Tecnologie e Metodi Avanzati per il Recupero e il Riciclo dei Materiali

Case Study: Fluff Sorting from Car Dismantling

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Recycling in automobile industry

Fluff sorting from car dismantling

Recycling strategies are more and more addressed to reduce waste disposal and to increase recovery of valuable materials. In the automobile industry, usually about 75% by weight of an end-of-life vehicle (ELV) is recycled.

Currently the attention is focused in reducing those residues, about 25% of the vehicle weight, which go mainly to landfill sites because of the lack of a cost-effective technology to recycle this waste.

Such a portion (25%) of the vehicle is the so-called fluff or Automotive Shredder Residue (ASR).

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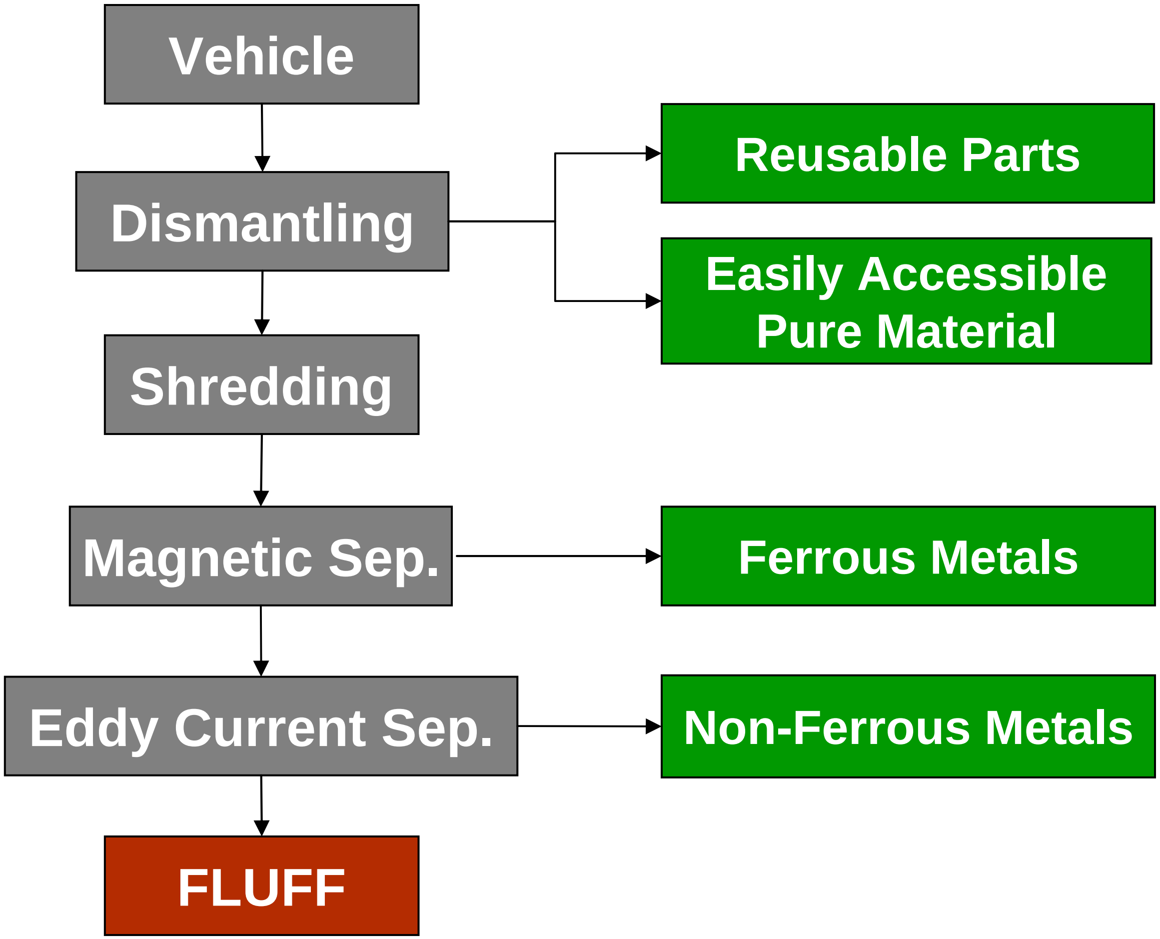
Vehicle dismantling and separation process



