OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Distr.
LIMITED
ID/WG.146/59
15 May 1973
ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Third Interregional Symposium
on the Iron and Steel Industry

Brasilia, Brazil, 14 - 21 October 1973

Agenda item 6

TRENDS IN THE CONSTRUCTION OF LD STEEL PLANTS[1/]

by

Ludwig Neuner
VÖEST-Alpine AG, Austria

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.73-2958

S U M M A R Y

In order to contribute to the further development of the iron and steel producing industry in the developing countries, it is important to inform all the responsible public and private authorities of the current trends in planning and construction of LD steel plants. It goes without saying that only the economically optimum solutions are dealt with, as, due to the generally stiff competition, close cost calculation is indispensable.

After a general comment on the various criteria for the lay-out of LD steel plants, the specific features of the following plant parts are dealt with:

hot metal system
scrap system
vessel unit
fume cooling and cleaning plant
additions system
lance equipment
slag system
teeming system
cranes

In addition to this, the exchange vessel plants and the general central control of the steel plant are touched upon :

After a short look into the future, the paper is concluded as follows:

Steel plant operators will always strive to lower the investment cost, at the same time keeping in mind that the operating cost shall be kept as low as possible. In the future, however, it will be inevitable to spend more money than hitherto on remote control, regulation, and automation (inclusive of the computer systems), higher demands being made also on the technical knowledge of the maintenance personnel.

Moreover, the increasingly severe regulations on environmental control will entail measures which, besides the required developing work, certainly will be expensive.

One of the most important tasks of the third Symposium on the Iron and Steel Industry, organized by UNIDO, is to promote the further development of the iron producing industry in the developing countries.

Therefore, it seems to be of interest to all the public and private authorities to know the trends that now exist when planning and constructing LD steel plants. Therefore, the following paper will show, how these problems present themselves from the view of a company owning four LD steel plants and, in addition to this, having been a major participant in the construction of many steel plants all over the world.

At the beginning, I should like to point out that, of course, only the economically optimum solutions shall be discussed here, as the generally stiff competition necessitates an exact cost calculation, now and certainly also in the future.

In the following, after responding to the actual trend resulting from the experience gained during many years, lines of future development will also be outlined.

1. General Considerations

With the first thought of constructing a steel plant, the annual capacity in million tonnes is taken to be an important criterion. This figure not only serves as a parameter for comparison of the steel plants among each other, but in most cases also is taken as characteristic figure, when the capacity of complete iron and steel plants is compared. If we now observe the generally applicable formulas on vessel sizes indicated on Fig. 1, which can be calculated from the annual capacity given, the following can be said: It is recommended that these formulae be corrected by a certain factor considering the climatic conditions, the experience of the operating and maintenance personnel, as well as the capacity of the plants ahead of and behind the steel plant.

It would be easy to rate this factor in such a manner that with maximum safety the required annual capacity will be achieved.

1. NUMBER OF OPERATING VESSELS IS CONSTANT (2-AND 3-VESSEL PLANT)

$$A = \frac{L \cdot t_{ch}}{n \cdot T \cdot 1440}$$

L = YEARLY CAPACITY IN TONS OF LIQUID STEEL
A = HEAT SIZE IN TONS OF LIQUID STEEL
T = EFFECTIVE WORKING DAYS/YEAR
t_{ch} = AVERAGE TAP-TO-TAP TIME
n = NUMBER OF OPERATING VESSELS

2. NUMBER OF OPERATING VESSELS IS VARIABLE

$$A = \frac{L}{n \cdot H \cdot T}\left(\frac{H \cdot t_{ch}}{1440} + Z\right)$$

H = VESSEL LIFE IN HEATS
Z = VESSEL RELINING TIME OR VESSEL CHANGING TIME IN DAYS

Fig. 1 - Formulae for calculating steelworks capacity

As, however, it is the duty of the planning engineer to find the most economical solution, it is important to scrutinize as far as possible the above-mentioned influence variables. Some of these influence factors are also time-dependent and one can say generally that almost all over the world increases in capacity of the steel plants occurred within the course of operation.

Undoubtedly, the knowledge of these factors negatively influencing the production has increased in the course of time, so that in this field a higher accuracy of aim is given. Moreover, by the stiff competition, a simpler layout with less production reserves is forced. Therefore, the high increases in production were possible in the past without too high additional investments probably cannot be reckoned with any more in the future.

In the former times of LD steel plant construction, it was doubted that with three vessels installed two of them could be kept in continuous operation. Now, there are certainly no doubts of that kind. On the contrary, it is even tried in some cases, to operate all three vessels at the same time for as long as possible.

This method is practicable since the invention of continuous casting, as a slab storage is quite capable of making up for certain discontinuities in steel plant production. But also the planning engineer's task may change, i.e. to obtain a maximum production with the space given. This situation occurs, when in existing iron and steel works little space is available for the construction of a new steel plant.

Among other solutions, exchange vessel plants have been developed which have proved a success in many years' operation. The ever increasing number of enquiries proves that in the future some new developments have to be expected. Thus, Fig. 2 shows a solution by which a maximum production can be achieved in a small area. The figure shows the LD-AC steel plant at Differdingen, where by means of an exchange vessel plant two vessels of 150 t capacity each are in continuous operation.

