Quest Journals
Journal of Research in Mechanical Engineering
Volume 2 ~ Issue 5 (2015) pp: 08-17
ISSN(Online) : 2321-8185
www.questjournals.org

Research Paper

Effect of Temperature of Preheated Budding materials on the Cost of Production of Electric Arc Furnace (EAF) 50 ton Capacity

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Received 01 July, 2015; **A**ccepted 16 July, 2015 © The author(s) 2015. Published with open access at **www.questjournals.org**

ABSTRACT:- Country like Nigeria needs sufficient metal products for different purposes. This study Investigates temperature of pre-heated budding materials and its influence on the working index of Electric Arc Furnace (EAF) which include: productivity, cost by limit, energy usage and continuity of furnace production).
Experiment were conducted with different values of temperature :(298, 600, 680, 850, 1000) K.
The results showed that the optimum temperature for EAF 50 t is 1000K .The corresponding values of Productivity for the whole of periods are: (71.16, 81.39, 84.24, 90.99, and 96.88) t/h respectively.
The conclusion therefore is that optimum temperature of budding materials for 50ton furnace capacity is 1000K.

KEYWORDS:- EAF, steel, furnace, temperature, oxygen, cokes.

I. INTRODUCTION

EAF being one of the modern and latest technologies for steel bulk production is used for melting the scrap into molten steel.EAF is assessed to contribute up to 1/3 of the world steel production [1].

The high demand for metal bulk had necessitated scientists from time immemorial to develop different types of furnaces among which are:

(a) Dominic furnace (where iron ore, lime and coke are processed to realize wrought iron, pig and slag).

(b) Oxygen converter (from which we can get steel of different specifications and this idea also provide bulk/mass production of steel).

(c) Siemens Martin open earth (which permits direct reduction of iron oxides but is no more popular because of liberation of toxic oxides), however it is still in use occasionally in Russia.

(d) EAF is the latest modern technology of getting steel of different specifications under safe atmospheric condition because all the processes take place in a close system. The gases escaping from the working plane (as waste) can be reabsorbed for heating the scrap and this has economic value. It therefore becomes important to Investigate EAF further as we tried to do in this study.

One of the factors which play vital role in the production of steel industries is temperature of the pre-heated metal. The working index of furnace which include productivity, Cost by limit (i.e the cost price per unit of the product), Energy usage and Continuity of production is a measure of efficiency. The target in any production unit is to reduce the cost of production to the barest minimum and one of the technological factors that influence the working index of EAF is temperature .This study therefore arrives at determining optimum temperature for heating scrap before they are fed into furnace.

II. MATERIALS AND METHODS

This project was carried out on an industrial scale for 50 tons EAF at Zerepaves Metallurgical plant. During the project design, manufacturing, installing, and operating of O_2 blowing system using the O_2 line .Camera system for controlling and viewing the surface of melting metal in the furnace with a monitor as well as the controllable O_2blowing lance. A flow meter and controlling flow systems with display and control panel are also present.

Different methods are available for use in refinery, but this study, adopted one slag tap-to-tap method in the furnace using alternating current and water cooling panel. Basically, the work of EAF is divided into two periods; which are melting period and refinery period. About 80% of energy supplied to the furnace is used in

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the melting oxidation period which is energy intensive; approximately 400kWh/t of steel is consumed [2], and modern furnaces consuming less than 300kWh/t of steel [3]; while the remaining 20% account for the chemical energy liberating from chemical reactions taking place within the furnace [4]; therefore, the economy of this period is very important to scientists. Among those factors considered for energy economy is temperature of preheated budding material (scrap) and also reducing the duration of that period.

Kabrera Brendex, a Cuban student of Ferrous Metal Department, St. Petersburg State Technical University, Russia (1993) attempted to work similarly with Initial value of t_{Tex} was taken from the condition that total continuity of refinery period was T = 20min and continuity of stopping for refinery period equal t_{Stop} = 7min .Then, $t_{Tech} = \frac{T - t_{Stop}}{60 \text{ x} G \text{ x } K_{EU}}$ H/t $= \frac{20-7}{60 \text{ X } 50 \text{ X } 1.07}$ H/t = 0.003975H/t [5]

III. TEMPERATURE OF PREPREHEATED BUDDING MATERIALS.

It is known that for EAF of a given capacity, time of melting the budding materials is directly depend but on power of furnace transformer and power of oxygen burning chamber. This will further influence relative usage of electricity and EAF productivity. The importance of technology of steel production adopted while considering those two periods with controlled quantity of alloying metals injection cannot be over-emphasized.

Energy usage also depends on the lining material of the furnace, water cooling panel or brick bottom and wall. In this study we used some initial data as basic variant of EAF and try to work with modern Method to improve EAF working index. Here, the working index considered is Cost by limit, mathematically given as: C = B + A (5)

Where; B -- quantities part of expenditure by limit by i-article /C_i/ in dividend /B_i/ belongs to variable part.

A -- quantity of expenditure by limit with article /C_i/ in dividend /B_i/ belongs to constant part of expenditure.

With reference to Ali Akbar Mottahedi in his work; project on 12ton used oxygen reaction as electric energy saving in EAF Steel making. The result was 20% reduction in energy consumption. [6]

To heat the scrap, charging to EAF in metallurgical plants were tried and accepted equipment of different constructions. Available equipment for this target are grouped into: Preheating metal scrap for example up to 400°C or more, but not more than up to (700-800)°C, so far affirmative condition increases oxidation of metals. Difference in these equipment is preheating metal up to 400°C can be realized in ordinary pot but for preheating up to more higher temperature, there is need for special pot. [7]

In order to avoid overheating of the top of the metal part, it is normal to preheat with cokes or natural gas, reduces it with significant excess air or dilutes them with product of burn-off.