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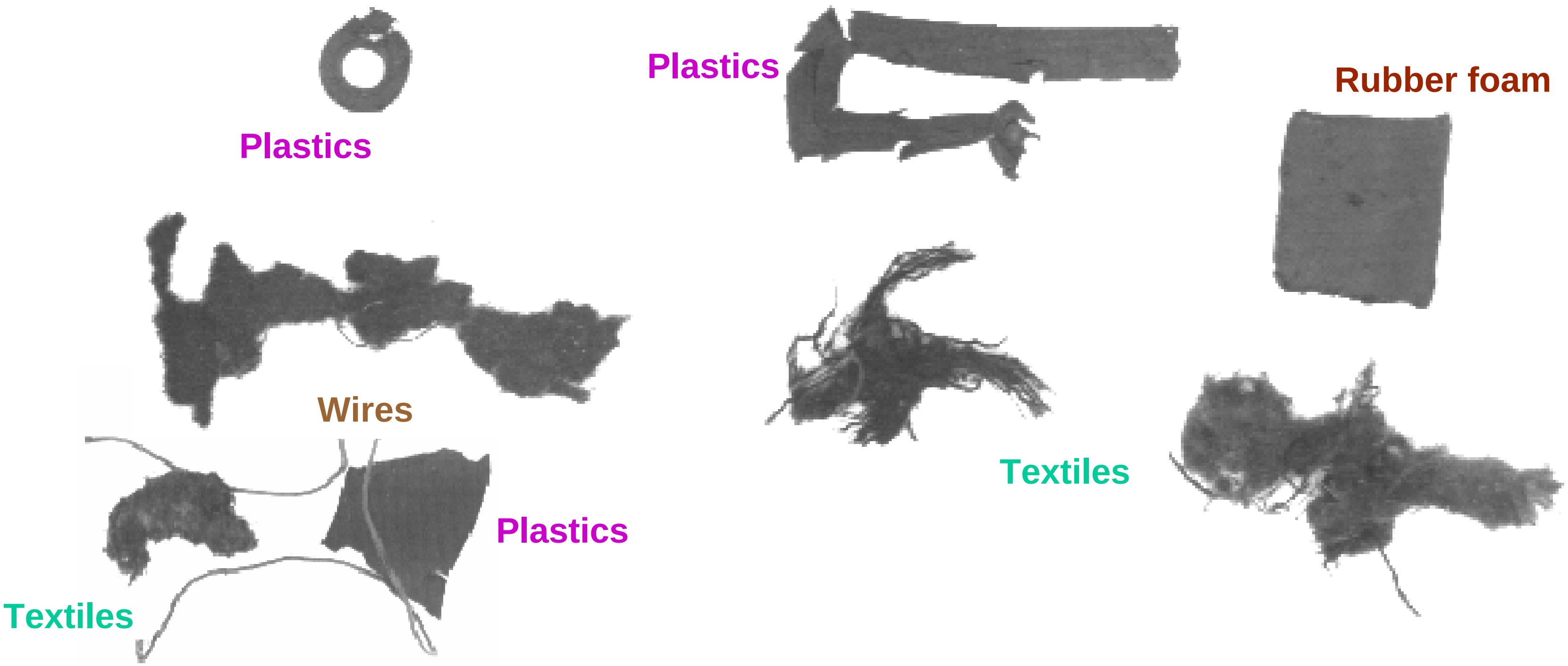
What is fluff?

Light fractions produced after vehicles dismantling are conventionally defined as fluff.

Fluff is usually constituted by materials characterized by low specific gravity, as plastics, rubber, synthetic foams, textiles, etc.



