MINI-PELLETIZING: CRISIS AS AN OPPORTUNITY FOR INNOVATION[1]

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Abstract

Circular Mini-Pelletizing Plant (CMPP), under development by CMO & CMPP Technologies Inc., from Canada, and Brazilian Minitec, will bring to the market innovation, competitiveness and solution for some specific niches of industrial fields. The circular grate machine has many advantages compared to straight grate. The capacity rate in the range of 0.5 to 1.5 Mtpy (*Million tons per year)* of fired pellets will permit the recovery of wasted iron ore fines stored during many years by small mines and improve their overall profitability. Also the much lower gross capital requirement makes the CMPP attractive in today's tight capital markets. This plant size could improve the operation of existing integrated steel mills by satisfying the incremental demand of pellets for substitution of scarce lump in the burden of blast furnaces (BF). It would also allow the recycling of some BF and BOF generated dust & sludge with new pellet feed, when locating the CMPP next to the steel mill. This would contribute to an improved environmental management and a better energy balance. Other advantageous applications of CMPP have been identified already for Coal and Gas based DR plants as well as for incremental pellet capacity increases at existing pellet plants. Additionally in Brazil, there is also the possibility of recovering the ultra-fines produced in Manganese ore mining, actually wasted. The status of CMPP project is shown, emphasizing the main points which led to the development of this new mini pellet plant for various niche markets.

Key words: Pelletizing; Iron ore; Innovation; Iron making.

MINIPELOTIZAÇÃO: CRISE COMO OPORTUNIDADE PARA INOVAÇÃO

Resumo

A Minimáquina Circular de Pelotização (CMPP), ora em desenvolvimento pela CMO & CMPP Technologies Inc., do Canadá, e pela empresa Brasileira Minitec, trará ao mercado inovação, competitividade e solução para alguns nichos da indústria. A grelha no formato circular apresenta muitas vantagens, comparativamente à retilínea. A capacidade de produção na faixa de 0,5 a 1,5 milhão de toneladas por ano de pelotas permitirá a recuperação de finos de minério de ferro, acumulado durante anos em bacias de rejeito, nas pequenas minas, melhorando a sua lucratividade. Considerando-se a crise de crédito atual, o baixo nível de investimento numa planta CMPP a torna muito atraente. Essa escala de produção possibilita melhorar a operação de usinas siderúrgicas integradas, através do suprimento de pelotas para o alto forno, em substituição ao minério granulado, cada vez mais escasso. Quando instalada na área da usina siderúrgica, a planta CMPP possibilitaria, também, reciclar parcelas de pós e lamas, gerados nas operações de alto forno e LD, em mistura com pellet feed natural. Haveria uma contribuição para a gestão de meio ambiente e para a melhoria do balanço de energia. Outra vantajosa aplicação da planta CMPP tem sido identificada para as unidades de redução direta a carvão e a gás, bem como para aumento de capacidade marginal em plantas de pelotização existentes. Além disso, no caso brasileiro, haveria a possibilidade de recuperação de ultrafinos de minério de manganês, atualmente rejeitados. É mostrado o estágio do projeto CMPP e são destacados os principais pontos que nortearam o desenvolvimento dessa miniplanta de pelotização, visando o atendimento de vários nichos de mercado.

Palavras-chave: Pelotização; Minério de ferro; Inovação; Produção de ferro.

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1 INTRODUCTION

Pelletizing Technology for agglomeration of iron ores has been producing pellets for blast furnaces and direct reduction use, since the early 1950's. It started taking advantage of low grade taconite in United States, using the now obsolete shaft furnaces. Over the years, two other processes came on stream bringing greater capacity, better performance and efficiency in this process. One of them, Traveling Grate, was proven to be usable for any kind of iron ore, hematite, magnetite and hydrated ones, sharing today more than 60% of total capacity ever built in the world [(1)]. The other, Grate Kiln or Rotary Kiln, was more indicated to treat magnetite ores, showing some limitations for hematite and or hydrated ores.

