Iron Making

MT410502

Reference Books:

Modern Iron Making by R.H.Tupkary (Khanna Publication)

Iron Making and Steel Making: Theory and Practice, A. Ghosh and A. Chatterjee,

(Prentice Hall)

Syllabus

- B.F. Operations: Operational steps
- Blast furnace irregularities and remedial measures,
- Blast furnace gas, properties, cleaning and utilization.(Already covered in Unit 2)

Blast Furnace Operations

- Blowing in:
- The process of starting a newly lined furnace is called blowing in.
- In general the operations involves four main steps, viz. drying, filling, lightning, and operation until normal production is established.
- There is no standard practice of blowing in and the details depend on the local conditions and customs.

Drying

- The new lining of a furnace contains a significant proportion of moisture which must be slowly and completely removed before the temperature of the furnace is raised.
- This operation is known as drying in which the furnace is slowly heated.
- The stoves that are lined anew dried by introducing a lighted gas pipe in the combustion chamber, slowly increasing its intensity about 10-15 days to the level when firing on the normal way could be started.

- Repaired stoves can be bought to working temperatures in a day or two.
- *Blast* furnace drying can be accomplished by any one of the three different techniques
  1. Supply of hot blast from the stove.
  2. Use of a Dutch oven as an auxiliary furnace to generate and supply hot gases.
  3. Use of wood or coke fire on the hearth.
- Any amount of time and trouble taken in ensuring careful and gradual drying of the furnace is more than repaid in its subsequent operation.

Filling

- At the end of drying, depending upon the method used for drying, *the furnace* is cleared off all the things used for filling. The coolers *are turned* on and once the inside temperature is tolerable furnace personnel can get in and prepare for filling the furnace.
- The off coolers at this stage is a must since rectification of faulty coolers is readily possible at this stage. In fact a check list is prepared and each item is checked off as reports are received of their satisfactory performance

- Simultaneously the equipment's for weighing, charge hoisting , material disposal, etc. are also prepared for putting them into action at the appropriate time. The tap holes are prepared and coolers, which were earlier removed to have access inside, are packed in position.
- Filling of the furnace usually means filling the hearth with light-kindling wood and shavings saturated with oil upto the tuyere level and laying over this a scaffold of old timber slippers.

- Coke is charged above the timber scaffold from the top upto the bosh level. A quantity of limestone sufficient to flux the ash in the charged coke, is also charged along with the coke after the initial coke blanks.
- A small amount of old blast furnace slag is also incorporated with coke after the coke level rises beyond the mantle level. The early slag volume is deliberately maintained at high level to heat up the hearth and prepare it to receive iron.

- On the coke blanks are laid light burden charges of ore, stone and coke *i.e.* the ratio of iron ore to coke is low, about 0.5-0.6.
- Burden weight that is iron ore is increased every 8-10 charges in increments of approximately 0.03-0.05 ratio of iron ore to coke.
- The furnace is now ready to be lighted or ignited.

Lighting and Operating Until Routine Practice is Established

- After filling the furnace as mentioned above for blowing-in the bells are opened and the dust catcher dump valve is closed.
- The air in the dust catcher is purged out with full head of steam. The furnace is lighted either by inserting red-hot bars through the tuyeres or slaghole and iron notch.
- Alternatively gas torch may also be used.

- Generally highly combustible material is kept in front of the tuyeres during filling to light the furnace readily.
- Burning is allowed with natural draught alone for the first 24-36 hours ; a light blast is put on only thereafter.

- As soon as good amount of gas emerges from the furnace top the bells are closed and the dust catcher dump valve is slowly opened to conduct exit gases through the gas cleaning system.
- The blast volume is fairly rapidly increased to normal volume of blowing. Usually more than three fourth of the standard volume of blast is blown by the end of fourth day and full blast is on by the end of a week after the furnace is ignited.

- Tap holes are kept open for hot gases to escape out during the early period. Once coke burning and slag formation starts furnace crew are Are vigilant in observing the tap holes.
- The first indication of a sudden decrease in the out coming gas through the tap hole is taken as an indication of beginning of slag accumulation in the hearth and the tap hole is immediately closed thereafter.
- Nearly six to eight hours may elapse after this before sufficient slag has accumulated to warrant flushing.

