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of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1067.

Pig Iron Conservation in Gray Iron Foundries.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
ORE DRESSING AND
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CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH
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During the present emergency, an increasing shortage of pig iron will be encountered by gray iron foundry operators. This may be alleviated to some extent by substituting scrap iron for part of the pig iron requirements. The accepted practice in many gray iron foundries is to use pig iron and foundry returns with possibly small amounts of foreign scrap iron in making the mixtures for melting in their cupolas. Foreign or outside scrap iron is used to describe material which is purchased from outside sources and which was not originally cast in that particular foundry. It is so named in comparison with domestic or 'own' scrap, better known as foundry returns, which is that particular foundry's own product consisting of gates, sprues, risers, shrink bobs or heads, over iron or gangway pig, defective castings, etc., all a necessary part of a previous melting operation.

Present use of Scrap Iron and Steel:

The use of large amounts of foreign scrap, both iron and steel, in cupola mixtures, as high at times as 60% of the total charge, has been the general practice for quite a long time in the large, continuous-operating foundries of the so-called "production" type which require metal made and held to strict specifications at all times. This is made possible by very close supervision and control at all stages of the process. In smaller foundries with considerably less supervision available, it would hardly be advisable to try to duplicate this practice. However, it can be done on a smaller scale which, with careful attention to the various details of the melting process, should yield satisfactory results.

It should be stated at the outset, however, that conditions vary not only from one foundry to another making similar castings, but vary from time to time in the same shop. This calls for considerable application of common sense. The following remarks concern general conditions, not any one particular instance, to serve as a guide in the utilization of scrap.

The use of various classifications of steel scrap in gray iron foundries melting iron for various applications requiring superior physical qualities, usually known as "semi-steel" has been common practice for many years. The success of this operation has been mainly due to the close attention given to all foundry operations generally and the melting practice in particular. However, by application of the same careful attention to the details of operation, satisfactory iron for ordinary castings is being made using considerable percentages of foreign scrap iron to replace part of the pig iron in the charge.

Preparations for use of Scrap:

Every gray iron foundry operator knows what constitutes good melting practice in a cupola. A foundry cupola given reasonable care and attention, with charges of pig iron, foundry returns with or without some foreign scrap in the mixture and a reasonably good grade of coke will produce an iron that will be satisfactory enough for the intended purpose. The substitution of part of the pig iron by foreign scrap will entail somewhat closer attention to the various details involved. Before commencing the substitution of scrap, it would be beneficial to check the various phases involved in cupola operation in order to obtain maximum efficiency in the melting operation.

The physical characteristics of a cupola, the tuyere area and ratio, the height of tuyeres about the bottom plate, and their type are usually determined over a considerable period of time, and for the present purpose should not be changed, unless found necessary for increasing the holding capacity of the crucible, tank or well that receives the metal when it is melting down.

The preparation of the cupola for the day's heat or cast should be conscientiously done with the proper care given to the chipping out, patching, the repair or replacing of tap hole and slag hole areas, and putting in the sand bottom.

After lighting up the cupola, special attention should be given to the burning in of the first coke bed and obtaining the proper height of the second coke bed before starting to charge the materials for melting. The proper height of bed for best melting conditions has to be determined by experience. When this height has been determined, it should be strictly adhered to. Commencing operations with the coke bed properly burnt in and of prescribed height is one of the most important considerations of

efficient cupola operation regardless of the length of time metal is required, whether it be for one hour or eighteen.

The weight of each cupola charge, (the term used to describe the mixture of various materials to be melted together simultaneously), is usually determined by the cross sectional area of the cupola, with certain variations to meet particular conditions. It is important that the size of the various materials used be of the proper proportion to the cross-sectional area of the cupola in order to obtain uniform melting conditions and a homogeneous molten iron. Other very essential details are the accuracy of the weighing, the proper sequence of placing in the cupola, and the spreading of the materials evenly. The same care is also required in the weighing and placing in the cupola of the coke required to replenish the bed coke for melting the following charge.

One other important point to be considered is that of fluxing or 'slagging' of the cupola, to remove the refuse which accumulates from the ash of the coke, the rust of the pig iron and scrap, and the burnt sand that adheres to the foundry returns by the addition of limestone on top of each coke charge. The "tapping-out" of the slag is as an essential operation as the "tapping-out" of the iron if smooth running cupola operation is to be insured.

