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Loris Cuman obtained his degree in Mechanical Engineering, specialising in the techniques and technologies of precious metals at the Padua University's satellite campus in Vicenza.
He has been collaborating at IECO Keeps On Improving since 2007 as metallurgic designer and technician and has held the positions of Technical Office Manager and Coordinator in the Research and Development area for heat processing since 2008.
IECO Keeps on Improving produces machinery and systems for the smelting and heat treatment of non-iron metals and has always aimed at finding innovative processes and technologies through its own Research & Development department. This strategy has enabled it to assist its customers in finding the right solutions for the most varied production needs.

Can safety and respect for the environment co-exist in a new method for producing bank ingots? Why is it important to transform minerals extracted from mines or retrieved metals into ingots as quickly as possible? The traditional method is called the "melting-pouring process" and consists of top-pouring molten metal from the crucible to the mould and the use of flames to protect the surface of the product with the consequent problems of energy dispersion, safety risks and an unhealthy environment. The method that now runs parallel with the "melting pouring process" is the natural evolution of a project called "Flameless Tunnel Technology" that began 15 years ago in IECO and refers to an ingot production system using a tunnel oven in a protected atmosphere. This new process eliminates the problems of the traditional system, increases safety conditions and produces perfect surfaces on the finished products without free flames or smoke. The process will be described and the advantages and disadvantages of the two methods will be analysed during the presentation, highlighting the strong and weak points of both systems.

Flameless Tunnel Technology: a fast, safe and ecological method of producing gold and silver ingots

Introduction

Dr. Chris Corti, in his talk at the last JTF 2011 entitled "Sustainable production: being ecological and ethical in the jewellery business" spoke of gold ethics, sustainable production and honest work.

The innovative FTT process presented herein has many points in common with Dr. Corti's paper. If, in fact, the mining industry is raising its standards, then the industry that deals in transforming raw materials into semi-processed or finished products must also take a qualitative leap towards finding processes and technologies that are friendly to both mankind and the environment.

In this short presentation, we would like to analyse a particular productive process especially in consideration of the increased importance that the products resulting from this process have had in recent years due to the precious metal price trend and in reference to the production of bank ingots for gold and silver investments.

Raw material trend

The economic trends for gold and silver have led to an expansion in the business of precious metal mining, retrieval and recycling. The soaring price of raw materials has, on the one hand, created enormous difficulties for those working in the jewellery business, while on the other, it has made it necessary to invest in the sector that transforms these materials into investment products. It has become a priority to receive the metal and convert it into guaranteed products for the banking and private markets as quickly as possible.

Figure 1: trend in the price of gold (Goldprice.org)

Figure 2: trend in the price of silver (Goldprice.org)

Overview on the upstream process

The final aim of the extraction, retrieval and recycling of precious metals is, as we all know, the refining process where the metal is purified and becomes pure or impure.

