Improvement of the Quality of Grinding Media cast at the Ceylon Steel Corporation

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SUMMARY

Grinding media in the form of metal balls are being supplied by the Ceylon Steel Corporation to the Ceylon Cement Corporation to use in their ball mills for crushing cement clinker. Approximately 13% of the cost of the cement is accounted for by these balls. Constant complaints were received from the customer stating that these balls wear out much faster than the imported balls and also fail by breaking apart. This project was undertaken to examine reasons for the above, and to improve the quality of the local product. Preliminary tests showed that the poor quality of the balls were due to the presence of blow holes and cavities and an unsatisfactory microstructure. The major part of the investigation was to study and alter the casting procedure to produce a defect free product. This was undertaken during a two months training at the Ceylon Steel Corporation works at Oruwala and this paper describes the investigations carried out. The manufacturing procedure at the Ceylon Steel Corporation foundry was studied in detail. This was followed by a series of tests to optimise the moisture content, permeability and green strength of the moulding sand. The pattern, mould, drying procedure, casting procedure and the composition to be used were also modified. A trial casting with the above modifications was conducted at the CSC foundry and tests on the products showed that they were defect free. A cost analysis was carried out to show that the modified composition and procedure resulted in a cheaper product as well. These balls are now being tested in the laboratories of the School of Applied Science, University of Sri Lanka, Katubedda Campus to improve the quality further by heat-treatment.

1. Testing the C.S.C. product:

1.1 Chemical analysis:

The chemical composition specified by the Ceylon Cement Corporation was:

C	1.1 — 2.0%
Cr	1.0 — 2.4%
Mn	1.0 — 1.6%
Si	0.5% max.
P	0.4% max.
S	0.4% max.

Several of the C.S.C. products selected at random were used to obtain drillings for a full wet chemical analysis. It was noted that many of their products contained very much higher C and Cr contents as shown in Table 1.

	C	Cr	Mn	Si	P	S
Sample A	2.3	3.8	1.8	0.4	0.1	0.1
Sample B	2.1	3.7	1.9	0.3	0.1	0.1
Sample C	1.9	3.7	1.6	0.4	0.2	0.1

Table 1—The Wet chemical analysis of sample: drillings

Always the P and S were under the specified value ruling out any embrittlement at the grain boundaries.

1.2 Metallography:

Several of their products were sectioned, polished, etched in nital for 12 seconds and observed under the microscope. Besides the "as cast" ordinary wear balls some balls that were heat-treated by them were also examined. The heat treatment used by them was to raise the temperature of the balls to about 750°C and then water quench. It was noted that to transfer each heated up ball to the water an unnecessarily large time was taken.

In the "as cast" specimens the pearlitic structure was clearly seen. The grain boundaries had white films and the grains were fairly large. In the heat-treated specimen the white films on the grain boundaries looked more dispersed. The grains had become slightly larger and a pearlitic structure was observed.

1.3 Hardness contours:

Hardness contours in two directions perpendicular to each other were done on several sectioned grinding media balls. In the "as cast" specimens the contours done showed a constant hardness value of 413 DPH throughout. In the heat-treated specimens a constant hardness value of 287 DPH was recorded throughout the contours.

Most of the balls in section had large contraction cavities in the middle. On the average most balls had at least six tiny blow holes clearly seen even with the naked eye. A completely pearlitic structure with a very poor carbide formation and distribution within does not bring about the required hardness and toughness properties. The constant hardness values throughout the section was a clear indiction of "through hardening". Thus we do not have a tough core and a hard case which is essential for grinding media balls undergoing sudden impact in the crushing operation.

The hardness of the heat-treated specimen is lower than the "as cast". This is clear evidence of a wrong heat-treatment procedure. The hardness should be just under the mill lining hardness of 375 HB. The CSC balls does not conform to this.

Therefore these preliminary tests showed that the poor quality of the balls was due to the presence of blow holes and cavities and an unsatisfactory microstructure which is the consequence of an unsuitable chemical composition.

Therefore it was necessary to alter the casting procedure to produce a defect free ball.

