Patented Oct. 18, 1949

2,485,358

UNITED STATES PATENT OFFICE

2,485,358

FREE MACHINING STEEL

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No Drawing. Application January 29, 1947, Serial No. 725,170

2 Claims. (Cl. 75—123)

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This invention relates to steels that are freely machinable and more particularly to free machining steels that are readily forgeable and which have good ductility together with an improved method of making the same.

Heretofore, sulphur has been added to steel to improve the machinability thereof. This is quite effective but the results vary widely from heat to heat. Moreover, in order for the sulphur to be effective, considerable amounts thereof were necessary which tends to make the steel hot-short and therefore not readily forgeable. To offset this tendency, the manganese content had to be increased and this in turn tended to lower the machinability and to render the steel too hard for certain purposes. Thus, it is desirable to obtain machinability with minimum sulphur additions. Accordingly, it is an object of my invention to provide free machining steels of uniform quality and at the same time that have enhanced machining qualities without sacrifice of forgeability or ductility. It is a further object to provide a method for commercially making the steels of this invention.

In my improved free machining steel, the carbon should be maintained below .08%, as carbon has a deleterious effect on machinability, as is shown by the following chart:

Steel No.	C	Mn	P	S	Si	Machinability Index
1	0.02	0.61	0.111	0.126	0.002	117.5
2	0.05	0.53	0.124	0.137	0.002	90.5
3	0.12	0.58	0.123	0.137	0.002	80.5

I have determined that very beneficial results so far as machinability is concerned, can be obtained by maintaining the silicon content of free machining steels below .01%. This should result in an oxygen content of .04% when the carbon is at the maximum of .08% and correspondingly higher oxygen contents for lower carbon contents. The greatly improved machinability resulting from the silicon content being below .01% is clearly shown in the following table.

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Effect of silicon

Steel No.	C	Mn	P	S	Si	Machinability Index
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	
4	.12	.96	.106	.138	.003	91.2
5	.07	.57	.104	.128	.004	111.4
6	.10	.81	.099	.130	.006	94.0
7	.09	.74	.104	.132	.008	95.9
8	.12	.71	.108	.106	.014	75.3
9	.12	.73	.093	.120	.028	66.9
10	.11	.82	.102	.107	.044	66.9

I have discovered that, in combination with the above specified low silicon content, it is desirable to increase the phosphorus content to a point somewhat higher than is customary for steels of this type. The increase in machinability to be gained by increased phosphorus is clearly shown in the following table:

Steel No.	C	Mn	P	S	Si	Machinability Index
11	0.03	0.57	0.107	0.129	0.004	97
12	0.04	0.43	0.164	0.124	0.006	103
13	0.04	0.64	0.200	0.108	0.005	112
14	0.04	0.53	0.261	0.118	0.004	115

From this it is seen that increasing the percentage of phosphorus in a sulphur-bearing low-silicon steel improves the machinability thereof. To obtain the benefits of phosphorus the content thereof should be at least .06% and preferably at least .08%. Due to certain unfavorable reactions, it is desirable to limit the phosphorus to a maximum of .25% even though larger amounts will have a beneficial effect on machinability.

In order to obtain optimum beneficial results from sulphur additions, it has heretofore been necessary to add at least .15% sulphur. By maintaining the silicon and manganese low and the phosphorus high, I have determined as shown in the following table that good machinability can be obtained with considerably less sulphur, i.e., as low as .05% which is considerably less than was heretofore considered necessary. However, if even more enhanced machinability is

desired, the sulphur can be increased to .30% and the manganese correspondingly increased to 1.00%. A minimum of .45% manganese should be used with the minimum sulphur content. The effect of varying manganese and sulphur content is shown in the following table:

Steel No.	C	Mn	P	S	Si	Machinability Index
15	.06	.65	.094	.059	.008	114
16	.07	.86	.097	.051	.006	81
17	.06	.70	.099	.079	.010	124
18	.08	.87	.090	.066	.006	87
19	.06	.57	.090	.133	.002	162
20	.07	.77	.086	.129	.002	166
21	.07	.55	.094	.183	.002	175
22	.07	.73	.085	.169	.004	205

While the exact explanation of the mechanism leading to the improved machinability of high-sulphur steels is not definitely known at present, a hypothesis may be offered that the higher oxygen content introduces the changes in the Fe—Mn—S—O system which affects the nature of the manganese-sulphur compounds embedded in the steel matrix which in turn influences the cutting properties. Evidence available is not conclusive regarding the exact composition of these compounds, but it is definitely established that low-silicon high-oxygen steels of the type herein disclosed having good machining properties have heavy inclusions of these types of a generally globular shape. In steels of average machinability, these inclusions incline to be of an elongated shape which suggests that at rolling temperatures, they are less hard and more ductile than those in the low-silicon high-oxygen steels of this invention.

There is at present no method of obtaining commercially a free-cutting Bessemer steel having a maximum silicon content of .01%. The equilibrium constant for residual silicon and FeO is strongly influenced by the temperature thereof. For instance, .05% FeO is in equilibrium with .02% silicon at 2770° F. and with 35 times as much silicon (.70%) at 3100° F. This apparently is one of the fundamental reasons for the wide variability in machining qualities of Bessemer screw grade steels. Therefore, it is essential in obtaining uniformly low silicon in such steel to blow it as cold as possible.

In acid Bessemer blowing practice, the preponderant source of heat is the oxidation of silicon during the first part of the blow. Thus an iron charge having a uniformly low silicon content is a prime requisite of obtaining the low

silicon contents of the steel of my invention. This may be accomplished by adding a sufficient amount of dried roll scale or iron ore to the molten iron before charging it to the converter. Experiments have shown that such additions can reduce the time of the silicon blow by 3 or 4 minutes. The iron ore or scale should be added to the charge by placing it on the bottom of the ladle and pouring the molten iron from the mixer on top thereof. This causes a violent agitation and instant reaction with the formation of a heavy iron-manganese-silicate slag which should be skimmed off when charging the low-silicon iron into the converter. The ore or scale should not be successfully added to the converter because it causes a thin watery slag and frothing and splitting during the blow. Moreover, greatly increased quantities of ore or scale are required.

While I have shown and described several specific embodiments of my invention, it will be understood that these embodiments are merely for the purpose of illustration and description and that various other forms may be devised within the scope of my invention, as defined in the appended claims.

I claim:

1. A free cutting Bessemer steel containing not more than .08% carbon, .05 to .30% sulphur, .45 to 1.00% manganese, .06 to .25% phosphorus and less than .01% silicon, the balance iron and incidental impurities.

2. A free cutting Bessemer steel containing not more than .08% carbon, .05 to .30% sulphur, .45 to 1.00% manganese, the manganese content being at the lower end of the manganese range when the sulphur content is at the lower end of the sulphur range, .06 to .25% phosphorus and less than .01% silicon, the balance iron and incidental impurities.

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