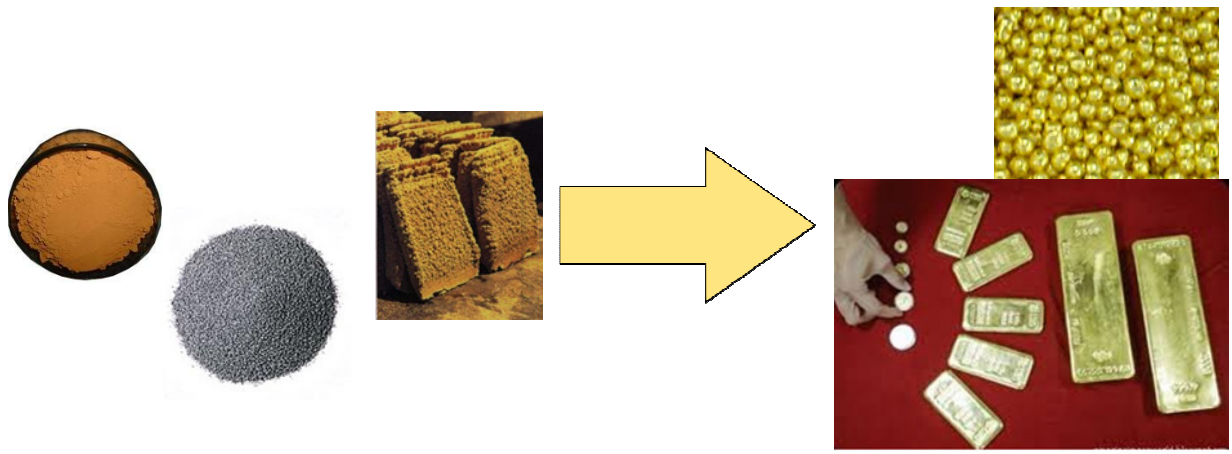

Figure 3: From gold and silver dust to semi-processed products (grains) and finished products (ingots and coins)

The greater focus on precious metals due to the economic crisis and the relative increase in the quantity of precious metals extracted, retrieved and recycled, has necessarily led to a swell in work volume for refining

plants and the consequent increase in the quantity of extracted products, especially gold dust and silver crystals. The gold dust and silver crystals from refining plants, given their considerable volatility, must be transformed immediately into physical mass products in order to reduce the risk of weight loss.
The dust and crystals are normally transformed into 4 types of product:

- Good Delivery bars
- casted bars
- minted bars
- coins

The rapid changes in precious metal price fixing means that transforming dust into ingots and coins needs to be done as quickly as possible.
Moreover, the high value of gold and silver has also increased customer demand in terms of the aesthetic quality of the ingots. Those who can offer good-looking ingots can also up the market price compared to those who sell ingots with a mediocre aspect. Up until a few years ago, the physical aspect of a gold ingot had no effect on its value, but nowadays, even the look of an ingot plays a definite role in terms of selling power.

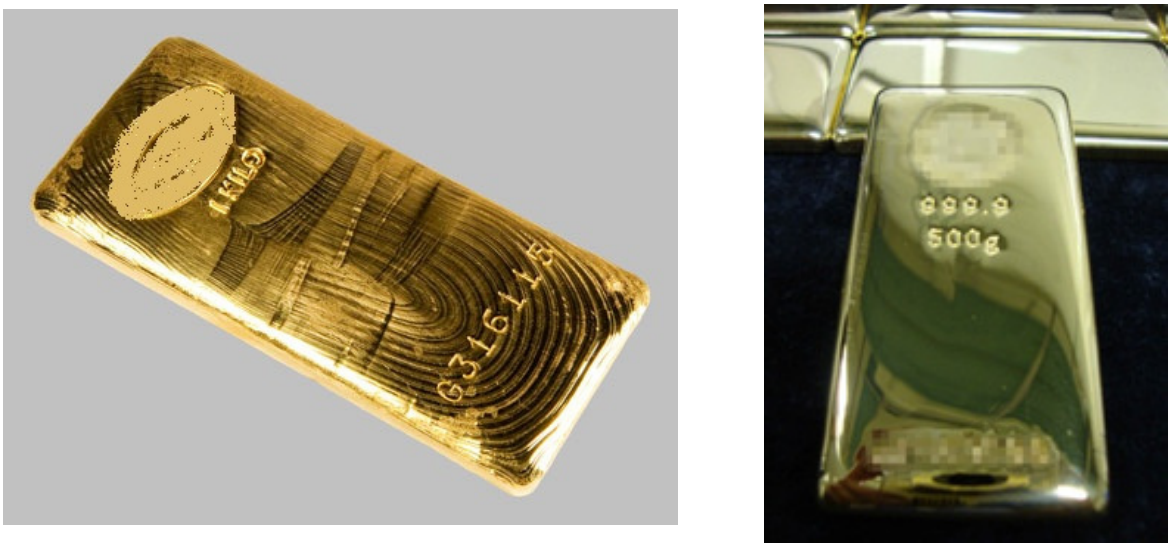

Figure 4. On the left: a kilobar ingot obtained by the traditional system. On the right: an ingot obtained by the FTT system, without brushing.