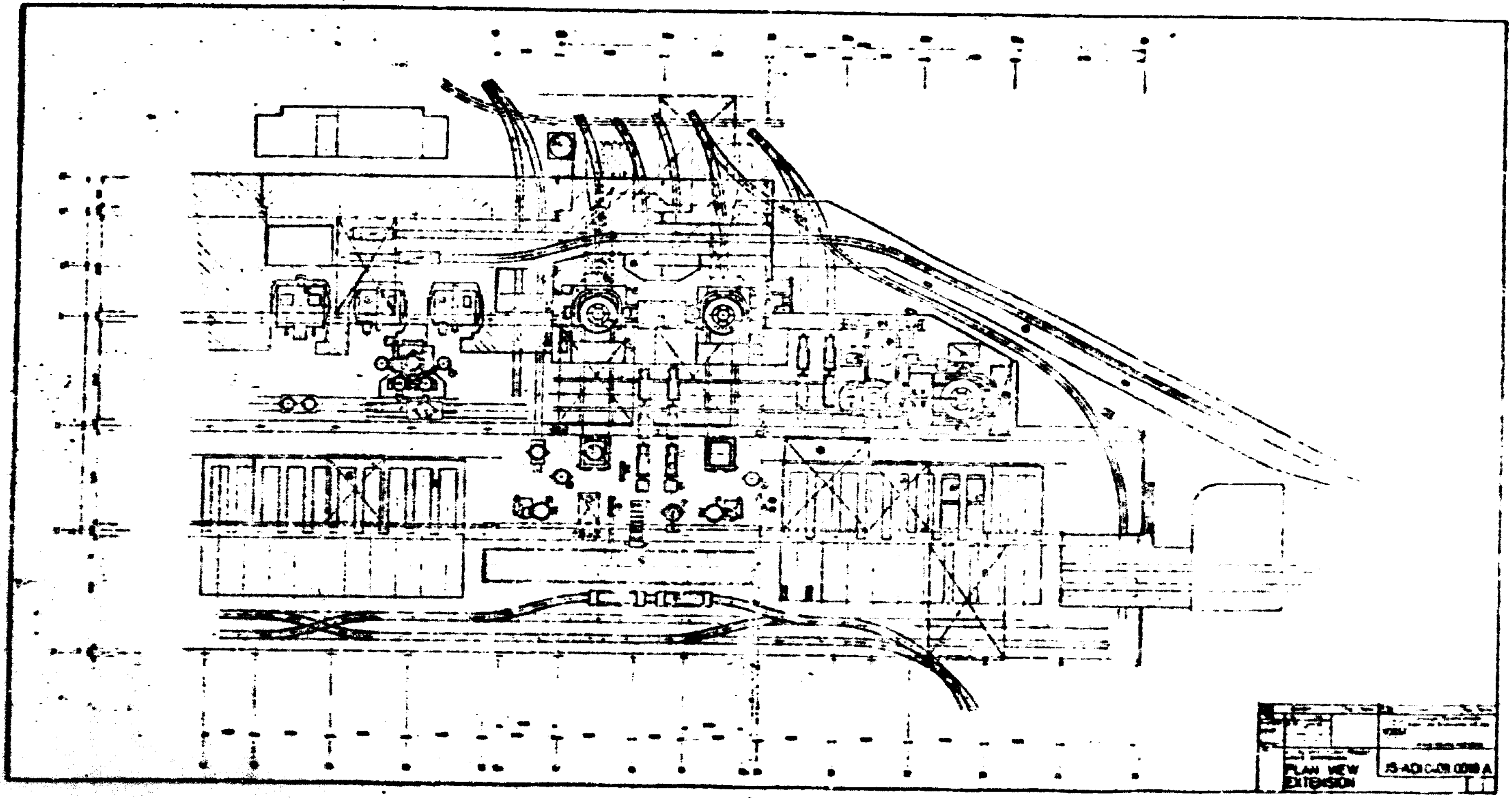


Fig. 2 - Layout of LD plant at Differdingen

Thus, as soon as the decision on the definite size and number of vessels to be installed has been made (undoubtedly, the most important figures in de.ining the LD steel plant) and also all the equipment grouped around the vessel such as dust collecting system, steel ladle transfer car, slag pot car, lance equipment, vessel additions system, ladle additions system, in some cases the ladle tilting tables, etc. have been determined with respect to their number and capacity based on various proved design formula, the material flow shall be considered in detail prior to working out the "lay-out".
Based on the experience gained, therefore, in the future it will be tried, as far as possible not to depart from the basic conception of an LD steel plant shown in Fig. 3. Projects providing the vessel bay as border bay or, properly speaking, as first bay, must be considered unfavourable from the materials flow point of view within the steel plant. A solution of that kind will only be chosen if adverse circumstances require it.
As environmental control nowhere in the world can be neglected, the sludge-treating plants and enclosed water circuits with recooling plants entailing an increased pump requirement will be of ever-increasing importance and therefore must be taken into consideration in any case when designing a new plant.
In addition to this, the entire utilities supply shall be a determinant factor in working out the lay-out. This is absolutely required, as with increasing remote control, regulating and automation technique, the space requirement for this equipment, such as space for contactor racks, instrumentation, computers, etc. will increase more and more. Parallel to this, also all the cable and piping connections will increase in quantity so that, in order to save money, one has to try to plan the pump rooms and the rooms for the electrics as near as possible to the consumption points. A quick glance at the list of all the LD steel plants in the world clearly shows that maximum three vessels are installed in one steel plant. Four vessels combined in one steel plant lead to certain problems as to the transport within the steel plant and therefore are not ideal.
According to the author's opinion, in the future no more 4-vessel plants will be planned.

