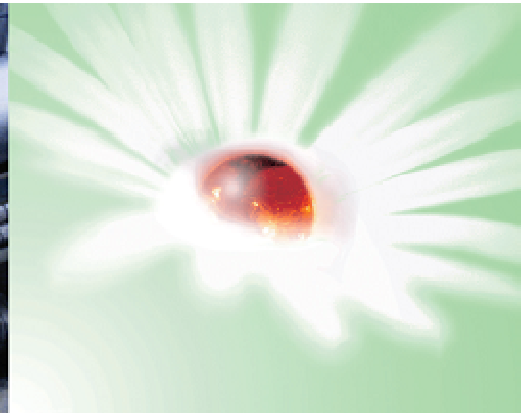
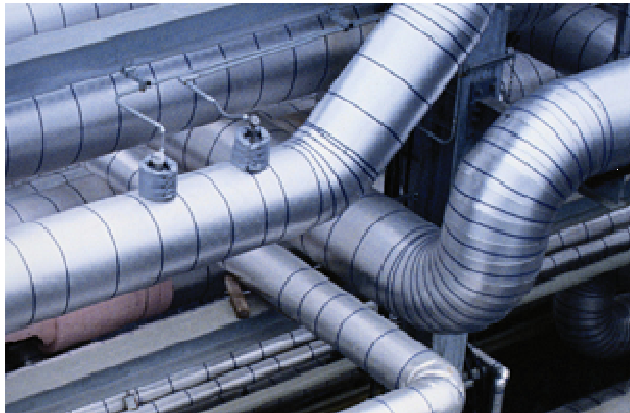




PROJECT

MAGMA

MULTIPURPOSE
SMELTING UNIT
AND ITS APPLICATION



MULTIPURPOSE SMELTING UNIT

MAGMA

APPLICATION CONCEPT -

Mankind has accumulated and dumped on the Earth an enormous amount of industrial and household waste generated by human activities.

Waste has been and continues to be disposed of in dumps, storage sites, deposits and special landfills that cover vast areas.

Waste exerts an adverse effect on the environment and people themselves. Intensive economic development and the concept of “a consumer society” speed up the accumulation of such waste in the 21st century.

At the same time, there is a continuing increase in the extraction of resources necessary for accelerated economic growth and for meeting the demands of “the consumer society”: ore, energy carriers and mineral components required for growing production.

As a consequence, the surface of our planet continues to be covered with new metallurgical waste dumps, slag heaps, tailing ponds, abandoned pits, etc.

The problem of efficient processing most of the above-mentioned waste is solved with the help of MAGMA. MAGMA is a cost-effective continuous skull smelting unit that can process and convert waste into useful products (metals, construction materials, thermal power and electricity) by waste-free and environmentally clean technologies.

MAGMA AND ITS APPLICATION

The multipurpose smelting unit MAGMA is primarily intended for efficient processing of industrial and municipal waste, ores and energy carriers by waste-free and environmentally clean technologies.

A model type of MAGMA depends on the specific purpose of its application.

The main modules of the unit are the smelting chamber and its original cooling system.

The other components of the unit (driers, pre-heaters, charge feeders and feeders of additives to molten metal, the release system of smelting products, i.e. slag and metal, the process automated control system, the system for use of the thermal power of off-gases and their purification) are all selected depending on the application purpose of MAGMA.

Natural gas or thermal coal are used as fuels; they are burned in oxygen. This engineering solution has allowed reaching high temperatures: up to 1900°C in the working space of the smelting chamber of the unit and up to 1650°C in the molten slag zone.

An original cooling system design of the smelting chamber uses a liquid-metal coolant to maintain temperature of the body of the smelting chamber at 500°C.

Under such conditions, skull is formed in the molten slag zone on the working surface of the smelting chamber and this skull is used instead of the slag zone lining of conventional refractories. The molten metal zone (bottom of the smelting chamber) is lined with refractories that are cooled through the body by the liquid-metal coolant, which ensures high resistance of the zone.

As a result, MAGMA can operate for a long time without interruption for maintenance.

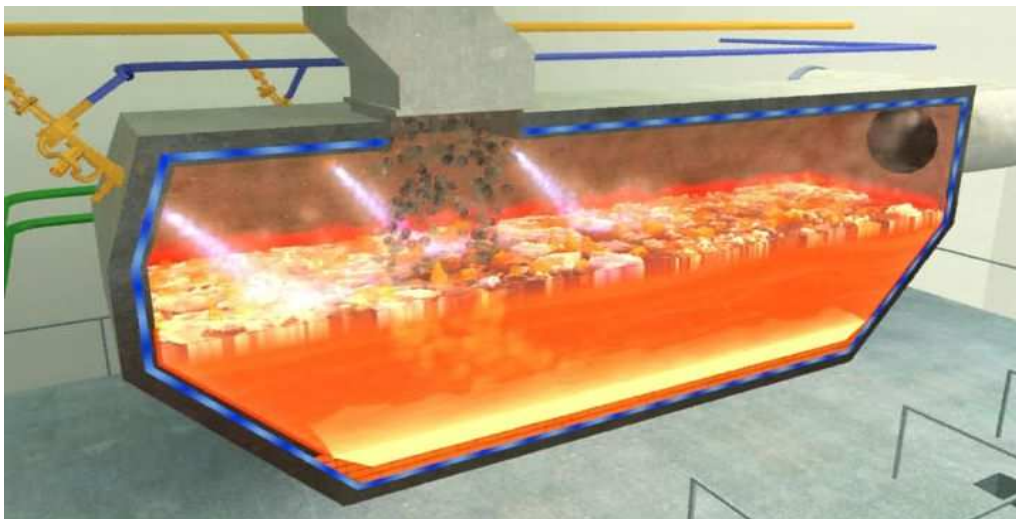
MAGMA is heated by fuel-oxygen burners. Heating of the unit with thermal coal is possible, where the coal is fed onto the surface of the molten slag.

If necessary, a solid reducing agent can be fed to the molten ore and slag by using injectors. Air or Nitrogen is transport gas that is heated in heat exchangers to cool down the liquid-metal coolant.

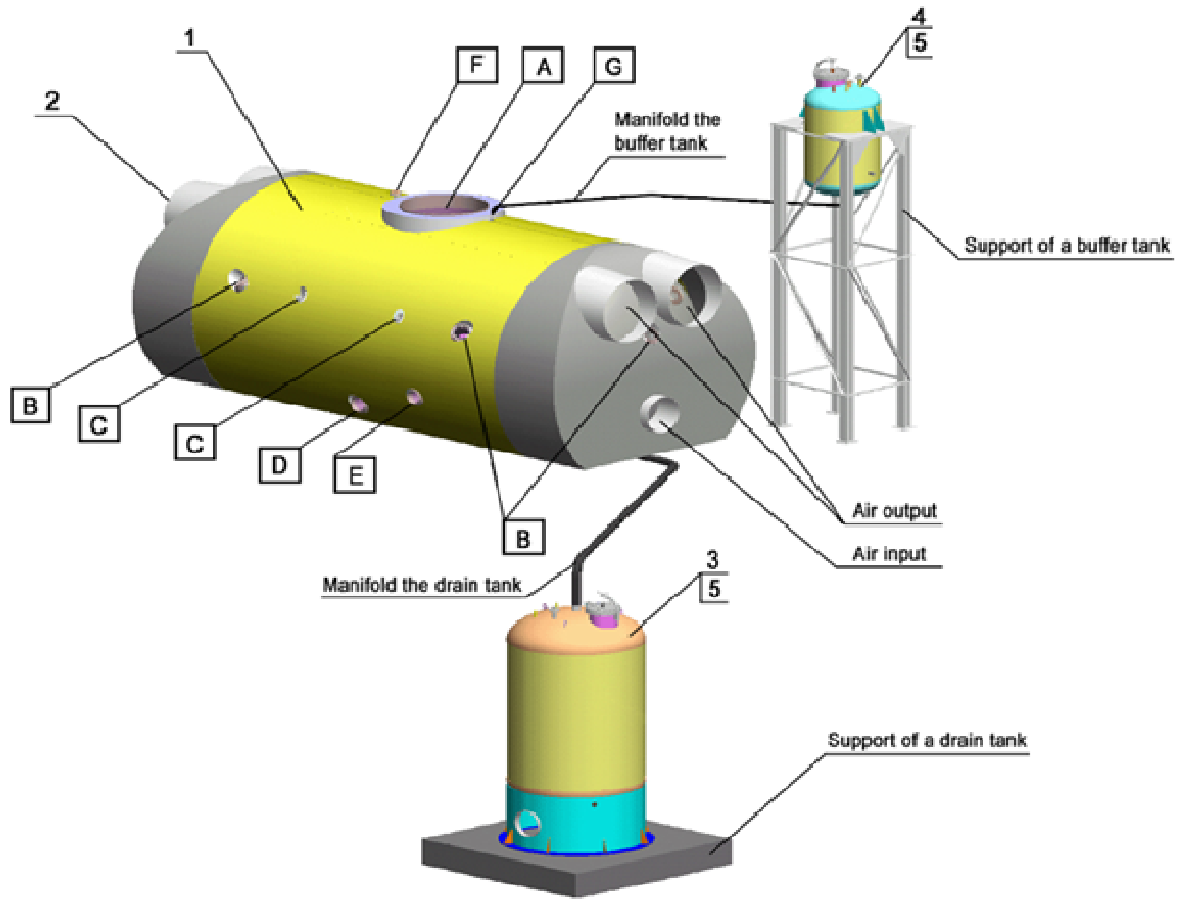
Metal and slag are released from the smelting chamber of the MAGMA continuously or non-continuously depending on the design of further processing stages for production of final products.

The heat of the off-gases from the smelting chamber can be used in a boiler unit and for generation of electric power or for preliminary heating up of the charge fed to the unit. Process gases are treated by modern gas purification systems.

Schematic view of the working of MAGMA Smelter from inside-



Schematic view of MAGMA Smelter from outside-



	Quantity / pieces
A Combustion gases discharge	1
B Burner	6
C Injector	2
D Output of the fused metal	1
E Output of the fused slag	1
F Branch pipe for the thermocouple	1
G Branch pipe of a tank buffer	1
1 The melting chamber APM	1
2 Air-delivery system	1
3 Drain tank	1
4 Buffer tank	1
5 Electro heaters and thermal insulation	1

Principal specifications of MAGMA are given in Table 1.