The "traditional" method

The most common method – for the last 1000 years – used to transform precious metals is the Melting-Pouring Process: the dust or crystals are melted in a crucible and then the molten metal is poured into a mould where it solidifies and takes the shape of an ingot.
This operation is normally carried out by hand or by robotic means for the "pouring" action.

These processes, however, do not produce ingots of the exact same weight because even a very small amount of precious metal can be withheld by the porosity of the crucible or the unevenness of the mould or may even spill during pouring. It is therefore necessary to account for a certain "drop" which leads to an increase in production costs (gold loss). The gold withheld by the crucible and moulds must be recovered by disposing of the crucible and other accessories thus making production costs higher (gold loss + cleaning costs).

Figure 5: Producing a 1000 Oz (~31.5Kg) silver ingot

Figure 6: Producing a 1000g gold ingot

Ingots made by hand with the pouring system have uncontrollable surface defects because manual operations do not allow for constant and correct control of all the melting-solidification parameters.

Solidification is a very important phenomenon for the properties of metallic materials because it is in this phase that the first crystals form and take on their typical characteristics: shape, dimensions, orientation, which influence all of their physical and technological properties. It is also important because, almost all metals and their alloys are obtained from the liquid state and therefore their structure and constitution are practically directly linked to what happened during solidification.

PROS:

-Tradition: *ingots have always been made in this way and it is still a valid process and one which must be preserved.*

-Operator control (feeling): *a manual process increases operator safety. It is a simple process, the machine is not "difficult".*

-Little distortion: *if a company has developed over time, it is more than likely that an adequate melting and pouring system has been established around it in terms of the infrastructure for loading, weighing, dosing, control and packaging.*

Figure 7: Protection flames

CONS:

-Operator-linked process: *it is the skill of the operator that produces a high quality finished product and it is the operator who determines productivity. It is, however, an extremely repetitive job and should not involve long shifts.*

-Danger from pouring molten metal: *the process involves top-pouring molten metal. There is a danger of splashing and overspill. The metal is extremely costly and losing some during pouring is not tolerable.*

-Smoke and flames in the work area: *good surface finishing is obtained using a GPL nozzle with a flame that protects the bath. This inevitably means that flames and smoke are generated in the areas where operators are working on the process.*

-Drop in weight: *the traditional system suffers from a loss of precious metal and the weight of the ingots is never constant because the precious metal can be withheld by the porosity of the crucible and the unevenness of the mould or can even spill during pouring.*

-Need to check the weight: *further resources are needed during production to check the weight. Even if robotic systems are used, a little bit of metal still remains in the crucible and weight checks are necessary to prevent imprecision.*

-Need to clean: *the precious metal withheld by the crucible and moulds, or any lost during pouring, must then be recovered by disposing of the crucibles and accessories, thus increasing productions costs.*

-Poor surface quality: *ingots produced manually with the "pouring" system have uncontrollable surface defects because manual operations do not allow for constant and correct control of all the melting-solidification parameters.*

-Limited production: *production is based on the skill and manual work of the operator and this limits productivity.*

FTT: flameless tunnel technology, a fast, safe and ecological process without flames.

We have grouped together the three adjectives "fast", "safe" and "ecological" because they are what distinguish the FTT process, which offers an alternative method to the traditional one. It is a production line process comprising: tunnel oven, loading area, heat induction or resistance area, solidification and cooling area and unloading zone.

The process consists of inserting the metal to be melted in grain or dust form into the graphite ingot moulds (patented system), which then, at regulated times, go through the controlled smelting and solidification areas, continue into the cooling zone and then appear at the unloading end where an operator collects the cold moulds and extracts the ingots.