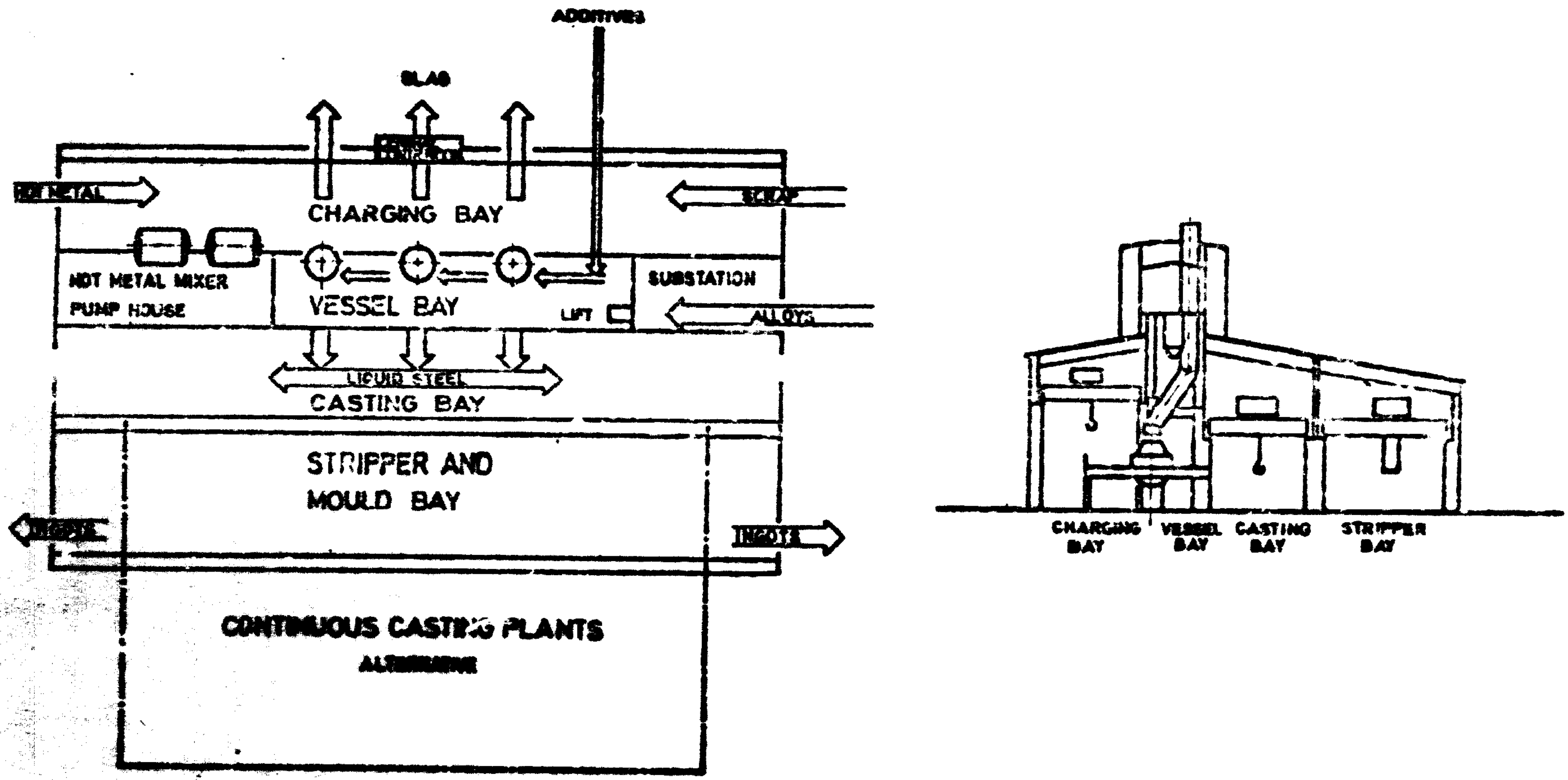


Fig. 3 - Basic LD steel plant design

These general remarks on the construction of LD steel plants in the following will be supplemented by some further comments.

2. Specific Features

2.01 Hot Metal System

In order to obtain as far as possible an ideal material flow in an LD steel plant, the latter should be planned within the integrated iron and steel plant so that scrap and hot metal can be supplied in the most favourable manner. If this cannot be realized, one will try to influence the traffic routes outside the steel plant in such a manner that the most favourable conditions possible result for the charging and/or teeming side. Compromises in this field in the course of operation always have resulted in disadvantages and therefore should be avoided in the future. Under the justified assumption that not more than three vessels are provided in one steel plant, the best solution would be to supply the scrap from one side of the charging bay and the hot metal from the other side. By this arrangement, also good slag discharge conditions can be obtained (see Fig. 3).
Where, due to the unfavourable space conditions or due to local regulations, the above-indicated, ideal solution cannot be realized (e.g. regulations on hot metal transportation), one should try to carry out material transport in two levels. According to our experience, the use of these arrangements is decreasing more and more.
The layout of a charging bay, moreover, is essentially influenced by the decision, whether the hot metal is supplied from the blast furnace by means of torpedo ladles or in normal hot-metal ladles, in this case hot-metal mixers being provided.
In this paper, it is, of course, not possible to discuss in detail all the advantages and disadvantages of the two systems of hot-metal supply mentioned. With most of the projects carried out by us, the relevant customers had made a preliminary decision in this respect. However, where no

-

such preliminary decision is made by the customer. In future, the decision should be based on a sober comparison of cost. Such comparison of cost, however, only is reliable, if after exact planning the cost for the bay structure, the cranes, the relining equipment, foundations, etc. of both variants are considered and if to the entire investment costs also the operating and maintenance cost of both variants are added. If a decision in favour of a hot metal mixer is made, in any case the possibility of installing a second mixer at a later date shall be provided in the lay-out, the construction of a second mixer being parallel to the construction of a third vessel on occasion of a steel plant expansion. Analyzing the mixer capacities you find an obvious trend towards ever-increasing mixer shell, the largest mixers built by us up to now having a capacity of [illegible]00 tonnes. From the merely technical point of view it is quite possible to build even larger mixers: according to the literature on this subject, however, the limit of economy is at about 2500 tonnes. Because of the little statistical material available on this matter, however, all the factors of influence are not definitely analyzed as yet.

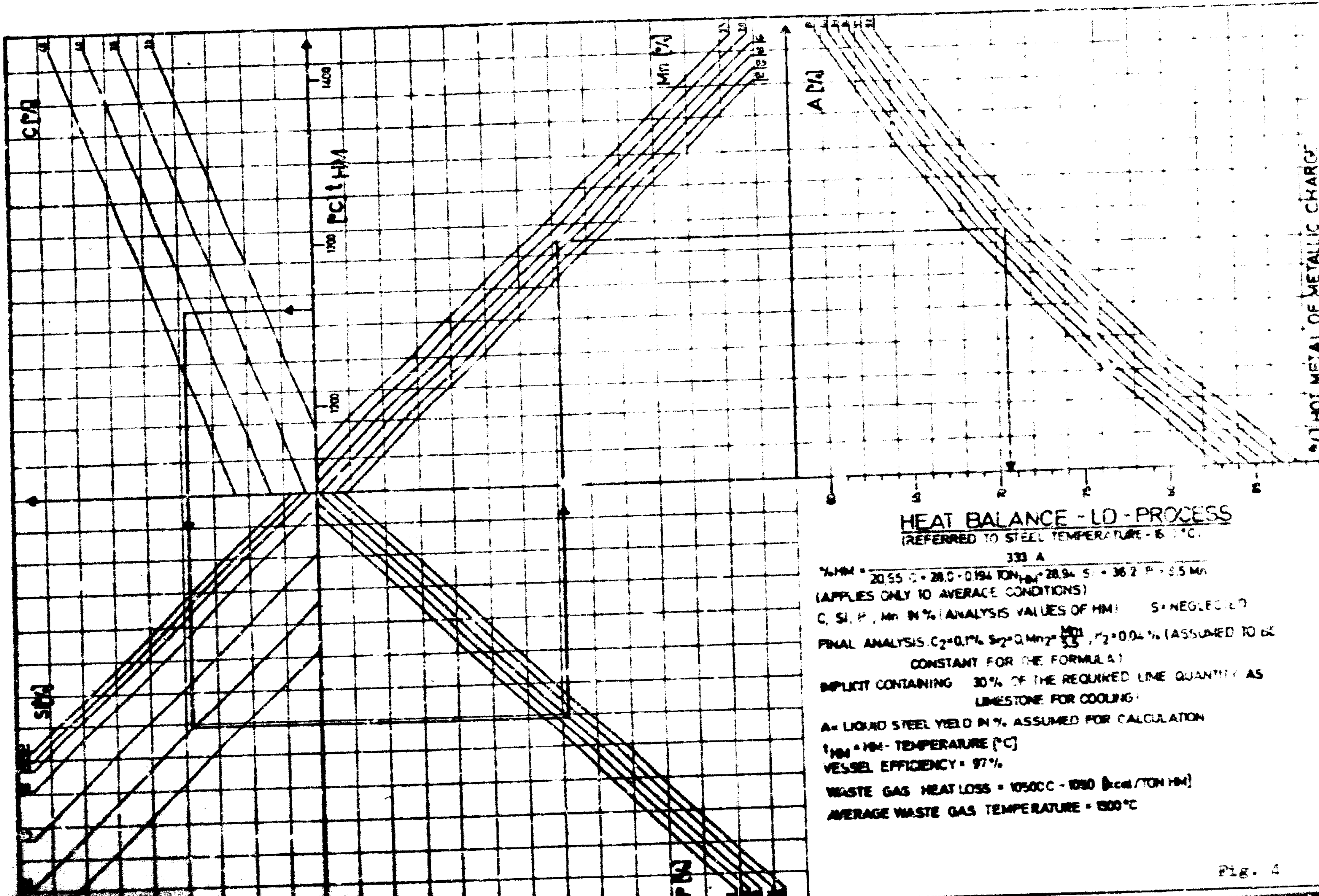
As it is the case with stationary mixers, also with torpedo mixers there is obviously the tendency to construct larger units. Here, however, certain limitations are imposed by the rail gauge and the capacity of the track system.
Because of the increasingly severe environmental control regulations, with future projects it will be essential to provide amply dimensioned exhaust systems for discharge of the fumes formed at charging and emptying of the hot metal mixer. More favourable will be the hot-metal supply by means of torpedo mixers, as at the reladling pit it is easier to provide an effective exhaustion of the fumes.
If the reladling station is accommodated in an ancillary bay outside the charging bay, fume nuisance in the charging bay is least noticeable. Also in the future in many cases a slagging stand will be provided because of its favourable influence on