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Fluff sorting

Fluff contaminants

Fluff results polluted by metal contaminants (copper, brass, iron, aluminum, etc.), that are parts of the electrical devices of the vehicle that, for their shape and size (wires, metal straps, slip rings, wipers, etc.) remain concentrated in the lighter products.

Metal contaminants, especially the finest size fractions, are not well removed by classical separation techniques.

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Fluff recycling

Fluff can be recycled as fuel in co-combustion process, but the quantity and quality of the metal contaminants have to be strongly controlled to not prejudicate the final fluff based fuel.

The possibility to set up more efficient recycling strategies could allow to improve the separation of the lighter fractions, reducing waste disposal and environmental impact, increasing energy production.

Innovative selection-control strategies, based on hyperspectral imaging, in the visible-near infrared field (400-1000 nm), of fluff have been investigated and critically evaluated.

Fluff collection

The industrial plant

Fluff samples have been collected in a recycling plant (Centro Rottami s.r.l., Cisterna, Italy) characterized by different processing comminution-classification stages.

The products

In the plant fluff is divided in the following fractions:

Aluminium

Heavy plastics

Light plastics

Mixed metals

< Inert 5mm

Smelters

RDF Production

Steel Plants

Asphalt Prod. (10%)

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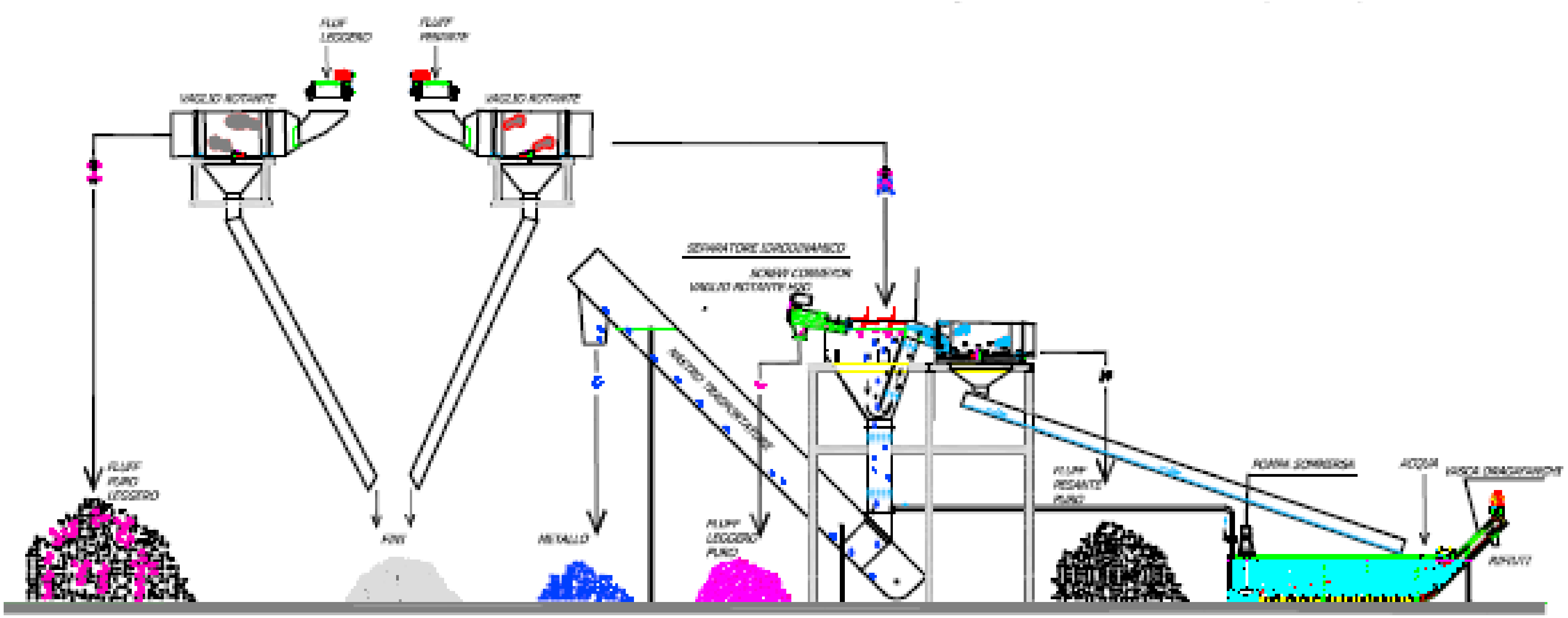
The industrial plant



