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AUSTENITIC STEEL

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My invention relates to austenitic steels. It is directed primarily to the improvement of the machinability of such steels, although it is not necessarily limited thereto. In technology and industry, it is well recognized that austenitic steels are difficult to machine. Certain prior art patents have been directed to the improvement in the machinability of such steels. Thus, it has been proposed that the machinability of such steels be improved by the addition of relatively large amounts of sulfur. However, the addition of too much sulfur in steels of this type may have a harmful effect on certain of the mechanical properties thereof. It has also been proposed to add selenium or tellurium or a combination of these two elements with and without an embrittling agent to improve the machinability of austenitic steels.

Prior to my invention, certain patentees have suggested the addition of lead to steels. However, in most cases, it has been proposed that the lead be added either as a means for removing the impurities in the steel or as a vehicle for such means, designed to insure the sinking of the purification medium beneath the surface of a molten bath of steel. So far as I am aware, no one in the prior art has appreciated that lead when introduced into molten steel and recovered in a proper state in the solidified product will improve the machinability thereof.

This application is a continuation in part of my applications, S. N. 177,292, filed November 30, 1937, and S. N. 208,069, filed May 14, 1938.

My invention involves the realization that lead if properly recovered in austenitic steels will result in marked improvement in machinability thereof. It is important that the lead be introduced into the steel in such a way and under such conditions that the major portion thereof will be substantially uniformly dispersed throughout the steel. In the preferred form of my invention, the percentage of lead retained in the steel should range from .03 to .478 per cent. However, it is within the scope of my invention to have a content in the steel of lead ranging from .03 to 1 per cent. The lower range is preferable where it is desired to insure against loss of desirable mechanical properties of the steel, since my tests indicate that it is difficult to obtain substantially complete uniform dispersion of the lead throughout the steel when the content therein is in excess of .478 per cent. However, in austenitic steels designed for some classes of service, some decrease in mechanical properties is permissible

so that the amount of retained lead may exceed .478 per cent.

In the term "austenitic steels," I intend to include those steels which are characterized by an austenitic structure, that is, those steels which are largely austenitic, the austenite having been obtained by composition, heat treatment or other means and methods well known in the art. In other words, my invention applies to steels which are predominantly austenitic, regardless of the manner in which the austenitic structure has been obtained. Representative compositions of such steels which are well recognized in industry are as follows:

Carbon	Chromium	Nickel	Silicon	Manganese	Sulfur	Phosphorus
.07-.20	17-19	7-9	.75	.60	.03	.03
.07-.20	18-20	8-10	.75	.60	.03	.03
.08-.20	19-22	10-12	.75	.60	.03	.03
.20	24-26	11-13	1.0-2.0	.75-1.5	.03	.03
.25	24-26	19-20	1.0-2.0	.75-1.5	.03	.03
.40-.60	14-16	34-36	.75-1.25	.75-1.0	.05	.05
.07-.20	17-19		.75	7-9	.03	.03
.5-1.7			.60-1	10-20	.05	.05
.90-1.5	13-17	13-16	2.0-3.5	.20-.30	.05	.05
.40-.60	23-25	4-6	*1.0	.50	.05	.05
.50-.90	20	30	.5-1.0	.50	.05	.05
.50-.90	1-2	19-23	1-3	.50	.05	.05

*Maximum.

My invention contemplates the introduction of lead in percentages ranging from .03 to 1 per cent in any austenitic steel and it will be understood that the steels set forth in the above table are merely illustrative. There are other austenitic steels to which this invention applies, as will appear from the following description.

In these steels, the carbon content has little or no influence on the application of my invention and for the purpose of carrying out my invention the carbon may be in any suitable range for the intended use of the steel, that is, from effective amounts to 1.7 per cent. Typical or customary ranges have been indicated in the above examples, however. Of course, it is well known to the art that the percentage of carbon present in a ferrous alloy is an important factor in the attainment of an austenitic structure.

My invention is applicable to nickel steels, that is, steels containing from 5 to 44 per cent nickel with the balance substantially iron except for the impurities normally found in such steels. Thus, it is within the scope of my invention to provide an austenitic steel containing from 5 to 44 per cent nickel, from .03 to 1 per cent lead and the balance substantially iron except for impurities.