A drawing showing simple wall of preheating scrap is shown on the fig 1. In this case, the stand is meant for preheating scrap in one pot used also for loading scrap into the furnace. The smoked gases must be completely combusted in a vertical camera burning before allowing them escape to the wall of heat or ejecting them to mix with second smoke before escaping to the filters.

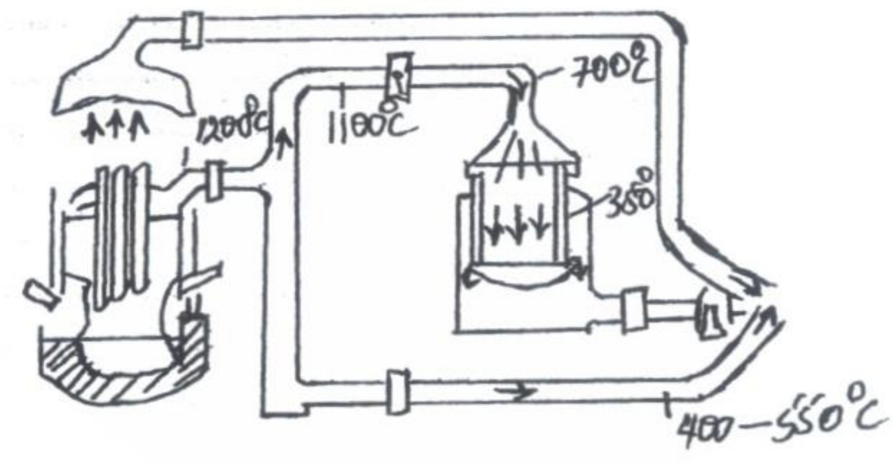


Fig 1: Stand for preheating the scrap.

Utilization of energy of smoked gases EAF for the preliminary preheating of the budding materials into those EAF by the achieved resultant: energy economy of the electrodes, increasing productivity of furnace, undoubtedly effective, more than using those energy to achieve hot water and steam. It can be explained by fast and widely spread method of preheating scrap. Definition of technical-economic index of furnace by calculation method, working with preheating the scrap, can be used ranging from 298 to 1273K.

IV. RESULTS AND DISCUSSIONS

Energy of the budding materials preheated up to 400 ^{o}C is 196KJ/t/54kWh/t, and those preheated up to 700 ^{o} C – is 415MJ/t,/115kWh/t/. On this quantity reduced also the amount of useful energy necessary for melting the scrap. The quantity of factual usage of electric energy observed reduced.

In Europe were used equipment for preheating metal scrap with furnace of 50t capacity. With the available data, usage of energy, gas equipment of that type were from 35 to 43%.. reheating the scrap outside the furnace as a result of additional fuel, so also heat from the outgoing gases from the furnace, were used on the plant in Villadossle/Italy/ by the Brown-Bovary-Bruce process. Constructive ejection of gas from furnace realized through inclined pipe of rotating furnace sited between bunkers for budding and furnace, serves at the same time both for supply of metalized iron ore or crushed scrap on the plane between electrodes.

At the lower part of rotating furnace is located the chamber for complete combustion of outgoing gases from the furnace and combustion of 30m ^{3} of natural gas on 1t of steel. About 70% of heat entered as a result of burning natural gases but remaining with gases escaping from furnace. Relative usage of electricity on melting preheated average up to 1000^{o}C scrap is 1000MJ/t,/280kWh/t/.

Method and installation of stand of preheating scrap only at the expense of energy of burning gases escaping from the working plane of ESF, used up to industrial level of Japanese firm NIKKO and widely used at the beginning of 80’s not only in Japan but even outside. This capable of increasing productivity per hour EAF and usage of wall oxygen chamber inside them with high oxygen content/ 10- 30m^{3} /t/. From these types of furnace through 4th outlet with escaping gases up to 500-540 MJ on 1t of scrap included, apart from enthalpy of preheated gases, and potential energy of complete combustion of CO and hydrogen. Scrap preheated up to (350-380) ^{o}C. Energy economy with consideration of general efficiency of EAF/0.75/ and can be realized also up to 215-235MJ/t/60-65 kWh/t/ steel.

Practically attainable energy economy with preliminary preheating of scrap with outgoing gases from EAF normally is ~125-144MJ/t/35-44kWh/t and more. Continuity of smelting is reduced to 5-10min and usage of electrodes also reduced to 0.2-0.4kg/t.

Preheating the budding material reduces usage of electric- energy on warming and melting metal bulk: i.e. reduces W_{UEU} for basic variant of melting period W_{UEU} which is 0.371MW-h/t. When using the preheated budding up to temperature 600, 680, 850 and 1000K, value of W_{UEU} respectively equal to 0.306, 0.291, 0.259 and 0.234. Calculation of computer allows definition of the melting period furnace index, which is shown in the table 1 and fig 2 below.