1.4 The manufacturing procedure at the CSC foundry:

The foundry at the CSC contained three main divisions, which closed in at a common passage. The first division was the melting bay where there were two arc furnaces. The first was a 1/2 ton arc furnace which supplied a variety of melts and the other a 3 ton arc furnace which was normally used to obtain pig iron melts. Located on one side of the melting bay was a laboratory exclusively for the foundry. This had the normal sand testing equipment and the necessary equipment to provide an accurate carbon analysis of any melt sample. However, no carbon drop curves were available for any type of melt. Also no facilities were available for the analysis of any other element in the melt. The pattern shop and the maintenance workshop were situated below the laboratory. The melting is done almost daily. A variety of castings like grinding media, anvils, dorset plates etc. were done in this foundry. Ahead of the melting bay was the moulding and casting bay. In the moulding section there was a good stock of burnt sand ready. It was sieved and stored in bins for immediate usage. This was used as the backing sand in moulds. The facing sand was made using a muller type mixer. The raw materials were stored in seperate sections and the most common ones were Nattandiya sand, dextrin, ball clay and water. Bentonite was used less often. Over the entire span of the melting bay and the moudling and casting bay an overhead crane could be run. The heat-treatment and fettling bay was the third division. This bay too had an overhead crane with a span covering the entire length of the bay. There were two furnaces. The first was an oil fired annealing furnace. A similar type of furnace normally used for quenching operations was the second furnace. Beside the annealing furnace, a welding unit was kept to fill in little surface cavities in the casting. The final operation of fettling was done manually using one of the three fettling machines available. The fettled castings were stocked in piles outside and a lack of storage facilities was clearly noted.

1.4.1 The moulding sand:

Analysis of the mould materials were carried out. During the first two weeks the raw materials used for the preparation of the moulding sand were Nattandiya sand, dextrin, ball clay and water. These were mixed and used as the facing sand. Sometimes a little Kaduwela soil was added. During the last 2 weeks Bentonite was used instead of ball clay. The mixture used was the same, with only an equal quantity of bentonite being added instead of ball clay

The proportions and the method of making was carefully observed many times. About four to five bucket loads of sand was mixed with one large snocem paint tin each of dextrin and ball clay (or bentonite) and two scores of water amounting to about two flat canned tins. The average mixing time in the muller was 66 5 seconds. The maximum green mould hardness that could be attained with this mixture was 75.

It was also noted that the backing sand used was burnt moulding sand. This sand was sieved to separate it from the undesirables and then stored. The properties of this sand had to be studied as it occupied an appreciable proportion of the mould. The usual practice was to sieve and store the necessary quantity of sand for that particular shift, which is indeed the correct practice.

The following tests were carried out on a number of samples.

(1) Sieve analysis—the Nattandiya sand and the burnt moulding sand.
(2) Mixing time in the muller.
(3) Moisture content of the moulding sand mixture.
(4) The premeability of the moulding sand.
(5) The green strength of the moulding sand.

The use of bentonite instead of ball clay made it necessary to carry out a fresh estimation of (2), (3), (4) and (5).

The results were as follows:

(*a*) Nattandiya sand:

It was a 3-sieve sand with angular grains. The A.F.S. fineness number was 60.6. The sand was considered satisfactory.

(*b*) The mixture with Nattandiya sand, dextrin ball clay and water had the following properties.

The average moisture content	—	1.9%
The average permeability	—	1719.2 ml
The average green compression strength	—	1.9 lb in

(*c*) The mixture with Nattandiya sand, dextrin, bentonite and water had the following properties:

The average moisture content	—	2.6%
The average permeability	—	514.5 ml.sec^{-1}
The average green compression strength	—	3.1 lb in^{-2}

(*d*) The burnt moulding sand:

It was a .3-sieve sand with angular grains. The A.F.S. finess number was 35.9, a low value. The other properties were:

The average % moisture content	—	2.2%
The average permeability	—	475.7 ml.sec^{-1}
The average green compression strength	—	3.0 lb in^{-2}

1.4.2 The pattern

The pattern plate was such that a sprue height of only 4" was allowed for a total mould height of 36". The dimensions of the ingates were extremely small. No risers were accommodated. For 60mm balls one pattern plate accommodates sixty balls. Ball to ball flow takes place in many instances.

1.4.3 Mould making:

Four boxes (pattern plates) were accommodated in one mould set up. Therefore it amounted to that 240 balls were being cast in a mould at a time. The total height of the mould was 36" and each box was closed up using nuts and bolts on the sides. The entire mould was also tightened by a long bolt and nuts and it was revealed that due to insufficient tightening the boxes

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moved due to the pressure of the metal being poured and most of the balls cast had a mismatch especially at the bottom of the mould. When balls of a larger diameter were being cast a "dead box", 8" in height was accommodated at the bottom of the mould. No mould drying was done in most cases. In some cases drying from above and below using fire wood was carried out but the usual practice was to cast immediately after the mould is made which allows a very good probability of moisture contaminating the hot metal being poured.

