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METHOD OF PROTECTING STEAM BOILERS AGAINST CAUSTIC EMBRITTLEMENT

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The present invention relates to steam boilers which have been protected against caustic embrittlement.

One of the objects of the invention is to treat the metallic parts of a steam boiler, and particularly those parts which are likely to become embrittled as a result of excess alkalinity of the water used in the boiler, by causing to be formed in the seams and crevices of the boiler a solid deposit of a salt which counteracts the embrittling action of caustic soda on the metal.

A further object of the invention is to operate a steam boiler by using as the source of the steam a solution of an embrittling preventing material, so as to effect the crystallization of this material from the solution and its resulting deposition in the seams and crevices of the boiler.

A further object of the invention is to operate new steam boilers by means of a solution of an embrittling preventing material such, for example, as sodium sulfate, sodium phosphate, or other alkali sulfates or phosphates, so as to cause to be deposited in the seams and crevices of the boiler a crystalline deposit of the sodium sulfate, or of the phosphate, whereby subsequent embrittlement at the seams and crevices is prevented when alkaline water is used in the boiler.

Still further objects of the invention will become apparent from the further disclosure herein.

Embrittlement has been the term applied to the intercrystalline cracking of boiler steel below the water line in boilers. Much controversy has existed as to its cause, and it has been the subject of considerable research. Some attribute the embrittlement to initial stresses set up in the metal itself, while others contend that it is caused by the absorption of hydrogen released as the result of decomposition of caustic soda in the boiler. Irrespective of what the true cause of embrittlement may be, the fact remains that steam boilers made of steel and iron are subject to embrittlement and breakage of the metal if the amount of sodium hydroxide in the water used to make the steam is too great, and it is therefore the object of the present invention to overcome this difficulty and danger in the operation of steam boilers. In general, the higher the pressure in the boiler, the greater the danger of embrittlement; and therefore in modern steam boiler technique, particularly in automotive equipment, locomotives and high pressure boilers, the danger is very real and presents a distinct problem. It has been found that the embrittlement may be limited by maintaining in the boiler water a specified ratio of the sulfate radical to the total alkalinity, the ratio varying with the steam pressure. In accordance with the recommendations of the American Society of Mechanical Engineers, this ratio of sodium sulfate to total alkalinity, the latter expressed in terms of sodium carbonate, should vary as follows: in the case of 150 pounds boiler pressure it should be about 1:1; at 150 to 200 pounds pressure, 2:1; and at 250 pounds and above, 3:1. That is to say, in a boiler carrying a pressure upward from 250 pounds per square inch, embrittlement can be limited by maintaining in the water a ratio of sodium sulfate to sodium carbonate of at least as high as 3:1. The total alkalinity of the water is determined by titrating a sample of feed water with any standard acid, using methyl orange as an indicator. It has also been found that trisodium phosphate, as well as monosodium phosphate, may be substituted in part or total for the sodium sulfate.

The prior art, however, is predicated upon the maintenance, during the operation of a boiler, of the sodium sulfate to total alkalinity ratios as above specified. This therefore requires more or less constant supervision of the feed water supply, and the time of a skilled operator to perform the necessary chemical analyses and calculations as well as the adjustment of the sodium sulfate to sodium carbonate ratio of the water being fed to the boiler. While this may be done with more or less success in large stationary plants of sufficient size to warrant the employment of a man sufficiently skilled to carry out such supervision, it becomes well-nigh impossible in railroad practice and in the operation of boilers of smaller size and at isolated points where a chemist or equally trained person is not readily available.

The present invention makes it possible to overcome all of these difficulties and to feed a boiler with almost any kind of water, even though the sodium sulfate to sodium carbonate ratio of the water may be much lower than that prescribed by the American Society of Mechanical Engineers as a criterion of safe operation.

The inventor has discovered that if a new boiler is initially operated with a solution of sodium sulfate or other embrittlement-inhibitor, sufficient crystalline sodium sulfate or other inhibitor becomes deposited as a solid crystalline deposit in the seams and crevices of the boiler, so that, even though the boiler be subsequently operated with water not having the desired sulfate to carbonate ratio, the embrittlement of the metal

of the boiler at the seams and crevices will be prevented; in fact, the formation of such a deposit will be a substantial guaranty against metal failure even where the correct ratio of sulfate to carbonate in the feed water is not maintained. It will be obvious that this greatly increases the safety of operating high-pressure boilers, locomotives, steam cars, and the like, in that it insures the prevention of embrittlement while at the same time it lowers the cost of operation, as no particular attention need be paid to the composition of the feed water.