My invention is also applicable to manganese steels, that is, to steels containing from 10 to 20 per cent manganese and the balance substantially all iron, except for impurities. Thus, it is within the scope of my invention to provide an austenitic steel containing from 10 to 20 per cent manganese, from .03 to 1 per cent lead and the balance substantially iron except for impurities.

Both nickel and manganese are recognized as alloying elements which favor the formation of austenitic structures in steel. Therefore, I may use manganese in combination with nickel to obtain an austenitic steel, obtaining improved machinability by the introduction of lead, preferably in percentages ranging from .03 to .478 per cent but possibly in percentages ranging from .03 to 1 per cent.

Another type of steel to which my invention is applicable is an austenitic steel in which chromium is used in combination with nickel or manganese or with nickel and manganese. In steels of this type, the chromium is normally utilized to obtain enhanced corrosion resistance and heat resistance, while the nickel or manganese or both are utilized to facilitate the attainment of an austenitic structure. Thus, it is within the scope of my invention to provide an austenitic steel containing chromium in percentages ranging from 5 to 28 per cent and nickel ranging from 5 to 44 per cent, lead from .03 to 1 per cent and the balance substantially iron, except for impurities. It is contemplated, however, that the total of the nickel and chromium contents will in all cases be less than 50 per cent. It is also preferred that the lead content be less than .478 per cent.

Where both nickel and manganese are used as the elements which tend to promote formation of an austenitic structure or where some other element effective for this purpose is substituted for nickel or manganese or both, either in whole or in part, it may be desirable to use as little as 1 per cent nickel or 1 per cent manganese and this is within the scope of my invention. Likewise, in alloys made in accordance with my invention containing chromium with nickel or manganese or both, I may use as little as 1 per cent chromium without departing from my invention.

Machinability tests have been made on austenitic steels with and without lead after heat treating the specimens to give the comparison specimens approximately the same Brinell hardness. For illustration, it has been found that the addition of .08 per cent lead to an 18 per cent Cr-8 per cent Ni steel as quenched from 2000° F. resulted in an improvement in machinability of 11 per cent, as determined by comparison of the time required to saw a bar of the steel without lead with the time required to saw a bar of the same steel with the lead incorporated therein.

Tests have also been made on a high-manganese steel such as is known in industry as "austenitic manganese" steel or "Hadfield manganese" steel. This steel contained approximately 1.25 per cent carbon and 13-14 per cent manganese with no lead added to one heat and 0.50 per cent lead added to another. The rolled stock of these approximate analyses was heated to 1900° F. held for one hour then quenched in water. Machinists observed that the specimens to which the lead had been added machined more easily and produced a surface which showed less of what is known as "chatter" markings on the finished machined surface.

Though the steels which I have previously discussed have a sulfur content ranging from traces to .05 per cent, it is within the scope of my invention to embody lead in the percentages indicated in austenitic steels containing sulfur in percentages ranging from .05 to .50 per cent. In other words, it is within the scope of my invention to add lead in the percentages indicated to austenitic steels containing from traces to .50 per cent sulfur. I have reason to believe that when lead in percentages ranging from .03 to 1 per cent is added to an austenitic steel containing from .05 to .50 per cent sulfur, the lead and sulfur cooperate to further improve the machinability of the steel.

Likewise, it is within the scope of my invention to utilize phosphorus as an embrittling agent in percentages as high as .50 per cent. Approximately .05 per cent phosphorus is preferable but higher percentages may be used as indicated in conjunction with lead ranging from .03 to 1 per cent.

Other supplementary elements may be present in the steel provided they do not destroy the austenitic structure and the steels containing one or more alloying elements from the group consisting of molybdenum, tungsten, copper, silicon, vanadium, cobalt, titanium, columbium and aluminum may be essentially austenitic. The usual range of these supplementary alloying elements is about 1/2 to 5 per cent.

Austenitic steels are characterized by showing relatively low hardness in the usual hardness tests but have a very strong tendency to harden in cold-working and to harden in the machining operation. There is a tendency for the austenitic steels to flow ahead of the cutting tool and to develop high frictional resistance in contact with the machine tool. By the use of lead in certain ranges in these austenitic steels I am able to improve the machinability. The exact mechanism of this improvement in machinability is not definitely known at this time. It has been observed in machining steels containing lead as compared with those without lead that the tools show less heating when lead is present and this indicates that the lead serves as a lubricant for the tools and therefore causes less frictional resistance. Lead also appears to have some effect on the character of the chip produced. Austenitic steels containing lead show less wear of the tools and less tendency for the steels to pile up on the tool in the machining operation.