1.4.4 Melting and pouring practice:

Temperature measurement of the metal is done using an optical pyrometer. This is very important to avoid premature solidification. It was observed that temperature measurements were taken after transferring a small portion of the melt to a container. This is not safe enough. For example—In a Hadfield Manganese steel melt, when the temperature was 1570°C inside the furnace, the temperature in a small sample measured outside was 1450°C. All measurements were taken just 5 minutes before tapping. Therefore to get a fairly correct idea about the temperature measurement must be taken both inside and outside, using an optical pyrometer. Normally degassing techniques are not used at all and only Al shot is added at the end. The practice of pouring a sample of hot metal to a container and observing the surface was not done. Slagging off is done only in the furnace and rarely is the slag analysed. Ladle drying was carried out for about 4 hours. One other important aspect was that the furnace to mould distance was unnecessarily extended. The hot metal in the ladle was transferred to the casting bay using an overhead crane which had a maximum run from the further end of the melting bay to the extreme end of the casting bay. This trip provided a good number of jerks. Therefore if unnecessary time was allowed for the transfer it was an additional exposure of the metal to the atmosphere and more water may be absorbed by the metal, aided by the jerks also. An additional disadvantage is that the temperature of the metal keeps dropping extremely fast from the time the metal enters the ladle. Therefore, more time of transfer even results in the metal solidifying prematurely. Therefore we must always try to bring the moulds to the end closer to the melting bay and carry out the pouring there.

It was noticed that the ladles were dried properly but the jig mechanism operated sometimes gave way to find that all the metal was allowed to pour waste into a pit or sometimes poured non-uniformly into the mould with metal sparks all over as a result of the hot metal striking the sprue edge. The jig mechanism used had a central rod with a stopper at the end and this rod was lifted using an iron rod handled by a man wearing gloves when it was necessary to pour the metal into the mould. Often this lever system failed to function because of the friction of the joints. In some instances the stopper got stuck in its aperture and a crude method of pouring with the ladle tilted was adopted. In some other cases the central rod made of fire clay refractory was cracked. All in all this is an unsuitable way of pouring. A tea pot ladle using a tundish would be ideal.

2. The modifications recommended:

2.1 The moulding sand mixture:

In order to optimise the % moisture, permeability and the green compression strength the following tests were done.

(*a*) Using Nattandiya sand, dextrin, ball clay and water—
   - (i) Variation of permeability and green compression strength with % moisture
   - (ii) Variation of permeability and green compression strength with % dextrin
   - (iii) Variation of permeability and green compression strength with % ball clay

(*b*) Using Nattandiya sand, dextrin, bentonite and water—
   - (i) Variation of permeability and green compression strength with % bentonite
   - (ii) Variation of permeability and green compression strength with % moisture
   - (iii) Variation of permeability and green compression strength with % dextrin

For a high melting point, heavy metal like steel the permeability should be a relatively high value to withstand the high back pressures. Also for the mould to retain the shape of the pattern well, the green strength is a decisive factor. The component dextrin had poor green strength and thus it was decided to try out a mixture.

(*c*) Using Nattandiya sand, bentonite and water to determine—
   - (i) Variation of permeability and green compression strength with % bentonite
   - (ii) Variation of permeability and green compression strength with % moisture.

All these variations were graphed and an example is given in Figure 1.

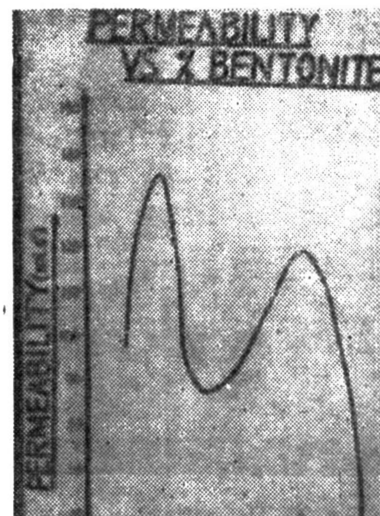

Figure 1 - Graph of Permeability VS % Bentonite mentioned under (b) (i)

Figure 1—Graph of Permeability vs % bentonite mentioned under (b) (i)

Taking into consideration that bentonite is very costly when compared to dextrin and that it was important to impart high dry strength (which could not be measured due to lack of equipment) and considering the optimisation graphs plotted and the metal to be poured the following moulding sand mixture was decided on. The amounts are given in terms of their normal measuring apparatus within brackets.

Nattandiya sand	200 g (4 buckets)
bentonite	6.0% (1½ paint tins)
dextrin	4.0% (1 paint tin)
water	3.0% (2 scores from the small)

These are the ingredients for one mix. The mixing time should be 5 minutes, the minimum. This sand is be used as the facing sand and the burnt sand (sieved and stored to be used immediately) to be the backing sand. The overall green mould hardness of the mould should be 90.