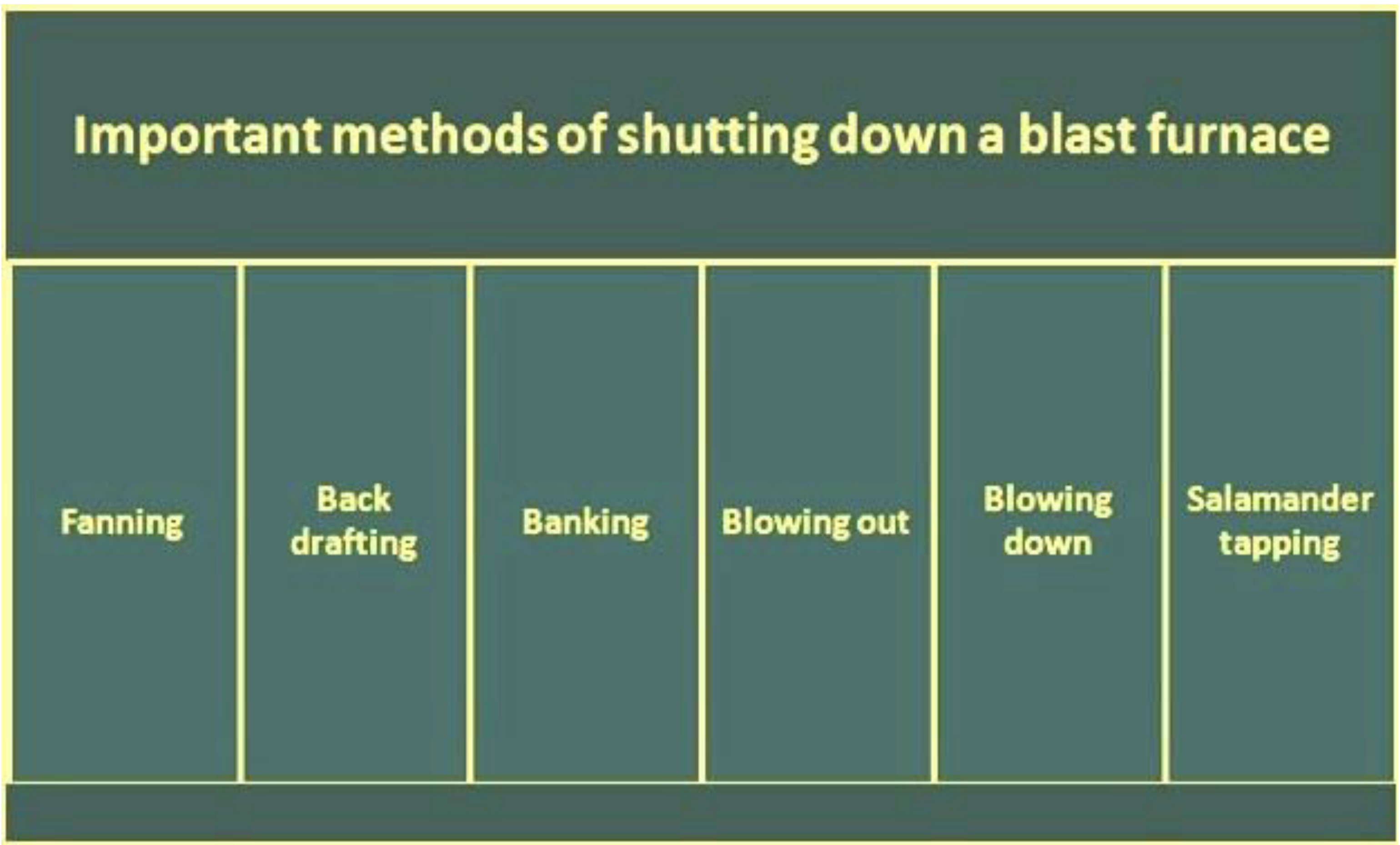
- After nearly two days, as the ratio of iron ore to increase in the burden, that the first cast may be due. The amount of slag and metal flowing out of the furnace is correlated to the charge schedule and proportion in order to assess the progress of blowing-in operation.
- After the first cast is over charging and tapping schedules are established and are strictly adhered to until routine production is established Even if changes in these become necessary alternatives are kept ready before hand for immediate execution without any delay.

- The changes become necessary perhaps because of changes in temperature and composition of metal and in the relative amounts of slag and metal tapped.
- The maximum blast temperature and volume rate are achieved rather quickly to have proper blowing-in.
- It generally takes nearly a week to establish normal routine practice so that metal and slag of desired composition will be tapped out of furnace at the desired intervals

Shutdown.