Table 1 Effect of budding material temperature on usage of electric- energy and productivity of EAF during melting period

T_{BM} (K)	I_1(A)	q_{MP} (t/h)	W_{MP} (MW-h/t)	T_{MP} (h/t)
298	61479	99.0	0.4920	0.01010
600	61497	120.0	0.4062	0.00833
680	‘’	126.3	0.3860	0.00792
850	‘’	142.1	0.3430	0.00704
1000	‘’	157.0	0.3105	0.00637

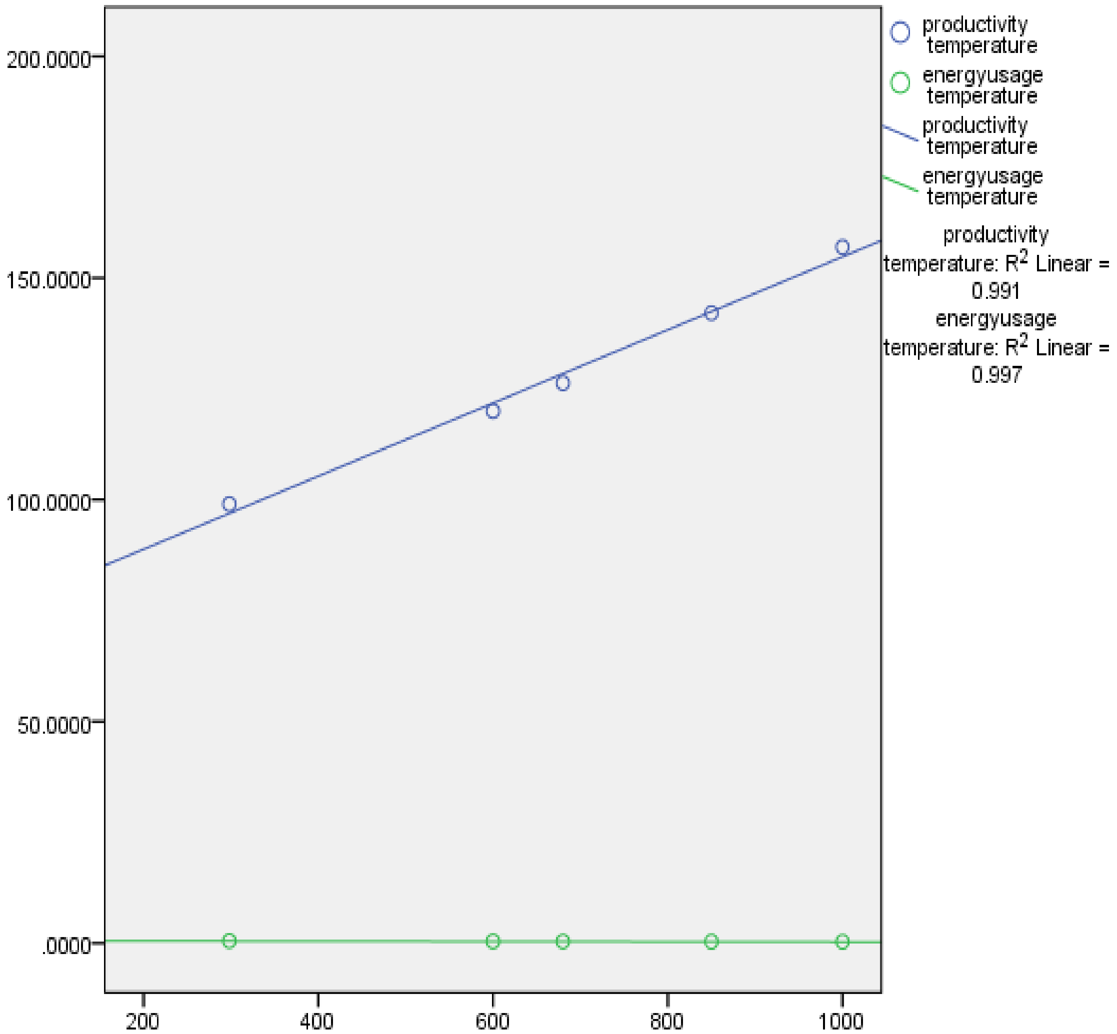
On figure 2, shown values of q^{I}_{MP}& W^{I}_{MP}, calculation by empirical formula (q^{I}_{MP}, W^{I}_{MP}) = f (T_{GM}). These given calculations on computer as an example for preheating the scrap up to 1000K is shown on the tables 1 and 2.

Table 2

	I (A)	COS F1	η (NUE)	V (V)	S (KVA)
J01	9.42E + 03	.995	.902	337.0	9.74E + 03
J02	1.88E + 04	.900	.964	325.8	1.94E + 04
J03	2.82E + 04	.955	.945	311.2	2.92E + 04
J04	3.77E + 04	.919	.923	292.7	3.89E + 04
J05	4.71E + 04	.870	.899	269.8	4.87E + 04
J06	5.65E + 04	.806	.869	241.9	5.84E + 04
J07	6.59E + 04	.724	.830	207.5	6.82E + 04
J08	7.54E + 04	.616	.772	164.1	7.79E + 04
J09	8.48E + 04	.463	.660	105.4	8.77E + 04
JA	4.62E + 03	.990	.000	0.0	4.78E + 03
JS	4.00E + 04	.900	.918	207.4	4.14E + 04
J1	6.14E + 04	.766	.851	224.8	6.35E + 04
J2	6.79E + 04	.704	.821	199.5	7.02E + 04
JB	9.33E + 04	.222	.220	16.9	9.65E + 04
JK	9.42E + 04	.175	.000	0.0	9.74E + 04

I – Current (A); COS F1 – Cosine F1; V – (Voltage); S – Nominal power of furnace transformer (kWh/t)

Fig 2 Dependence of productivity of furnace and electric energy usage during melting period on temperature of preheated budding materials