the mixer lining life; slagging proper certainly will not be carried out manually, but by means of slagging machines.

In the past, in some cases also equipment for desulphurization of the hot metal were provided within the steel plant. If and to what extent, such equipment will be required in the future will certainly depend on the general raw-material situation. There do also exist steel plants where mixers and torpedo ladles are used. The hot-metal system, therefore, is somewhat split-up in such plants. In our opinion, however, in the future the percentage of plants of that type will not increase.
As steel plant operators always endeavoured to exactly measure the material flow in the steel plant, it will become more and more a matter of course to exactly weigh, by means of platform and crane scales, the hot-metal quantities supplied and charged and to feed the data to a central computer system.

02 Scrap System

As a basis for the lay-out of the scrap system, the Nomogram shown on Fig. 4 has proven a success. Other than in former times, steel plant operators strive to provide as little scrap loading and scrap handling as possible within the steel plant. With widely spread quality program and certain variations in the hot metal analysis, in the future it will also be possible to provide adequate equipment in the steel plant by means of which certain additional taring of the scrap boxes can be carried out, unless ore can be used for balancing out.
On the basis of these considerations, many iron and steel works have arranged a centralized scrap reloading place from which the scrap is supplied to the individual steel plants. In some steel plants it has also become usual to charge the scrap classified into light and heavy scrap, which certainly is of positive effect on the vessel lining life. Shortest heat cycle times can be obtained by charging the entire scrap quantity required in one chute; however, such large chutes


C [%]
[°C] t HM
1400
1300
1200
Mn [%]
A [%]
[%] HOT METAL OF METALLIC CHARGE
Si [%]
P [%]
HEAT BALANCE - LD - PROCESS
(REFERRED TO STEEL TEMPERATURE - 16 °C)
%HM = 333 A / (20.55 C + 28.0 - 0.194 t_HM + 28.94 Si + 36.2 P + 6.5 Mn)
(APPLIES ONLY TO AVERAGE CONDITIONS)
C, Si, P, Mn IN % (ANALYSIS VALUES OF HM)
S = NEGLECTED
FINAL ANALYSIS C2 = 0.1% Si2 = 0 Mn2 = Mn1/5.5, P2 = 0.04 % (ASSUMED TO BE CONSTANT FOR THE FORMULA)
IMPLICIT CONTAINING 30 % OF THE REQUIRED LIME QUANTITY AS LIMESTONE FOR COOLING
A = LIQUID STEEL YIELD IN % ASSUMED FOR CALCULATION
t HM = HM - TEMPERATURE [°C]
VESSEL EFFICIENCY = 97 %
WASTE GAS HEAT LOSS = 1050CC - 1050 [kcal/TON HM]
AVERAGE WASTE GAS TEMPERATURE = 1500 °C
Fig. 4

sometimes entail an increased expenditure in investment cost such as for higher craneways, etc.
This expenditure, however, is justified by the profit resulting from the increased annual output due to quicker scrap charging.

An ideal solution for the future would be to try to fill the scrap into boxes and transport it to the steel plant by adequate railway cars, the boxes being taken up by the crane and directly charged into the vessel. In the future trackless scrap transfer probably will win through more and more. The future will show, however, whether this method is also possible with very large vessel units, where an hourly scrap handling capacity of more that 100 tonnes is required.

2.03 Vessel Plant

The vessel is the dominating unit in the LD steel plant. To this core, the entire steel plant planning must be completely subordinated. This applies, e.g., to the column distance, the platform height, the space around the vessel unit, etc. Special care must be taken that the supply and discharge of all the material can take place quickly and without any disturbances. Short heat-cycle times mean high productivity and, thus, a financial profit.

As, however, steel plant operators sometimes want to put into operation a newly lined vessel, before the other vessel has to be withdrawn due to worn-out lining, in the future it will be tried the more to reduce to a minimum the lining times by adequate equipment which will be fully mechanized, as far as possible. This can be achieved, e.g., by quick supply of the lining material, favourable brick pallet storage possibilities, etc. Experience has shown that good accessibility for repair work, easily demountable platforms, adequate arrangement of the tilting drive, quickly mountable bearing dismantling brackets, are details that have to be taken care of at any rate. Although many competent companies today are able to offer fully developed vessel constructions, the development certainly is not finished. Especially the vessel bearings will be further developed in order to reduce the cost of spare-part stock keeping. Moreover, the great number of patent applications shows that the connection between vessel shell and trunnion ring still requires a more ideal solution. As the vessel shell is a wear part, in each steel plant it has to be replaced by a new one from time to time. Therefore, the connection between shell and trunnion ring is to be designed in such a manner that this vessel exchange can be carried out quickly. Due to the increasingly severe environmental control regulations, the effective exhaustion of the fumes during charging and tapping of the vessel is a problem urgently requiring an adequate solution. As up to now no convincing solutions have been found, it is indispensible to carry out more developing work in this field.