MAGMA principal specifications -

Table 1

Thermal power, MW	up to 200
Fuel types	natural gas, thermal coal
Oxidizing agent	technical oxygen (95% O ₂)
Metal temperature in liquid bath, °C	1350-1550
Temperature of molten slag, °C	1400-1650
Temperature of gas phase in free space (above molten slag), °C	1800-1900
Smelting chamber dimensions:	
Outside diameter, m	up to 4
Length, m	up to 15
Smelting chamber steel	Stainless alloy steel
Cooling of smelting chamber body	liquid-metal coolant
Bath lining	periclase-carbonaceous or high alumina bricks
Lining in slag zone of smelting chamber	slag skull

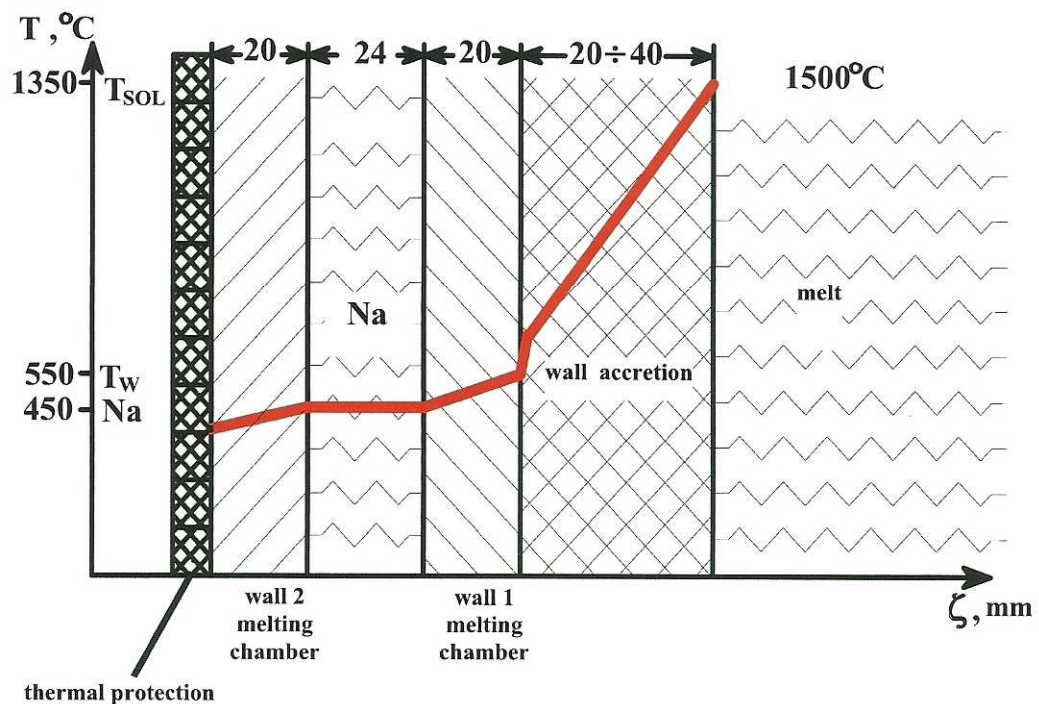
Elements of technologies used in MAGMA –

Technology	Common usage
Liquid phase iron reduction	Electric arc-furnace, Romelt technology
Kish formation on the walls of body/housing	Electric arc-furnace with water-cooling, Vanukov furnace, Ferro-alloy furnace
Fuel-oxygen burners	Modern iron-melting Electric arc furnace
Liquid-metal coolant	Nuclear-power industry (fast neutron power reactor, submarine power reactor)
Pre-heating of charge with waste gas	Electric arc furnace with pit pre-heater, Consteel furnace, pit melting unit

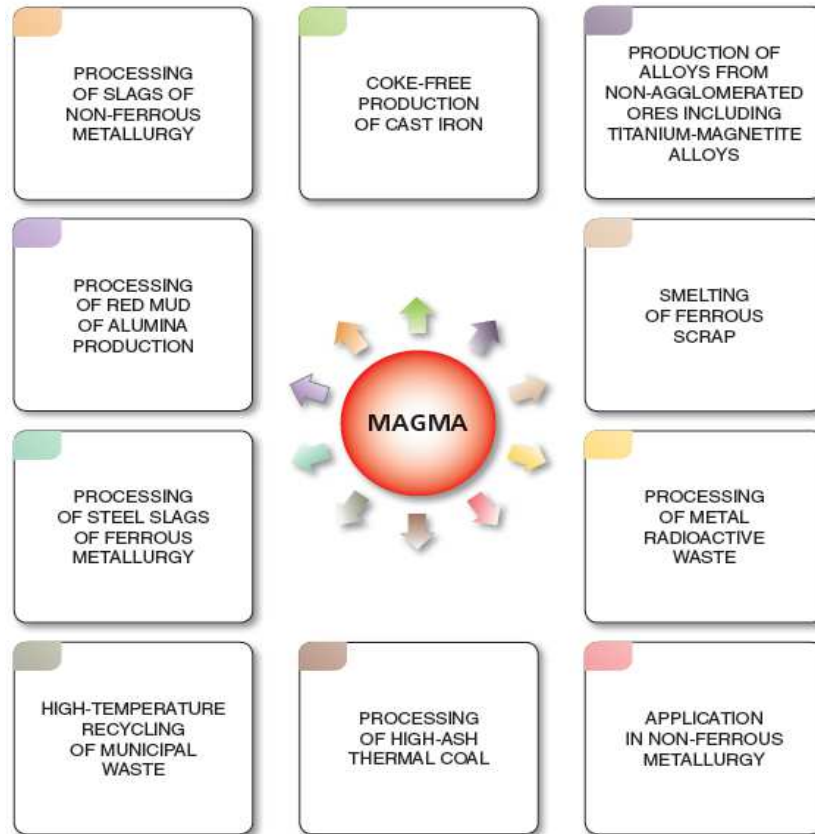
All calculations of the MAGMA unit and processes (physical-chemical, thermo physical and hydrodynamic) taking place in it, are made by means of special mathematical models and DINCOR-codes model in particular, assigned for numerical solution of non-stationery two dimension equations of hydrodynamics and heat transfer of in-compressible multi-component medium, taking into account the processes of components' melting/hardening due to heat-transfer processes.

The DINCOR codes were appropriately modified and then applied for calculation of thermal-hydraulic processes taking place in the MAGMA unit, particularly for defining time, place and size of the generating skull, space materials distribution, slag, metal and gas phases in the melting chamber, their quantity and temperature. The results of some calculations are presented below –

Temperate distribution near the wall of melting chamber by the normal to the surface



MAGMA APPLICATIONS-



More applications for India –

- Ilmenite ore Smelting
- Nickel-Laterite ore Smelting
- Ferruginous manganese ore Smelting
- Making Green Steel in a Sugar factory
- Conversion of Sponge iron Plants into Pig iron Plants
- Combined production of Sugar / Steel / Power / Cement
- Coal Gasification & Combined Cycle Power Plant
- Coal to Methanol, DME (LPG substitute) & Petrol
- Coal to FT Liquids & Diesel
- Coal to Ammonia & Urea
- Coal to Hydrogen

1. COKE-FREE PRODUCTION OF CAST IRON

Significant capital and operating costs for preparation of iron ore (concentration and agglomeration of ore) and coke production in many cases do not allow to organise efficient cast iron production on a small scale (up to 1 million tpy).

Organization of iron production by the method of direct reduction does not require same high expenses for preparation of iron ore.

With relatively small capital costs, MAGMA can be used for efficient coke-free production of small amounts of cast iron from non-agglomerated iron ore by continuous process (figures 1 & 2 below).

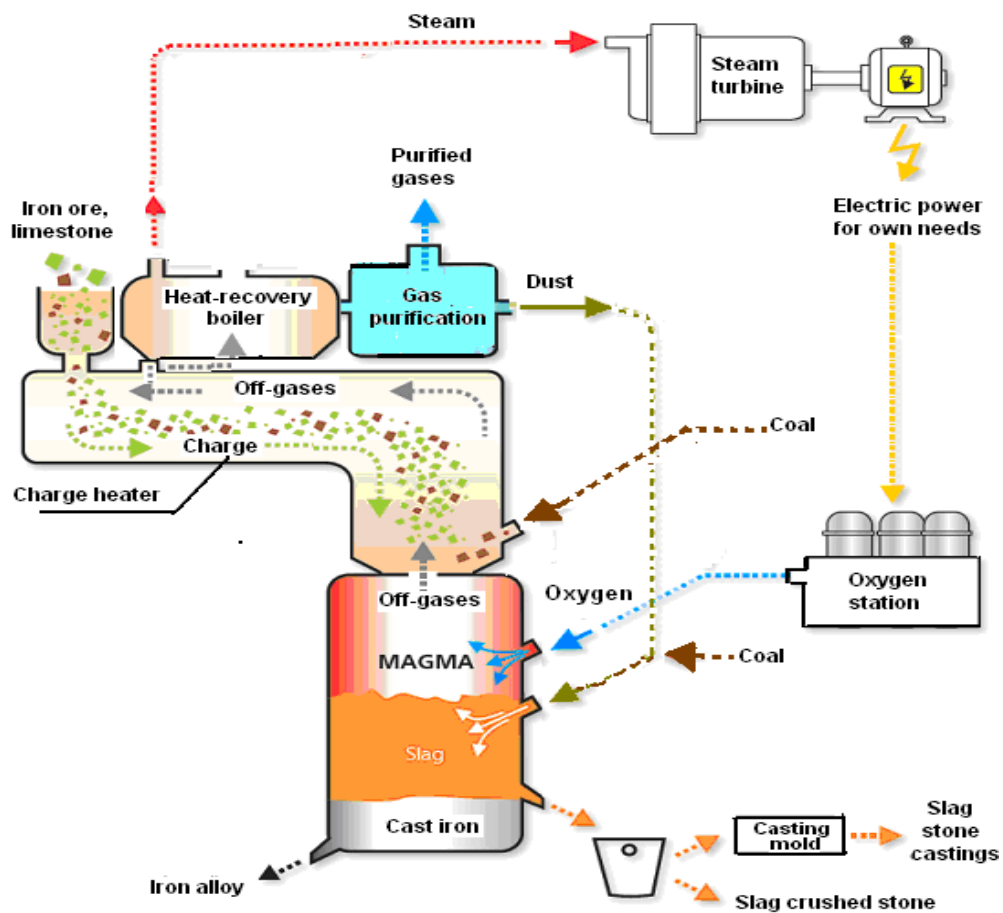


Fig.1.Flow diagram of coke-free production of cast iron from non-agglomerated iron ore & coal