X-axis – Temperature of budding material
Y-axis – Productivity
Y-axis – Energy usage

q_{MP} . W_{MP} – Result (during smelting) of computed value

q^{I}_{MP} . W^{I}_{MP} – Result (during smelting) of calculated value by formula

$q^{I}_{MP} = 0.078\ T_{BM} + 75.26$ T/h (2)

$W^{I}_{MP} = 0.537 – 0.00025\ T_{BM}$. MW-h/t (3)

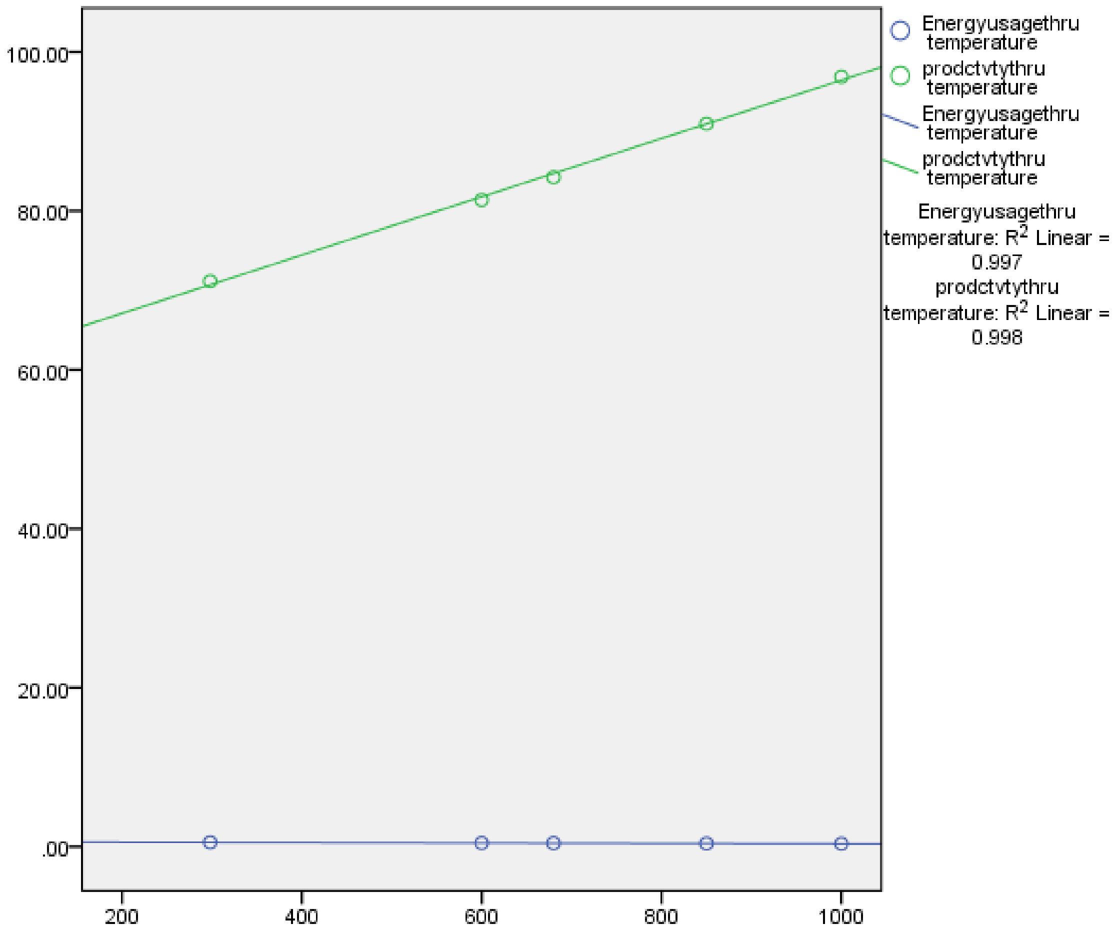
With variation of temperature of budding material, dependence of usage of electric-energy and furnace productivity throughout the smelting on that factor observed (Table 5).

Table 5 Effect of temperature of budding material on Furnace working index throughout smelting

T_{BM} (K)	I_1 (A)	W_{MP} (MW-h/t)	$W_{\square}$ (MW-h/t)	q_{MP} (T/h)	$q_{\square}$ (T/h)
298	61497	0.4921	0.5463	99.0	71.16
600	61497	0.4062	0.4604	120.0	81.39
680	61497	0.3860	0.4402	126.3	84.24
850	61497	0.3430	0.3972	142.1	90.99
1000	61497	0.3105	0.3647	157.0	96.88

Values of q'_{Σ}, and W_{Σ} were as plotted in the graph of effect of temperature of budding material, K. The values of q'_{Σ}, and W'_{Σ} were known to us through calculation from empirical formula.

Fig 3 Influence of temperature of budding on EAF productivity and electric Energy usage throughout production



X-axis – Temperature of budding material
Y-axis – Productivity (throughout production)
Y-axis – Energy usage (throughout production)

$q_{\Sigma}.q^{I}_{\Sigma}$ – Dependence of productivity (throughout production) on the temperature of preheated budding material by computed value and calculated value by formula:
$q_{\Sigma} = 0.034\ T_{BM} + 60.636$ t/h (4)
$W_{\Sigma}\ W^{I}_{\Sigma}$– Dependence of energy usage (throughout production) on temperature of preheated budding material by computer value and calculated value by formula:
$W^{I}_{\Sigma} = 0.625 - 0.000275\ T_{BM}$ MW-t/h (5)
Dependence of usage of electric-energy and productivity of EAF on temperature of preheated budding materials has the following form: Equation founded from graph.

$$w'_{\Sigma TBM} = 0.625 - 0.000275 \times T_{BM}$$

$$q'_{\Sigma TBM} = 0.0348 \times T_{BM} + 60.636$$

Hence, we can form a table of dependence of electric-energy and productivity on the temperature of budding materials.

