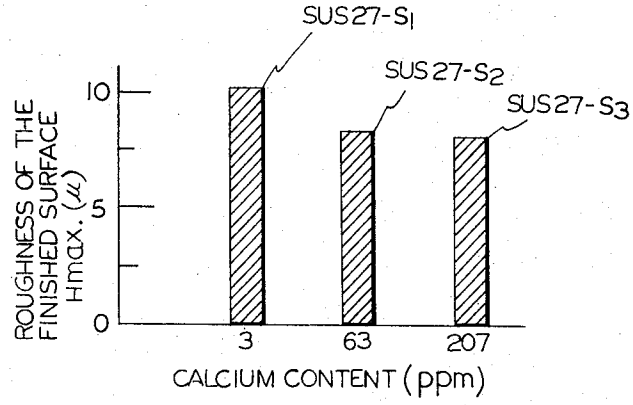


FIG.3

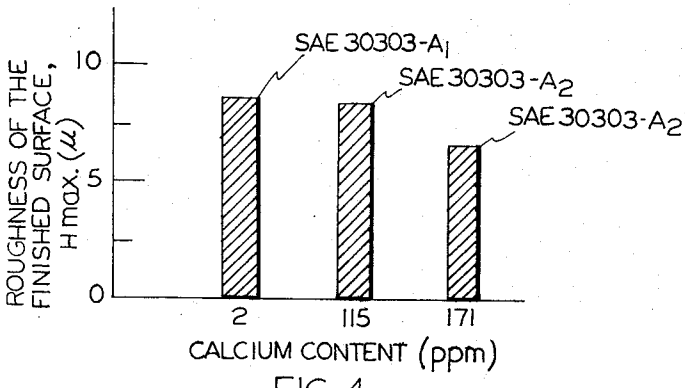


FIG.4

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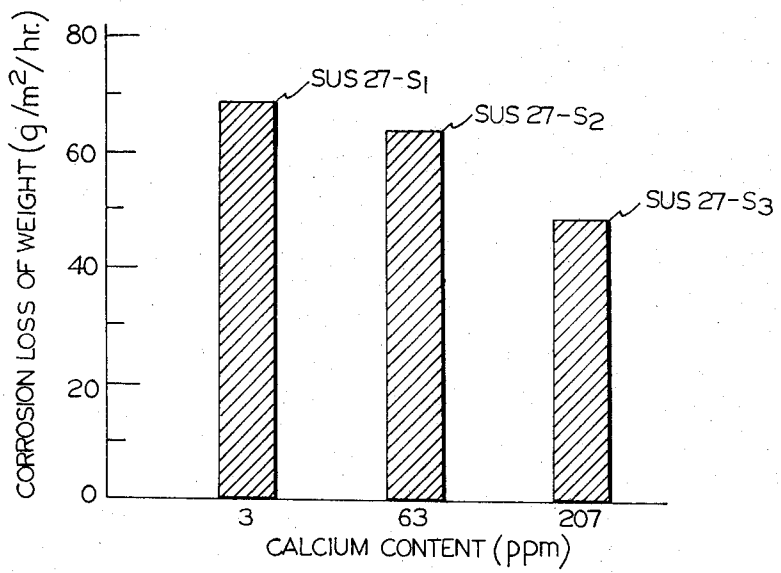