For the purposes of the present invention, sodium sulfate is the least expensive and most readily obtainable material, and the method employed in the present invention is therefore described in its preferred form as involving the use of ordinary sodium sulfate.

The process is carried out by charging a new boiler with a solution of sodium sulfate. This may be ordinary feed water to which sufficient soluble sulfate has been added to bring the concentration of sulfate ions in the water to that equivalent to the presence of at least 10 grains per gallon (128 fl. oz.) of Na_2SO_4, or its equivalent. If phosphates are used, stoichiometrical amounts of the PO_4 radical are to be employed. As the molecular weight of PO_4 is only one unit less than SO_4, this therefore would mean an amount of PO_4 equivalent to about 10 grains per gallon of, say, Na_2HPO_4.

For example, a locomotive boiler may be filled up to the normal operating level with a solution of sodium sulfate containing at least 10 grains of the latter per gallon and then be operated with this solution, using as make-up water the ordinary feed water which may be available, with sufficient added sodium sulfate to maintain this concentration, and the operation continued for four or five days or until a deposit of sodium sulfate is built up in the seams and crevices. After this, the water contained in the boiler may be blown out, and the subsequent operation of the boiler may then be carried on with water having the usual sulfate to carbonate ratio, although this need not be accurately maintained, because by the treatment of the boiler with the sodium sulfate the desired deposits will have been produced in the seams and crevices of the boiler. It will be seen, therefore, that subsequent close control of the boiler feed water in order to maintain the recommended sulfate to carbonate ratio in the boiler water thus becomes unnecessary.

In actual field operation of locomotive boilers, the present invention has been shown to be highly effective. As a specific example, it may be recited that in one case two new locomotives were sent out on the road, one of them being first operated with water high in sodium sulfate; that is to say, water containing at least 10 grains Na_2SO_4 per gallon, while the other was operated on water containing large amounts of sodium carbonate but practically no sulfate. The first locomotive after a time was transferred to the same service as the second locomotive, where both were operated under identical conditions for some time. The metal at the seams of the second boiler, i. e., the one which had not been first subjected to sulfate-containing water treatment, became embrittled, and an analysis of the deposit in the seams thereof showed that this deposit consisted almost entirely of caustic soda. No embrittlement was found in the first boiler. Analysis of the deposit in the seams of the first boiler showed 80% sodium sulfate, 10% sodium chloride, and 10% sodium carbonate.

It will be obvious that the invention is not limited to steam boilers as such but is equally applicable to evaporators or any container in which water containing free alkali or carbonate may be heated. Thus, for example, the invention might equally well be applied to autoclaves and other pressure equipment in which embrittlement is to be feared. Therefore, in the hereunto appended claims the term "steam boiler" is to be construed broadly as meaning any metallic vessel subjected to internal pressure in which water or other fluid containing free alkali is heated. Furthermore, in the claims the term an alkali metal salt of an acid from the group consisting of sulfuric and phosphoric acids is intended to cover sodium sulfate, sodium phosphate, potassium sulfate, potassium phosphate, and their equivalents. The phosphate need not be the triphosphate but may just as well be the disodium monohydrogen phosphate.

While a concentration between 10 and 20 grains of embrittling-preventer per gallon has been given as an example, the invention is not to be limited thereby, and it is to be understood that any solution of sodium sulfate of sufficient strength to effect within a few days the deposit of sodium sulfate in the seams and crevices of the boiler is to be construed as being suitable for the purposes of the present invention.

I claim:

1. The process of preventing the caustic embrittlement of the metal of a steam boiler which comprises initially maintaining and heating therein, while the boiler is still new, water containing a sodium salt of an acid from the group consisting of sulphuric and phosphoric acids in an amount not substantially less than 10 grains thereof per gallon for a time sufficient to produce a film or deposit of said sodium salt in the seams and crevices of the boiler, thereby protecting the same against the effects of high caustic soda concentrations which the boiler might encounter during subsequent operation in service.

2. The method of protecting the metal of a steam boiler against subsequent caustic embrittlement which comprises boiling in the boiler while still new an aqueous solution of sodium sulfate containing at least 10 grains thereof per gallon at least long enough to fill the seams of the boiler with a deposit of sodium sulfate.

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