2.04 Fume Cooling and Cleaning Plants

The relatively large fume cooling and cleaning plants used in LD steel plant construction in former times certainly are still remembered, especially the electric precipitators which, because of their big volume, had to be arranged outside the steel plant. These large plant volumes were due to the enormous excess air factors usual at that time. Therefore, it was endeavoured to reduce these excess air factors as far as possible, so that now we can already speak of "minimum gas plants". Moreover, in former times, steel plant operators in some cases installed only one fume cooling and cleaning plant behind two alternately operated vessels. These designs, however, did not turn out favourable and therefore, solutions of this type will not be chosen any more. Also designs with which for each vessel unit a fume cooling plant is installed but in which fume cleaning proper is carried out in a common dust collection system in our opinion have almost no chance in the future. Therefore, in any case the modular system has to be given preference, a modular-type plant being a plant, in which each vessel unit is provided with its own fume cooling and cleaning plant.

Considering the formula (see Fig. 5) on the maximum gas quantity generated, according to which the fume cooling and cleaning plants have to be designed, today's tendency to use as low an air factor as possible is quite understandable: a low air factor results in small gas quantities and, as a consequence of this, in correspondingly smaller plants.

Furthermore, due to the lower weight of the fume cooling and cleaning plants, the vessel bay steel structure, which takes a considerable part in the cost of the steel structure of the entire steel plant, becomes lighter and

THEORETICAL DRY GAS QUANTITY (PEAK VALUE)

PRIMARY GAS QUANTITY

$$Q_{Prim} = 18{,}6 \left(\frac{dc}{dt}\right)_{max} \cdot HM \, [Nm^3/min]$$

$\left(\frac{dc}{dt}\right)_{max}$ = C- BURNING SPEED IN % / min
HM = HOT METAL QUANTITY [TON]
n = AIR FACTOR

SECONDARY GAS QUANTITY

$$\overset{n \leq 1}{Q_{Sek}} = (18{,}6 + 31{,}4\, n) \cdot \left(\frac{dc}{dt}\right)_{max} \cdot HM \, [Nm^3/min]$$

$$\overset{n \leq 1}{Q_{Sek}} = (10{,}1 + 39{,}9\, n) \cdot \left(\frac{dc}{dt}\right)_{max} \cdot HM \, [Nm^3/min]$$

RELATION BETWEEN MAX. O_2-FLOW AND MAX C- BURNING SPEED

$$O_{2\,max} = 10{,}25 \left(\frac{dc}{dt}\right)_{max} \cdot HM \, [Nm^3/min]$$

Fig. 5 - Theoretical dry gas quantity (peak value) and relationship between maximum oxygen flowrate and maximum carbon burning speed

LIME QUANTITY

$$K = \frac{CaO}{r} \cdot 100$$

K = LIME QUANTITY [Kg]
CaO [Kg]
r = CaO-CONTENT OF LIME IN %

CaO-REQUIREMENT LD

$$CaO = 1{,}7\,(40\,\Delta Si + 27{,}2\,\Delta P) \; [Kg/TON\ OF\ HOT\ METAL]$$

ΔSi = BURNING OF SI IN %
ΔP = BURNING OF P IN %
(ACC. TO MARINCEK)

CaO-REQUIREMENT LD-AC (TOTAL REQUIREMENT) - REUSE OF 2nd SLAG

$$CaO = 1{,}35\,(40\,\Delta Si + 27{,}2\,\Delta P) \; [Kg/TON\ OF\ HOT\ METAL]$$

Fig. 6 - Lime quantity, lime requirement for LD, and lime requirement for LD-AC

thus cheaper. Due to the high CO concentration, at present wet scrubbers are mainly used for cleaning the fumes. It is known that various firms are actually carrying out tests with dry electric precipitators for filtering this type of fumes. The cases of application of such electric precipitators, however, up to now are very few. The development of wet scrubbers today has reached a high state of technology, so that these units fully correspond to the anti-air pollution laws. From the point of view of investment cost, the wet scrubbers are morefavourable than electric precipitators. Thus the wet scrubbers will clearly prevail in the future. With new plants, the number of fume cooling plants with which the physical and chemical heat of the vessel waste gases is used for steam generation and simultaneous utilization in an iron and steel plant is continuously decreasing. There also exist only a few plants utilizing the CO gases immediately upon generation. In short, the energy inherent in the fumes will be eliminated or carried off with as little expenditure as possible in the future. It would be beyond the scope of this paper to enter into particulars of the individual well proved dust collection systems; however, some important details will be touched upon here.

The part arranged immediately above the vessel, the so-called hood, naturally is exposed to the highest thermal and mechanical stresses. In the past, this part had to be repaired very often. Meanwhile the steel plant operators have found adequate constructive measures to improve the safety in operation. One can say that the totally piped hood has prevailed over the plate type formerly used.
In spite of this, it is advisable to take care already when planning the plant that this part can be quickly exchanged in case major repair work should become necessary. In this connection it has to be mentioned that large handling space for repair purposes, especially in the vessel bay, is expensive and therefore, it would be

favourable to move the hood into the crane area by means of quickly mountable auxiliery structures. Moreover, we have made the experience that even to companies well specialized in this field time and again the following circumstances have to be pointed out:

Besides the theoretical design data it has to be considered that from time to time an especially intensive decarburation may occur and these short-time peaks have to be handled by the plant.

In the hood, in most cases two additions chutes are provided. Moreover, it should also be possible to insert into the vessel an additional lance besides the blowing lance proper. This additional lance could serve, e.g., for temperature measuring which, in cooperation with continuous carbon determination, is an important pre-condition for dynamic process control in the future.

It also must become a matter of course to prevent the stamping out or breaking-through of flames at the lance sleeves and at the additions chutes, as this is detrimental to the plant parts arranged above.

As you know, with certain plant types, nitrogen seals are used at these points. As nitrogen, however, represents a high cost factor, it is tried to keep the nitrogen consumption per ton of steel as small as possible.