FIG. 5

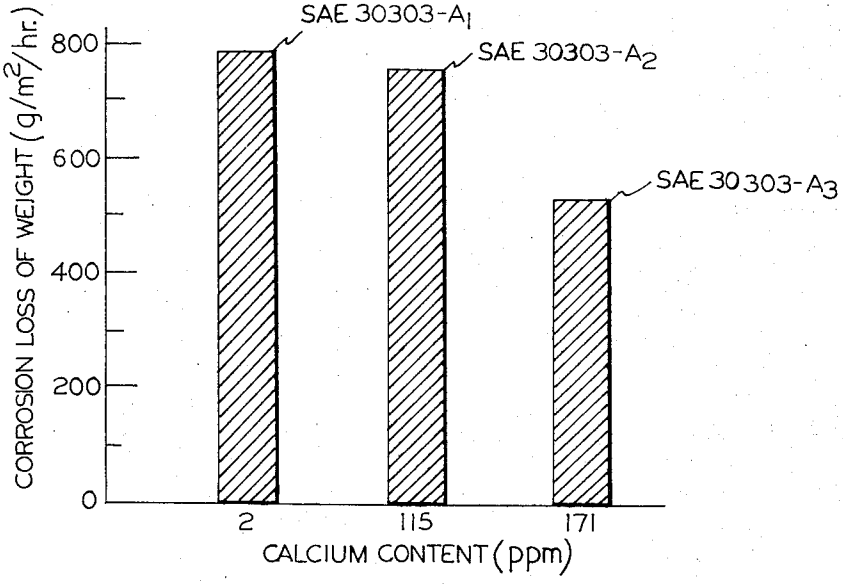


FIG. 6

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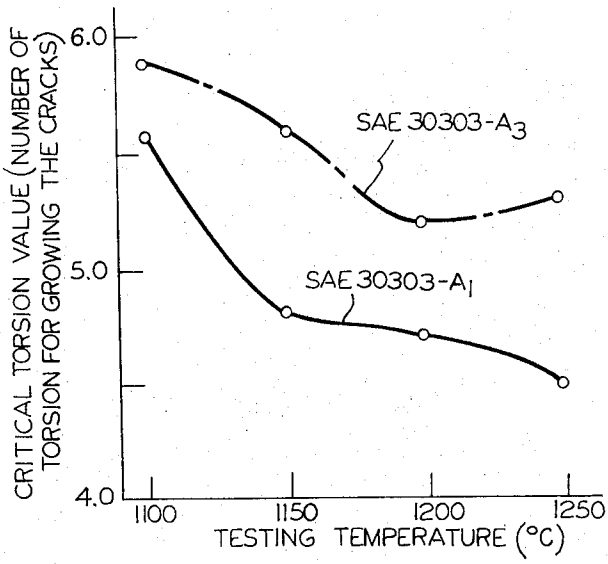


FIG.7

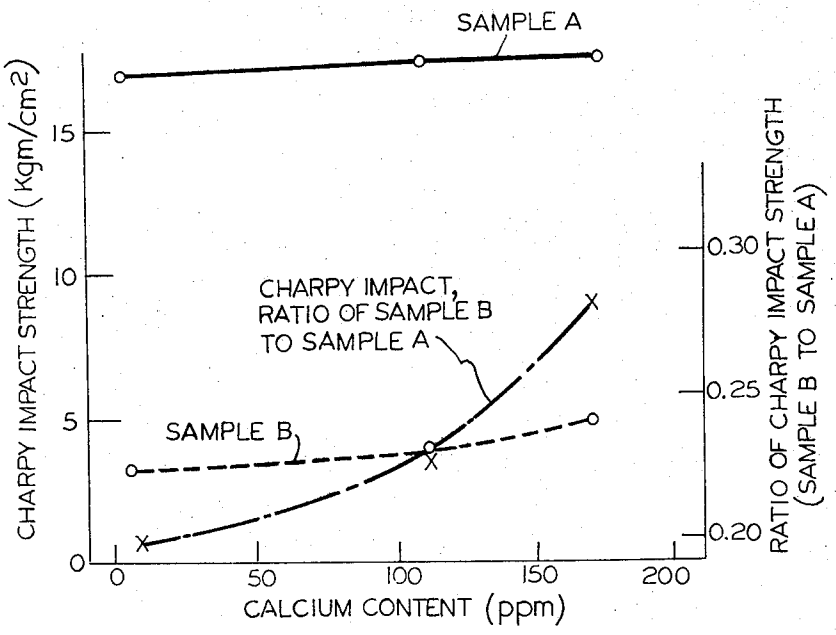


FIG.8

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United States Patent Office

3,598,574

Patented Aug. 10, 1971

3,598,574

FREE CUTTING STAINLESS STEELS

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Filed Nov. 5, 1968, Ser. No. 773,404
Claims priority, application Japan, Mar. 8, 1968, 43/14,630
Int. Cl. C22c *39/20*
U.S. Cl. 75—128R 5 Claims

ABSTRACT OF THE DISCLOSURE

A free cutting stainless steel having a chromium-nickel or chromium-nickel manganese base, and having from 0.01–0.06% by weight of calcium therein as the free cutting element.

stainless steels. The free cutting stainless steels have a tendency to increase their anti-corrosive property and workability as the calcium content increases but the maximum amount of the calcium contained in the free cutting stainless steels of this invention is defined to 600 p.p.m. depending on the alloying metals contained in the base stainless steels.

As the embodiments of this invention, some austenite type free cutting stainless steels are illustrated but it should be understood that this invention includes martensite type free cutting stainless steels. The austenite type free cutting stainless steels designed as SUS 27–S_1, SUS 27–S_2, SUS 27–S_3, SAE 30303–A_1, SAE 30303–A_2 and SAE 30303–A_3 are shown in the following table. It is noted that such free cutting stainless steels contain calcium in an amount varying from 0.0002% to 0.171% and also that they were produced by using the base stainless steels designated as SUS 27 in the Japanese Industrial Standards and SAE 30303.