For years, lump ore was the main direct charge material in the burden of blast furnaces. With the depletion and or degradation of the reserves of hard and rich hematite ores (Figure1), the agglomeration technologies played an important role in making available sinter and pellets as feedstock for blast furnaces (BF). In this case the pellet became a direct charge feed, same as the lump ore, and with the arrival of direct reduction became the main feedstock to DR reactors.

Particularly, in Brazil, the reserves of iron ores in the state of Minas Gerais contain great amounts of itabirites. Because of this, the crude ore needs more intensive treatment, with increased generation of ultra-fines like pellet feed. When analyzing the greenfield projects which are being developed at this time, one can see that many of them will generate 100% of pellet feed. Pelletizing is the available technology to take care of such fines. Other facts influencing the expansion of pelletizing are related to favorable environmental issues and better performance of pellets in iron making reactors.

CMO & CMPP Technologies Inc joined with MINITEC Minitecnologias Ltda, to develop the CMPP (Circular Mini-Pelletizing Plant) with capacity in the range of 0.5 to 1.5 Mtpy of pellets. This process will bring to the market innovation, competitiveness and solution for some specific niches of industrial fields. The circular grate machine has many advantages compared to the straight grate. On the other hand, the smaller rate of capacity will permit to recover wasted pellet feed stored during many years by small mines and improve their overall profitability. Also the much lower gross capital investment makes the CMPP attractive in today's tight capital market.

This plant size could help to replace scarce lump in the burden of large blast furnaces (BF), in an amount up to 20%. In such case, it would be possible to recycle some of the dust/sludge generated by BF and BOF, when installing CMPP unit just at the steel mill site, thereby also improving environmental management and energy balance. In the Brazilian case, there is also the possibility of recovering the ultra-fines produced in Manganese ore mining, actually wasted.

With CMPP in its portfolio, MINITEC will also be able to cover the full range of mini steel mills' requirements, in regard to agglomeration and steelmaking. It has a proven experience with the design and operation of circular mini sintering machines, which will be helpful for final development of CMPP. In the near future, all mini-processes for BF and DR burden preparation will be available to the market through MINITEC.

The status of CMPP project is shown, with main points on the economics and drivers which led to the development of this new technology for many market niches.