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RDF (Refuse Derived Fuel) Plant

Light and heavy fluff fractions are utilized with other waste materials (tires, packaging) to produce an RDF material.

It can be used for co-combustion in incinerators (electric energy production) or in cement industry (heat production).

Produzione bricchette di RDF

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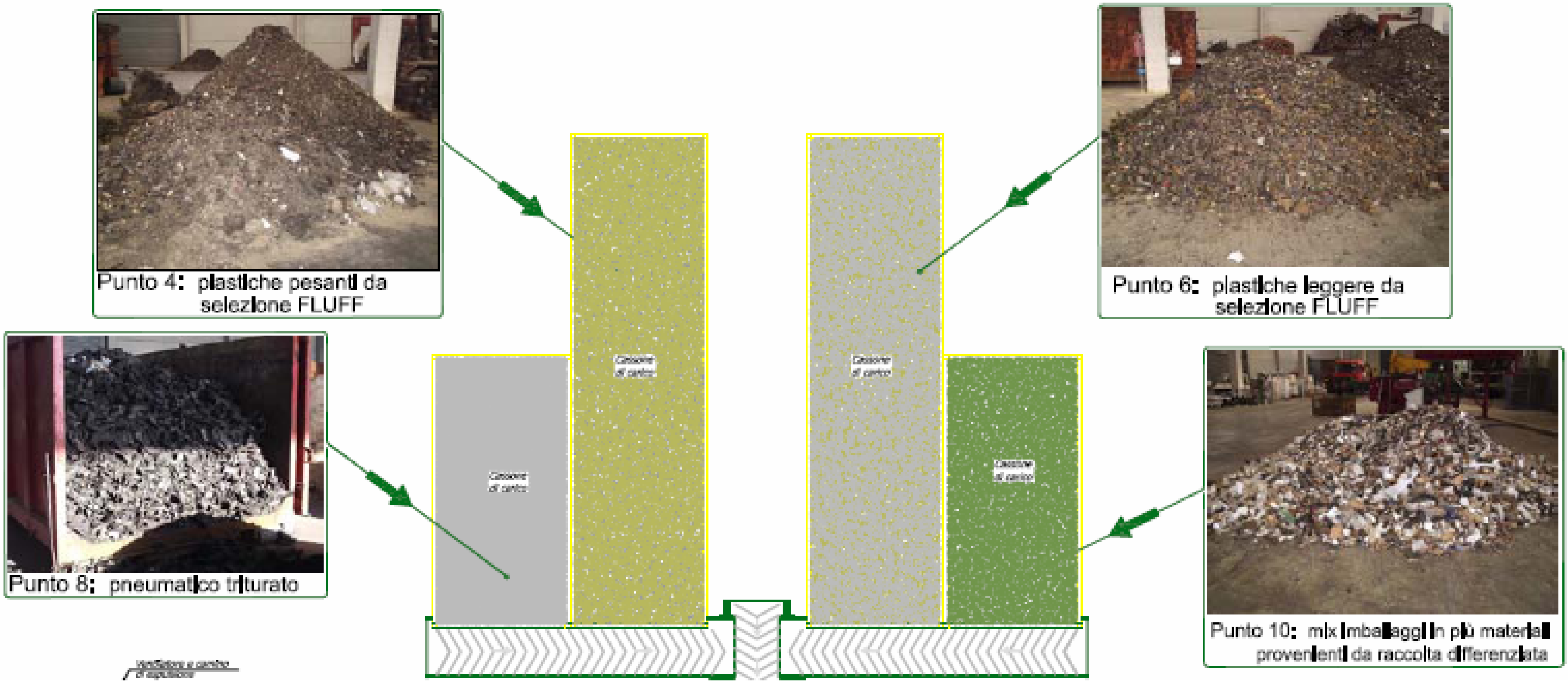
RDF (Refuse Derived Fuel) Plant