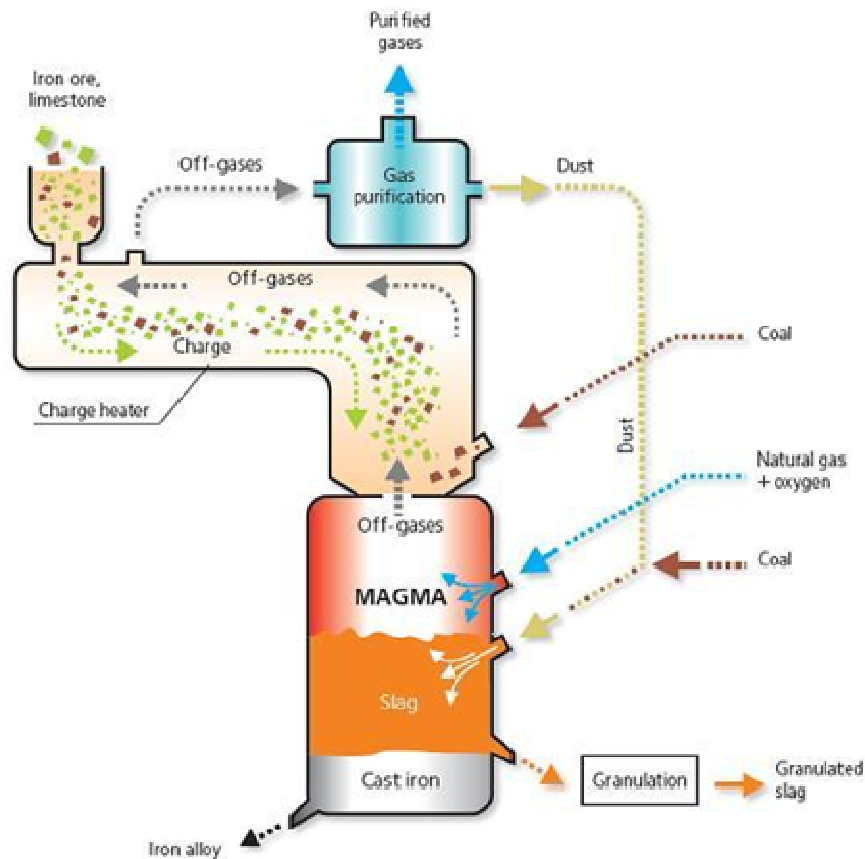


Fig.2. Flow diagram of coke-free production of cast iron from non-agglomerated iron ore, coal & natural gas

Charge (iron ore, limestone), before feeding to the unit, is preliminary heated up by off-gases of the smelting chamber in a rotating cylindrical heater to temperature 900-1000°C. At such temperatures, process of partial decarbonisation of limestone proceeds with formation of lime and partial reduction of iron oxides.

Charge heated in the heater is fed to the surface of the molten mass, charge smelting and reduction of iron oxides occurs in the liquid bath.

Coal required for reduction of iron oxides and adjustment of carbon content in cast iron is fed into the smelting chamber onto the surface of the ore and lime molten mass and additionally injected inside by injectors.

Injectors are located in the body of the smelting chamber at the level of the upper limit of the metal molten mass that is formed as a result of reduction of iron contained in the slag.

The dust captured by the gas treatment system is recuperated by injectors to the smelting chamber into the molten slag.

Heat, which is necessary for smelting the charge, heating the molten mass, endothermic reactions of reduction of metal oxides and compensation of thermal losses of the unit, is fed into the working space of the smelting chamber by gas-oxygen or oxygen burners.

Cast iron and slag are released from the unit non-continuously. Chemical composition of slag is close to the composition of blast furnace slag.

Production capacity of the standard model of MAGMA for cast iron is 40,000-400,000 tpy and depends on composition of the iron ore being used & coal / natural gas being used.

Specific consumption of energy carriers for production of 1 ton of cast iron, using natural gas:

- Natural gas - 120-150 Nm³;
- Thermal coal - 300-400 kg;
- Oxygen - 250-300 Nm³.

Specific consumption of energy carriers for production of 1 ton of cast iron, using Coal:

- Thermal coal (For example, South African Coal) - 900-1,100 kg;
- Oxygen - 600-700 Nm³

2. SMELTING OF FERROUS METAL SCRAP AND SPONGE IRON

Scrap and slag-forming materials are smelted in a liquid bath of molten metal formed upon starting the smelting unit MAGMA.

For refining of the molten metal from phosphorus and partially from sulphur, oxidised basic slag (slag ratio 0.05-0.06) is put over the molten metal which is from time to time renewed.

The heat required for metal heating and smelting is fed into the working space of the smelting chamber by fuel-oxygen or oxygen burner and by oxidation of coal by gaseous oxygen fed into the bath by special lances.

Temperature of molten slag is 1600-1650°C and temperature of metal is 1500-1580°C.

The generated metal semi-product is non-continuously released from the smelting chamber into the ladle transported further to the heating facility of the ladle-furnace unit.

Processed slag is released from the smelting chamber non-continuously. At a later stage it can be used for production of portland cement clinker.

Production capacity of the standard model of MAGMA for scrap reaches 50-55 tons per hour.

The smelting unit can also operate with extra-furnace heating of scrap by off-gases. Above the smelting chamber, a hermetically sealed shaft heater of scrap in this case is installed, the shaft heater being equipped with holding and dozing devices and lances for afterburning of CO in the off-gases.

Production capacity of MAGMA in this case increases up to 65 tonnes per hour.

Use of MAGMA for continuous smelting of ferrous metals scrap and production of metal semi-product allows to significantly reduce the aggregate consumption of fuel as compared with conventional arc steel furnaces due to more rational use of the energy of primary fuel.

The proposed technology of scrap processing has a number of technical and economic advantages over the conventional combination used in electric-smelting of steel: steel electric arc furnace - ladle- furnace unit.

First of all, this means an increase of output of proper liquid metal in smelting. Whereas conventional smelting of scrap in an arc furnace with the use of smelting intensifiers provides an output of proper product in the range of 91-92%, the proposed technology provides an output of proper product after scrap smelting in the range of 94-95%.

Increase of output of the proper product is achieved through:

- Lesser oxidation of iron when smelting in a liquid bath (immersion of a piece of scrap into the molten mass);
- Lesser development of iron oxidation in the presence of coal carbon;
- Recuperation of iron-containing dust captured by the gas treatment system by injectors to the molten slag;
- Small losses of iron in the form of prills in cast slag due to the use of small volume of slag in the process of re-smelting of scrap and application of original siphon design of release of slag from MAGMA;
- Exclusion of slag pumping from MAGMA due to application for metal of a tap hole equipped with a siphon channel.

The proposed technology of smelting of ferrous scrap, as compared with the technology conventionally used, decreases capital costs because of absence of heavy-duty electric arc furnace and respective costly power infrastructure for its operation (Fig. 3).

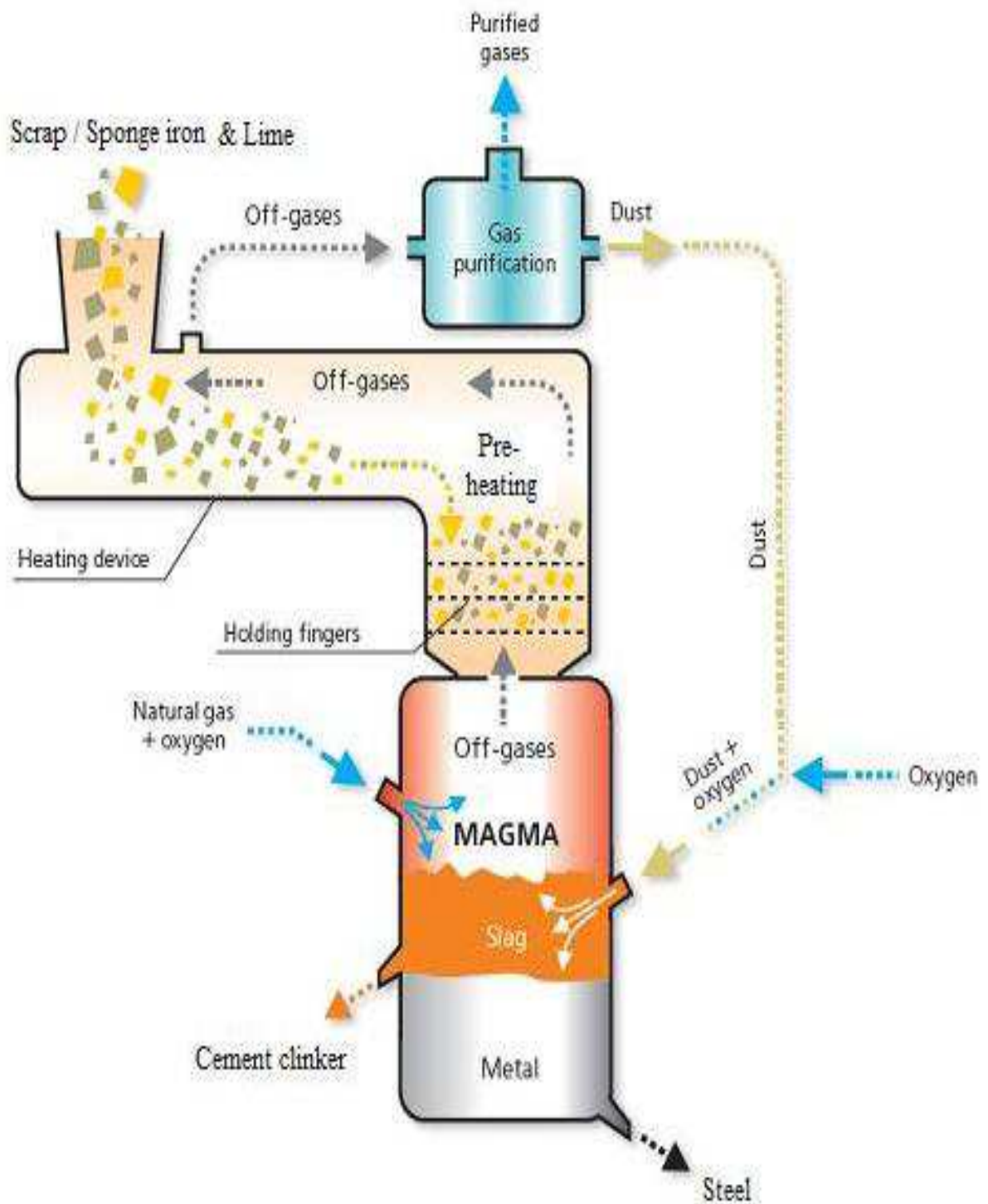


Fig. 3. Flow diagram of smelting of ferrous metal scrap & sponge iron into Steel

3. PROCESSING OF STEEL SLAGS OF FERROUS METALLURGY

Production of cement can be increased by increase of extraction of natural resources and construction of new plants for processing these natural resources. However, this is a costly and environmentally detrimental method.

At the same time, waste of ferrous metallurgy contains an enormous amount of oxidised steel slags with a high basicity.

After meltdown of such slags in the smelting unit MAGMA and partial reduction by carbon of oxides contained in them by process route shown below (Fig. 4), we get molten slag (molten clinker) similar by its chemical composition to cement clinker manufactured by conventional methods at existing cement plants (Table 2 below).