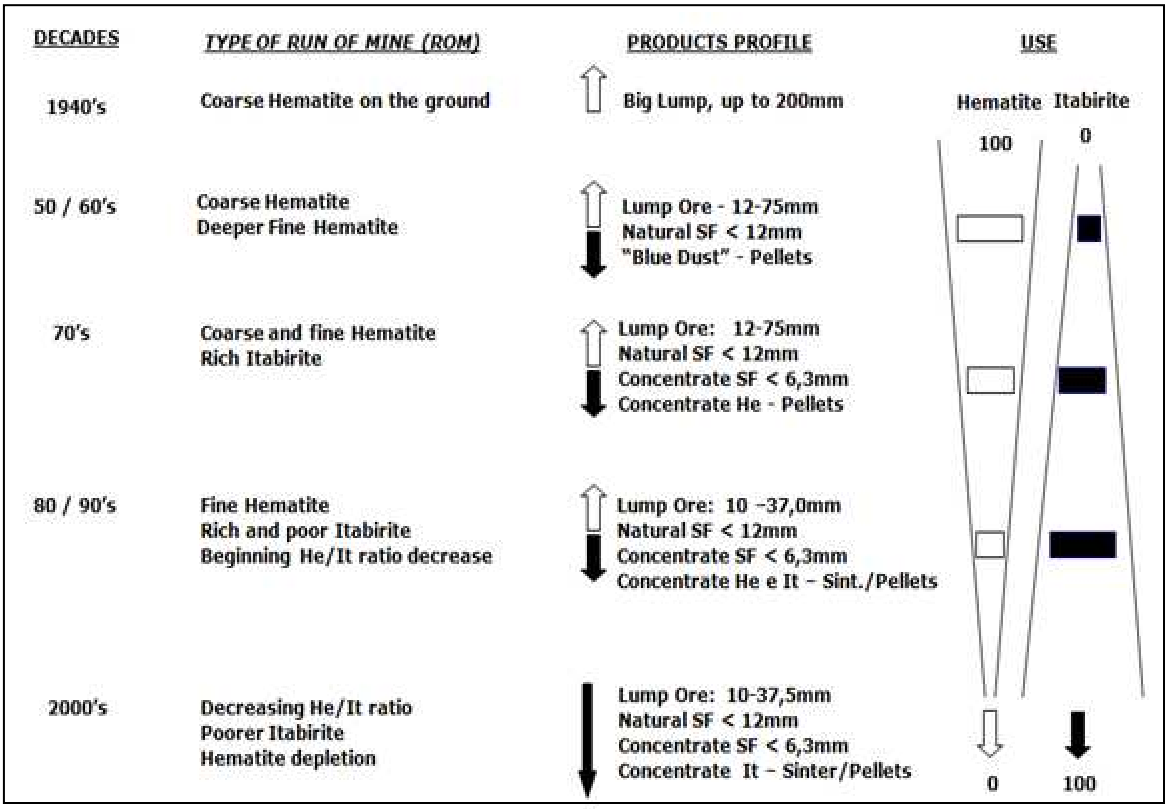

Figure 1 – Quality degradation of iron ore reserves in Minas Gerais – Brazil. [1]

2 INNOVATION IN PELLETIZING

The worldwide continuous decrease in lump availability coupled with the lower iron ore grade has forced the industry to beneficiate the ore and produce more pellet feed. At the same time the 2 leading pellet technologies, straight grate (SG) and grate kiln (GK) have continually increased the annual production capacity of the equipment to take advantage of the scale effect on capital and operating cost to the point that 7.5 Mtpy for an SG unit and over 5 Mtpy for a GK are normal and it is known that larger units are in the pipeline today.
This has left a void for a low capacity unit in the range of 0.5 to 1.5 Mtpy and created a niche market in various parts of the world for a large number of low capacity units. Such a unit will be of interest to:

- Mining companies that have, over the years, accumulated vast quantities of iron ore fines as by product from their screening and/or washing operation to produce lump. These fines will require grinding and may also require some up-grading for use as pellet feed.
- Small capacity concentration plant could add a low capacity pellet plant and thus obtain added value for their concentrate through pellet production.
- Direct Reduction plants that have also accumulated fines and other process recoverable fines. These can be recycled with fresh pellet feed to produce DR quality pellets.
- Indian market, where there are many coal based DR plants supporting mini steel mills that have accumulated screened out fines and could convert those fines to pellets, thus improving the feedstock due to poor quality lump ore.
- Incremental capacity increase at existing pellet plants.

- Blast furnace operations that have accumulated iron ore fines from screening of lump and/or from screening out of pellet fines prior to addition to the furnace burden as well as fines from other process units. This includes the possibility to recover alongside some dust/sludge generated in BF and BOF operations.
- Large port operations where recovery of iron ore fines resulting from screening operations of lump can be economically converted to pellets.
- Shaft furnace operators who may want to replace the obsolete shaft furnaces with modern and more efficient induration units. This applies specially to the Chinese market.
- Small mines in developing countries, where a lower capital cost for small pellet plants may permit their entry to the pellet market.

Considering all of the above CMO & CMPP Technologies Inc. has revisited the concept of a low capacity circular pellet plant originally proposed by Arthur G. McKee, and built in Northern Mexico, in late 1960s and came to the conclusion that an efficient circular grate was technically and economically feasible. For this to be achieved the pallets must be allowed to tilt to dump the fired pellets, thereby achieving the necessary self cleaning of the grate and avoiding the plugging between the grate bars. Numerous other mechanical and instrumentation improvements were also added to the design for the new Circular Mini Pellet Plant - CMPP (Figure 2).

The feed preparation for the CMPP, filtering (if required), additives mixing and balling are not included in this description. The pellet feed can be filter cake or slurry from a concentration plant.

2.1 Induration Process Description

The concept of CMPP [2] indurating machine is basically a straight grate configured in a circular design to provide a more efficient use of the pallets. It includes many of the features proven on a straight grate machine.