2.2 The pattern and the mould set up:

The pattern and the mould was completely modified to avoid the defects mentioned earlier and especially to avoid unfilled spaces, contraction cavities and mismatches. It was our contention that ball to ball flow should not be allowed as this would make flowability difficult and the ball that facilitated flow to its neighbour would be defective with contraction cavities. But as the foundry authorities argued that this need not be so it was decided that ball to ball flow be allowed in the pattern plate but that in 2 stacks of moulds ball to ball flow would be blocked. The pattern plate is shown in Figure 2. The ingates from the sprue was increased from the earlier value of 20 mm to 25 mm. The ingates to the balls were also increased from 10 mm to 15 mm.

The moulds were to consist of 4 boxes (pattern plates) and each box and the entire mould was to be tightened carefully with nuts and bolts on two sides in each case.

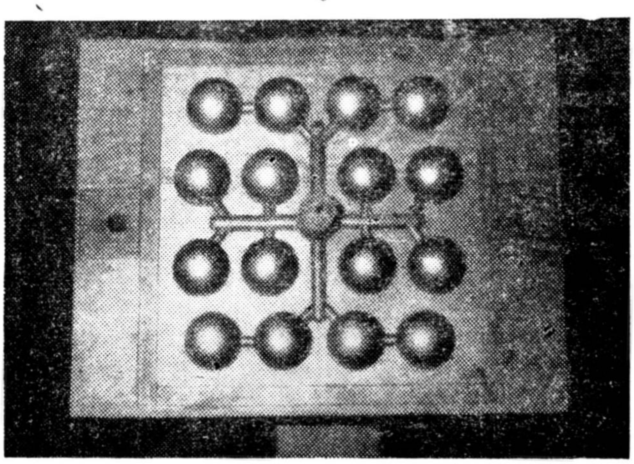

Fig. 2 - The pattern plate

2.3 Drying the moulds:

Very good consideration was given here. It was clear that most of the blow holes were due to poor drying.

The moulds must be air dried for 24 hours and subsequently dried in the annealing furnace for 6 hours, before pouring.

2.4 The chemical composition to be attained:

It was also decided to change the composition of the ordinary wear grinding media balls completely. This was possible, because a grinding media ball with overall properties could be obtained with a much simpler composition. This composition if used had the added advantages of—

(*a*) Being very much cheaper to manufacture due to the reduction in alloying elements.

(*b*) It is possible to do an effective heat treatment on such a simple composition.

The composition recommended by us for ordinary wear balls was as follows:

TABLE 2—The recommended composition for ordinary wear grinding media

Alloying element	Range needed	Real achievement
C	0.7 - 0.9	0.7 - 0.8 should be aimed at
Mn	0.2 -0.95	0.5 should be aimed at
Cr	0.15 - 0.3 small balls ($<$ 50 mm diameter) 0.4 - 0.6 large balls	As the balls are large (6c mm dia) a composition of 0.5 should be aimed at.

2.5 Melting

In the melting operation, it is observed that C analysis should be done more frequently. After the first sample is taken at melt down, samples should be taken every 15-20m, at least. It is regretted that the other elements cannot be analysed before pour. Cr and Mn must be controlled as far as possible by—

(*a*) Using a mild steel scrap charge—with the initial composition known as far as possible,

(*b*) No returns.

The charge in order to achieve the modified chemical composition for 1/2 ton of hot metal should be as follows:

Limestone	10kg
Coke	8kg
Scrap	500kg
Fe-Cr	4kg
Fe-Mn	4kg
Fe-Si	3kg

The C drop curve for a similar melt (0.6–0.9% alloy steel melt) was also supplied.

It was observed that degassing is not strictly adhered to. Before a final pouring it is a must to pour a little of the melt to a container to find out whether the top surface is close to flatness. If the melt is not degassed properly the surface is convex, and when over-degassed concave.