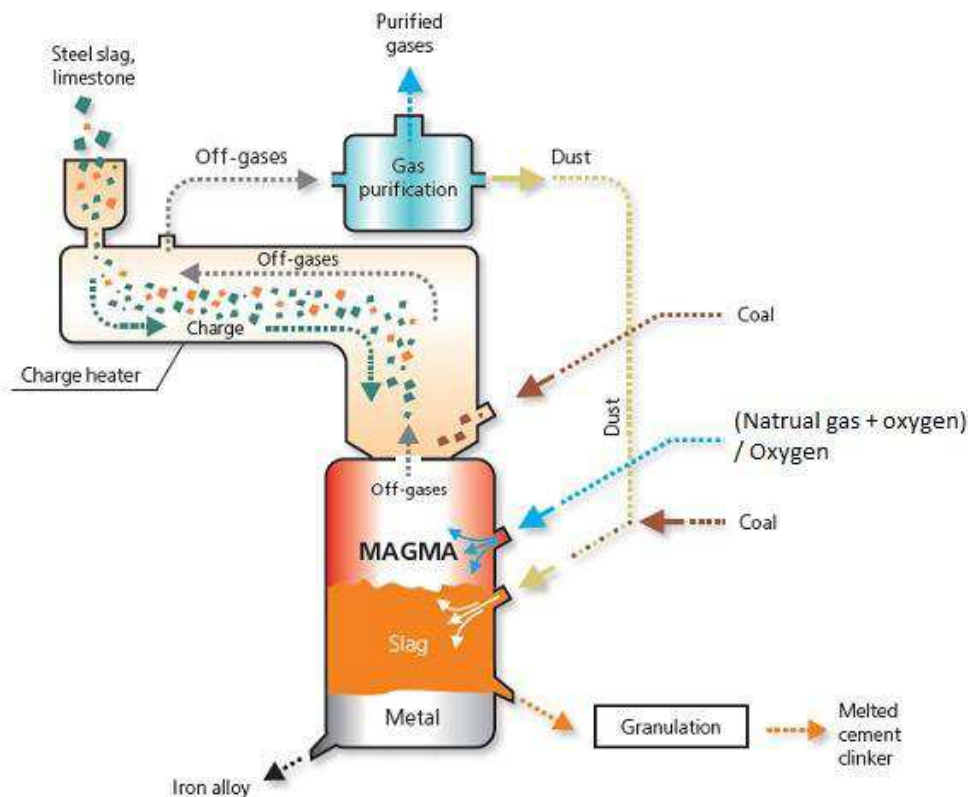


Fig. 4. Flow diagram of melted cement clinker production

Chemical composition of oxidised steel slag, cement clinker and Portland cement type CEM1-

Table 2

Material	content, %							
	CaO	Al ₂ O ₃	SiO ₂	MgO	Fe ₂ O ₃	MnO	Fe, prills	So ₃
Oxidised steel slag	40-55	1.5-3	15-19	1.5-2.5	18-25	4-7	4-6	—
Slag smelted and partially reduced in MAGMA	61.7-63	1.8-3.7	18-24	1.8-3.1	4.5-5.2	2.5-4	0	—
Conventional cement clinker	60-67	3-8	17-25	2,5-5	4-5	—	0	—
Typical portland cement type CEM 1	62-64	5.5	21.5	1.5	3-4	—	0	1.9

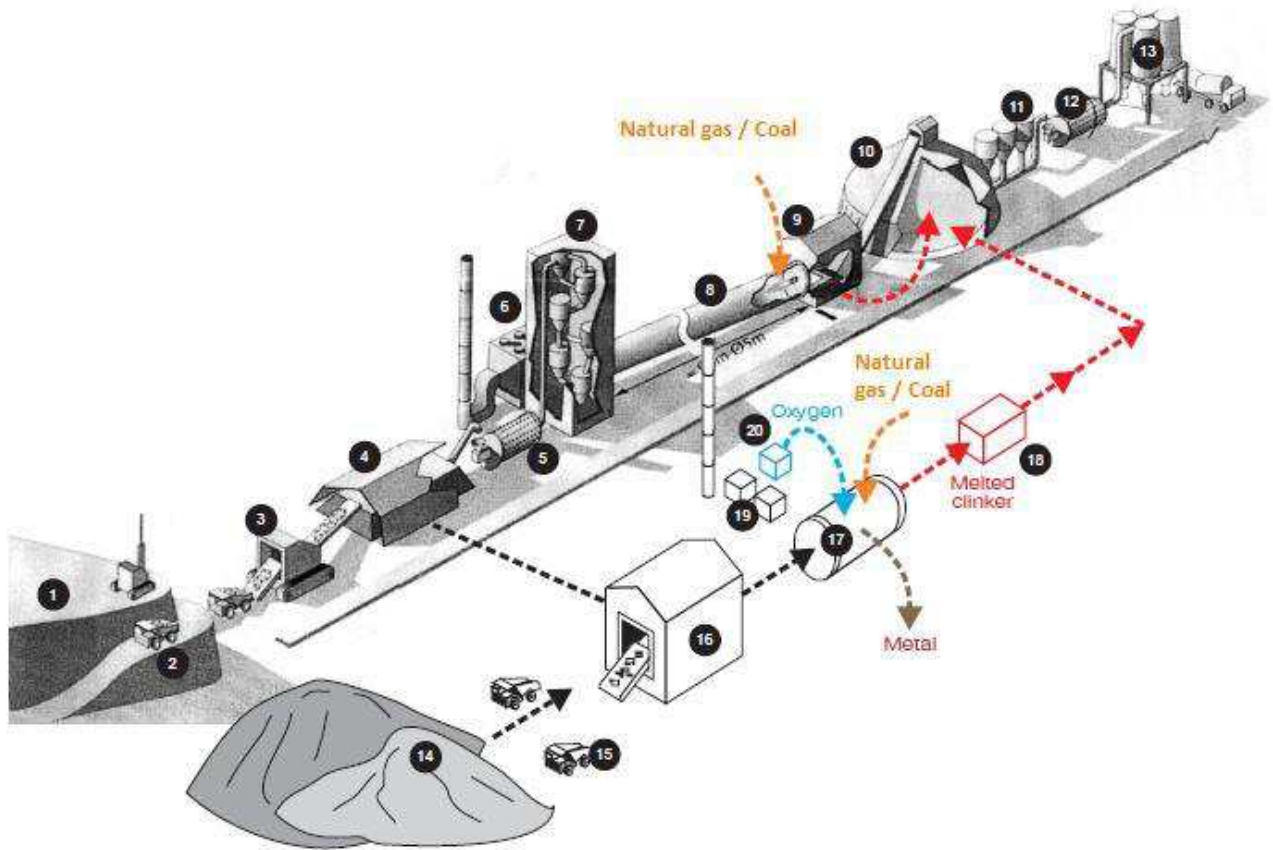
Production capacity of MAGMA for clinker is 200,000-400,000 tpy and depends on chemical composition and the temperature of the slag being processed.

Up to 800 kg of melted cement clinker and up 250 kg of iron alloy can be produced out of 1 ton of re-smelted steel slag.

This allows to significantly reducing the costs of production of the melted clinker.

Production of melted cement clinker out of ferrous metallurgy waste allows to decrease the environmental impact due to refusal from the use of natural resources, reduce energy intensity of production and CO₂ emissions per ton of products, i.e. achieve a significant environmental improvement (Flow diagram & Table 3 below).

Flow diagram of the Portland cement production –



Conventional method of Clinker production

1. Pit (Limestone, clay)
2. Transport
3. Crushing
4. Pre-homogenizing
5. Grinding
6. Gas purification
7. Preliminary roasting
8. Rotary kiln
9. Cooling

Production of Portland cement

- 10. Warehouse of clinker
- 11. Additives
- 12. Grinding of Portland Cement
- 13. cement silo, shipment

Production of Melted clinker

- 14. Slag dump
- 15. Transport
- 16. Warehouse, charge heating
- 17. MAGMA Unit
- 18. Granulator
- 19. Gas purification
- 20. Oxygen Station

Comparative figures of cement clinker production methods -

Table 3

Production method	Raw materials	Saleable products	Energy carriers used	specific units per 1 ton of product				
				Limestone consumption	Natural gas consumption	Coal consumption	Off-gases volume	CO2 emissions
				kg	m3	kg	kg	kg
Conventional method	Natural resources (clay, limestone)	Cement clinker	Natural gas, electric power	1150-1850	82-96	—	1500-1700	720-840
MAGMA method (range of given figures depends on slag composition)	Ferrous metallurgy waste (oxidised steel slags, scales, gas treatment dust)	Cement clinker, iron alloy	Natural gas, electric power, coal	50-570	60-70	70-110	520-930	290-615

4. PROCESSING OF HIGH-ASH THERMAL COAL

The multipurpose smelting unit MAGMA can be used for waste-free processing of high-ash (ash content up to 35%) thermal coals for generation of electric power.

Production capacity of MAGMA for incineration of high-ash thermal coal is 50-100 tons per hour. Production of saleable electric power is up to 90 MWh.