TABLE

Steels	Chemical components (percent)								
	C	Si	Mn	P	S	Ni	Cr	Mo	Ca
SUS 27–S1	0.07	0.55	1.25	0.027	0.019	0.17	18.12	----	0.0003
SUS 27–S2	0.07	0.60	1.27	0.026	0.017	9.29	18.37	----	0.0063
SUS 27–S3	0.80	0.58	1.31	0.025	0.015	9.21	18.30	----	0.0207
SAE 30303–A1	0.09	0.54	1.48	0.022	0.302	8.62	17.80	0.45	0.0002
SAE 30303–A2	0.09	0.59	1.38	0.020	0.282	8.67	17.99	0.46	0.0115
SAE 30303–A3	0.09	0.56	1.46	0.021	0.271	8.65	17.51	0.44	0.0171

This invention relates to free cutting stainless steels having the inherent good anti-corrosive property which are produced by incorporating calcium in an amount above 100 p.p.m. (0.01%) as a free cutting element with Cr-, Mn or Cr-Ni-Mn-base stainless steels.

In general, the conventional stainless steels, and particularly the austenite type stainless steels, which contain a large amount of nickel (6%–22%), chromium (11.5%–26.0%) or manganese (1%–2%), have low workability, low cutting efficiency and less accuracy of the finished surface because they have high hardenability and low thermal conductivity and therefore such stainless steels require a large amount of power for cutting them thereby causing a large amount of heat evolution and increase in the temperature of the edge of tool when they were subjected to the cutting and working procedures.

In order to eliminate such defects inherent in the conventional stainless steels, there was proposed in the art some free cutting stainless steels which were produced by incorporating S, P, Se, Al, Zr, Te or Pb or a mixture thereof as a free cutting element with the stainless steels and they are improved in their workability. In fact, a few free cutting stainless steels are practically used.

Such a free cutting stainless steel, however, has the defect that it is inferior to the conventional stainless steels not containing a free cutting element in its anti-corrosive propery which is essential for the stainless steels.

The object of this invention is to provide free cutting stainless steels without the above-mentioned defects of the conventional free cutting stainless steels to satisfy the requirements for anti-corrosive property and workability.

According to this invention, the free cutting stainless steels are characterized by incorporating calcium in the

This invention will be fully explained by referring to the accompanying drawings in which:

FIG. 1 shows the relationship between the flank wear width of a tool and the calcium content of each of the above-mentioned SUS 27–S_1 steel, SUS 27–S_2 steel and SUS 27–S_3 steel when they were subjected to a cutting test.

FIG. 2 shows curves illustrating the relationship between the flank wear width of a tool and the cutting time of each of the above-mentioned SAE 30303–A_1 steel, SAE 30303–A_2 steel and SAE 30303–A_3 steel when they were subjected to a cutting test.

It is obvious from FIGS. 1 and 2 that the flank wear width of the cutting tool is considerably reduced when the SUS 27–S_3 steel and the SAE 30303–A_3 steel were cut with the cutting tool.

FIG. 3 shows the relationship between the maximum roughness of the finished surface and the calcium content of each of the above-mentioned SUS 27–S_1 steel, SUS 27–S_2 steel and SUS 27–S_3 steel when they were cut for two minutes.

FIG. 4 shows the relationship between the maximum roughness of the finished surface and the calcium content of each of the above-mentioned SAE–30303–A_1 steel, SAE–30303–A_2 steel and SAE 30303–A_3 steel when they were cut for four minutes.

It can be understood from FIGS. 3 and 4 that the SUS 27–S_3 steel and the SAE 30303–A_3 steel have improved surface roughness as compared with that of other steels. It is also noted that the SUS 27–S_3 steel has a calcium content of 0.0207% and the SAE 30303–A_3 steel has a calcium content of 0.0171% as shown in the table mentioned above.

As is obvious from the results of the cutting tests, the SUS 27 type stainless steels (18Cr–8Ni stainless steels) and the SAE 30303 type stainless steels (high percent sulfur-containing free cutting stainless steels) can be remarkably improved in their workability when they contain calcium in an amount of about 100 p.p.m. (0.01%).

FIGS. 5 and 6 show the relationship between the corrosion loss of weight and the calcium content of the test steels when they were tested for corrosion. Namely, the SUS 27–S_1 steel, the SUS 27–S_2 steel and the SUS 27–S_3 steel were tested for corrosion by dipping them in a 5% sulfuric acid which was boiling and the weight loss per square meter per hour was measured. The results of tests are shown in FIG. 5. Similarly, the SAE 30303–A_1 steel, the SAE 30303–A_2 steel and the SAE 30303–A_3 steel were tested for corrosion by dipping them in a 5% sulfuric acid which was boiling and the weight loss per square meter per hour was measured. The results of tests are shown in FIG. 6.

As is obvious from FIGS. 5 and 6, the good results are observed upon the free cutting stainless steels containing calcium in an amount of above about 100 p.p.m. Also, similar test results are observed when the same steels as mentioned above were tested for corrosion by dipping them in a 65% nitric acid which was boiling.