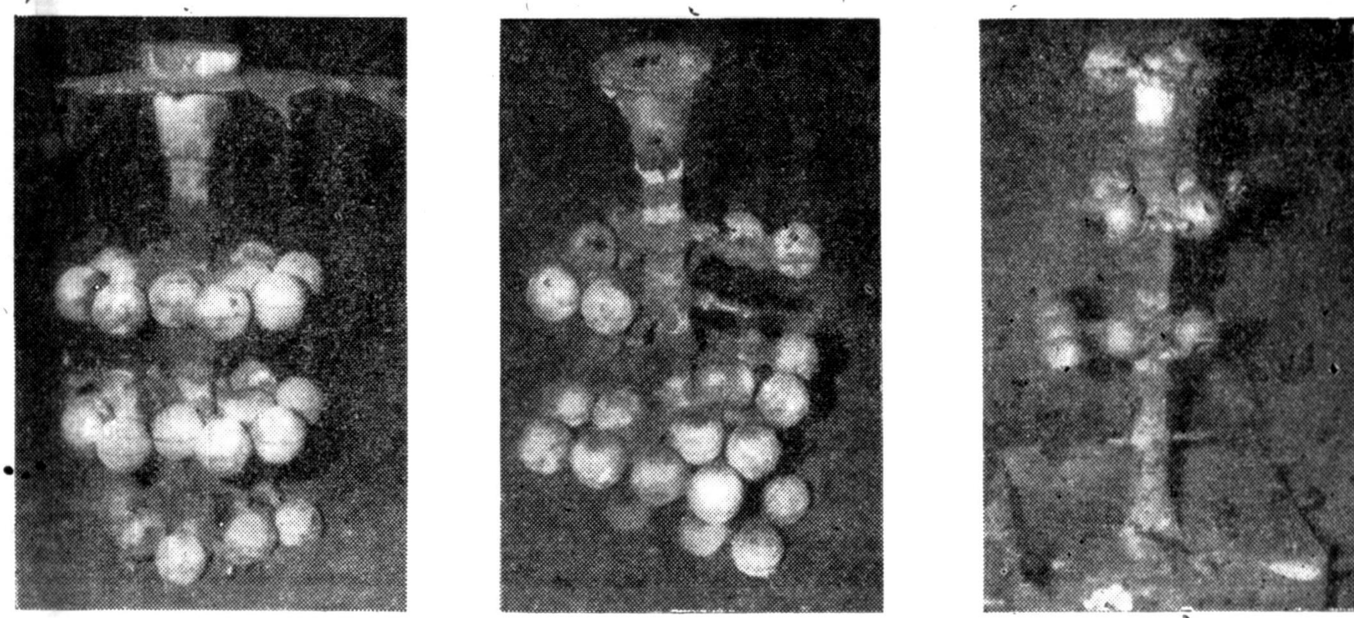

Fig. 3 - The products of the moulds A B & C

The degassing should be done in the ladle using some degassing powder. Ladle should be heated up for at least 3-4 hours before pouring.

Pouring from the bottom ladle should be resorted to with the metal being not allowed to pour quite a distance—(i.e. reduce as far as possible the bottom outlet to sprue distance). It had been noted that while transfer after pouring the temperature (if = 1500°C, drops at the rate of 50°C per minute) drops rapidly. Therefore we must keep the moulds as close as possible at the near side of the casting bay in order to reduce the time lag between tap and actual pouring to mould. This prevents premature solidification and water and air entrapping, while the ladle is removed by a crane—(as the distance of transfer using the crane is reduced).

A trial casting with the above mentioned modifications was conducted using the 1/2 ton arc furnace. The pattern plate was prepared for 60 mm balls. Two stacks of moulds (Mould A) did not have ball to ball flow. Two others (Mould B) did have ball to ball flow. Another two moulds (Mould C) was prepared according to the CSC practice described under section 1.4.

3. Analysis of the Product from Trial Casting:

3.1 Results of the trial casting:

The day after the trial casting was performed, all the moulds were opened up and the products carefully examined. The following observations were made.

1. All our products WERE COMPLETELY FREE FROM MISMATCHES.
2. Both the trial moulds were photographed just after being removed from the sand (i.e. the products in "tree form")
3. Mould A (no ball to ball flow—see Figure 3(a))
   Expected yield — 48 balls
   Obtained yield — 40 balls
   Mould B (with ball to ball flow—see Figure 3(b))
   Expected yield — 60 balls
   Obtained yield — 50 balls
4. It was seen that the ball to ball flow affected the other balls in that layer, and in some instances ball to ball flow never took place.
5. For comparison sake, the Mould C prepared by CSC according to their practice (and air dried) gave a yield of only 2 complete defectless balls out of an expected yield of 80 balls (see Figure 3 (c)).
6. On removal it was seen that *only* the trial castings gave sufficient products. Other moulds gave only a 10% yield when compared to the 90% yield in our trial moulds.
7. Selected specimens were fettled for further investigations.

3.2 Cutting into section:

A careful cutting up into section of certain balls clearly showed that—

(*a*) the majority of the balls (99%) were DEFECT FREE—i.e. especially the contraction cavities and blow holes were not present.

(*b*) where ball to ball flow took place the interior ball (one which provided the flow to its neighbour) had a large contraction cavity. This agrees with our earlier contention that ball to ball flow should not be allowed.

(*c*) For some balls the Archemedes principle immersion method was also used to detect any cavities within. The results indicated that there were no blow holes.