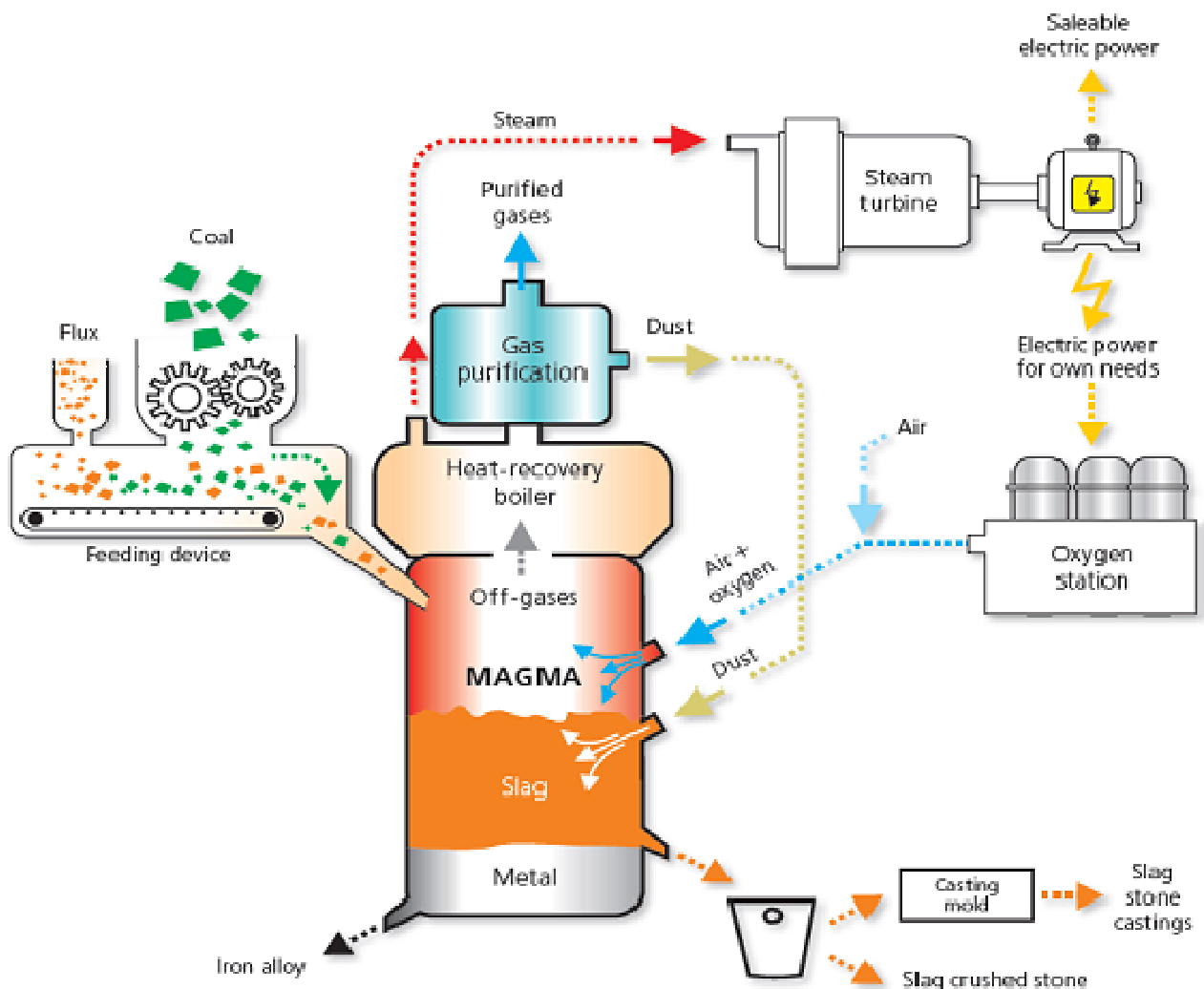


Fig.5. Flow diagram of processing of high-ash thermal coal

Principally, two routes of processing of high-ash coal can be implemented.

Processing Route 1 -

- 1) Incineration of coal in the smelting chamber of the unit in air enriched with oxygen on the layer of the molten slag;
- 2) Afterburning of the formed flue process gases in a heat-recovery power boiler installed over the smelting chamber of MAGMA;
- 3) Production of electric power by traditional processing route used in thermal power industry.

When burning high-ash thermal coal in MAGMA, ash contained in it is smelted and dissolved in the slag bath.

Temperature of molten slag in the smelting chamber is 1500- 1600°C. This allows to adjust the composition of the slag being smelted by adding fluxes.

slag is used for production of cast-slag products or cast-slag crushed stones that by their quality are not inferior to natural granite crushed stones (Table 4 below).

Principal physical and mechanical properties of cast-slag crushed stones - Table 4

Properties	Cast-slag crushed stones	Granite crushed stones
Density, kg/m ³	2800-3000	2500
Strength limit, Mpa	200-500	100-300
compression bending	20-30	5
Abrasivity, kg/m ²	0.5-0.7	1-5
Water absorption, %	0.1-0.2	0.1-1
Frost resistance, cycles	over 300	300

The dust captured by the gas treatment system is injected by injectors into the smelting chamber, to the molten slag where it is assimilated by slag.

Processing Route 2 -

- 1) High-temperature gasification (incomplete burning) of high-ash thermal coal in the smelting chamber of the unit on the layer of the molten slag. The produced gas is mainly composed of CO and H₂ and some quantity of water vapour;
- 2) Cooling of gas in a waste heat recovery boiler & passing the steam in a turbine for generating electrical power in the first cycle. Cleaning of gases from dust and dewatering;
- 3) Generation of electric power in the second cycle from dried gases in a gas turbine.
- 4) Generation of electric power in the third cycle in a waste heat recovery boiler & steam turbine, using medium temperature tail gases of a gas turbine.

Chemical composition of molten slag is also adjusted by adding flux and it is used at a later stage for production of saleable cast-slag products.

The dust captured by the gas treatment system is injected into the molten slag.

Thus environmentally clean and waste-free processing of high-ash thermal coal is achieved. When incinerating high-ash coal, partial reduction is possible of iron from oxides contained in the ash.

The additional saleable product thus produced is used in production of steel at a later stage.

MAGMA can be used for processing of waste from concentration (beneficiation) of thermal coal.

5. HIGH-TEMPERATURE RECYCLING OF MUNICIPAL WASTE

The multipurpose smelting unit MAGMA provides autogenous technology of high-temperature recycling of unsorted municipal waste on a layer of molten over-heated slag that forms from mineral components of waste and fluxes specifically added in the process of recycling.

Temperature of the working space of the smelting chamber over the layer of molten slag is 1800-1900°C and temperature of slag is 1400-1650°C.

Under such conditions, the selected speed of waste feeding, the weight of molten slag and the dimensions of the smelting chamber produce a «thermal shock», under which the fed waste is immediately heated up to high temperatures that rule out the possibility of formation of dioxins.

In the MAGMA unit, gases stay at 1,850⁰C for 3 seconds. Under such conditions, in less than a second, almost 100% destruction is ensured of dioxins & furans contained in the waste delivered to the plant.

A number of principally new technological solutions are used in processing municipal waste:

- 1) Preliminary drying of waste to moisture content 10-15%;
- 2) recycling of waste in oxygen allows to decrease the volume of the off-gases and reach concentrations $\text{nox} < 80 \text{ mg/m}^3$, $\text{CO} < 7 \text{ mg/m}^3$.

MAGMA is equipped with highly efficient cooling systems of the unit body, afterburning of co and recovery of heat from process gases in heat-recovery power boiler.

Off-gases are treated by a multistage processing route:

- 1) “Quenching” of gases for exclusion of secondary formation of dioxins and furans;
- 2) Cleaning of gases from hazardous substances.

The waste drying and feeding system, as well as the smelting unit, is hermetically sealed, which creates a small under-pressure in the working space of the smelting chamber. This rules out the possibility of non-organised emissions of process gases from MAGMA to the environment.

Waste is recycled in oxygen fed to the working space of the smelting chamber by water-cooled combined burner-lances.

The metal component of waste, when molten and accumulated at the bottom zone of the smelting chamber, as well as excessive amount of slag, is released from the unit non-continuously for subsequent processing into finished products.

In the process of high-temperature recycling of unsorted municipal waste, chemical composition of molten slag is adjusted by adding fluxes for the purpose of further production of cast-slag saleable products not containing toxic compounds.

The dust captured in gas treatment facilities is injected back to molten slag where it is assimilated by slag (Fig. 6 below).

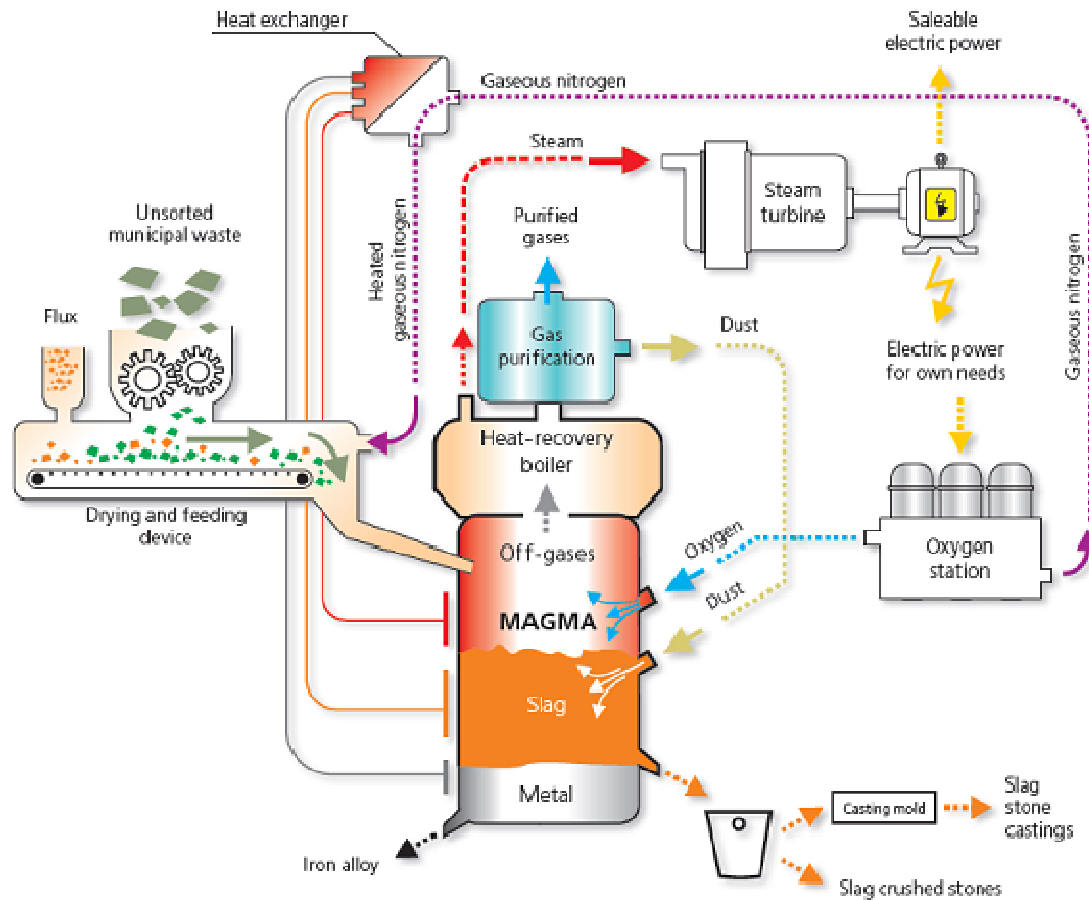


Fig.6. Waste-free processing of municipal waste

Comparative performance of waste incineration plants -

Table 5

Parameter	MAGMA plant (Russia)	MVA Weisweiler GmbH (Germany)
Maximum production capacity for wet unsorted municipal waste, thousand metric tons per year (000 tpy)	300 (1 module 300,000 tpy)	360 (3 processing lines 120,000 tpy)
Waste recycling method	incineration on surface of molten slag in oxygen	incineration on burning grate of power boiler in air
Waste from recycling process	no waste	toxic ash, toxic dust of gas treatment

Heat recovery	heat-recovery power boiler	heat-recovery power boiler
Temperature of molten slag, °C	1400-1650	—
Temperature of gas phase, °C	1800-1900	1100
Construction period, years	2	4

MAGMA can be used for remediation of existing municipal landfills.

Production figures of high-temperature recycling of municipal waste in the MAGMA unit

Table 6

Output products	Unit per tonne of wet waste	Amount
Electric power	MWh/t	0.45-0.55
Iron alloy	kg/t	5-30
Construction materials	kg/t	250-300

Production figures are given per ton of municipal waste with initial moisture content 30% and can change depending on morphological composition of municipal waste.