The machine has a variable speed drive and includes hearth and side layer chutes, with control gates, wide belt with roller screen to remove fines from the green balls, pallet cars with removable end casting with wheels and side wall blocks, conventional grate bars, pallet changing mechanism, pallet sag measuring device, windboxes with double dump valves, a pallet car dumping and discharge hopper with dust collection system, a pallet changing area and a drive system.

The induration cycle is a conventional straight grate one, with up-draft, down draft, pre-heat, firing, after-firing, primary cooling and secondary cooling zones with efficient re-use of hot gas. The cooled pellets leave the induration machine at 100℃ or less.

The screened green pellets are deposited as a uniform layer on a 100 mm bed of hearth layer on the circular grate. Two side layer chutes provide protection for the sidewall blocks and improve air distribution.

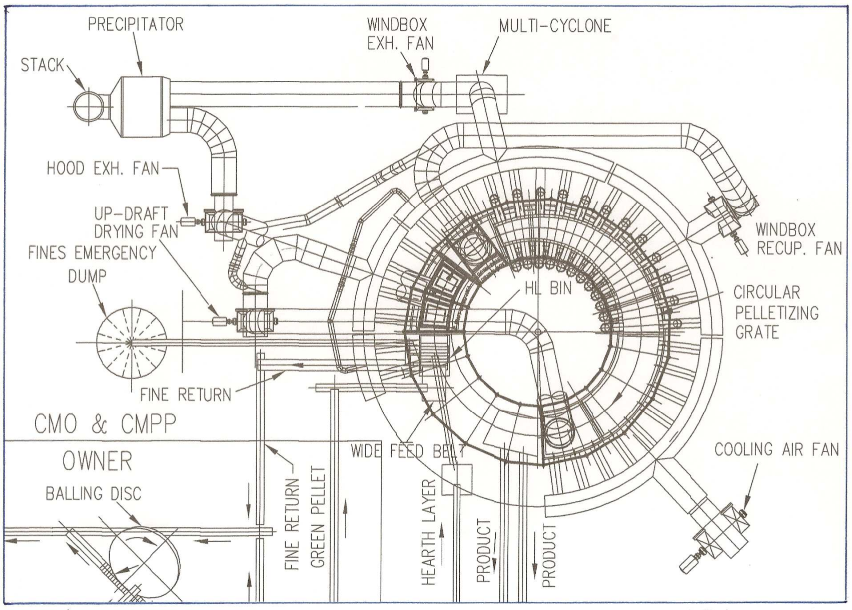

Figure 2 – Layout of Circular Mini-Pelletizing Plant – CMPP.[2]

The bed height is expected to have about 35 cm of green balls over a 10 cm of hearth layer for a total bed height of 45 cm. Three ultrasound probes continuously measure the bed height and adjust the machine speed to maintain a constant bed level and compensate the fluctuation in production from the balling section production.
For each of the various zones of the machine the temperature profile is computer controlled by the control room operator by adjustment of the burners in a zone and/or controlling bleed in or bleeds out if necessary.
The hood above the grate and the windboxes below the grate are lined with refractory as are the direct recuperation header and various hot gas ducts. The various zones of the CMPP hood are separated by brick partition supported by water cooled cross lintels. Below the grate, the various sections of windboxes are separated by floating dead plates. The two false windboxes at the feed end of the machine also have dead plates to minimize the inflow of ambient air.
The fired pellets are tilted off the pallet cars and dumped into a discharge hopper for further segregation into hearth layer and finished product.
Multiclone and wet scrubbers are included to collect the dust and the waste gas from the hood exhaust and the windbox exhaust fans can be rejected through electrostatic precipitators if environmental considerations require that this be done.

2.2 CMPP Equipment Features

The circular grate is 12 meter in radius measured from the outer end of the pallet casting thus resulting in a circumference 75.4 meters with a 3.5 meter wide pallet. Considering a 7 meter wide service area around the machine, the footprint of the CMPP will be about 40 meters in diameter.
The above CMPP will produce over 1 Mtpy of pellets with a very conservative grate factor, availability and large safety factor. Test work on the actual feed materials to be processed will confirm the grate area required and will permit optimising the area of the individual process zones.
Heavy duty trapezoidal pallet castings are running on circular tracks. The center castings are symmetrical and can be reversed to correct sagging.