- A blast furnace, after it is blown in and the production of hot metal starts, runs for a large number of years before it is put down for relining. This continuous run of the blast furnace is known as campaign life.
- In modern blast furnaces a campaign life of 15 years to 20 years is expected. When a furnace has reached the end of its campaign, it was usually blown out/blown down.
- Between the blown in to blown out/blown down, the blast furnace may have to be shut down for short periods due to various reasons.

- The various types of shut downs of a blast furnace are described below.



Fanning

- Very often while running of the blast furnace, a situation can arise when the full productive capacity of the furnace is not required for a period of time. This can be due to some problems which may arise in downstream or upstream facilities.
- When this occurs, the problem can be solved either by the shutting the blast furnace down or curtailing the operation of the blast furnace by reducing the quantity of hot blast. The hot blast rate is usually reduced until the hot blast pressure at the tuyeres is very low

- However, it is a must that a positive pressure is kept in the hot blast system to assure that there is no danger of blast furnace gas coming back from the blast furnace into the blower system.
- The technique of reducing the hot blast volume to less than 20 % to 25 % of normal is known as fanning.
- Fanning has the advantages of keeping the blast furnace gas system pressurized and furnishing a small quantity of blast furnace gas for use as fuel, and enables a resumption of near full operation on relatively short notice.

- This technique is used for emergency situations or short periods only. Prolonged use, such as 8 hours out of every 24 hours, or on weekends, often results in a hearth buildup and frequently promotes in wall scab formation.

BACK DRAFTING

- During the campaign life of a blast furnace , there are occasions when the blast furnace is taken off blast for short periods to perform various maintenance functions such as the replacement of tuyeres, tuyere coolers or maintenance of the peripheral equipment.
- In such instances, the blast furnace is back drafted. In this operation, as soon as the hot blast is stopped, the bustle pipe is put under negative pressure

- This is done normally by opening the chimney valve and the hot blast valve to a stove that has already been prepared by heating it to temperature and then shutting off the gas valve.
- As the blast furnace gas is drawn back into the hot blast stove, air is admitted through the peep sights and stove burner, and the operator makes certain that the gas burns in the stove.
- During the operation, the bleeders at the top of the blast furnace are also opened to pull some of the blast furnace gas out through the top.

- In some of the blast furnaces, a special back draft stack is installed so that it is not necessary to draw the blast furnace gas back through the blast furnace stove.
- This stack is connected to the bustle pipe or to the hot blast main.
- In some places, it is closed by a water cooled gate valve at the level of the bustle pipe while in some other places it is closed by a cap valve at the top of the stack which is not cooled.

- Opening of the valve allows the blast furnace gas to draft to the atmosphere where it burns without difficulty.

Banking

- In the present day running of the blast furnace, banking of the blast furnace is seldom being practiced.
- However banking is considered as a standard technique for blast furnace shut down unless the outage is of short duration.
- Blast furnaces are normally blown down these days which mean that they are run without being charged until the burden level reaches the tuyeres

- Plans for an extended shutdown or interruption to furnace operation either for a breakdown, scheduled repair or because market conditions indicate a pause in production is desirable, may influence management to blow down a blast furnace.
- Banking process in the blast furnace is adapted, since the procedure of banking is useful for short outages
- The word banking is used because of a similarity to the operation of banking a fire. The origin is lost in antiquity, however, generally it means covering a fire with ashes or fresh fuel to restrict air, reducing the combustion rate, and thus preserving the fuel for future use.

- Banking is also resorted to as an emergency measure when some unforeseen event requires a shutdown of the blast furnace.
- In case of banking of the blast furnace, the blast is taken off, the blow pipes are dropped and the tuyere openings are plugged with clay to prevent air from drafting through.
- Thus, the heat of the hearth is preserved and the blast furnace can be returned to operation with a minimum effort.

- If the downtime exceeds four or five days in duration, some difficulty can be expected in resuming operation, although examples are available that no trouble has been experienced even after a seven day bank.
- If the furnace is to be banked for only a few days, an extra blank or two of coke may be charged without flux and the furnace taken off when the coke descends to the bosh zone.

- If it is to be banked for a slightly longer time, the ore and lime stone burden is to be reduced by 5 % to 10 % following the coke blank, possibly for ten or fifteen charges before normal charge weight is resumed. This technique is still used very short outages.
- A banking burden for a shutdown for an undetermined length of time is very similar to a blow in burden. Prior to the start of a banking burden, miscellaneous iron bearing materials are removed from the charge and a large reduction is made in the amount of limestone charged.

