PLASTIC MATERIAL RECYCLING IN STEEL INDUSTRY: A FRUITFUL EX-AMPLE OF CIRCULAR ECONOMY

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ABSTRACT

Plastic production is an important industrial sector. The annual amount of produced plastic in Europe is about 50 Mt. The H2020 project POLYNSPIRE has been launched to demonstrate a set of innovative, cost effective and sustainable solutions, aiming at improving the energy and resource efficiency of post-consumer and post-industrial plastic recycling processes, targeting 100% waste streams. To reach this ambitious goal, three innovation pillars are addressed:

A. Chemical recycling to recover plastic monomers and valuable fillers;
B. Advanced additivation to enhance recycled plastics quality;
C. Valorization of plastic waste as carbon source in steel industry.

The Electric Arc Furnace, EAF, has been purposely developed to re-melt recycled steel scrap. For this reason, the EAF based production cycle is already very close to the concept of circular economy.

This character can be further reinforced, increasing the process sustainability and maintaining at the same efficiency and productivity constrain of the melting process, transforming the EAF in the core of a more complex industrial eco-system, where materials from other industrial sectors are recycled in EAF and fossil fuels are replaced by biomass and recycled plastic materials.

In the EAF the scrap melting is accomplished by supply electrical and chemical energy to the furnace. The chemical energy is supplied via several sources such as natural gas burning and injection of carbon-based materials.

The mix of polymers discharged at the end of recovery chain, can be used in the steel sector with the aim to recovery their carbon content and to valorize also its energetic content replacing the fossil fuels currently used in EAF process, such as natural gas and coal.

The results demonstrated that a pluri-disciplinary and cross-sectorial approach, based on the circular economy paradigm, together with effort in technological innovation, allow to significant re-duce the environmental impact and the sustainability of important and heavy industrial sectors.

FOREWORD

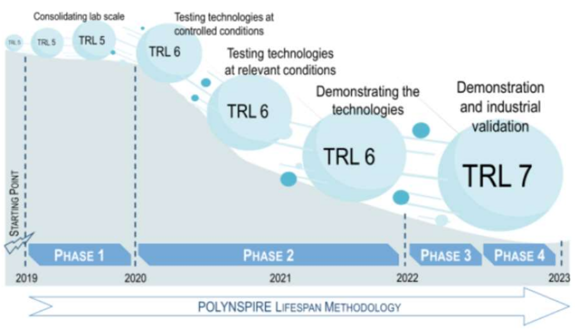
The H2020 project POLYNSPIRE has been launched to demonstrate a set of innovative, cost effec-tive and sustainable solutions, aiming at improving the energy and resource efficiency of post-consumer and post-industrial plastic recycling processes, targeting 100% waste streams. To reach this ambitious goal, three innovation pillars are addressed:

A. Chemical recycling to recover plastic monomers and valuable fillers

B. Advanced additivation to enhance recycled plastics quality

C. Valorization of plastic waste as carbon source in steel industry

In particular, the application of plastics in the steel sector is studied by the Consortium Rina Consulting Centro Sviluppo Materiali as research center, Ferriere Nord (steel factory), I BLU (plastic collection of grains development and production), HTT Engineering (engineering company). The consortium will vali-date the proposed approach with industrial trials, up to TRL 7 (Threshold Readiness Level).



APPROACH

The mix of polymers, discharged at the end of plastic recovery chain, can be used in the steel sector with the aim to recovery their carbon content and to valorize its energetic content replacing the fossil fuels currently used in the Electric Arc Furnace (EAF) process, such as natural gas and coal.

In the EAF scrap melting is accomplished by supply electrical and chemical energy to the furnace. The chemical energy is supplied via several sources such as natural gas burning and injection of carbon-based materials. In order to reduce the electricity consumption in the last decades the chemical energy suppling has been increased, transforming the EAF from a simple scrap melting furnace to a chemical reactor where steel refining is also carried out.

In order to reduce the need of fossil material alternatives carbon bearing materials can be used in the EAF. The advantages arising from such new practice are:

- Utilization of waste materials from other production cycles
- Insertion of steel factory in a logic of industrial symbiosis and circular economy
- Promotion of new local economies
- Mitigation of CO_2 emission (depending on the characteristic of waste material individuated)
- Prevention from oscillation of raw materials price

Among these alternative materials waste plastic can be considered a valuable substitute, due to fol-lowing characteristics.

- High carbon content
- High heating value
- High hydrogen content

The plastics residues are composed of low-grade plastics with lower recycling potential coming from the packaging sector (mainly based on polyolefins such as PE and PP).

Parameter	Plastic residue	anthracite c
HHV** (MJ/kg)	32.37	26-30
Ash (% dry)	9.50	1-10
Cl (% dry)	0.38	<0.01
S (% dry)	0.03	0.5-1.5
H (% dry)	10	0.5-1.5
N (% dry)	1.1	0.2-0.3
C (% dry)	65.0	80-85
O (% dry)	14.88	0.1-0.5
Volatile matter (%)	88.50	1-10
Fixed carbon (%)	1.5	75-80

In order to use in efficient and sustainable way the low grade plastic in EAF, the following activities are ongoing:

- Individuation and implementation of an optimized net-work for waste collection, storage and trans-fer to EAF sites in order to minimize economic and environmental impact of transport and to guarantee stable and consistent supply of plastic waste to steel production site.

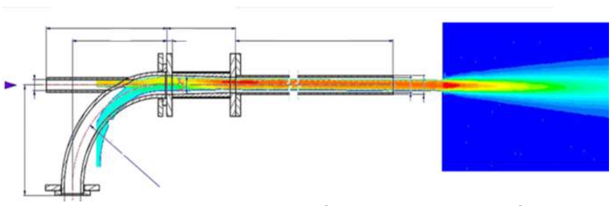
- Development of technological solutions for pre-treatment of plastic waste and use in routine op-erations in EAF process: the injection requires homogenization of the material, milling and grinding to produce grains with controlled properties. Plastic separation, washing, hot extrusion and grinding are opti-mized.

- Design and realization of new injection system to inject the granulated plastic into the liquid steel bath. The current injec-tion system is optimized for pulverized coal injection. A new sys-tem for plastic grains is under development, with the support of CFD modelling.

Plastic grain produced according to Standard regulation

For example the combustion kinetic of a single plastic grain has been studied in a laboratory furnace, varying grain size, combustion temperature and atmosphere.

On the basis of physico chemical characteristics of plastic grains the new injector design has been carried out



New developed injector and CFD simulation of plastic grains jet

The plastic grains have been studied at laboratory level: reaction of a single grain in inert and oxidizing environment, thermogravi-metric test and melting test in contact with steel. Obtained data showed that the plastic grain has a good reactivity and this mate-rial is suitable for EAF use

CONCLUSIONS

The polynspire projects (started on the 1st September 2018) has the ambitious goal to study a set of innovative, cost effective and sustainable solutions, aiming at improving the energy and resource efficiency of post-consumer and post-industrial plastic recycling processes, targeting 100% waste streams.

The laboratory tests and the first CFD simulations gave en-couraging results about capability of the material to be injected into the EAF and to foam slag.

The results demonstrated that a pluri-disciplinary and cross-sectorial approach, based on the circular economy paradigm, together with effort in technological innovation, allow to significant reduce the environmental impact and the sustainability of im-portant and heavy industrial sectors.