FIG. 7 shows curves illustrating the relationship between the amount of torsion for growing the cracks and the testing temperature when SAE 30303–A_1 steel and SAE 30303–A_3 steel were subjected to a hot torsion test. It is noted that the critical torsion value is indicated by the amount of torsion at which the cracks occurred in the test samples during the hot-torsion test. As is obvious from the curves as shown in FIG. 7, the SAE 30303–A_3 steel containing a 0.0171% of calcium has a higher critical torsion value than does the SAE 30303–A_1 steel at the indicated temperatures ranging from 1,100° C. to 1,250° C. This fact shows that the SAE 30303 type stainless steels can be improved with respect to their hot workability by adding calcium.

FIG. 8 shows curves illustrating the relationship between the Charpy impact strength and the calcium content when the test steels were tested for impact strength. Namely, the SAE 30303–A_1 steel containing the 2 p.p.m. calcium, the SAE 30303–A_2 steel containing the 115 p.p.m. calcium and the SAE 30303–A_3 steel containing the 171 p.p.m. calcum as listed in the above-mentioned table were cut along the rolling direction for preparing the test samples which are referred to as sample A hereinafter. Also the same steels were cut in the direction perpendicular to the rolling direction for preparing the test samples which are referred to as the sample B hereinafter. The samples A and B were tested for Charpy impact strength and the tested results are shown in FIG. 8. In FIG. 8, the solid line indicates the relationship between the Charpy impact strength and the calcium content when the samples A were tested, and the dotted line indicates the test results when the samples B were tested. The chain line indicates the ratio of the Charpy impact strength measured for the sample B to the Charpy impact strength measured for the sample A. It is obvious from the curves as shown in FIG. 8 that the SAE 30303 type stainless steels can be improved with respect to their impact strength by containing calcium. This fact shows that high percent sulfur-containing free cutting stainless steels (SAE 30303 type stainless steels) have their hot workability and the directional strength improved by the addition of calcium.

Further the inventors have found from the results of tests that Mn-Ni-Cr type stainless steels such as SAE 30201 steels can have their workability and mechanical properties improved by adding calcium as in the SUS 27–S_1, SUS 27–S_2 and SUS 27–S_3 steels. It is noted that the SAE 30201 steels contain carbon in an amount below 0.15%, silicon in an amount below 1.00%, manganese in an amount of 5.5 to 7.5%, phosphorous in an amount below 0.060%, sulfur in an amount below 0.03%, chromium in an amount of 16 to 18%, nickel in an amount 3.5 to 5.5% and nitrogen in an amount of below 0.25%.

From the foregoing, it can be concluded that the conventional stainless steels containing chromium or chromium plus nickel or chromium plus manganese can have their workability and anti-corrosive property greatly improved by incorporating a small amount of calicum therein.

What we claim is as follows:

1. A free cutting chromium-nickel base stainless steel consisting essentially of carbon in an amount of less than 0.15% by weight, chromium in an amount of from 17 to 20% by weight, nickel in an amount of 8–13% by weight, and as a free cutting element calcium in an amount of 0.01–0.06% by weight, and the balance iron and incidental impurities.

2. A free cutting chromium-nickel base stainless steel consisting essentially of carbon in an amount of less than 0.15% by weight, chromium in an amount of from 17 to 20% by weight, nickel in an amount of 8–11% by weight, and as a free cutting element calcium in an amount of 0.01–0.06% by weight, and the balance iron and incidental impurities.

3. A free cutting chromium-nickel base stainless steel consisting essentially of carbon in an amount of less than 0.08% by weight, chromium in an amount of from 18 to 20% by weight, nickel in an amount of 8–11% by weight, and as a free cutting element calcium in an amount of 0.01–0.06% by weight, and the balance iron and incidental impurities.

4. A free cutting chromium-nickel base stainless steel consisting essentially of carbon in an amount of less than 0.15% by weight, chromium in an amount of from 17 to 19% by weight, nickel in an amount of 8–10% by weight, an element selected from the group consisting of molybdenum and zirconium in an amount of less than 0.60% by weight, and as a free cutting element calcium in an amount of 0.01–0.06% by weight, and the balance iron and incidental impurities.

5. A free cutting chromium-nickel base stainless steel consisting essentially of carbon in an amount of less than 0.15% by weight, chromium in an amount of from 16 to 18% by weight, nickel in an amount of 3.5–5.5% by weight, manganese in an amount of 5.5–7.5% by weight, and as a free cutting element calcium in an amount of 0.01–0.06% by weight, and the balance iron and incidental impurities.

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HYLAND BIZOT, Primary Examiner

U.S. Cl. X.R.

75—128A