An important function with minimum gas plants is taken over by the movable closing ring. After difficulties in the beginning, due to the unfavourable conditions to which the lifting and lowering mechanism of the closing ring was exposed, the technicians were now successful in finding designs which come up to the conditions given. As, moreover, it has now become possible to govern the LD process with reference to the ejections, this problem now can be looked upon as solved.

The dust formed, which may amount to about 1.5 % of the metallic charge, from the economic point of view should be utilized somehow, quite apart from the fact that the "dumping" especially with electric precipitators certainly to some extent has a negative effect on the environment. One only has to realize that about 15,000 tonnes of dust accumulate per year with an annual steel production of 1 million tonnes. Besides some other cases of application, which will not be dealt with in this paper, the dust generally is supplied to the sinter plant. In this connection I should not fail to mention the tests for re-use of LD dust in the steel plant proper, as they are carried out, e.g., in our LD steel plant in Donawitz and in the new Kōverhar LD plant (Finland). We are convinced that also in the future the re-use of LD dust in the steel plant will be dealt with.

2.05 **Additions System**

The additions system besides the fume cooling and cleaning plant holds an important place in the vessel bay.

As large quantities of additions have to be stored at high levels, the additions system contributes a great deal to the weight of the vessel bay steel structure. Even if you include the bunker walls as carrying parts into the steel structure, this only brings a certain facilitation, but no essential reduction in the weight. Regarding capacity, the opinions of the steel plant operators are split into two groups as to the planning principles. One group is interested in storing as large a quantity as possible in the vessel bay. Typical representatives of this view are many American steel plant operators. They want to store in the steel plant at least the [illegible] of three shifts, [illegible] minus one [illegible] ([illegible] of the operator), whereas the other group only want to store in the vessel bay the quantity required for several heats (especially lime). To this group belong e.g. the Japanese steel plant operators. We think that in the future the golden mean between these two extremes will be the right one and therefore we follow the the rules given below.

The lime requirement per heat, being calculated according to the Marincek formula at an aspired basicity of 3 (see Fig. 6), will be transformed into the hourly requirement. In our opinion, a minimum stock for 6 hours should be available. During this time, it is quite possible to carry out minor or medium repairs to the additions conveyor systems.

Moreover, an automatic feeding system shall be provided, ensuring that feeding is started immediately after a certain minimum level has been reached in a bunker. As shown in Fig. 7, with this method relatively small lime bunkers can be used. Therefore, the weight of the steel structure can be reduced and, moreover, less personnel is required due to the automation provided. The worker in former times responsible for filling the day bunkers is no more required and the feeding system can be supervised by one man who is also responsible for the underground bunkers and the reloading station outside the steel plant.

For the dimensioning of the flux material bunkers, the ore, and (possibly) the coke bunkers, no firm rules can be indicated. These dimensions have to be determined according to the circumstances. The capacities in most cases are determined according to the space still available in the vessel bay, the bunkers always having to be at least 1.5 m wide and their height being about the same as for the lime bunkers.

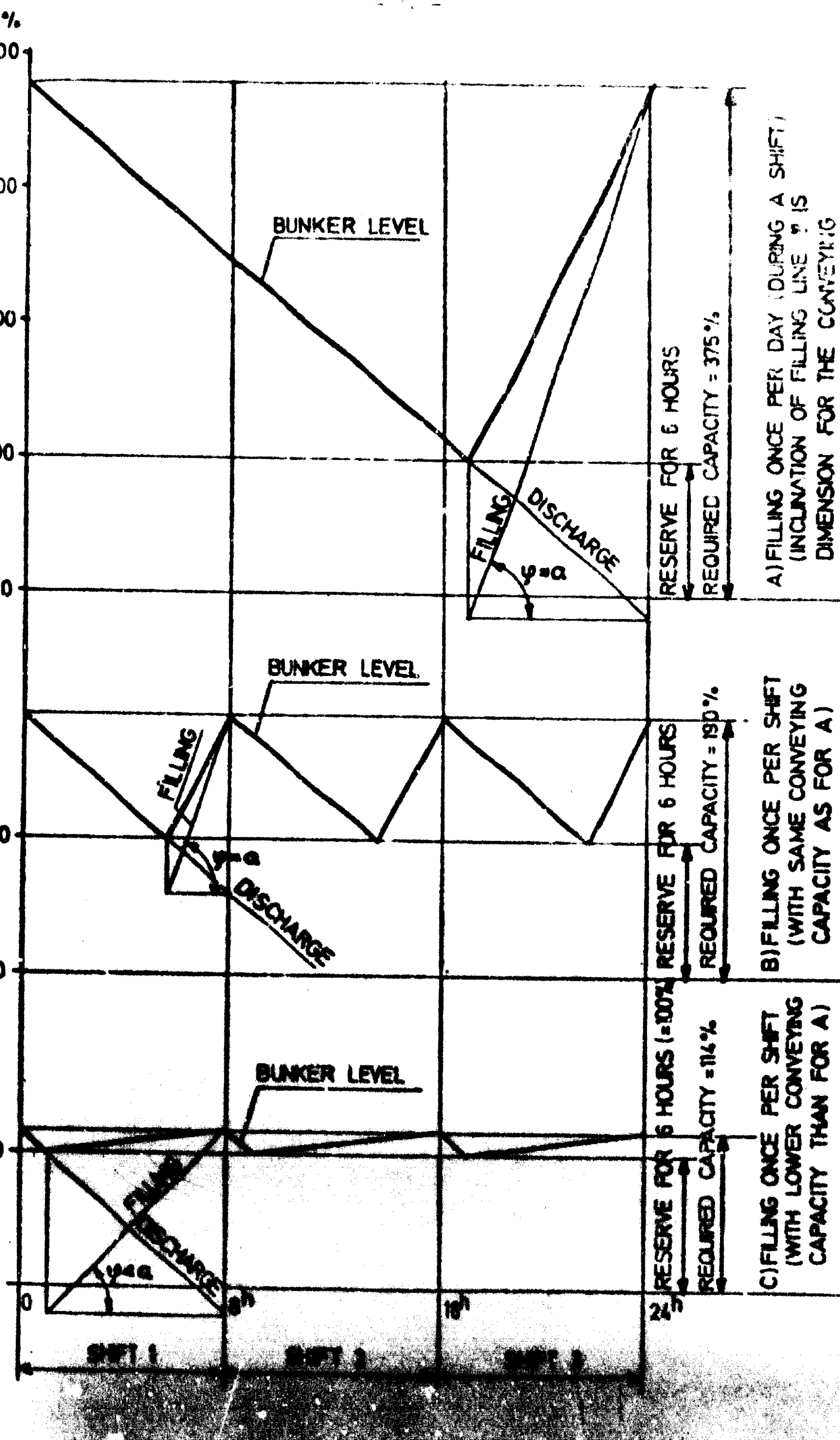


Fig. 7 – Required capacity of elevated bunkers, depending on filling and discharge rates

It should become a matter of course that the additions system proper, consisting of the weigh hoppers and the discharge devices, will be automated and controlled from the central control room. In addition to this, it is worth while to reflect on the required accuracy.