Recycling of unsorted municipal waste by MAGMA gives the following benefits –

- 1) Environmentally clean process in accordance with European Union requirements;
- 2) Profitable production;
- 3) waste-free technology.

6. APPLICATION IN NON-FERROUS METALLURGY

The multipurpose smelting unit MAGMA can be efficiently used in non-ferrous metallurgy instead of conventional units: Shaft furnace, Vanyukov furnace, Ausmelt unit, unit for fuming in production of ni, cu, pb, sn, etc.

Thanks to design peculiarities and high cumulative thermal efficiency, MAGMA provides better technical and economic performance.

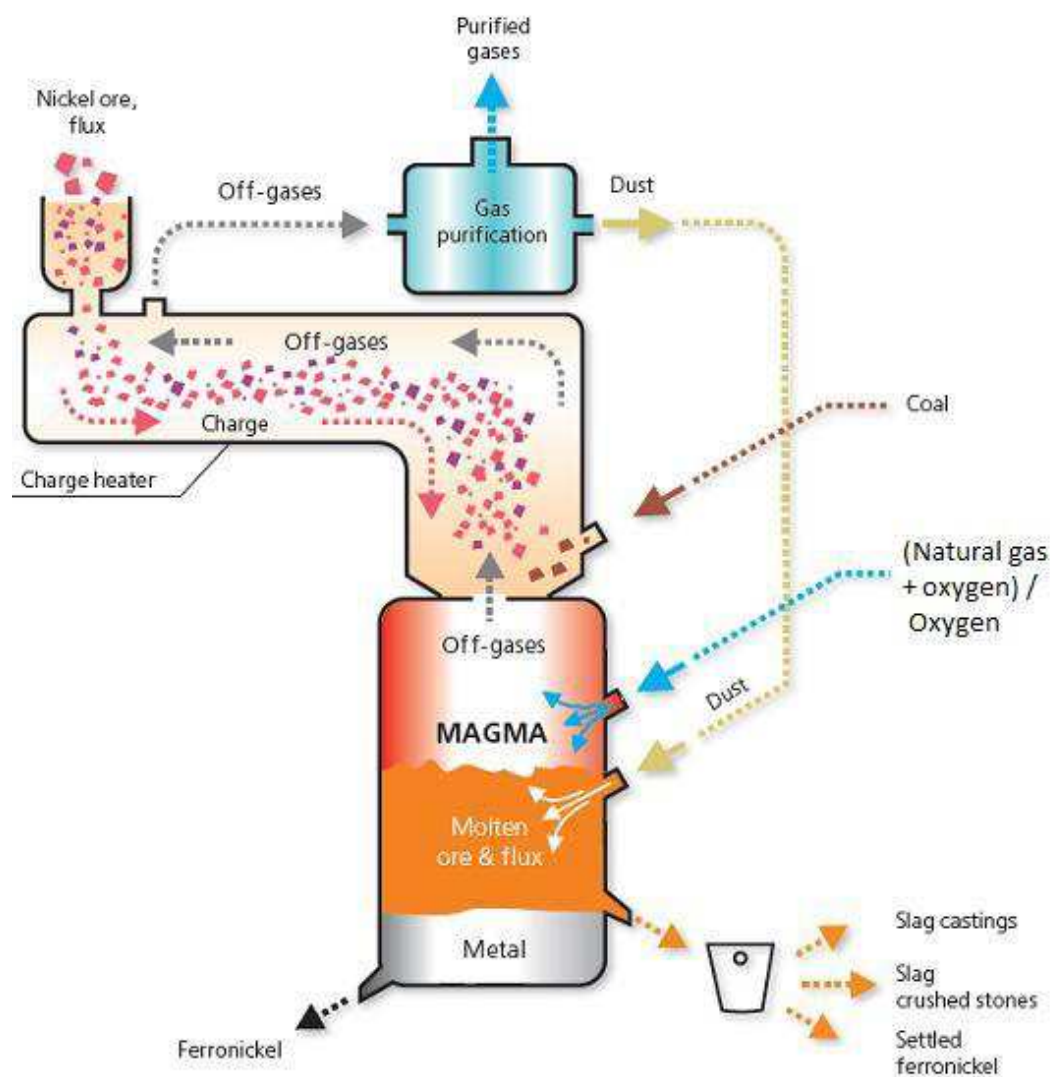


Fig.7. Flow diagram of production of ferro-nickel from oxidized nickel ore

Continuous smelting of ferro-nickel with the use of MAGMA envisages preliminary heating of nickel ore and flux by process gases from the smelting chamber of the unit.

Fed materials are smelted in a liquid bath of ore-flux molten mass. For liquid-phase reduction of nickel, cobalt and some part of iron, carbon reducer is used that is fed to the surface of the molten mass.

The smelting chamber of MAGMA is heated by fuel-oxygen burners / oxygen burners located on the perimeter of the body of the smelting chamber.

The dust captured by the gas treatment system is injected in the flow of heated nitrogen into the ore-flux molten mass, where nickel and cobalt are additionally reduced from the dust.

The produced ferro-nickel is also released from the smelting chamber non-continuously.

The depleted reduced slag not containing oxides of nickel and cobalt is continuously released from the smelting unit.

Further, after settlement and sedimentation of ferro-nickel prills, the slag is used for production of cast-slag products or slag crushed stones.

Production capacity of MAGMA for smelted charge material is 300,000 tpy.

7. PROCESSING OF RED MUD FROM ALUMINA PRODUCTION

In the Bayer production of alumina, red bauxite sludge is produced as a by-product, which is a fine substance of the following composition, %

Fe ₂ O ₃	CaO	SiO ₂	Al ₂ O ₃	MgO	TiO ₂	S	P ₂ O ₅	Na ₂ O
40-55	8-11	5-15	14-16	0.5-1.4	2-5	up to 2	0.2-0.5	up to 2

Moisture content in such product is 40-60%.

For absence of efficient processing technologies, the main mass of red mud is not used and is stockpiled in special sludge storages that affect the environment badly. More than 100 million tons of red mud has been accumulated in Russia to date.

The smelting unit MAGMA is applicable for pyrometallurgical processing of red mud by the method of liquid-phase reduction of iron oxides by carbon in one-stage process (Fig. 8), or by two-stage process in combination with electrical arc furnace.

The heat recovered from the body of the unit by the liquid-metal coolant is used for dewatering (drying) of initial red mud.

Partially dried mud fed to the unit is smelted in a liquid slag bath. Iron oxides contained in red mud are reduced by carbon (coal) fed to the surface of the molten mass. Reduced iron in the form of cast iron settles down to the bottom of the unit. Composition of the re-smelted and reduced slag is adjusted by adding fluxes according to the type of its further use.

Cast iron, raw material for additional recovery of alumina or clinker for production of alumina cement are the products produced in the one-stage route of red mud processing.

In the two-stage process, ferro-silicon can be produced in addition to the above-mentioned products.

Processing of red mud by MAGMA is a completely waste-free technology because the dust captured in the gas treatment system is recuperated by injectors to the smelting chamber of the unit to the molten slag.

Production capacity of the standard model of MAGMA for processing red mud dried to moisture content 15% is 200,000-250,000 tpy.

Up to 0.35 tons of cast iron and up to 0.5 tons of alumina clinker can be produced out of 1 ton of processed red mud.

Specific consumption of energy carriers for processing of 1 ton of red mud:

- Thermal coal up to 200 kg;
- Natural gas up to 50 Nm³ or coal up to 100 kg ;
- Technical oxygen up to 100 Nm³.

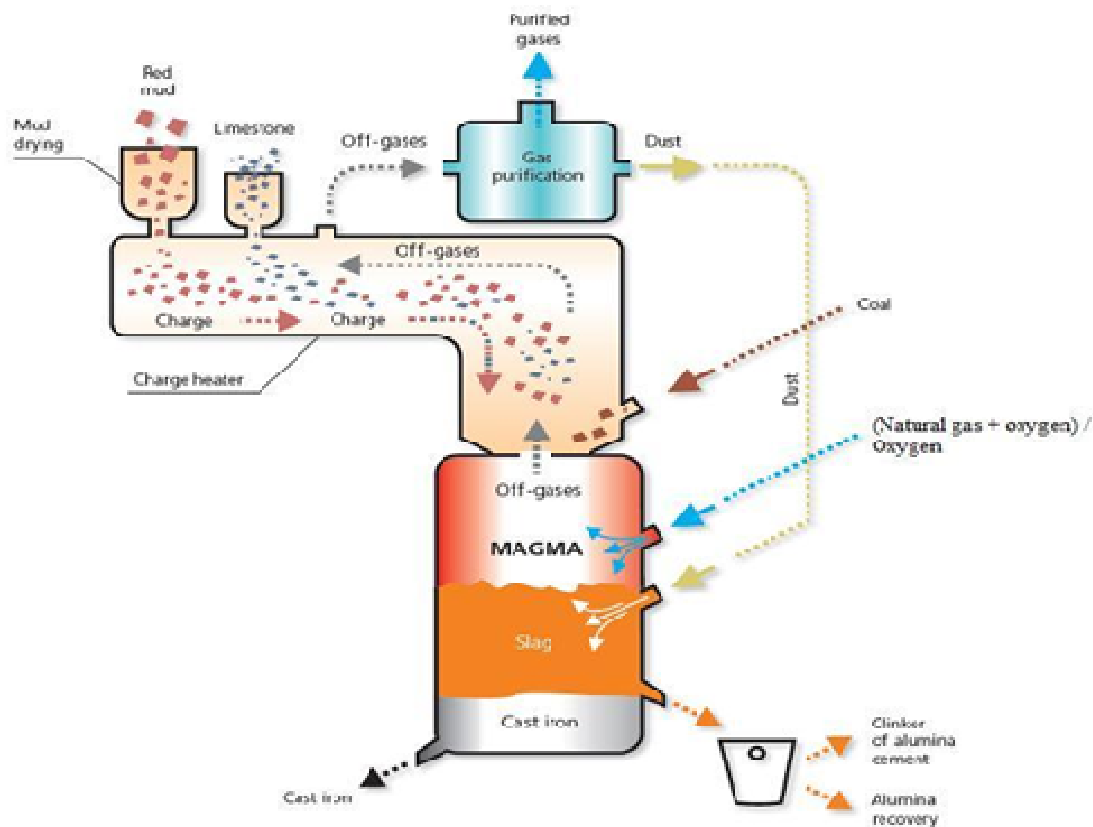


Fig.8. Flow diagram of one-stage processing of red mud

8. PROCESSING OF TITANO-MAGNETITE ORES

The Urals region (Russia) experiences an acute deficit of iron ore for blast furnaces of metallurgical plants. Iron ore has to be brought in from remote regions (Karelia, central Russia, East Siberia, etc.). At the same time, chelyabinsk province (Urals, Russia) has large deposits of titano-magnetite ore with high contents of TiO_2 and Vn.