One final point is uniformity of blast pressure, which, once determined for a desired melting rate of iron should be maintained, although slowing down is not as hazardous as speeding up which causes all kinds of trouble.

Classifications of Gray Iron Foundry Scrap:

In contemplating either the substitution of foreign scrap for part of the pig iron or increasing the amount being used at present, consideration must be given to the kind of iron required for the general class of castings being made.

Classifications of Grey Iron Foundry Scrap (continued) -

The American Institute of Scrap Iron and Steel have a standard classification of scrap which is followed as a basis by the purchasers of large amounts, and may serve as a guide for those whose requirements will not be so great. For smaller foundries, consideration should be given to the kind and amount available in local scrap yards. The scrap classifications as given in Simplified Practice Recommendation R-58-36 of the U. S. Department of Commerce, 1940, for Gray Iron Foundries are as follows:

58. No. 1 Machinery Cupola Scrap. -- Clean machinery cast-iron scrap. Must be cupola size, not over 24 by 30 inches in dimensions, and no piece to weigh over 150 pounds.

59. No. 1 Machinery Breakable Scrap. -- Clean machinery cast-iron scrap, weighing over 150 pounds, and which can be easily broken by an ordinary drop into cupola size.

60. No. 1 Standard Cupola Scrap. -- Clean cast-iron scrap, such as columns, pipes, plates, and castings of miscellaneous nature, but free from stove plate and agricultural scrap. Must be cupola size, not over 24 by 30 inches in dimensions, and no piece to weigh over 150 pounds. Must be free from foreign material.

61. No. 1 Standard Breakable Scrap. -- Clean cast-iron scrap, such as columns, pipes, plates, and castings of miscellaneous nature, weighing over 150 pounds, and which can be broken by an ordinary drop into cupola size.

62. Burnt Cast Scrap. -- Burnt cast-iron scrap, such as grate bars, stove parts, and any miscellaneous burnt scrap.

63. Stove Plate Scrap. -- Clean cast-iron stove plate. Must be free from malleable and steel parts, window weights, plow points, grates, burnt iron, etc.

64. Agricultural Scrap. -- Cast-iron parts of agricultural machinery, including plow points. Must be free from steel, malleable, and full-chilled iron.

65. Cast-Iron Car Wheels. -- Cast-iron car and locomotive wheels.

66. Brake Shoes. -- Driving and car brake shoes of all types, exception composition-filled shoes.

67. No. 1 Radiator Scrap. -- Broken radiator castings, cupola size, with all steel parts removed. Must be free from excessive scale, rust, and corrosion.

68. No. 2 Radiator Scrap. -- Unbroken radiator castings. Must be free from excessive scale, rust, and corrosion.

69. No. 1 Malleable Scrap. -- Malleable parts of automobiles, railroad cars, and miscellaneous malleable castings. Must be free from steel and cast-iron parts.

70. No. 2 Malleable Scrap. -- Malleable parts of agricultural implements and other miscellaneous malleable castings. Must be free from steel and cast-iron parts. May include No. 2 rail steel, cropped rail ends under 3 feet long, 50-pound and over standard section.

These specifications are given as a guide only. For foundries operating with small diameter cupolas, the dimensions given would probably be too large and also too heavy. Classes 62, 65, and 66 should not be considered by the average shop and Classes 69 and 70 only in special cases.

Selection of Class of Scrap:

The selection of the scrap to be used for any particular type of iron requires a certain amount of judgement. For example, it would not be advisable for a foundry melting iron for casting into small, light, easily machineable castings to endeavour to use heavy machinery cast scrap or scrapped automobile cylinder blocks or heads for the reason that the heavy machinery castings

are usually made of an iron with a silicon content of 1.25% to 1.75%, and the automotive scrap, although containing satisfactory amounts of silicon, as a rule contains appreciable amounts of alloys, nickel, chromium, copper, etc. In this case, it would be better to commence the use of scrap by using stove plate scrap, (no. 63) which in addition to clean stove plate usually contains other scrap parts of various small articles, sewing machines, lawn mowers, kitchen pumps, flat irons, etc. This material is usually made from iron with a minimum silicon content of 2.25% and in addition with a fairly high phosphorus content, usually well above 0.50%. Scrap of this classification can be used in substitution for part of the pig iron of the grade known as "Foundry". For Foundries engaged in making a heavier class of work, consideration can be given to the other grades of scrap, and for those requiring a superior grade, stove plate scrap should not be considered.