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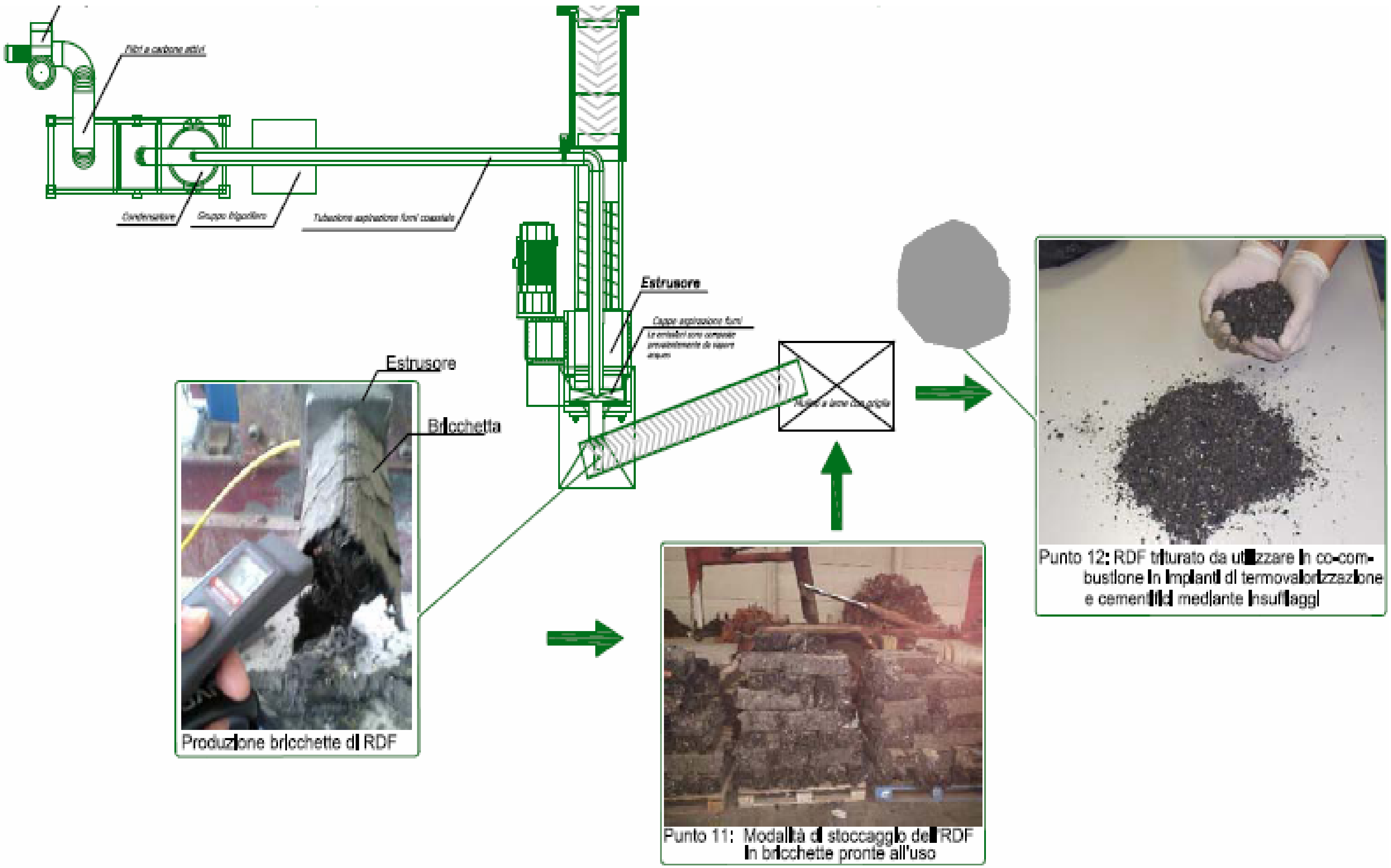
RDF (Refuse Derived Fuel) Plant