Complex processing of such ores by blast furnaces is practically impossible because of formation of high-melting-point slag with a high TiO_2 content.

The task of efficient and complex processing of titano-magnetite ores is solved by using highly efficient cooling system of the smelting unit MAGMA that allows to use high temperatures in the working space of the smelting chamber (Fig.9 below).

The result of primary separation of titano-magnetite ores is vanadium cast iron and titanian slag, from which the following products can be produced at later stages of complex processing: vanadium slag (raw material for production of vanadium alloys), steel, ferrotitanium, highly titanian slag (raw material for a TiO_2 -based colouring pigment, titanium sponge, etc.).

Processing of titano-magnetite ore by the proposed technology is completely waste-free.

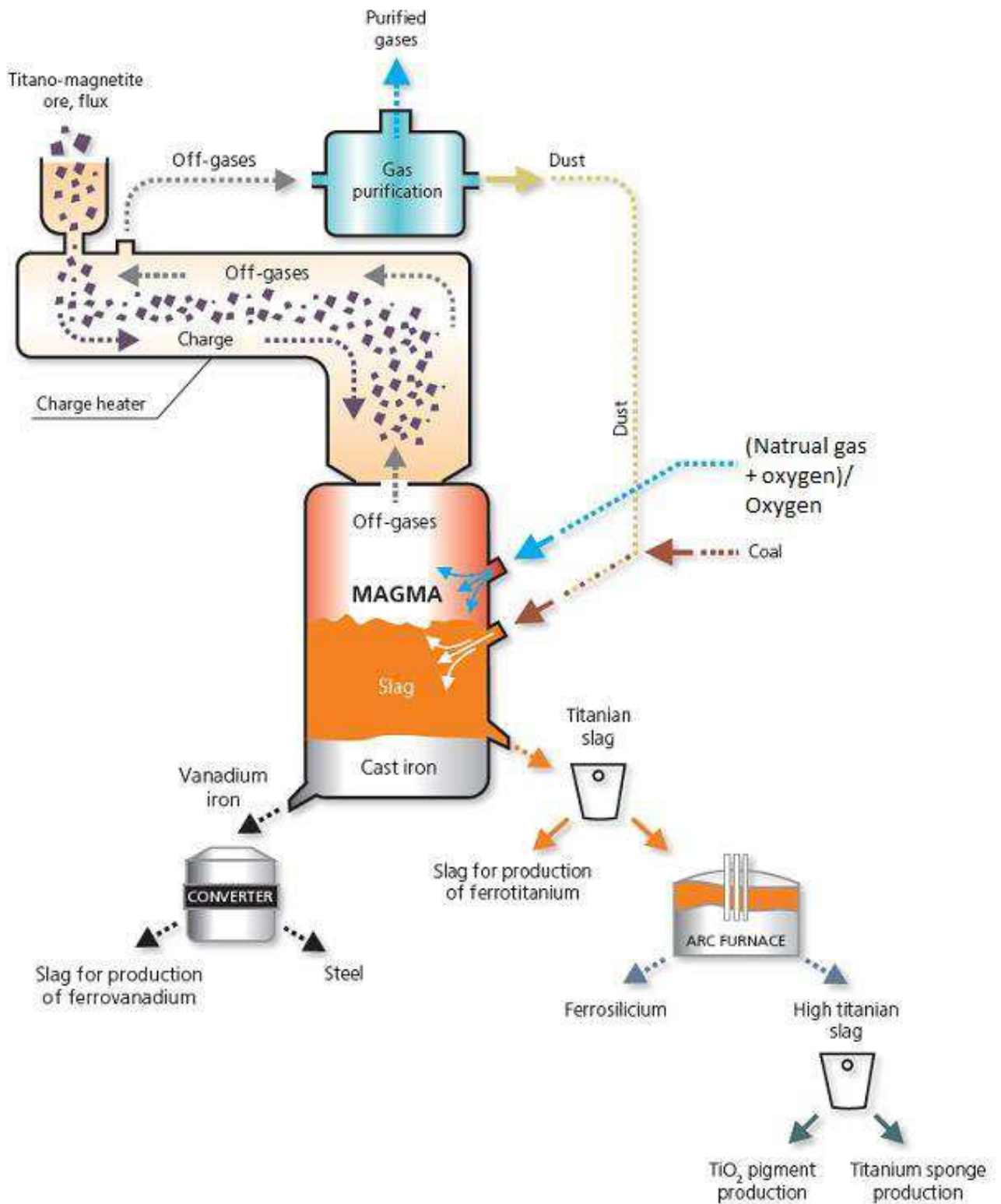


Fig.9. Flow diagram of processing of titano-magnetite ores

9. PROCESSING OF SLAGS OF NON-FERROUS METALLURGY

Leading scientific centres of Russia conducted researches that showed efficiency of use of liquid slags for production of cast slag products: parts of tunnel lining, weighting material for pipe-lines, products for chemical, metallurgical and construction industries.

Best quality is achieved in slag castings made out of low basicity (acidic slags) with high content of iron oxides (Table 7).

Such chemical compositions are characteristic of the slags from non-ferrous metallurgical plants that produce nickel and copper and for the slags of thermal power stations that work on thermal brown coal (Table 8).

Properties of cast slag products -

Table 7

Parameter	Unit	Value
Volume weight	kg/m ³	2900 - 3000
ultimate compression strength	Mpa	200 - 500
ultimate bending strength	Mpa	15 - 50
Impact strength	kJ/m ²	1.06 - 1.25
Elasticity modulus	Mpa	(0.43-1.01) · 10 ⁵
Poisson number	-	0.25
Thermal resistance	0C	200 - 600
Thermal conductivity at 20 0C	W/ (m · 0C)	1.07 - 1.52
specific heat capacity at 20 0C	kJ/(kg · 0C)	0.67- 0.85
Temperature coefficient of linear expansion within interval 20-600 0C	0	-5
Abrasion coefficient	kg/m ²	0.1 - 0.2
Water absorption	%	0.03 - 0.1
Freeze resistance	cycles	over 300

Acid resistance in 20% hydrochloric acid	%	up to 97.8
Acid resistance in concentrated sulphuric acid	%	up to 99.7
Alkali resistance in 35% alkali	%	up to 98.6
Diffusion coefficient of sr and cs ions: - at t=25 O _c - at t=600 O _c	cm ² /s	~10 ⁻¹⁸ ~10 ⁻¹⁴

Average compositions of slags from non-ferrous metallurgy and thermal power plants-

Table 8

Type of slag	Content, %											Melting temperature, °C
	Sio2	Feo	CaO	Al2o3	Mgo	Cu	Co	Ni	Zn	Pb	S	
Copper smelter slags	32-45	25-45	12	3.2- 9.7	2-11	0.3- 0.9	—	—	0.5-1	0.22- 0.8	0.4- 1.2	1100-1150
Nickel shaft furnace slags	39-45	16-24	12-21	4.5- 7.5	9-17	—	0.010 - 0.024	0.1- 0.17	—	—	0.43- 0.5	1100-1200
Nickel basic oxygen furnace	25-35	40-60	2-3	3-10	2-4	0.1- 0.2	0.01- 0.02	0.3- 0.7	—	—	2-3	1100-1200
Ash of thermal power plants working on brown coal	54-55	2.5- 10	1.6- 2.5	24.7- 25.2	2.5- 2.6	—	—	—	—	—	0.1- 0.3	1400
Average composition of slag castings	44-49	7-20	6-16	9-20	5-13	—	—	—	—	—	—	1300-1350

These waste, which have relatively low melting temperature, are annually produced in large amounts and are accumulated in dumps.

MAGMA allows to economically smelt slags of non-ferrous metallurgy and thermal power plants with adjustment of chemical composition and temperature of molten mass in the process of re-smelting.

Furthermore, the metal component present in slags of non-ferrous metallurgy is extracted from it and is used as additional saleable product.

The gas treatment system of the unit can capture zinc and lead contained in the slags being re-smelted.

As a result, production costs of slag castings can be significantly reduced through sale of additionally produced metal.

MAGMA has better technical performance than slag-smelting units conventionally operated in industry (Table 9).

MAGMA has still more effective performance in case of using hot liquid slags fed into the smelting chamber of the unit directly from metallurgical furnaces.

In this case the unit will be also used for leaning of slags of non-ferrous metallurgy.

Comparison of performance of slag-smelting units -

Table 9

Type of slag-smelting unit	Production capacity for smelted charge	Fuel consumption per 1 ton of charge		Consumption of blowing per 1 ton of charge	Temperature of slag
		Absolute units	MJ		
Smelting unit MAGMA	up to 50	natural	2600-	oxygen	1400-1650

		gas 70-82 m3	3000	157-182	
Arc stationary furnace with water cooling of the unit body (limestone-alumina slag)	2.5 - 3	electric power 1500 kWh	5400	—	1650-1700
Regenerative tank furnace for production of mineral molten mass	3	natural gas 200 m3	7340	air 3700	1380