As disclosed above, I have been able to show an improvement in the machinability of an austenitic steel of the 18 chromium-8 nickel type by the addition of .08 per cent of lead. Traces of lead do not have an important influence on the machinability. I, therefore, consider the minimum amount of lead which may be useful to be about .03 per cent and for most purposes I prefer to use not less than .10 per cent. Experiments with the addition of lead to steel to improve the machinability show that when an attempt is made to add large percentages of lead, the recovery is relatively poor. Large amounts of lead also present some difficulty with reference to proper dispersion of the lead in the steel and for that reason may harmfully affect certain of the mechanical properties. For these reasons I consider the desirable upper limit of the lead content retained in the steel to be less than .50 per cent, such as .478 per cent, although as high as 1.0 per cent may be used with improvement in the machinability.

My preferred method of adding the lead is to add it to the molten steel in the ingot mold in sub-divided form after a small amount of steel has entered the mold by delivering a stream of sub-divided lead particles against the stream of steel pouring downwardly from the ladle and over a substantial period of time. Other methods are possible but the principal requirements as regards the improvement in machinability are to so add the lead and at such a time that it will be recovered in the steel with the major portion thereof substantially uniformly dispersed throughout the steel and mainly in sub-microscopic form.

The phrase "balance being substantially iron" is intended to cover small amounts of supplementary elements such as titanium, cobalt, copper, tungsten, molybdenum, silicon, vanadium, columbium and aluminum within the total range of $\frac{1}{2}$ to 5 per cent. However, the amount of such elements should not be large enough to prevent the attainment of the austenitic structure in the steel.

From the above, it will be seen that I have been able to materially improve the machinability of austenitic steels by the incorporation therein of lead in properly dispersed form and in the percentages indicated. Furthermore, I have been able to accomplish this without sacrificing the mechanical properties of the steel although, as stated, in some classes of steels mechanical properties may be sacrificed to some extent.

Having thus described my invention, what I claim is:

1. A steel containing carbon from effective amounts to 1.7 per cent and lead from .03 to 1 per cent with at least a portion of the lead being substantially uniformly dispersed, said steel having a substantially austenitic structure and being characterized by improved machinability in comparison with the same steel having less than .03 per cent lead.

2. A steel containing carbon from effective amounts to 1.7 per cent and lead from .03 to .478 per cent with at least a portion of the lead being substantially uniformly dispersed, said steel hav-

ing a substantially austenitic structure and being characterized by improved machinability in comparison with the same steel having less than .03 per cent lead.

3. A steel containing carbon from effective amounts to 1.7 per cent, from 1 to 44 per cent nickel, and from .03 to 1 per cent lead with at least a portion of the lead being substantially uniformly dispersed, said steel having a substantially austenitic structure and being characterized by improved machinability in comparison with the same steel having less than .03 per cent lead.

4. A steel containing carbon from effective amounts to 1.7 per cent, from 1 to 20 per cent manganese and from .03 to 1 per cent lead with at least a portion of the lead being substantially uniformly dispersed, said steel having a substantially austenitic structure and being characterized by improved machinability in comparison with the same steel having less than .03 per cent lead.

5. A steel containing carbon from effective amounts to 1.7 per cent, from 1 to 28 per cent chromium, at least one element from the group consisting of nickel and manganese and from .03 to .478 per cent lead with at least a portion of the lead being substantially uniformly dispersed, said steel having a substantially austenitic structure and being characterized by improved machinability in comparison with the same steel having less than .03 per cent lead.

6. A steel consisting of carbon from effective amounts to 1.7 per cent, from 1 to 44 per cent nickel, from 1 to 20 per cent manganese, from 1 to 28 per cent chromium, with a total of nickel, chromium and manganese not exceeding 50 per cent, and lead in amounts from .10 to .478 per cent with at least a portion of the lead being substantially uniformly dispersed and with the balance substantially all iron, said steel having a substantially austenitic structure and being characterized by improved machinability in comparison with a steel having less than .03 per cent lead.

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