The main drive is composed of inner and outer chains which propel the pallet cars along circular rails.
The area between the second cooling hood and the beginning of the up-draft drying section will be occupied by the machine discharge, the pallet change area, the drives, the hearth and side layer chutes and control gates, the green ball reciprocating conveyor, the wide belt, the roller screen (single or double decks) and associated fines return and fines emergency dump conveyers and finally the machine bridge and bed level control will be adjacent to the end wall of the up-draft drying section of the machine.

2.3 Advantages of the CMPP

Because there is no return strand, a 12 meter machine will have over 74% of the pallets under the hood compared to less than 50% for a SG machine.
The induration building will have a substantially lower profile.
The balling section will also be lower to match the induration section.
The conveyors will be shorter on account of the lower elevation and the proximity of the machine discharge to the hearth layer bin.
All of the above will result in a lower investment cost for a given production capacity CMPP
A further advantage is that the pallet changing time will be substantially reduced as a casting can be ready to be lowered in place as soon as one is removed. This feature will contribute to higher productivity by minimizing the loss of time due to pallet change and improve pellet quality by minimizing the up-set conditions resulting from any stoppage of the machine.
The cost of additives, power and fuel are expected to be in line with larger plant and, due to the compactness of the plant, the operating crew will also be reduced resulting in operating cost more or less in line with larger plants.

3 STATUS OF THE CMPP

CMO & CMPP Technologies Inc (CMO) of Toronto, Canada has retained the services of MINITEC Minitecnologias Ltda, from Divinópolis/MG, Brazil, for the joint development of a basic engineering package with sufficient details to allow the preparation of a cost estimate for the proposed mini-pellet plant. With a reliable cost structure for the CMPP, CMO can then solicit the interest from potential clients for this mini pellet plant with the objective to complete a site specific feasibility study, which after client approval would lead to the detailed engineering of the plant.
Before starting to look for the necessary capital for the launching of the manufacturing phase, efforts have been concentrated on establishing the magnitude of the potential market for the CMPP. This would allow the investor to evaluate the ”Risk to Reward” ratio for this new product line. Market analysis indicate that over the next 10 years about 140 mini pellet plants (CMPP`s) could be built around the world of which 60 would be in China (Table 1).
This high demand for CMPP’s reflects the need to maximize the use of small resources, the recycling of useful iron units at Direct Reduction and BF-BOF facilities, and the realization that for every 3 to 4 Mtpy of integrated steel making capacity, a mini pellet plant could provide 20% of pellets to substitute the shortage of lump. Therefore in periods of worldwide retrenchment of raw materials you would no longer idle the large 700 Million USD pellet plants. Instead the resource industry and the

steel mills could better manage a gradual expansion of pellet capacity with the use of the CMPP.

The trucking and rail transport costs ahead of ocean shipping as well as the cargo unloading and handling at the receiving port, followed by subsequent transport and re-handling costs to the end user appreciably add to the overall raw material costs at the mouth of the BF or the DR reactor. Generally the CMPP will be receiving the feed either as a "dry" filter cake or from an on-site Filter Plant attached to an ore preparation circuit. However to further lower the costs it is suggested that the end users should evaluate the transport of pellet feed from the port to their BF or DR operation via a slurry pipe line and use the mini pellet plant to convert it to pellets. It is not unreasonable to consider the discharging of pellet feed (loaded as a slurry or as a filter cake) from the vessel in slurry form as was done in 30,000 DWT vessels in the late 1960`s by Marcona. This would allow Cape size ships to deliver pellet feed to locations around the world that do not have deep water port facilities. They would use the Marcona-Flo "capsules", which in a ship`s hold repulp the solids into a slurry and pump it via a small support barge to a slurry storage pond on shore. A small dredge recovers from the pond the iron ore fines and pumps the iron ore slurry to the filtering facility attached to the mini pellet plant in order to convert the resulting filter cake to fired pellets. These examples demonstrate how a mini pellet plant becomes a useful tool to further lower the steelmaking costs.