Table 6 Effect of temperature of budding materials on usage of electricity and productivity (throughout production)

T_{BM} (K)	200	400	600	800	1000	1200
$W_{\square TB}$ (MW-h/t)	0.570	0.515	0.460	0.375	0.350	0.295
$q_{\square TBM}$ T/h	67.606	74.576	81.545	88.515	95.484	102.454

Expenditure by limit when varying temperature of budding can be writing as follows in the formula:

$$C_{TB} = \frac{n_i}{0.0348 \times Tш + 60.636} + m_i\,(0.625 - 0.00027 \times T_B) + A \qquad (6)$$

$$C_{TBmin} = \frac{n_i}{0.0348 \times 298 + 60.636} + m_i\,(0.625 - 0.00027 \times 298) + A = 0.01108n_i + 0.5430m_i + A. \qquad (7)$$

$$C_{TB\,max} = \frac{n_i}{0.0348 \times 850 + 60.636} + m_i\,(0.625 - 0.00027 \times 850) + A = 0.01108n_i + 0.3913m_i + A. \qquad (8)$$

$$\Delta C_{TB} = C_{TBM\,max} - C_{TBMmin} = 0.01108n_i + 0.3913m_i + A - 0.01408n_i - 0.5430m_i - A = -0.003n_i - 0.1517m_{i.} \qquad (9)$$

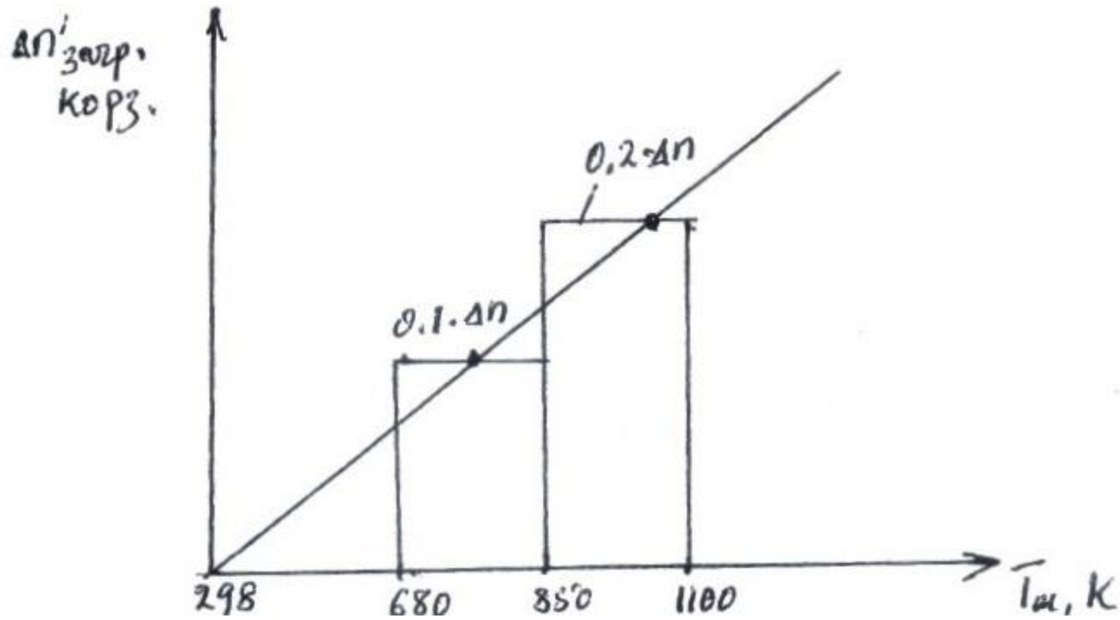
Definition of factual cost by limit demands defined consideration connected to the expenditure on equipment, preheating the budding material and expenditure on the fuel and service of plant. If T_{BM}< 680K; then, the loading basket is made from ordinary steel. When T_{BM} within the range 850 > T_{BM}> 680, the basket is made from heat resisting steel, and if T_{BM} > 680, then the basket in use can be lining fire bricks. By so doing, additional capital investment becomes. The higher the temperature of budding, the higher the capital investment; the value of n_i will change respectively as function of temperature of T_{BM}.

$n_i = f(T_{BM})$ (10)
$n_i = n + \Delta n_i$ (11)
Or $n_{TBM} = n + \Delta n_{TBM}$ (12)

In order to heat the budding we have to use compressed air and natural gas, usage of which increases by increasing temperature T_{BM}. Gas usage and usage of stressed air are defined in form of ΔA as a function depending on $T_{BM.}$

$\Delta A = f(T_{BM})$ (13)

Fig 4 Change in capital expenditure on the equipment against temperature of the Preheated budding material.