Fig. 8 shows the effects of the tolerance on the final temperature. The greatest influence on the temperature is exercised by inaccurate measurements of hot metal quantities and the carbon content, whereas inaccuracies in weighing the lime quantities have almost no influence on the final temperature. The diagram clearly shows that a weighing tolerance of about 1 % is acceptable by all means. This shows that in the past some requirements had been too severe and we are convinced that in future e.g. belt weighers, being of less accuracy - will do.

Some steel plant planners also saw an advantage in considering the ladle additions as an integral part of the vessel additions. In our opinion, this is no economical solution, as it does not make much sense to convey additions that in the end are used some meters above floor level, to up to about 40 to 45 m level. Moreover, a separate ladle additions supply system is certainly more advantageous and the bunkers for the ladle additions will be arranged in the vessel bay only at the absolutely required level.

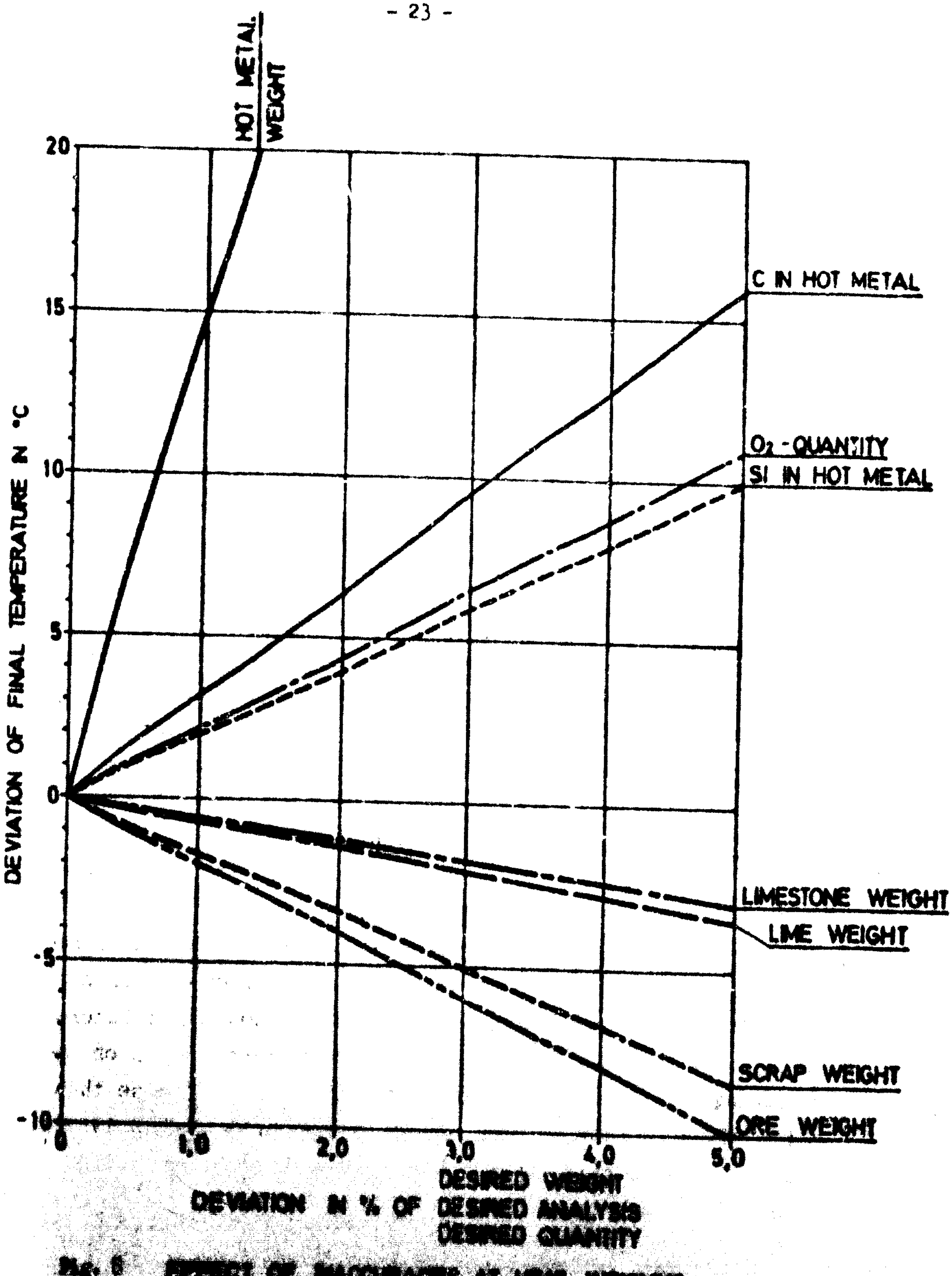


Fig. 6 EFFECT OF INACCURACIES AT HEAT WEIGHING [illegible] AND DETERMINATION OF ANALYSIS ON THE FINAL TEMPERATURE

(ACC. TO O. HARTMANN AND R. BRUCH WITH SUPPLEMENTS)

.06 Lance Equipment

In the past, the designer in most cases was compelled to design the lance equipment within a narrow given space. Later, the lance equipment was given more space, as experience showed that lance changing requiring too much time results in a loss in the output. This was also the reason why quite soon the lance equipment was provided with two lances and lance changing was remote-controlled. In any case, care must be taken that the lances can be easily removed from the vessel bay. The most favourable solution is to provide a lance slot in longitudinal direction through the entire vessel bay. This lance slot, being extremely advantageous for lance dismantling, however, requires certain statical measures at the steel structure. As especially big lances are difficult to handle, care must be taken to accommodate the lance repair shop as near as possible to the place where the lances are used.

The time certainly will come when, besides continuous temperature measuring, also the carbon content will be continuously measured during blowing. Already now, it is recommended to provide sufficient space beside the lance equipment, where the equipment necessary for carbon content measuring can be installed above the vessel at a later date. In addition to this, with the changing conditions on the scrap market, again and again situations will arise that raise the interest in the use of scrap preheating lances. Also for these situations, adequate measures should be taken.