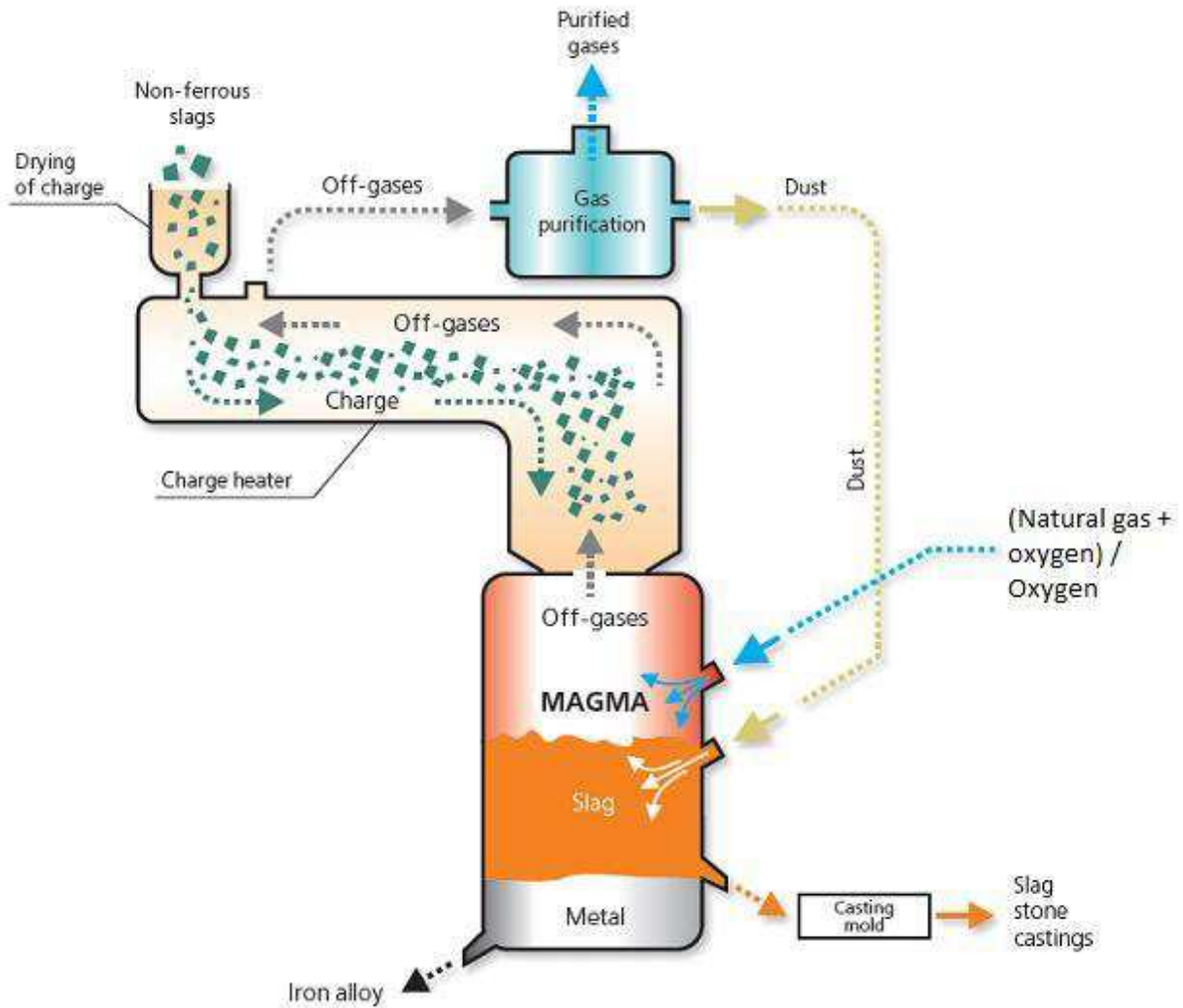


Fig.10. Flow diagram of processing of non-ferrous metallurgy slags

10. PROCESSING OF METAL RADIOACTIVE WASTE

The amount of metal radioactive waste of low and average contamination accumulated in Russia exceeds 1 million tonnes.

Due to the forthcoming closure and dismantling of out-dated equipment of atomic power stations and nuclear fuel cycle enterprises and disposal of ships with nuclear power units, accumulation of significant amount of metal radioactive waste is also expected in the future.

Similar situation builds up in a number of industrially developed countries.

Insignificant amount of metal radioactive waste in Russia and other countries is decontaminated by pyrometallurgical method in induction and electrical arc furnaces of low capacity. These smelting aggregates operate non-continuously and due to their design peculiarities do not provide a sufficient purification of metal. Therefore metal radioactive waste are preliminary purified mechanically, hydraulically or otherwise, which is a reason for high cost and small amounts of processing of metal radioactive waste.

The smelting unit MAGMA allows to carry on pyrometallurgical decontamination of metal radioactive waste continuously at considerably lower costs of processing.

The process of metal radioactive waste fed into the unit is carried on continuously. Before feeding to the unit, metal radioactive waste are heated in a shaft heater to temperature 700-800°C. This allows to decrease energy consumption and increase production capacity of the unit.

Metal radioactive waste are smelted in a liquid metal bath under oxidizing conditions, which speeds up smelting, improves decontamination of metal radioactive waste and reduces dust formation.

For assimilation of radionuclides oxidised and removed from the molten metal, a layer of oxidised slag of low basicity with temperature 1600-1650°C is formed and permanently maintained over the metal. Amount of slag is not high (2-3% of the metal weight).

Decontaminated metal is non-continuously or continuously released to the ladle, ladle out to form ingots that are further used as charge in steel production.

Slag contaminated with radionuclides is non-continuously released from the smelting unit into containers for disposal of radioactive waste.

The generated oxidised slag of low basicity does not fall to pieces with time and is an ideal substance for absorption and storage of radionuclides.

The dust captured by the gas treatment system that contains radionuclides is transported by injectors to the molten slag assimilating with the slag.

Production capacity of MAGMA for processed and decontaminated metal radioactive nuclide achieves 250,000 tpy.

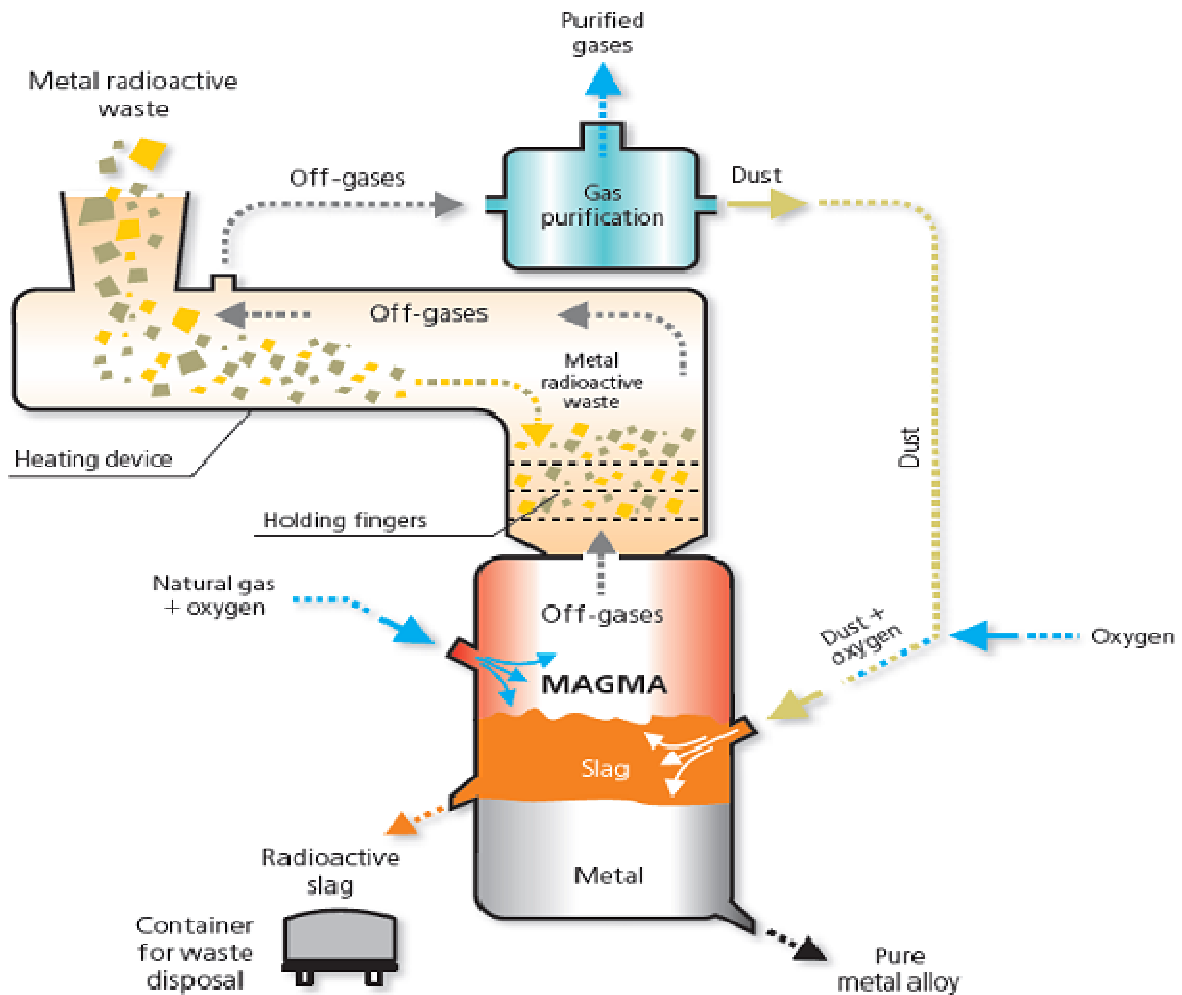


Fig.11. Flow diagram of decontamination process of metal radioactive waste

Comparative performance of radioactive metal waste disposal -

Table 10

Parameter	MAGMA project	Existing companies
Decontamination	Pyrometallurgical	Mechanical, chemical, pyrometallurgical
Contamination level of the metal radioactive waste being disposed	low, average	low, rare - average

Smelting unit type	hermetically sealed, fuel-oxygen, skull, body cooling by liquid-metal coolant	electrical induction and arc furnaces with refractory lining
Type of operation	continuous	non-continuous
Volume in terms of metal	up to 100 tons	mainly up to 5 tons
Slag ratio	0.02-0.03	0.04-0.05
Production capacity, tpy	50,000-250,000	3000-7000
Consumption for smelting of 1 tonne of metal radioactive waste:		
natural gas, m3	100-120	—
oxygen, m3	200-240	—
electric power, kWh	—	600-800
Secondary radioactive waste produced, relation to the weight of metal radioactive waste	slag 2-3%	slag 4-5%, refractories 2-5%, radioactive dust 1-2%
Limitation in use of decontaminated metal	98-99% without limitations	10-65% without limitations
Costs of disposal of 1 ton of metal radioactive waste	1000 Euro	2000-8000 Euro

CONCLUSION -

Application of MAGMA is based on environmentally clean waste-free technologies.

Capital costs for implementation of technologies with using MAGMA are lower than the capital costs of existing plants that produce similar products.

Period of construction - 2 years.

Payback period for capital costs does not exceed 2-5 years depending on the purpose of application of MAGMA and availability of relevant infrastructure at the construction site.

COMPANY PROFILE

Industrial company "Technologiya Metallov" (Technology of Metals), Chelyabinsk, Russia, is an engineering company that develops and implements innovative technologies of environmentally clean and waste-free processing and disposal of industrial and municipal waste, efficient processing of ore and energy carriers, creation of principally new designs of smelting units for implementation of created technologies.

The company brings its know-hows to the Russian and international markets.

Industrial company "Technologiya Metallov" (Technology of Metals) co-operates with leading scientific research and design bureaus of Russia for creation of innovative technologies and modern designs of smelting units.

The MAGMA project successfully passed expert review at the Urals Institute of Metals, the validation authority at Ekaterinburg, Russia and at the National University of Science & Technology (MISIS), Russia.

The MAGMA project, in its application for processing of unsorted solid municipal waste, received a positive conclusion of the state Environmental reviewing department of the office of the Federal service for overseeing in Environmental Management (rosprirodnadzor) in Chelyabinsk province.

Assembly design of MAGMA and created technologies of application of MAGMA are protected by Russian and international patents.

MAIN PARTNERS FOR MAGMA PROJECT –

- Technologiya metallovs LLC – owner and leader of project
- A.I. Leipunsky Institute of Physics and Power Engineering - justification of innovative cooling method
- South Ural State University – theoretical and practical justification of technology
- Akont R&D company – engineering of other equipments



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