3.3 Chemical analysis:

The composition aimed at was more or less achieved. Stricter control cannot be made with regard to elements like Cr, Mn since these amounts cannot be determined while melting. (Table 3).

3.4 Metallography

Several of our products from the trial casting were sectioned, polished and looked under the microscope in the same way that theirs was done.

The structure was completely pearlitic. This was in accordance with the composition.

3.5 Hardness contours:

Hardness contours carried out on 2 perpendicular directions revealed that the hardness on the surface was 252 DPH at the case and 237 DPH at the core. This is a good achievement because—

(*a*) after a proper heat treatment the hardness can easily be increased to over 500 DPH on the surface,

(*b*) A hardness variation to achieve a tough core and hard case can be achieved in order to have the correct impact properties.

The sections indicated further that the product was free of cavities and blow holes. An abrasion resistance test will also be done after the heat treament is completed.

TABLE 3—Wet chemical analysis of drillings from several fettled balls

Element	A	B	C	D	E
C% ..	0.71	0.71	0.70	0.72	0.71
Cr% ..	0.64	0.64	0.68	0.62	0.63
Mn% ..	0.58	0.64	0.60	0.64	0.64
Si% ..	0.09	0.09	0.09	0.09	0.08
P% ..	0.10	0.16	0.10	0.12	0.12
S% ..	0.12	0.10	0.10	0.10	0.10

4. Cost Analysis:

A cost analysis per MT ton of hot metal for the 60 mm CSC grinding media balls is as follows. The % alloying elements are taken as an average.

i.e.— C	1.1	—	2.0%
Cr	1.0	—	2.4% (avg. 1.25%)
Mn	1.0	—	1.6% (avg. 1.3%)
Si		—	0.5% max
P		—	0.04% max
S		—	0.04% max

(*a*) Hot metal cost

		Rs. cts.
Steel scrap	100 kg	65.00
Coke	40 kg	106.00
Fe Mn	30 kg	193.50
Limestone	65 kg	13.00
Fe Si	30 kg	277.20
Electrodes (Graphite)	15 kg type (8″)	347.10
Fluospar	5 kg	35.20
Al shots	1 kg	19.17
K.W. hours	1500	225.00
Magnesite Pea	30 kg	60.00
Fe-Cr	30 kg	542.40
Iron ore	20 kg	1.80
	Total	1,885.97

(*b*) Rerfractories:

	Rs. cts.
Wall bricks 150 metric tons—lifetime	777.93
Bottom and 120 roof bricks ,, ,, ,, ,,	229.85
Magnesite 150 powder ,, ,, ,, ,,	31.57
Na silicate 150 ,, ,, ,, ,,	5.00
Asbestos packing—150 MT Tons—lifetime ,, ,, ,, ,,	7.54
Hardboard 120 ,, ,, ,,	5.50

(*c*) Ladle

Ladle bricks	3t—30 MT Tons lifetime	150.00
Ladle nozzle	1.5 ,, ,,	3.30
Ladle stopper rods	10 ,, ,,	3.33
Ladle stopper heads	1.5 ,, ,,	3.30
Ladle stopper sleeves	0.5 ,, ,,	10.92
Fire Clay	50 ,, ,,	13.00
Total (b & C)		1,241.24

(*d*) Overheads (cost per metric ton)

Pattern shop	88.00
Moulding shop	755.40
Melting shop	136.68
Fettling shop	86.73
General overheads	211.25
Supervision and administration	165.53
Total	1,443.59
Total (a) + b) + c) + d))	4,570.80

The cost analysis per MT ton of hot metal for the 60 mm grinding media balls manufactured at the trial casting is as follows:

C	—	0.7—0.8%
Mn	—	0.5%
Cr	—	0.5%
Si	—	0.5%

The additions to achieve above was—

Ferro Mn	—		9 kg
Ferro Cr	—	if L/C	10 kg
		H/C	12 kg
Ferro Si	—	if L/C)	8 kg
		H/C	

The resulting cost would be (after considering a 0.5 loss to the slag).

			Rs. cts.
Ferro Mn	—		50.91
Ferro Cr	—	if L/C	163.65
		H/C	136.50
Ferro Si	—	if L/C	60.00
		H/C	55.00

Since H/C alloys are normally used, total cost in alloying additions = 242.41

Total alloying cost for their composition = 1,013.10

Reduction influenced in the hot metal cost = 770.69

Since the C% to be obtained are lesser the amounts of coke and limestone are reduced.