: 0.56 + 0.00014 (T_{BM} – 298)
K, where 0.56 – Δn_{Stand}, 0.00014 (T_{BM} – 298) = Δn_{LB} basket with an hour (n).
ost of furnace work plus additional expenditure on preheating the scrap is as shown in the table

Table 7 Dependence of □n□ and n_{MDV} on temperature of budding material T_{BM}

T_{BM} (K)	298	600	680	850	1100
□ n_{TBM} (R/h)	–	0.602	0.613	0.637	0.672
N+□ n_{TBM} (R/h)	1329.27	1329.872	1329.883	1329.907	1329.942

Definition of expenditure on preheating scrap; we have to know usage of gases and air. Usage of gas depends on the temperature of preheating budding materials, quantity of heat used to preheat the budding materials.
Starting from the formula:

$$W_M = (T_{MP} - T_o) \times C_{TB} \quad (14)$$

$W_{EUH} = C_{TB} (T_{BM} - T_o)$, MW-h/t/ can be converted to MJ/t (15)

Where C_{TB} – 1.95 x 10^{-4}MW-h/(tk) –average heat capacity of metallic scrap.

T_o – temperature of cold scrap (T_o = 298K).

K_2 – coefficient of calculation W_{EUH} KJ/t (2.78x10^{-7} MW-h/kJ)

Necessary heat needed to preheat the metallic budding can be obtained from burning the natural gas. If we divide $\frac{W_{\text{под}}}{Q_H^p}$x K_2, then we can calculate the usage of gas in m^3/t. From there Q_H^p is the heat generating ability of gas in KJ/m^3. However, not all the heat is supplied to budding gas. There is need to consider efficiency of burning process, the value of which accepted equal η_T = 0.2

$$\Delta A_{298} = \frac{1.95 \text{ x } 10^{-4}(298-298)\ (0.028+11.5 \text{ x } 0.0019)}{2.78 \text{ x } 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 0$$

$$\Delta A_{600} = \frac{1.95 \text{ x } 10^{-4}(600-298)\ (0.028+11.5 \text{ x } 0.0019)}{2.78 \text{ x} 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 1.622\text{R/t}$$

$$\Delta A_{680} = \frac{1.95 \text{ x } 10^{-4}(680-298)\ (0.028+11.5 \text{ x } 0.0019)}{2.78 \text{ x } 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 2.051\text{R/t}$$

$$\Delta A_{850} = \frac{1.95 \text{ x } 10^{-4}(850-298)\ (0.028+11.5 \text{ x } 0.0019)}{2.78 \text{ x } 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 2.964\text{R/t}$$

$\Delta A_{1000} = \frac{1.95 \text{ x } 10^{-4}(100-298)\ (0.028+11.5 \text{ x } 0.0019)}{2.78 \text{ x } 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 3.769\text{R/t}$

$\Delta A_{1100} = \frac{1.95 \text{ x } 10^{-4}(1100-298)\ (0.028+11.5 \text{ x } 0.0019)}{2.78 \text{ x } 1o^{-7} \text{ x } 0.2 \text{ x } 32560} = 4.306\text{R/t}$

$G_{UBV} = \frac{1.95 \text{ x } 10^{-4}(298-298)}{2.78 \text{ x } 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 0$

Usage of gas and air is as follows: $G_{UHM600} = \frac{1.95 \text{ x } 10^{-4}(600-298)}{2.78 \text{ x } 10^{-7} \text{ x } 0.2 \text{ x } 32560} = 32.53\text{m}^3\text{/t}$ (16)

$C_{G\ 600} = 32.53 \text{ x } 0.028 = 0.913\text{R/t}$ (17)

$G_U\ 11.5 \text{ x } 32.53 = 374.09\text{m}^3\text{/t}$ (18)

$C_A = 374.09 \text{ x } 0.0019 = 0.714\text{R/t}$ (19)

Table 10 Usage of air and natural gas and their cost when used to preheat the scrap

T_B (K)	G_{gas} (m^3/t)	G_{air} (m^3/t)	C_{gas} (R/t)	C_{air} (R/t)	□ □
298	O	O	O	O	O
600	32.53	37.41	0.911	0.711	1.622
680	41.15	47.32	1.152	0.899	2.051
850	59.46	68.38	1.665	1.299	2.964
1000	75.62	86.96	2.117	1.652	3.769
1100	86.39	99.35	2.419	1.887	4.306

Fig 5 Influence of temperature of preheated budding materials on the additional cost price of EAF work /auxiliary equipment/