The oven, instead of using GPL burners, operates in a protective atmosphere (nitrogen or blend) and there are no free flames and the operator runs no risk of coming into contact with molten metal.

The entire process, from heating times, set point temperatures (melting temperature) and the litres of water per minute needed for perfect solidification are all controlled by the PLC and stored in the consultable memory. The process can be customized, adapted and repeated.

*Figure 8 linear FTT oven produced by **IECO Keeps On Improving Srl** to produce ingots (patent pending)*

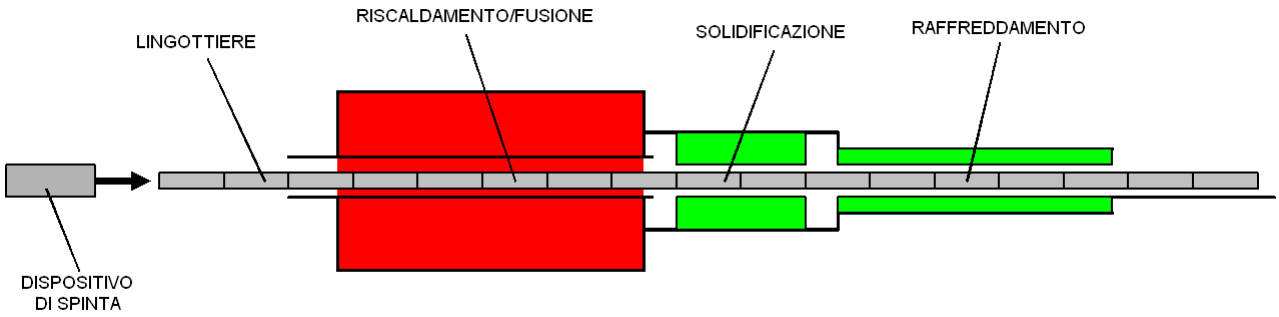

*Figure 9: diagram o fan FTT tunnel oven produced by **IECO Keeps On improving Srl** (patent pending).*

PROS:

-Operator-free process: *the machine, with its set functions, determines the standards. Changing the operator does not change the quality of the output. It is the machine that determines productivity, not the human variable.*

-The molten metal is not "poured": *melting occurs inside the grain-filled ingot moulds. The tunnel is a complete production line. It loads the mould, melts the grain, solidifies and cools the molten metal and unloads the ingots.*

-Perfect smoothness of the ingot surface: *a good surface finish is obtained by the time-temperature-flow*

parameters set on the machine panel and memorised for repeatability. The tunnel operates in a protective atmosphere thus free flames are not necessary.

-Weight loss: *no precious metal is lost in the FTT system.*

-Weight check (drop): *There is no need to check the weight. The exact quantity of metal to be melted is loaded into the ingot mould. No metal remains in the mould. The checking phase is therefore easier.*

-Less impact on the environment: *The traditional machine with crucible means that energy is dispersed into the environment from the oven mouth. This does not happen with the GSBGT oven. The induction technology "wastes" less energy. The crucible oven uses GPL while FTT ovens use nitrogen produced by generators.*

-Greater safety for the operators: *The operator is never in a danger area. He only manages harmless materials and only handles cold ingot moulds. He does not have to work with free flames, smoke or molten metal and therefore needs less protective clothing and accessories.*

-Insulating materials reduced to a minimum: *With FTT ovens insulating materials are reduced to a minimum or are even non-existent which leads to a significant reduction in impact on the environment during construction and less maintenance costs with no need to change or dispose of crucibles.*

-Production can be adjusted to suit every requirement: *the FTT system offers manual ovens with low productivity as well as automatic high-production ovens, even for small ingots.*

CONS:

-Different to the traditional method: *the process is different to the one habitual one.*

-Equipment: *since it is a production line oven, filling and emptying equipment is required.*

-Complex machine: *the process has many variable to be kept under control but are, in any case, controlled automatically by the PLC.*