Suggested Method for Commencing Use of Scrap:

In commencing the use of scrap in the cupola mixtures, it is best to begin with the replacement of a small amount of the pig iron content, possibly 2% or 3%. This amount can be increased at regular intervals of two or three operating days until such time as the maximum usable amount is reached. The highest possible yield of good, satisfactory castings is the desire of every foundry operator. The greatest percentage of scrap that can be used in the cupola mixture without affecting this yield can be considered the maximum usable amount under that particular foundry's conditions. It is not possible to replace all of the pig iron in the mixture but it is possible in many cases, with careful attention to details previously

mentioned, to replace part of it, the amount varying - as conditions vary - in different foundries. It should also be remembered that the percentage of scrap in the cupola mixture as decided upon in any particular foundry may have to be changed from time to time, and at times it may even be necessary to return to the mixture previously used.

Percentages of pig iron used in cupola mixtures vary from foundries casting individual cast piston rings which at times require 70% down to foundries using 10% or less of specially made grades of pig iron.

Calculating Cupola Mixtures Using Scrap:

In calculating the mixture, it may be necessary, especially if the scrap to be used is small and light, to allow for a slightly greater oxidation loss of the silicon and the manganese contents. If considerable silicon and manganese are required in the base cupola mixture as calculated, and it is not possible to obtain these contents from the material on hand, it is possible to increase these amounts by the addition of ferro-silicon and ferro-manganese. These ferro-alloys may be conveniently added in the form of briquettes which are made to contain a definite weight of the desired alloy. Since the sulphur content of the scrap is higher than that of pig iron, it is essential that, as previously mentioned, the cupola be kept properly fluxed. Careful observation of the results obtained will establish precedents to follow.

Control of Molten Metal:

The character of the molten metal tapped from the cupola is usually observed by some manner of test. This consists of taking a small amount of the iron from the cupola stream and

pouring it in some form of a wedge, step bar or other shape made in either a green sand or dry sand mold, and may or may not be cast against a chill. These allow for very rapid cooling and may be quickly broken for visual inspection. It is important that a standard routine be carefully followed to eliminate variations due to temperature, time, etc. Experience will tell the condition of the iron and if any corrections are necessary, the requisite action can be carried out immediately.

The test pieces in most general use in the automotive foundries who have developed the control of the metal by chill tests to quite a high degree, are the triangular wedge and the "key-hole". The former test piece is in the form of a triangle approximately 5/8" x 5/8" x 3/8", and about 4 inches in height, cast vertically in a dry sand core. This is about the fastest test possible, as it can be poured, cooled, quenched, broken and inspected in much less than a minute. The "key-hole" test, so named from its resemblance to a key-hole in an ordinary door lock, is approximately $1\frac{5}{8}$" in its overall long dimension, 1" at the widest part with the key way portion $\frac{1}{2}$" to 5/8" wide and about 4" in height, cast vertically in a dry sand core, with the key way bottom closed by placing the core against a metal chill. This test piece requires a little more time before it may be cooled and quenched, but with experience yields considerable information regarding the character of the metal. The utility of these tests for rapid control purposes can be readily seen, as the most rapid chemical analyses in specially set-up control laboratories require considerable time before results are available. However, the information on these two test pieces is offered as a suggested method, not a recommendation to replace the particular control tests that may now be in use.

The test pieces give a good indication of the operating conditions in the cupola, in addition to information on the characteristics of the metal. From observations of the depth of chill on test pieces, corrective measures may be immediately taken if such are required.

Need for Pig Iron Conservation :

In normal times, the economy that might be obtained by substitution of foreign scrap for part of the pig iron in a cupola charge probably might not be worth the extra effort and vigilance required to maintain consistently a uniformly satisfactory product. In view of the seriousness of the pig iron supply at the present time, however, any assistance in even partially relieving this situation would be well worth the extra exertion required.

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