Variety	*Earlier charge* (*kg*)	*Charge needed now* (*kg*)	*Present cost* Rs. cts.
Coke	40	20	53.00
Limestone	65	25	5.50

∴Total now Rs. 58.50 as against Rs. 119.00 earlier

∴Reduction—Rs. 60.50

∴Total decrease in hot metal cost

= Rs. 770.69 + Rs. 60.50

= Rs. 831.19

Due to a more complicated pattern, the pattern cost rises to Rs. 100.00 as against Rs. 88.00 earlier, an increase of Rs 12.00. As an excess Bentonite is used, the moulding cost increases to Rs. 805.00 as against Rs. 755.40 earlier, an increase of Rs. 49.60.

Also the 6 hr. drying of the mould at 150°C acquires a cost of Rs. 100.00 (calculated on a maximum temperature, maximum fuel consumption basis of Rs. 108 per hour for a full annealing cycle).

$\therefore$ Total increase = Rs. (12.00 + 49.60 + 100.00)
= Rs. 161.60

Net decrease in cost for all our modifications:

Total decrease	..	Rs. 831.19
Total increase	..	Rs. 161.60
$\therefore$ Net decrease	..	Rs. 669.59

This reduction is per I MT ton of hot metal, and a defect free product. It must be noted that if the proportionate yields were considered in addition to the basis of 1 MT ton of hot metal the reduction would be even greater. This is because at the trial casting the moulds incorporating our modifications gave yields of over 80% whilst in the CSC moulds (Mould C) the yield was under 10%.

5. Acknowledgements:

This project was conducted under the supervision of Professor A. R. T. de Silva, Head, School of Applied Science with Chemical Engineering, who was also Chairman of the Ceylon Steel Corporation during the period of the investigation.

We wish to record a special word of thanks to the laboratory and foundry workers who helped us throughout this work.

''ක්ලින්කර්'' අවස්ථාවේ ඇති සිමෙන්ති, කුඩක් බවට පත්කිරීමට යොදවන ලංකා වානේ සංස්ථාවේ නිෂ්පාදිත ලෝහමය ගෝල ඉක්මනින් වැය වී යාම හා ඛණ්ඩයවීම කරණකොටගෙන කාර්යය ඉටු නොවනුයේ මන්දැයි සෙවීම පිණිස මෙම විද්‍යාත්මක පර්යේෂණය කරන ලදී. ආරම්භයේ කරන ලද පරීක්ෂණවලින් හේතුකාරක ලෙස පෙන්නුම් කළේ ලෝහමය ගෝල තුල තිබූ වා හිඩැස්, කුහර සහ උචිත නොවූ සංඝටකවලින් එම ලෝහමය ගෝල සමන්විත වී තිබීමය. එම නිසා මූලික පියවර වශයෙන් දෝෂ රහිත ඵලයක් ලබා ගැනීම සඳහා වාත්තු ක්‍රමයෙන් නිෂ්පාදිත මෙම ලෝහමය ගෝලවල වාත්තු කිරීමේ ක්‍රියාකාරම සංශෝධනය කිරීම අවශ්‍ය විය. මෙම කාර්යය ඔරුවල වානේ සංස්ථා වාත්තු කම්හලේ ගත කළ දෙමසක කාලයක් තුළදී කරන ලදී. ප්‍රථමයෙන් ලංකා වානේ සංස්ථාවේ වාත්තු කම්හලේ නිෂ්පාදන පියවර හොඳින් නිරීක්ෂණය කර වාත්තුව සඳහා යොදන ක්‍රියාකාරමට අදාල වැලි මිශ්‍රණයේ ගුණාත්මක හා ප්‍රමාණාත්මක විශ්ලේෂණයක් කරන ලදී. ලෝහමය ගෝල වාත්තු කිරීම සඳහා යොදන සියලු සැලසුම්, වාත්තු කිරීමේ පියවර හා ලෝහමය ගෝලවල සංඝටක ද්‍රව්‍යද පිළිවෙලින් අවශ්‍ය වූ වෙනස් කිරීම් හා සංශෝධනවලට භාජනය කරන ලදී. මෙම සංශෝධන සියල්ල සහිතව අත්හදා බැලීම පිණිස ලෝහමය ගෝල වාත්තුවක් කරන ලදී. ඵල දෝෂ රහිත බව ඉන්පසුව කරන ලද පරීක්ෂණවලින් හෙළි විය. තවද පෙර තිබූ අඩු පාඩු ඉවත්වී තිබූ අතර මෙම සංශෝධිත ක්‍රමය ආර්ථික ලෙසද වාසිදායක බව පෙන්වා දෙන ලදී.