- Extra coke is also charged before the banking burden. The purpose is to develop a hot, siliceous slag which has a tendency to clean off the lime accumulation on the bosh walls and prevent an excessively high lime slag during blow in.
- High lime slag has a higher melting point and is apt to cause some operating problems early in the blow-in period.
- Often during the initial warm up period, temperatures are to be very high in the bosh which results into increase in the reduction of silica to silicon with the result that slag contains a higher proportion of lime.

- For this reason, effort is made to have a hot, siliceous slag at the time when the blast furnace is banked because a similar condition upon the resumption of operation is expected.
- After the initial preparatory charges, a heavy coke blank is charged and subsequent charging is similar to a characteristic blow in burden. Charging continues until the coke blank reaches the upper bosh area of the furnace.
- At this time, the final casting of the blast furnace is carried out. Effort is made to drain the hearth until a dry blow of the tap hole is observed to ensure a clean hearth for the future startup and eliminate as much as possible the need for melting cold slag early in the blow in period.

- Prior to the last casting, the blast furnace dust catcher is emptied. Accumulated dust has a tendency to consolidate into a rock like mass if undisturbed for a time and can present a difficult problem after operation begins again.
- About the end of the casting, before the blast furnace is taken off, a heavy blanket of ore may be dumped in the blast furnace to cover the upper burden surface, thus reducing the natural drafting tendency of the blast furnace.

- At the end of the casting, the tap hole is plugged, hot blast is taken off the blast furnace, bleeders are opened, steam is turned into the dust catcher, the blast furnace is isolated from the common gas system and stove valves are manipulated to draft gas back through the bustle pipe, hot blast main and out through the stove chimney.
- In many places, It is preferred to remove the tuyeres to avoid any chance of a stray water leak permitting water to accumulate in the blast furnace and also to provide an opportunity to observe the coolers for possible leaks

- Clay is solidly packed into the tuyere openings and backed up with sand to eliminate any chance of air filtering in. Sometimes this is followed by bricking up the openings as further insurance against air infiltration.
- As soon as the blowpipes are down after the final casting, blowers are stopped, and stove burner valves, chimney and hot blast valves are closed to preserve heat as long as possible.
- As a precaution, blow off valves are opened slightly to prevent a pressure buildup from developing in the hot blast stoves resulting from an undetected water leak or from some unsuspected source.

- Within a day or two, the manhole at the blast furnace top is opened and steam is shut off in the dust catcher. Daily inspection of the stock line is important. A slow stock movement is an indication that air is infiltrating and coke is being consumed.
- A small movement can be expected but a continual drop is undesirable and may force the operators to spray the bosh with a sealing material. A thin mixture of water, clay and water glass is sometimes used because the material is inexpensive and does an effective job.

Blowing out

- The blowing out is also called sometimes raking out. Blast furnace is normally blown out when the production from the blast furnace is no longer required.
- A blown out furnace can be restarted faster and with less effort than starting from a banked furnace, since the conditions approaches those of starting a new furnace.
- However, the costs in connection with blowing out, raking out and cleaning preparatory to starting is likely to exceed the cost of banking the blast furnace.

- When a furnace has reached the end of its campaign (that is, the lining has worn out), it is usually blown out. However these days the practice followed is to blow down the blast furnace.
- For the blow out, the operation is discontinued for a short period of time roughly 12 hours to 16 hours before the last casting of the blast furnace is done to permit the installation of water sprays in the top of the furnace and thermocouples in the uptakes.

- The burden composition is then normally changed to produce a very siliceous slag. This helps in removing as much lime as possible from the bosh and hearth walls.
- The purpose of this is to prevent the formation of calcium hydroxide which would occur if lime were to come in contact with the cooling water during the later stages of the blow out.
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- The formation of calcium hydroxide from lime imbedded in the lining can generate sufficient force to crack the steel hearth shell or to lift the furnace off its columns.
- After installation of the blow out equipment, the blast is put on and charging is continued.
- The activity of blow out starts with charging of a heavy coke blank in the blast furnace. The volume is to be equivalent to approximately the volume of the bosh.

- After the coke blank has been charged, washed and screened fluxes of size 25 mm to 50 mm is charged.
- During the blow out, water from water sprays is judiciously used to control the temperature of the blast furnace top.
- A decrease in the hot blast rate is needed as the height of the column of burden material in the blast furnace decreases.
- From the time that the heavy coke blank is charged in the blast furnace until the blow out is completed requires only around 6 hours to 8 hours.

BLOWING DOWN

- Around 1970s, It was realized that the procedures of banking and blowing out of blast furnace are expensive procedures.
- Also very often banking results into difficult startups because of water problems, or many unforeseen reasons.
- Also the blast furnace operators have now enough technical understanding of the process to allow operators to blow the furnace down.