Another phenomenon that will help the growth of mini pellet plants is the fact that the size of Investment Capital regulates the entry of entrepreneurs to a specific project. The smaller investments attract more entrepreneurs, and this can be documented by the following examples. In India, due to low capital costs, a large proliferation of small sized coal based rotary kiln DR plants took place in the last three decades. Today India produces 17 Mtpy of DR iron, which is 25% of the total world's DR iron output, requiring about 25 Mtpy of good lump ore or DR quality pellets. Also, India is making use of mini sinter plants and mini blast furnaces as a basis for mini steel plants. Similarly in Brazil there was a large proliferation of charcoal based mini blast furnaces for pig iron production, some of which support today mini steel mills.

CMPP offers the opportunity for various "co-investment" business models, one of which is a BOOT (Build-Own-Operate and Transfer) model, where an owner of low cost pellet feed supply can interest an investor to recover his capital in a short time period and then transfer the CMPP to the mine or the pellet feed source owner.

Table 1 –CMPP's Potential Market [2]

WORLD (excluded China)	*Number of Units*	*CHINA*	*Number of Units*
South America	15	Ocean Ports	30
North America	6	Obsolete Shaft Furnaces	20
Europe	3	Other opportunities	10
Middle East	12		
Africa	6		
India	30		
Korea, Australia	8		
Subtotal without China	80	*Subtotal in China*	60
TOTAL IN WORLD - 140 UNITS			

4 IRON ORE PREPARATION SOLUTIONS FOR MINI-STEEL MILLS

Minitec is an engineering company which counts on solid experience in designing and engineering of equipment for smaller sized iron and steel plants. This activity dates back to the 1980's, when MINITEC (then KTS) was a member of the KORF Group and installed more than 20 mini blast furnaces in Brazil and in India. Besides the well known mini blast furnaces and the innovative EOF steelmaking technology, also the carousel type mini sintering technology was a development of MINITEC, which has won broad recognition. This patented technology is answering to the requirements of small and medium sized ferrous and non-ferrous plants in Brazil and in India. (2)

The primary concern is to meet the specific requirements at each site, without neglecting technical standards applicable nor any safety and environmental requirements. This leads to customized, efficient and cost effective mini-plants.

With this approach as background, MINITEC joined efforts with CMO & CMPP Technologies Inc from Canada, for the development of the Circular Mini-Pelletizing Plant (CMPP), with capacity in the range of 0.5 to 1.5 Mtpy, aiming at the same range of small and medium sized customers.

The mini sintering plant (MSP) and the CMPP together present a good solution for iron ore agglomeration for integrated mini mills.

5 MARKET OVERVIEW

The reserves of iron ore in the world are under degradation in terms of hard hematite and Fe contents. In Brazil, for example, the mines situated in the state of Minas Gerais are exploiting run of mine with increasing proportion of poor itabirites. This fact is impacting mining and ore dressing cost, increasing the production of ultra-fines like pellet feed as well as decreasing the production of lump ores. Pelletizing is the only available technology to treat the great amounts of pellet feed. It will contribute to an improved overall balance of mining operations. Pellet feed can't be used directly in iron making or direct reduction. Also, it has very limited use in sintering process. Many new technologies, with focus on direct use of iron oxide fines for iron making, are being studied, such as Dios, Finmet, Iron Carbide, Circofer, Circored, Tecnored, HiSmelt etc. So far, none of them was proven for commercial use.

The dwindling of lump ore production and reserves is another demonstration of the change in quality of iron ore reserves. Not only in Brazil, but also in Australia and India the production of lump ore will continue to decrease in volume. At the same time, quality degradation is expected in terms of physical and chemical characteristics (undesirable elements like Al_2O_3, TiO_2, P, Na, K etc.). As an example, Table 2 shows how pelletizing will be important for mining and iron industries in Brazil, in face of the huge amounts of pellet feed which will be produced in the near future.