-Interlocking equipment: *high-production FTT ovens need structures for dosing, loading and unloading.*

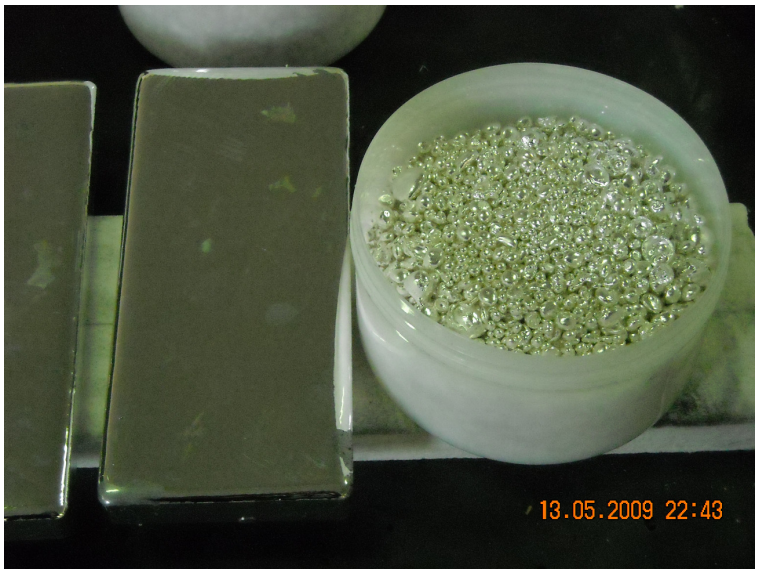

Figura 10: Esempi di lingotti FTT oven products. On the left: 250g gold ingots. On the right: 100oz silver ingots (~3,1Kg).

Ingot Type	Minimum productivity (pcs/day)	Minimum productivity (Kg/day)	Maximum productivity (pcs/day)	Maximum productivity (Kg/day)
100g Au (gold)	100	10	10.000	1.000
250g Au (gold)	50	12.5	6.000	1.500
500g Au (gold)	30	15	3.600	1.800
1000g Au (gold)	20	20	2.000	2.000
12.5Kg (400oz) Au (gold)	5	62.5	80	1.000
50g Ag (silver)	100	5	10.000	500
100g Ag (silver)	100	10	10.000	1.000
1000g Ag (silver)	20	20	2.000	2.000
3.15Kg (100oz) Ag (silver)	10	31.5	150	472
31.5Kg (1000oz) Ag (silver)	3	94.5	50	1.575

Figure 11: productive range of FTT technology ovens and systems

Conclusion

We have grouped together the three adjectives “fast”, “safe” and “ecological” because they are what distinguish the Flameless Tunnel Technology (patented system).

- **Fast** because the nature of the FTT system inevitably leads to greater productivity compared to the traditional method. For example, the tunnel oven method can easily produce 200 kg/hr of high-quality silver ingots while a manual operator working the traditional method can only produce 50-70 kg/hr of lower-quality ingots and a human being cannot be expected to keep up that rhythm for more than a couple of hours.

- **Safe** because the operators do not work in strict contact with molten metal, flames and smoke even if the melting process occurs inside an oven. The machine-regulated process alleviates the stress of doing such a repetitive job as the manual production method involves.

- **Ecological** because the FTT process is a clean machine and does not use insulating products that are dangerous to mankind and the environment. It is electrically powered and uses nitrogen produced by compressed air with special generators instead of GPL as a protection method. It does not disperse heat into the environment but is thermo-regulated by the PLC so that the energy required is limited to the amount needed merely for the melting process. Cooling water can be re-used throughout the company and, in any case, comes from closed circuits.

Acknowledgments

IECO Keeps On Improving would like to thank its staff and the customers who have allowed the FTT technology to develop and refine over the last 15 years or more, as well as JTF for allowing us to be here today.