- Blowing down of a blast furnace means running the blast furnace without charging until the burden level in the blast furnace is reduced to approximately the tuyere level.
- There are several reasons for the preference of the blowing down technique over the banking or blowing out a blast furnace.
- Some are when a furnace is blown-down it can be thoroughly inspected for leaking coolers or staves, and no effort is required to stop air infiltration because the furnace is empty.

- And, if the furnace is to be relined it is faster and less expensive to tear apart an empty furnace that one containing burden.
- The blow down technique varies from blast furnace to blast furnace but basically the following procedure is followed.
- Atomizing water sprays are installed at the top of the blast furnace on a shutdown prior to the blow down, somewhere in the vicinity of the 3 m to 5 m stock line level.

- Normally four to six spray nozzles are installed equally spaced around the furnace. The purpose of the water sprays is to control the top temperature of the blast furnace.
- The water flow rate usually needed is around 150 cubic m per hour at a pressure of 8 atm. Emergency backup water supplies are often provided for safety purpose.
- Depending on the type of blast furnace top and its condition, emergency water sprays are sometimes installed to fight in case there is a grease fire during the blow down.

- Steam sprays are also installed on one to three levels to provide some cooling and to maintain furnace pressure.
- If one level is used it is generally placed low in the stack at roughly the 12 m to 15 m stock line level.
- If additional levels are used they are placed roughly equidistant between the top water sprays and the bottom steam sprays.
- The steam injectors are activated once the burden descends below them.

- In some places there is also a provision of supplying nitrogen to the steam sprays as backup in case there is a loss of the steam pressure.
- Nitrogen injection is provided for purging the blast furnace at the end of the blow down. Usually the nitrogen is introduced through the bustle pipe.
- If nitrogen is used as backup to the steam injection system, that system can also be used to purge the blast furnace when the blow down is complete.

- Desired nitrogen flow and pressure levels required are around 150 cum per minute at 3.5 kg/sq cm.
- Provision is to be made for the analysis of process off gas. Normally this simply needs recalibration of the top gas analyzer.
- Analysis of hydrogen and oxygen is needed. Level of hydrogen is to be kept low (below 15 %) and there must not be any oxygen.
- There is also a requirement of the measurement of the stock line and the probe must be capable of extending well into the furnace.

- The rate of hot blast and its temperature is reduced as the burden descends to control the top temperature of the blast furnace.
- Also hydrogen and oxygen content of the top gas is to be controlled.
- Typically the maximum top temperature is to be in the range of 300 deg C to 450 deg C.

Salamander tapping

- After the blow down, especially when the blast furnace is to be completely relined (including the replacement of the hearth lining), the salamander is usually tapped.
- This operation saves days and possibly weeks in relining time which otherwise might be lost in blasting out the heavy chunk of solid iron that get formed if the liquid metal (that accumulates in the hearth as bottom block eroded during the campaign) is permitted to solidify.

- It is preferable to tap as much liquid iron as possible, because the removal of a solidified salamander costs many days, with additional risks of damaging the blast furnace, due to the use of explosives.
- Salamander tapping of a blast furnace is the final tap for draining out the last liquid iron from the blast furnace hearth.
- Because of its rare occurrence a salamander tapping represents a special job which needs a lot of preparation. Salamander tapping is normally considered , to a large extent, as an art.

- Heat transfer calculations based on thermocouples located in the under hearth allow the depth of penetration of the iron pool to be estimated.
- However this point is at best an estimate. Consequently, the location of the drilled hole is somewhat arbitrary and some, usually small, portion of the salamander often remains in the blast furnace after the tapping.

- Earlier it used to be difficult to find the best possible location of the salamander tap hole due to a lack of information on the blast furnace hearth interior and thus on the position of the wear line.
- Without any or insufficient data from thermocouples it was difficult to determine the optimal position to drill or lance the salamander tap hole.
- Professional experience was normally used in order to determine the drill location and angle to hit the salamander. More than once a number of holes were to be drilled and lanced before the salamander was hit for starting the tapping.

- With modern blast furnace hearths being more and more equipped with dense thermocouple grids, thermal calculation of the position of the wear line, and hence of the salamander position, has become possible.
- Densifying the thermocouple grid improves the calculation accuracy, so that guessing where the salamander may be hit, is now replaced by knowing where the drill hits the wear line and, hence, from where the hot metal can be expected.
- An additional advantage of a more precise location is the possibility to improve the engineering of the setting around the salamander tap hole.