Table 2 – New Iron Ore Mining Projects in Brazil–Pellet Feed Generation [1]

PROJECT	*CAPACITY (Mtpy)*	*STATE*	*% PELLET FEED*
Ferrous Mining	50	MG	100
Anglo Ferrous / Minas- Rio	33	MG	100
Usiminas / Serra Azul	28	MG	50
Namisa	40	MG	40
Bahia Mineração	15	BA	100
TOTAL	*166*	-	77

For years, lump ore was the main direct charge material in the burden of blast furnaces. Today it continues to play an important role in iron making, sharing in general up to 20% of big blast furnace burden. Smaller ones, like charcoal blast furnaces in Brazil, have been using 100% of lump. Pellets will bring solution for lump scarceness, as a real substitute.

Direct reduction cannot use sinter and makes use of almost 100% of pellets in the burden. There is no more high quality lump available for this technology, which demands higher Fe and lower impurities in feed. Any increase in DRI or HBI production means equivalent increase in pellet demand. The world capacity of direct reduction is growing and has reached today the level of 70 Mtpy (equivalent demand of around 100 Mtpy pellets). Middle East, Africa, India and Southeast Asia, based on their big natural gas reserves, are developing aggressive plans to put on stream new projects and new capacity of direct reduction. Additional demand of 20 Mt/year of direct reduction pellets will further drive investments in iron ore mining and pelletizing.

Today sintering is an agglomeration process responsible for the majority of iron units entering the blast furnace. The product, sinter, is the basic burden material in iron making in most developed countries like Japan, Korea, and the European countries, etc., where environmental laws impose hard restrictions to sintering emissions. Due to this fact, no new sintering capacity will be put on stream in these areas. Some steel mills located in Europe, Asia and Brazil have built new blast furnaces without sintering plants. To increase steel production via blast furnace/BOF route, the related steel mills would need higher quantity of pellets. Pellets improve performance of blast furnaces. In mixture with lump and sinter, it's possible to gain productivity and reduce coke/slag rates [1].

China increased enormously steel production, in the last 5 years. There the iron ore demand is growing very fast and mining companies are investing huge amounts of money to comply with market needs. Chinese steel mills have opted to increase their own pelletizing capacity to cover most of their pellet needs. Their plans are to increase in the near future the use of pellets in blast furnaces from 5-10% to 15-20%, in coming years. In order to produce their own pellets they will need to import concentrates to feed the pelletizing plants. In this particular case, Chinese mills still have in operation many obsolete shaft pelletizing furnaces which could be replaced by the CMPP indurating units, thereby improving operation and fired pellet quality.

