United States Patent Office 3,152,890 Patented Oct. 13, 1964

3,152,890

FREE MACHINING STEEL WITH SULPHUR PLUS TELLURIUM AND/OR SELENIUM

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No Drawing. Filed Nov. 14, 1963, Ser. No. 323,590
2 Claims. (Cl. 75—123)

The present invention relates generally to free machining steels, and more particularly to a readily machinable, readily hot workable steel containing relatively inexpensive amounts of tellurium and/or selenium together with amounts of sulphur in excess of its molecular equivalent relative to the tellurium and/or selenium.

This is a continuation-in-part of the present inventor's applications Serial Nos. 146,312, 146,313, and 146,314, all filed October 19, 1961, and now abandoned. Application Serial No. 146,312 is a continuation-in-part of the present inventor's abandoned application Serial No. 8,918, filed February 16, 1960, in turn a continuation-in-part of abandoned application Serial No. 725,501, filed April 1, 1958.

The use of relatively large amounts of tellurium and/or selenium to increase the machinability of steel is expensive. The subject steel has superior machining characteristics imparted thereto by relatively inexpensive amounts of tellurium and/or selenium supplemented by sulphur. The total tellurium and/or selenium content is about between 0.02–0.10 wt. percent and, alone, partially improves the machinability of the steel. With a tellurium and/or selenium content in this range it is important that the sulphur, in order to impart a substantial additional increase in machinability to the steel, be in molecular excess relative to the tellurium and selenium. For example, assume a tellurium and selenium content of 0.04 wt. percent of each. The ratio of atomic weights of sulphur to tellurium is 32.07 to 127.5 or about 1 to 4, and the ratio of atomic weights of sulphur to selenium is 32.07 to 79.2 or about 2 to 5. Accordingly, a molecular equivalent of sulphur relative to a tellurium content of 0.04 wt. percent is about 0.01 wt. percent, and a molecular equivalent of sulphur relative to a selenium content of 0.04 wt. percent is about 0.016 wt. percent. Thus, a sulphur content in excess of its molecular equivalent relative to the tellurium and selenium would be about 0.03 wt. percent or better. Assuming a content of 0.04 wt. percent tellurium alone or selenium alone, a sulphur content of 0.02 wt. percent or more would satisfy the criterion.

Although the sulphur is present in molecular excess relative to the tellurium and/or selenium, the weight of the sulphur does not exceed the total weight of the tellurium and/or selenium, themselves present in relatively inexpensive amounts not exceeding 0.10 wt. percent in total. Accordingly, the total weight percent of both the sulphur and the tellurium and/or selenium is relatively small, thereby reducing the likelihood of adverse effects (such as hot shortness) attributable to a high sulphur and/or tellurium and/or selenium content. To further reduce the possibility of hot shortness, it is important that the subject steel have a manganese content exceeding 0.60 wt. percent.

Because the subject steel relies upon relatively inexpensive amounts of tellurium and/or selenium and preferably no greater amounts of sulphur than tellurium and/or selenium to impart machinability thereto, it is important that the silicon content be low so as not to offset the increased machinability imparted to the steel by the limited amounts of sulphur and tellurium and/or selenium. Accordingly, the subject steel contains a silicon content of 0.05 wt. percent or less.

By utilizing an inexpensive tellurium and/or selenium addition in the range described supplemented by a sulphur

content in the amount described together with a silicon content of less than 0.05 wt. percent and a manganese content exceeding 0.60 wt. percent, there is provided a relatively inexpensive tellurium and/or selenium-containing steel which is readily machinable and which does not display the symptomatic adverse effects (such as hot shortness) otherwise characteristic of steels containing tellurium and/or selenium and/or sulphur.

Typical examples of steels having compositions (expressed in wt. percent) within the range of the present invention are as follows:

Table A.—Tellurium

	Steel I	Steel II	Steel III	Steel IV
C	0.18	0.16	0.16	0.10
Mn	0.75	0.70	0.65	0.60
P	0.012	0.011	0.02	0.04
Si	0.04	0.05	0.05	0.04
Te	0.10	0.08	0.05	0.03
S	0.03	0.05	0.02	0.03
Percent Molecular Equivalent of S	120	250	133	400

Table B.—Selenium

	Steel I	Steel II	Steel III	Steel IV
C	0.18	0.16	0.16	0.10
Mn	0.75	0.70	0.65	0.60
P	0.012	0.011	0.02	0.04
Si	0.04	0.05	0.05	0.04
Se	0.10	0.08	0.05	0.03
S	0.05	0.06	0.04	0.03
Percent Molecular Equivalent of S	125	188	200	250

Table C.—Tellurium and Selenium

	Steel I	Steel II	Steel III	Steel IV
C	0.18	0.16	0.16	0.10
Mn	0.75	0.70	0.65	0.60
P	0.012	0.011	0.02	0.04
Si	0.04	0.05	0.05	0.04
Te	0.06	0.04	0.04	0.03
Se	0.04	0.06	0.02	0.03
S	0.04	0.05	0.05	0.06
Percent Molecular Equivalent of S	129	144	277	300

With reference to the above tables, it should be noted that the sulphur content of all the steels is in molecular excess relative to the tellurium and/or selenium content, and the weight of the sulphur is no greater than the weight of the tellurium and/or selenium. The molecular excess of the sulphur in Steels II and IV of Table A, in Steel IV of Table B and in Steels III and IV of Table C is 150% or better, this being a preferable embodiment of the present invention.

There has thus been described a relatively inexpensive, readily hot workable tellurium and/or selenium-containing free machining steel characterized by: a relatively inexpensive amount of tellurium and/or selenium; a molecular excess of sulphur relative to the tellurium and/or selenium with the weight of the sulphur being no greater than the weight of the tellurium and/or selenium; a silicon content less than 0.05 wt. percent; and a manganese content of 0.60 wt. percent or better.

As used in this description, the term "steel" refers to an iron base alloy having a microstructure with a matrix containing ferrite or austenite.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary lim-

itations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. A free machining, at least partially hot worked steel consisting essentially of, in wt. percent:

0.10–0.18 carbon;

0.60–0.75 manganese;

0.012–0.04 phosphorus;

0.02–0.10 of a first machinability increasing addition selected from the group consisting of tellurium, selenium, and tellurium plus selenium;

sulphur in wt. percent no greater than the wt. percent of said first addition;

the minimum wt. percent of said sulphur being in molecular excess of the wt. percent of said first addition;

no more than about 0.05 silicon;

and the balance consisting essentially of iron.

2. A steel as recited in claim 1 wherein the molecular excess of sulphur is 150%.

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