- The salamander tapping is made at preferably the lowest level where liquid iron can be expected in the blast furnace hearth.
- Normally the salamander tap hole is positioned somewhere close under the cast house floor and usually it is in a difficult to reach area, full with piping, cables, etc.
- This difficult to access area also has insufficient or poorly accessible escapes routes and present a dangerous area for the operator who is drilling or lancing the salamander tap hole.

- The important issues during the salamander tapping include
  - (i) location of the salamander tap hole,
  - (ii) environmental aspects (big brown clouds are normally there) and
  - (iii) tapping of maximum of liquid salamander iron.
- The salamander tap is always organized to drain as much as possible liquid iron from the hearth and for using it as hot metal charge in the steel melting shop.
- In the past, salamanders were tapped after the blow down and after the blast furnace were completely off blast.

- As a result the salamander had only its own ferro static pressure as the driving force to come out of the blast furnace.
- Initial preparations for salamander tapping which are made include
  - (i) drilling a predetermined distance into the furnace bottom below the hearth staves, and
  - (ii) installing a trough or runner for the iron

- When all is ready, a long oxygen lance is inserted in the drilled hole and the remaining brickwork is burned through into the pool of iron. Usually the flow of iron is slow and several hours are needed for emptying out the accumulation which may be up to 400 tons to 600 tons.
- Not drilling the salamander tap hole completely through into the liquid and lancing the last part, results in an undefined tap hole diameter and sometimes in slowly running casts.

- These slowly running casts may also be retarded by a decreased hot metal temperature of the salamander, caused by the effect of the hearth cooling system during the waiting time between the end of the blow down and of the start salamander tap.
- The salamander hot metal is usually led to the hot metal ladles (normally torpedo) with runners shelled by dam plates. This allowed for a controlled filling of up to three hot metal ladles, as there is no possibility to switch back to a ladle position upstream.

- A tilting runner can also be used to exchange an unlimited amount of hot metal ladles, but its disadvantage is the extra height required, lowering the salamander drill angle.
- The use of the tilting runner requires a bended long runner to get a cross flow in the centre of the tilting runner and the tilting runner has to be actuated.

- An important aspect to improve the salamander tapping is to eliminate the safety risks since in most cases the salamander tap hole is situated in a difficult to reach and confined area, with difficult escape routes, inherent to their position directly under the cast house floor.
- To check whether or not the furnace was complete drained from liquid iron, a secondary safety salamander tap hole is engineered at some places with the salamander liquid iron to be collected in an open pit.

- This tap hole is opened when the flow from the main salamander tap hole is reduced.
- Very small amount is expected of salamander iron is expected from the second tap hole but it aids in the complete drainage of the hearth.

IRREGULARITIES IN BLAST FURNACE DURING OPERATION

- For a stable and efficient operation of a blast furnace, smooth and uniform movement of burden materials downward and movement of furnace gases in the upward direction is very important.
- To ensure this a lot of work has been done in the recent past. This includes improvement in the characteristics of the burden materials, improvement in the furnace charging system, adequate automation of the furnace operation to eliminate human errors and improvement in the furnace operating procedures.

- In spite of these improvements, the blast furnace does not run as smoothly as one is led to believe.
- Furnace upsets are not as frequent as they were in earlier years but irregularities still do occur. These irregularities are the main concern for a blast furnace operator and often need quick thinking and timely good judgment on the part of the operator to prevent serious trouble. The major irregularities in the blast furnace operation are described below,

Furnace hanging and slipping

- When the materials charged at the top of the blast furnace do not move continuously towards the hearth of the furnace, the phenomenon is called 'hanging' of the burden. Hanging of the burden material in the blast furnace stack occurs when the material below the hang continues to move downward, forming a space that is void of materials but filled with gas at very high pressure.
- This space continues to grow unless hang finally collapses. The collapsing of the hang is a phenomenon called 'slipping' during which the charged materials fall uncontrollably toward the hearth of the furnace in a thermally unprepared state which leads to the furnace getting cold. It also forces the hot gases upward with the force of an explosion.

- The sudden rush of gases opens the furnace top gas bleeder and sometimes can cause top equipment damage.
- Hanging conditions can develop due to a variety of reasons. Due to these reasons the permeability of the burden materials is decreased because some of the material plugs up the voids or openings between the charge materials and bonds them loosely together.