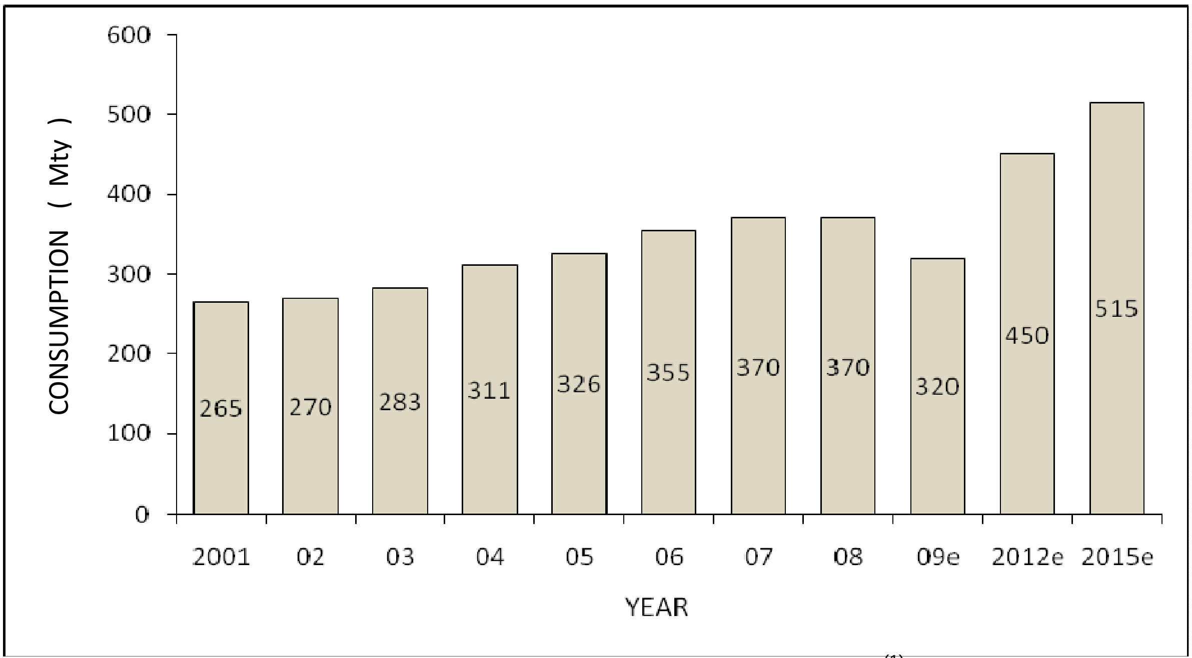

Figure 3 – Estimate of world pellet consumption.[1]

World pellet production has been growing, step by step, since 2001[1]. Figure 3 shows the evolution of pellet consumption in the world as well as the estimate for the near future. Many institutes and consulting companies predict that this trend will continue, at least up to 2015, overcoming the effect of the 2008/2009 financial crisis in the steel market. Total consumption of pellets will increase and surpass 500 Mt in 2015. Part of this demand will be covered by captive production in steel mills (opportunities for CMPP), other part will be supplied regionally by mining companies and the rest will go to the seaborne trade. Today the seaborne trade handles around 100 Mt of pellets annually, worldwide. By 2015, this quantity could reach 150 Mt/year. To comply with these market needs, mining companies are planning investments in new pelletizing capacity in different places around the world. New plants are being planned for starting operation up to 2015. By then, there will be an increase in pelletizing capacity of around 150 Mtpy, part of which could be shared by mini pelletizing plants like CMPP. In 2015, total capacity will also surpass 500 Mtpy of pellets. The comparison between the estimated consumption of pellets in the coming years and the evolution of world pelletizing capacity suggests that the supply-demand figures will stay in a very tight equilibrium.

6 CONCLUSION

The Circular Mini-Pelletizing Plant (CMPP) indurating machine is basically a straight grate configured around a circle. Because of a more efficient use of the grate and no return strand, a substantially lower profile building, and a smaller footprint makes the investment cost for a 1 Mtpy CMPP lower than for the same capacity straight grate . It fills a void for low capacity pellet plants in the range of 0.5 to 1.5 Mtpy niche markets, making it economical to produce pellets at small mines, Gas and Coal based DR plants and at Blast Furnaces requiring direct charge materials. Numerous examples for other small tonnage applications are also given. These include the recycling of low silica iron fines at DR plants for conversion into DR pellets, and at BF-BOF steel mills, the recycling of dust and sludge with imported pellet feed to produce BF pellets, thereby also contributing to better environmental management, energy balance and cost reductions.

The dwindling of lump ore production and reserves as well as the quality degradation of iron ore deposits has forced the industry to beneficiate the ores, thereby producing more pellet feed. The majority of this pellet feed will be turned into fired pellets by the two leading pellet technologies, straight grate and grate kiln large capacity units. However new niche markets for pellets will start to be served by mini-pelletizing plants such as the CMPP, specially if the slurry mode of pellet feed delivery could be embraced for the CMPP´s. This will appreciably lower the transport and re-handling cost of pellets to DR reactors, and in some cases to the Blast Furnaces, thereby contributing to further cost reduction of pellets for iron and steel making.

Between China and the rest of the world there is a projected demand for another 150 to 200 Mtpy of additional pellet capacity over the next 10 years. According to market survey the CMPP could partially fill this pellet demand through niche markets, in China with up to 60 units, and in the rest of the world with 80 units.

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