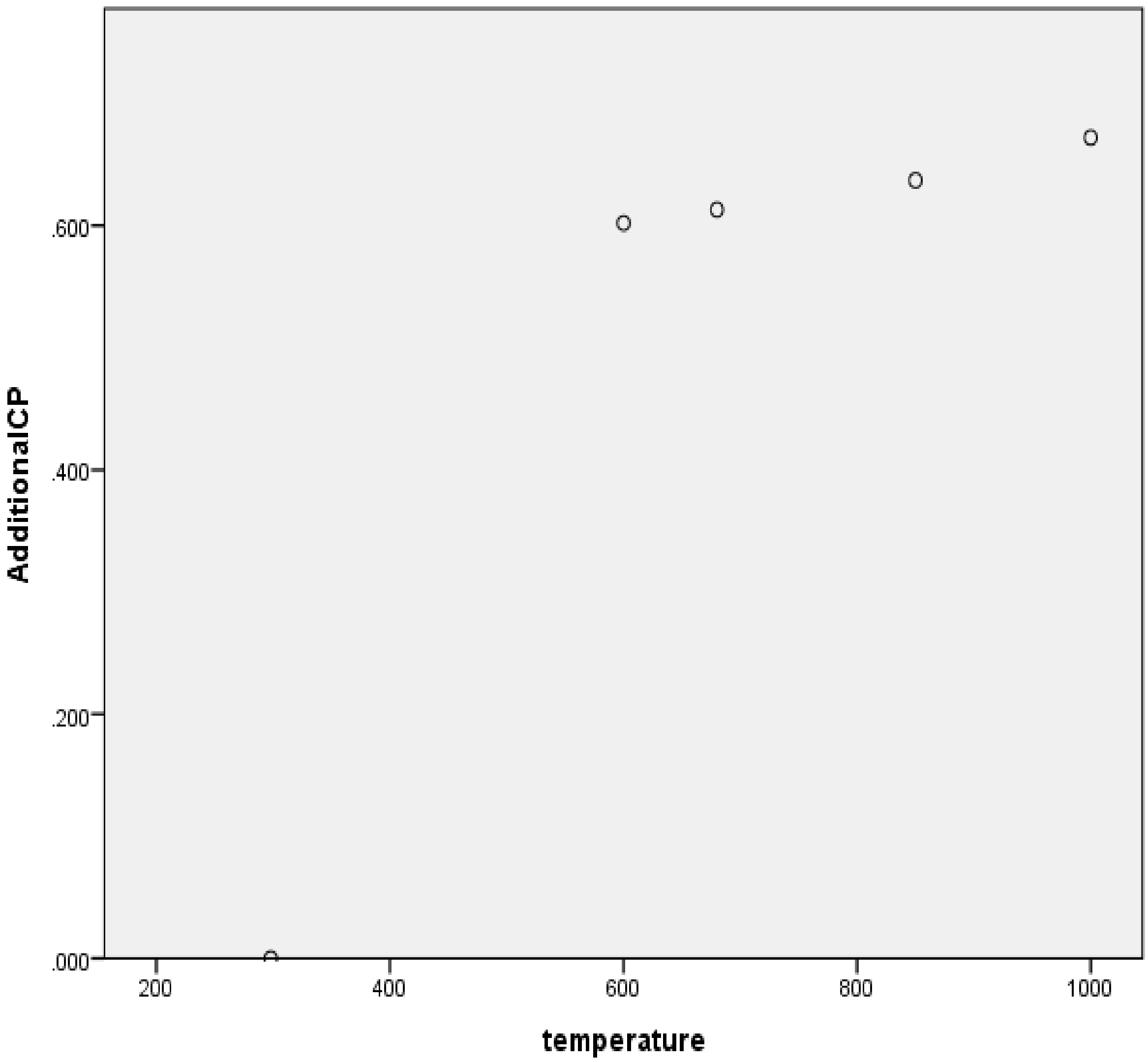
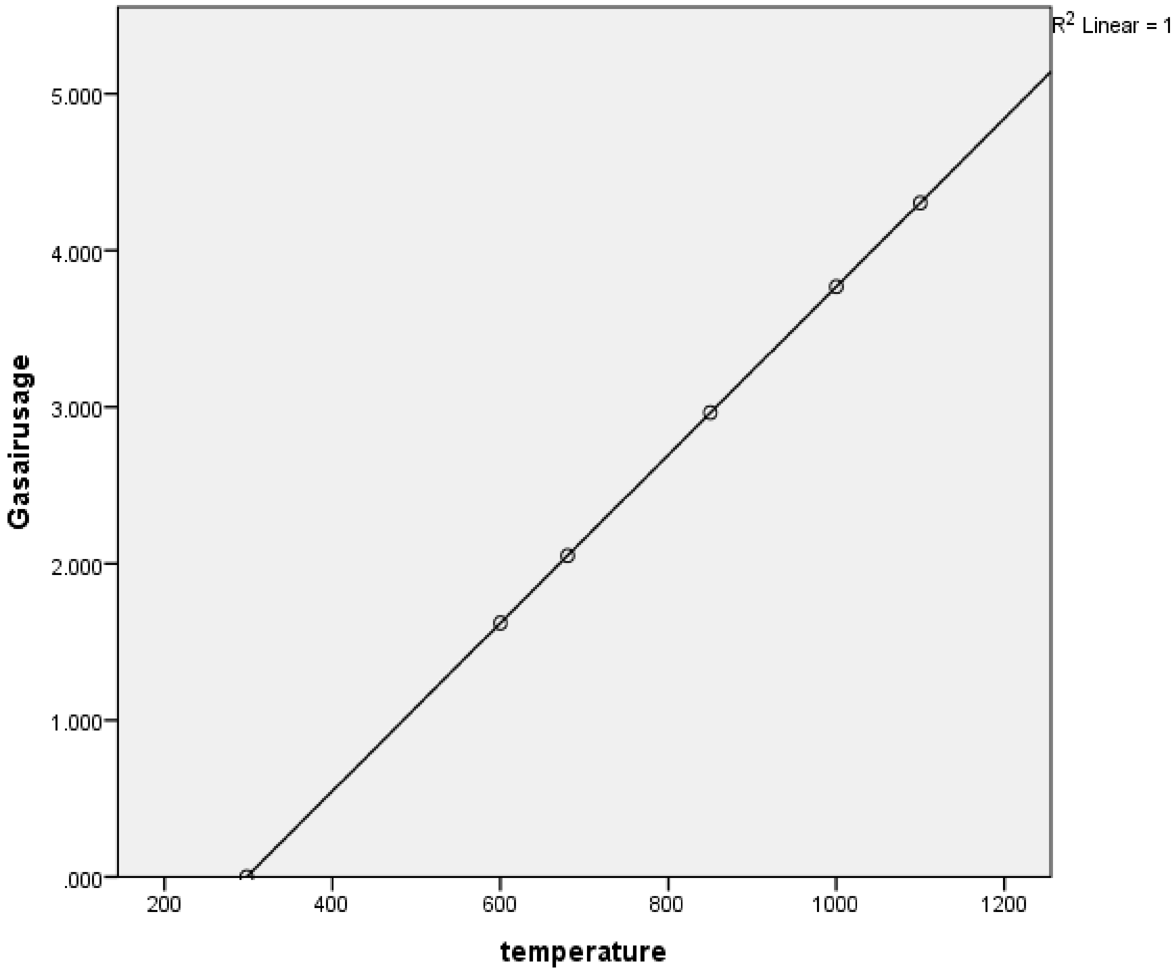