- This happens due to the following reasons.
- Loose bonding of burden materials happen specially when there are a high percentage of fines in the burden and the velocity of furnace gas is relatively high.
- Furnace slag that has been melted is blown upward in droplets. These molten slag droplets when subsequently contacts with colder burden material gets re-solidify and plugs up the openings between the particles and tends to cement them together.
- Sometimes the carbon monoxide decomposition reaction ($2\ CO = CO_2 + C$) will be catalyzed and the carbon deposited as soot will plug up the openings between the particles and will hold the particle together

- In some cases where the alkali content of the burden is high, the alkali compounds gets reduced in the furnace to alkali vapors which ascends with the furnace gases and condenses in the cooler portion of the charge material and thus cause plug up of the openings between the particles and results into hanging condition of the furnace.

- Sometimes hanging conditions occurs in those furnaces which are being run very efficiently and being pushed for higher production. Under these conditions if there is a slightly unfavorable change in the gas distribution, coke strength or the size variation of the burden in the furnace, then the iron oxide will not reduce to metallic iron rapidly enough, and will melt and run down as a liquid on the coke particles. If this happens the coke will reduce the liquid iron into solid iron and will consume considerable heat during reduction. This will cause cementing of the coke particles together resulting into significant reduction of the permeability and hence hanging.

- Hanging may also be caused if the blast furnace is run at too high a flame temperature for the quality of the burden material. When the high temperature isotherms expand far enough above the furnace, they can begin to melt unreduced material. As this material descends into a more reducing environment, it reduces and depending on the temperature it may solidify and plug the gaps between the materials. This happens since the melting point of FeO (1370 deg C) is lower than of pure iron (1535 deg C)

- When the furnace movement is not proper and there is sluggish movement of the burden material through the furnace, the furnace operator must take corrective measures immediately to avoid a major slip which can be very disastrous. Under very extreme condition this can lead to a frozen furnace. Every hanging and slipping is to be properly investigated to determine the causes of the hanging so that changes can be made in the operating procedure to prevent the hanging from recurring.

Scaffolding

- The term scaffolding is used when accretions or scabs build up on the furnace walls and cause a decrease in the cross sectional area of the stack of the blast furnace. Scaffolding can occur relatively at the higher level of the stack of the blast furnace or relatively low in the stack, near the top of the bosh.
- The scaffold formation near the top of the bosh often results because of excessive fines in the burden material and a higher than normal lime chemical composition of the slag (Reflected by the higher basicity of the slag). The solution of lime into the slags formed in the furnace stack increases the melting point of the slag.

- Since the slag often carries some of the fines particles from the burden in suspension, the increase in the melting point can cause this mixture of fines and slag to adhere to the upper bosh walls. This build up in the upper bosh wall deflects the hot furnaces gases farther to the centre of the furnace. With lesser volume of hot gases along the walls, the accretions tend to cool down and solidify completely. These scabs then may grow until they block a large percentage of the cross section area of the blast furnace.

- Alkali or zinc compounds are reduced to metallic vapors near the bottom of the blast furnace. These vapors rise with the furnace gases to the cooler top portion where they are reoxidized to very fine solid particles. These fine particles adhere to the furnace wall along with other fine materials entrapped in it. This is also another cause of starting of the formation of a scaffold.

- The blockage due to the scaffolding reduces the area available for smelting of the iron bearing materials. Scaffolds distort the gas flow inside the furnace and increases the fuel rate while promoting hanging and slipping of the furnace. It also decreases the furnace productivity. Due to higher fuel rate lower furnace fuel efficiency results. When the scaffolds dislodge from the walls, it descend into the hearth. This cause’s serious furnace upsets and reduces the quality of hot metal. In case the size of scab is too big, it can cause the furnace to freeze.