Produzione bricchette di RDF

Punto 11: Modalità di stoccaggio del RDF in bricchette pronte all'uso

Punto 12: RDF triturato da utilizzare in co-combustione in impianti di termovalorizzazione e cementifici mediante insufflaggi

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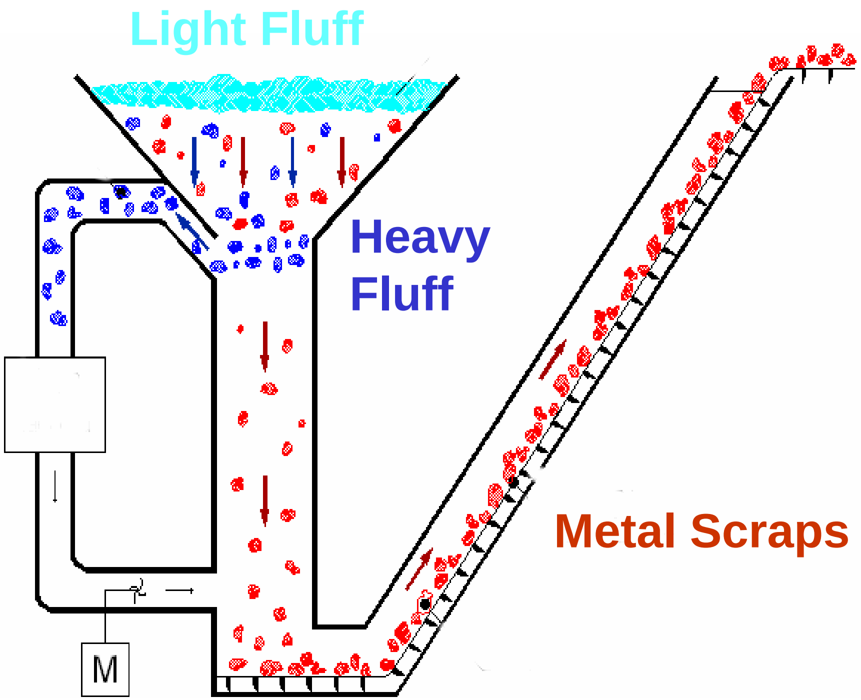
Fluff collection

The hydrogravimetric separation stage



3 different classes of particles have been collected after the separation stage:

- **light fluff**
- **heavy fluff**
- **metallic contaminants**

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Fluff collection

The collected samples

All samples have been sieved in different size-classes and, starting from the size class -17.0 mm + 8.5 mm, particles of different nature inside the different 3 classes have been manually sorted.

The following classes of samples have been obtained:

8 classes of light fluff

6 classes of heavy fluff

6 classes of metals

In addition, inside the 3 source classes of materials, particles of

glass, wood and stone

have been identified and selected.

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Fluff collection

Classes of light fluff

L1

L2

L3

L4

L5

L6

L7

L8

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Fluff collection

Classes of heavy fluff

H1

H2

H3

H4

H5

H6

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Fluff collection

Classes of metals

M1

M2

M3

M4

M5

M6

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Fluff collection

Wood, glass and stone contaminants

GLASS

WOOD

STONE

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Experimental results

Fluff spectral analyses

Reflectance spectra of 257 samples have been acquired, 58 for light fluff, 76 for heavy fluff, 79 for metals and 44 for glass, wood and stone particles.

The average reflectance spectra of the selected classes have been computed.

The spectral signatures of particles have been analyzed to highlight those characteristics useful for their recognition.