Fig 6 Dependence of gas and air usage on the temperature of preheated budding material



Factual usage by limit when preheated budding materials with consideration of additional expenditures /C_{MD}/ will be defined as follows:

$C_{MD} = t_{\Sigma} (n + \Delta n_{TBM}) + MW_{\Sigma} + (A + \Delta A)$

$$= \frac{(n + \Delta n_{\Sigma})}{0.0348 T_{III} + 60.636} + m\,(0.625 - 0.000275 \text{ x } T_{BM}) + (A + \Delta A) + \Delta C_{Wgas} \qquad (20)$$

Or in resultant form:

$$C_{MD\,TBM} = \frac{m + 0.56 + 0.00014\,(T_{III} - 298)}{0.0348\, T_{III} + 60.636} + m\,(0.625 - 0.000275\, T_B) + A + \frac{C_{TB}\left(T_{III} - 298\right)(Ц_T + 11.5Ц_B)}{K_2 \, x \eta_T \text{ x } Q_H^p}, \text{ R/t} \qquad (21)$$

$$C_{298} = \frac{1329.27 + 0}{0.0348 \text{ x } 298 + 60.636} + 13.58\,(0.625 - 0.000275 \text{ x } 298) + 10.218 + 4.72 + 0 = 41.03 \text{R/t}$$

$$C_{Simp\,298} = \frac{1329.27}{0.0348 \text{ x } 298 + 60.636} + 13.58\,(0.625 - 0.000275 \text{ x } 298) + 10.218 + 4.72 = 41.03 \text{R/t}$$

The results of calculation of C_{TBM} and C_{MDTB} are shown in the table 2.17.

By the calculated value of n = 1329.27R/h; m = 13.58R/MW; A = 14.938R/t

Table 11 Effect of preheating the budding materials on Expenditure by limit

T_{BM} (K)	**298**	**600**	**680**	**850**	**1000**	**1100**
C_{Simp}(R/t)	41.03	37.49	36.65	34.98	33.62	32.76
C_{MD} (R/t)	41.03	39.12	38.71	37.96	37.39	37.07

As seen in the table 11, Expenditure by limit when preheating the scrap up to 1100K reduces by calculation in simplified variant by 41.03 – 32.76 = 8.27R/t or by 25.2%, and by calculation in more difficult variant by 41.03 – 37.07 = 3.96R/t or by 10.7%.

In this case, when preheating the budding material by gases escaping from the furnace, there is no more need for purchasing the natural gas and stressed air, but expenditure on construction of stand rises. If we use $\Delta A = 0$, and Δn_{TBM} increased twice, then we got new value of C'_{MD}, and can be calculated by formula:

$$C'_{MD\ TBM} = \frac{(n + \Delta n_{\Sigma})}{0.0348\, T_{Ш} + 60.636} + m\,(0.625 - 0.000275 \times T_B) + A + \Delta C_{Wgas}$$

$$C'_{MD\ 298} = \frac{1329.27 + 2 \times 0}{0.0348 \times 298 + 60.636} + 13.58\,(0.625 - 0.000275 \times 298) + 14.938 = 41.03 R/t$$

The results of calculation of cost of preheating budding material with usage of escaping gases from furnace is as shown in table 12

Table 12 Cost of preheating the budding material with outgoing gases from furnace.

T_{BM}	298	600	680	850	1000	1100
2 □ n□ (R/h)	0	1.204	1.226	1.274	1.316	1.344
n+2 □ n□ (R/h)	1329.27	1330.474	1330.496	1330.544	1330.587	1330.614
C'_{TBM} (R/t)	41.03	37.51	36.67	34.69	33.63	32.77

Reduction of expenditure by limit within the condition limit 41.03 − 32.77 = 8.2R/t or 25.2%.

V. CONCLUSIONS

On the bases of the above we can conclude the following:

[1]. The founded mathematical dependence, connecting the cost by limit /C, R/t/ with temperature of preheating budding material /T_{BM},K/ for condition of work stand and usage, of natural gas /C_{MD}/ and gases outgoing from the working plane:

[2]. $C_{MD} = \frac{n + 0.56 + 0.00014\,(T_{Ш} - 298)}{0.0348\, T_{Ш} + 60.636} + m\,(0.625 - 0.000275\, T_B) + A' + \frac{CTB\,(T_{Ш} - 298)\,(Ц_T + 11.5Ц_B)}{0.0348 \times T_{Ш} + 60.636} + m \times (0.625 - 0.000275 \times T_{BM}) + A$, R/t

[3]. From figure 2.15 seen, that with increase in T_{BM} cost by limit decreases. This can be explained that usage of electric energy will decrease and productivity of furnace increases.

[4]. From calculation of $T_{BM.maX}$ /1100K/ by simplified variant, expenditures by limit decreased by 25% and by more difficult variant it decreased by 11% comparing with smelting without preliminary preheating the budding materials /T_{BM}= 298K/. This is because by preheating the scrap with hot escaping gases from furnace without additional expenses on natural gas and air we can realize even less cost by limit /25% instead of 11%.

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