இலங்கை சீமெந்துக் கூட்டுத்தாபனத்திற்கு, சீமெந்துக் கிளிங்கரினை (Clinker) அரைப்பதற்கு பந்து ஆலைகளில் (Ballmills) தேவைப்படும் அரைக்கும் ஊடகங்களான (Grinding Media) உலோகப்பந்துகளை இலங்கை உருக்குக் கூட்டுத்தாபனம் வழங்குகிறது. சீமெந்தின் விலையின் கிட்டத்தட்ட 13% ஐ இவ்வுலோகப்பந்துகள் பாதிக்கின்றன. நீண்ட நாட்களாக பாவனையாளர்களிடமிருந்து வருகின்ற புகார் என்னவெனில் இவ்வுருக்குப்பந்துகள் இறக்குமதி செய்யப்பட்ட உலோகப் பந்துகளைவிடவும் மிக விரைவாக உருக்குலைந்து போவதோடு மாத்திரமின்றி துண்டுகளாக உடைந்தும் போய்விடுகிறது என்பதாகும். மேற்கண்ட காரணங்களை ஆராய்வதற்காகவும், உள்ளூரில் உற்பத்திசெய்யப்படுகின்ற இவ்வுருக்குப் பந்துகளின் தரத்தை உயர்த்துவதற்காகவுமே இவ்வாராய்ச்சி முயற்சி மேற்கொள்ளப்பட்டது.

உலோகப்பந்துகளின் தரக்குறைவிற்குக் காரணம் காற்றுத்துளைகள் (Blow holes), சிறு குழிகள் (Cavities), திருப்தியற்ற நுண்கட்டமைப்பு (Micro structure) ஆகியனவே காரண்ங்கள் என்பது ஆரம்பப் பரிசோதனைகளிலிருந்து தெரியவந்தது.

இப்பந்துகள் உருக்கி வார்க்கின்ற முறையினை (Casting procedure) நன்முக அறிந்துகொள்வதும், அதில் திருத்தங்கள் செய்வதும் இவ்வாராய்ச்சி முயற்சியின் பிரதான அம்சமாக அமைந்திருந்தது. இலங்கை உருக்குக் கூட்டுத்தாபனத்தின் ஒருவல ஆலையில் பெறப்பட்ட இரண்டுமாதகாலப் பயிற்சியின்போது இம்முயற்சி மேற்கொள்ளப்பட்டது.

இந்த அறிக்கையானது அங்கு நடாத்தப்பட்ட ஆராய்ச்சி முயற்சிகளை தெளிவாக விளங்கப்படுத்துகிறது.

உருக்குக் கூட்டுத்தாபனத்தின் உருக்கு வார்க்கும் பகுதியில் கடைப்பிடிக்கப்படும் உற்பத்தி முறைகள் விரிவான முறையில் அறியப்பட்டன. இவை தொடர்ச்சியான பரிசோதனைகளால் அறியப்பட்டன அவையாவன.

உருக்கு வார்க்கும் அச்சுக்குத் தேவைப்படுகின்ற மணலின் (a) நீராவிக் கொள்ளளவைக் கட்டுப்படுத்துதல் (b) காற்றூடுபுகவிடும் அளவைக்கட்டுப்படுத்தல் (c) பச்சைத்தன்மையாயிருக்கும் போதுள்ள உறுதி (Green strength) ஆகியனவும்.

வடிவமைப்பு (Pattern), அச்சு (Mould), உலரும் முறைமை, வார்க்கும் முறைமை, பாவிக்கப்படும் உருகிய திரவத்தின் விகிதமைப்பு (Composition) ஆகியனவும் மாற்றியமைக்கப்பட்டன.

மேற்கண்ட மாற்றங்களுடன் ஒரு ஒத்திகையான வார்ப்பு (Social Costing) ஒன்று கூட்டுத்தாபன வேலைத்தலத்தில் செய்யப்பட்டது. ஆனல் கிடைக்கப்பெற்ற பந்துகளைக்கொண்டு செய்யப்பட்ட பரிசோதனைகள், விளைவானது பிழைகளின்றி இருப்பதைக் காட்டின. அதேநேரத்தில் இந்தப் பந்தினை இலாபகரமான முறையில் உற்பத்திசெய்யவும் முடியும் என்பதை செலவறிக்கை எடுத்துக்காட்டுகிறது. வெப்பச் சிகிச்சைமுறைமை மூலம் (Heat treatment) மேலும் இப்பந்துகளின் தரத்தை உயர்த்துவதற்காக இலங்கைப் பல்கலைக்கழகத்தின் கட்டுப்பெத்தை வளாக பிரயோக விஞ்ஞானபீட ஆய்வு கூடத்தில் இப்பந்துகள் தொடர்ந்தும் பரிசோதனைக்குட்படுத்தப்பட்டுள்ளன.