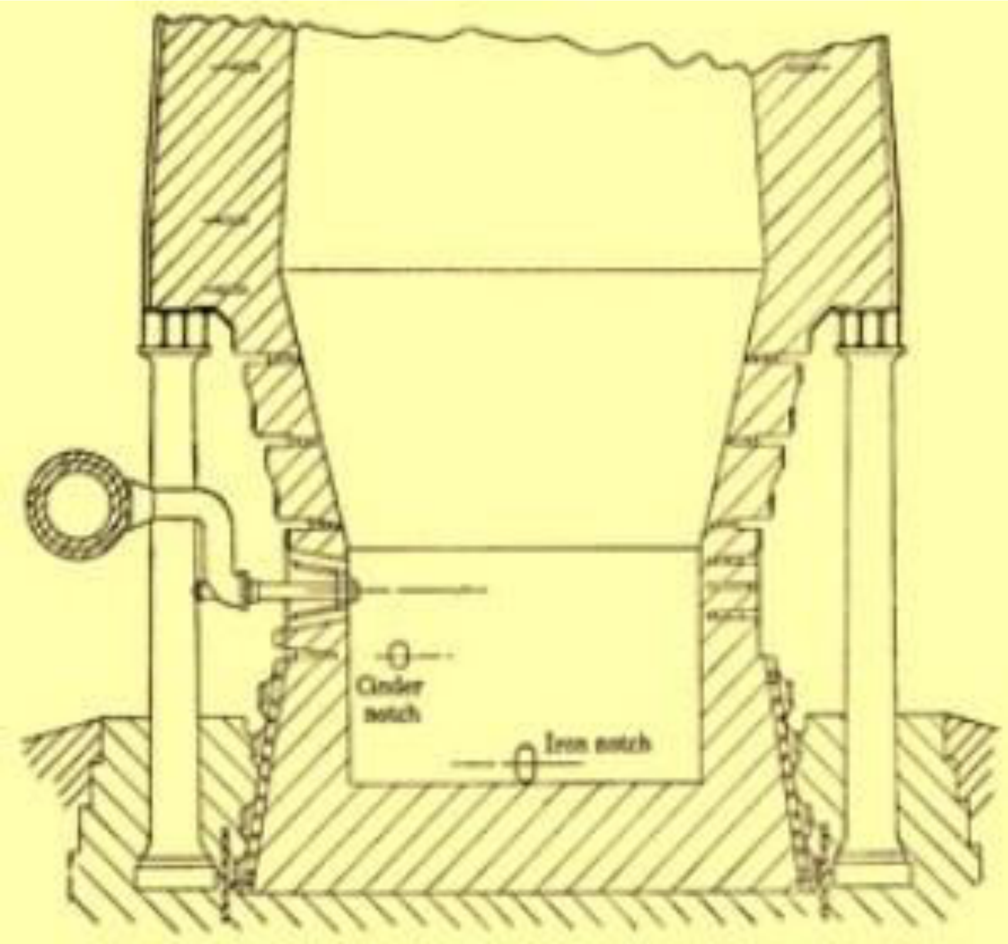
Channeling

- The phenomenon of channeling happens when the ascending gases in the furnace does not properly get uniformly distributed both radially and circumferentially in the furnace and find a passage of least resistance.
- The different causes for channeling to occur in the blast furnace are charging of excessive fines, improper distribution of the burden material inside the furnace and high level of liquid iron and liquid slag in the hearth. In case of fines charging, the channeling leads to the increase of the heat load at the walls of the blast furnace.

- Due to the fines, the ascending gasses gets diverted from the area and channel around the fines. This diversion of the ascending gases upset the preheat of the materials and the reduction process. It causes unscheduled bleeder opening, off chemistry of the hot metal, unstable production of the blast furnace and reduction in the furnace productivity.

Breakout

- A ‘breakout’ is the term used to denote the conditions and results of the escape of gas and coke, or slag, or iron, from the bosh, tuyere breast, or hearth of a blast furnace. Breakouts may occur at any point below the fusion zone in the furnace, but the most of the severe breakouts are of liquid slag and of liquid iron.
- Liquid iron breakout takes place at a level below the surface of iron lying in the hearth, and are either through the hearth walls and jacket or into the hearth bottom and out under the hearth jacket. Typical cross section of the lower part of a blast furnace showing hearth and bosh is at Fig
- These are the places where breakouts usually happens.


Cinder
notch
Iron notch

- Breakouts are caused by failures of the walls of the hearth, with the result that liquid iron or liquid slag or both may flow in an uncontrolled way out of the furnace and surrounding auxiliaries. Slag break outs are usually not as serious as iron break outs, because there are not as much danger from explosions as in the case where molten iron and water come into contact.
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- With either type of breakout, it is necessary, if at all possible, to open the tap hole and drain out as much liquid material as possible, and to take the furnace off blast.
- In case of a slag breakout, the breakout may be chilled by stream of water, and the hole where the breakout occurred may be closed by replacing the bricks, or pumping fireclay grout in the opening or ramming a plastic cement or putting asbestos rope into it.

- In case of iron breakout, there is practically no control. The hot metal is to run out of the hole until the furnace is dry. After the accumulated iron has been cleared away, a suitable refractory may be used for closing the hole. In iron break out is severe then a complete hearth repair will be needed. In case of non severe break outs it may be necessary to change the damaged hearth cooling stages.