2.07 Slag System

Among the great number of possibilities to remove the slag from the steel plant, trackless transportation is prevailing more and more. During slagging, the slag pot stands on a slag pot transfer car travelling on the same track as the steel ladle transfer car. After slagging, however, the slag pot is moved out of the vessel area by means of this car, until it can be taken up and removed by the trackless vehicle.

A basic rule to which not much importance was attached in the past, should, however, beabsolutely followed when planning new steel plants: slagging should be carried out on the side where scrap is charged into the vessel. This because the slag skin forming during slagging considerably protects the vessel lining from scrap falling down during charging. Comparative investigations have shown that by this method the wear lining life can be essentially increased. Due to automatic data logging gaining more and more importance in the steel plant, the necessity to also weigh the slag quantity becomes apparent, especially in LD-AC plants, where two slags are formed. Because of the unfavourable conditions of installation, this is an object hard to achieve, but in view of the ever-increasing importance of data logging, this wish certainly cannot be ignored.

2.08 Casting System

After the development of the LD process, in the field of the casting system, the conventional methods could be adhered to until continuous casting was developed. When designing the casting system, consideration had to be given to the enormous hourly output of an LD vessel. It is true that the scope of the individual units such as longitudinal and transversal teeming stands, mould depositing stands and ancillary equipment can be easily calculated, experience however has shown that quite often the teeming system turned out the bottle-neck of the entire production system, even with slight increases in the production beyond the layout figures.

Therefore, it is recommended to amply dimension the casting system, in order to cope with all the situations that might arise in operation.

Because of the rough working conditions in the casting system, also here, mechanization will gain more and more ground in the future (e.g. mould cleaning, remote teeming ladle stopper control, etc.)
A real revolution in the casting system was the development of continuous casting. Continuous casting will not be dealt with in detail, as this would be beyond the scope of this paper; however, it has to be mentioned that the number of steel plants casting 100 % of their production in continuous casting plants and providing conventional casting equipment only for emergency purposes is continuously increasing. In these emergency casting units, only the content of one steel teeming ladle can be cast.

2.09 Cranes

As nowhere in the iron and steel works are cranes so closely bound up with the production as in the steel plant, great importance must be attached to the safety in operation. In this connection, I should like to mention some directive points:

- absolute readiness for service, which in extreme cases will culminate in the decision to provide in the charging bay not one scrap-charging crane and one hot-metal crane, but two hot-metal cranes each of them being also capable of charging scrap.
  This investment only will produce full effect, if adequate depositing places are provided for the case of crane repair being required. This in most cases requires an additional area in the charging bay, so that the second crane can cover the entire field of operation. The main reason why the theoretical plans of a craneless steel plant have not been realized yet is the very endeavour to ensure a

100 % readiness for action.

- adequate protective measures against heat , such as heat shields to protect the crane structure, heat radiation shields for the cables, etc. should be provided from the beginning, as regarding this in the past many steel plant operators had to learn it the hard way
- in most cases, on the vessel charging side somewhat smaller approaches that usual and certain lifting heights are desireable. Due to this, special designs are required in some cases, but on the other hand, the danger of accidents is reduced, as the crane driver is not handicapped in his manipulation possibilities.
- also remote control and transmission of measured values such as weighing data will be of increasing importance in the future.
- air conditioning of the driver's cabs of the main steel plant cranes should become a matter of course.

3. Special Cases

Up to now in this paper only steel plants with stationary vessel units have been dealt with. There exists, however, a great number of steel plants where, due to the lack of space, the vessel units had to be designed in such a manner that they can be exchanged after each vessel campaign, so that - apart from the short exchange times - the plant can be continuously operated and the relining times are of no influence on the production times. Depending on the shape of the trunnion ring (horse-shoe shaped or closed trunnion ring), there are different solutions as to the design. Experience in operation of such plants has shown that they fully come up to the operators' expectations and therefore also in the future exchange vessels will be used. As to the certainly interesting technical details, in this connection I would like to refer to the various publications by VÖEST-ALPINE.

4. Control of the steel plant

Because of the positive experience gained, contrary to older steel plants, in the future as far as possible central control pulpits will be provided, where not only the control of the lance and the additions of all the vessels installed is combined, but also the control desks for the entire additions system and the fume cooling and cleaning plants are located. Only the controls of the tilting drive, the steel ladle transfer, and the slag car will be provided at the individual vessels. The ever-increasing requirements regarding control and regulation sometimes complicate the provision of the required space at the right point (Figs. 9 and 10 show advantageous solutions). In addition to this, also for the increasingly important process automation the required space must be provided.

At the moment, static models are still in use, but in the future certainly dynamic models will be used. As soon as it will be possible to carry out - together with continuous temperature measuring - also continuous carbon determination with sufficient accuracy, the desired accuracy of aim as to temperature and analysis can be achieved. All these measures - with simultaneous improvement in quality and output - are personnel-saving, but they do not reduce the requirement of qualified maintenance personnel.

5. Outlook to the future and conclusion

The fact that the profitability increases with the size of the plant raises the question, where the limit for maximum production units will be. It is known that vessels of up to 350 tonnes capacity can be safely operated. From the mechanical engineering points of view it is quite possible to build vessels between 400 and 500 tonnes.

Figure 9

Figure 10

Also the required ancillary equipment (e.g. cranes) do not pose any problems. A survey of all steel plants at present in operation or being planned, however, shows that medium-size-vessel steel plants are by all means justified. One reason for this - besides other reasons - might be the fact that in continuous casting plants only ladles up to 150 t shall be used.

Looking forward, there rises the question whether the dream of continuous steel production will soon become reality, so that continuous casting can be preceded by continuous refining. Considering, however, that by installing three large-size vessels of about 300 tonnes each, it is easily possible to achieve an hourly output of 400 tonnes in a steel plant, one can easily imagine that for all continuous processes it will be difficult to get a firm footing in this field.

If in the future, in order to save investment cost, the constructions of steel plants will be carried out even more rational than up to now, higher investments in the field of remote control, regulation, automation including computer system unfortunately will be unavoidable. Also the increasingly severe environmental regulations will require measures in the steel plant that certainly will be very expensive.

Moreover, the fact that some savings in the field of investment possibly may result in higher operational cost should be kept in mind and therefore it is the steel plant project engineer's duty to find the best compromise.

Although this paper only dealt with the trend in the construction of LD steel plants, finally I should like to mention that a great deal of the statements to the same extent applies to OBM steel plants under lively discussion at the moment.

75.11.19