Analyses have been carried out in order to investigate the possibility to develop innovative on-line control strategies for:

- **Evaluation of the separation efficiency of the jig,**
- **Design and implementation of an ejection system for sorting of undesired metal contaminants.**

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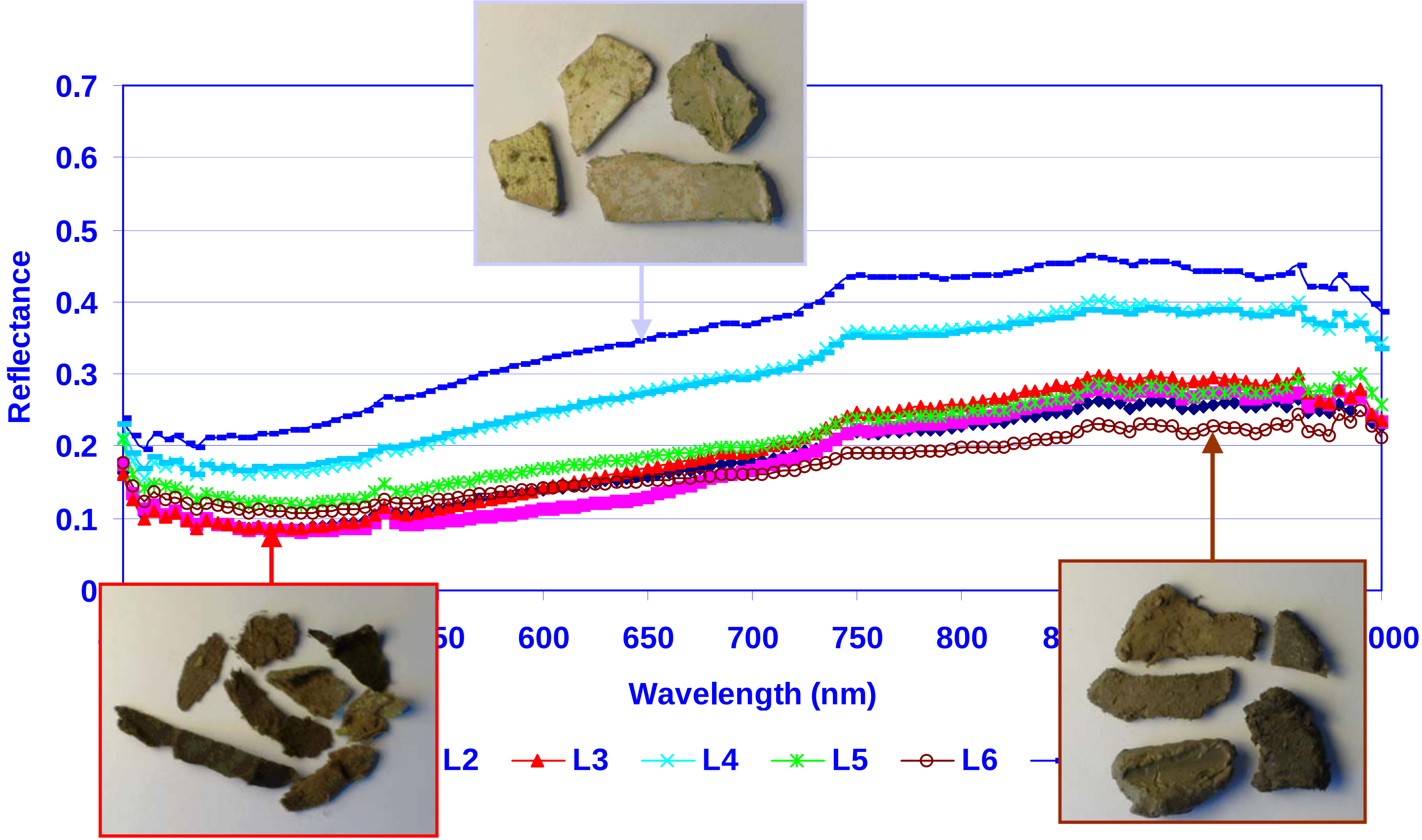
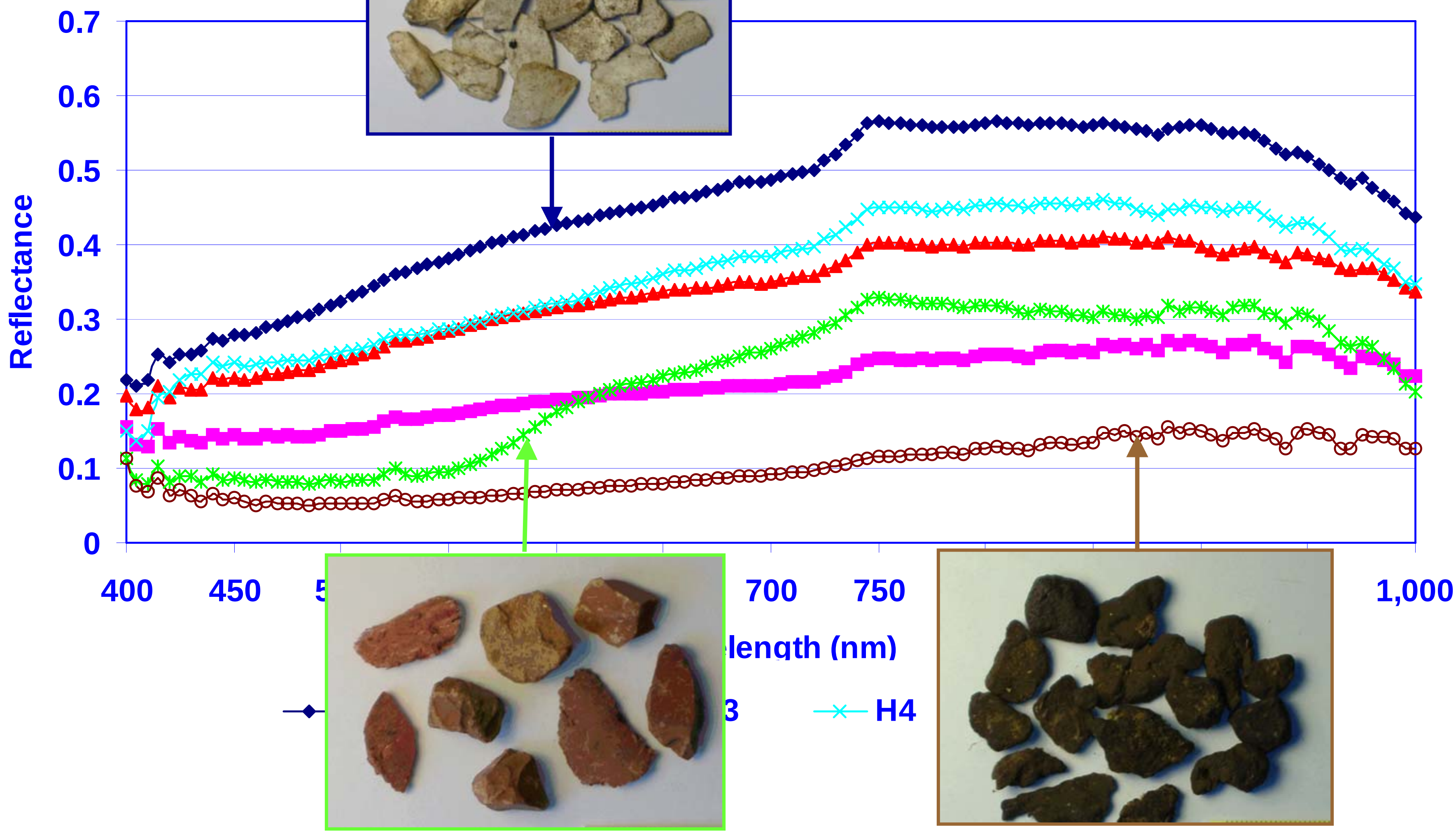
Experimental results

Reflectance spectra of light fluff



E… tal results

… tra of heavy fluff



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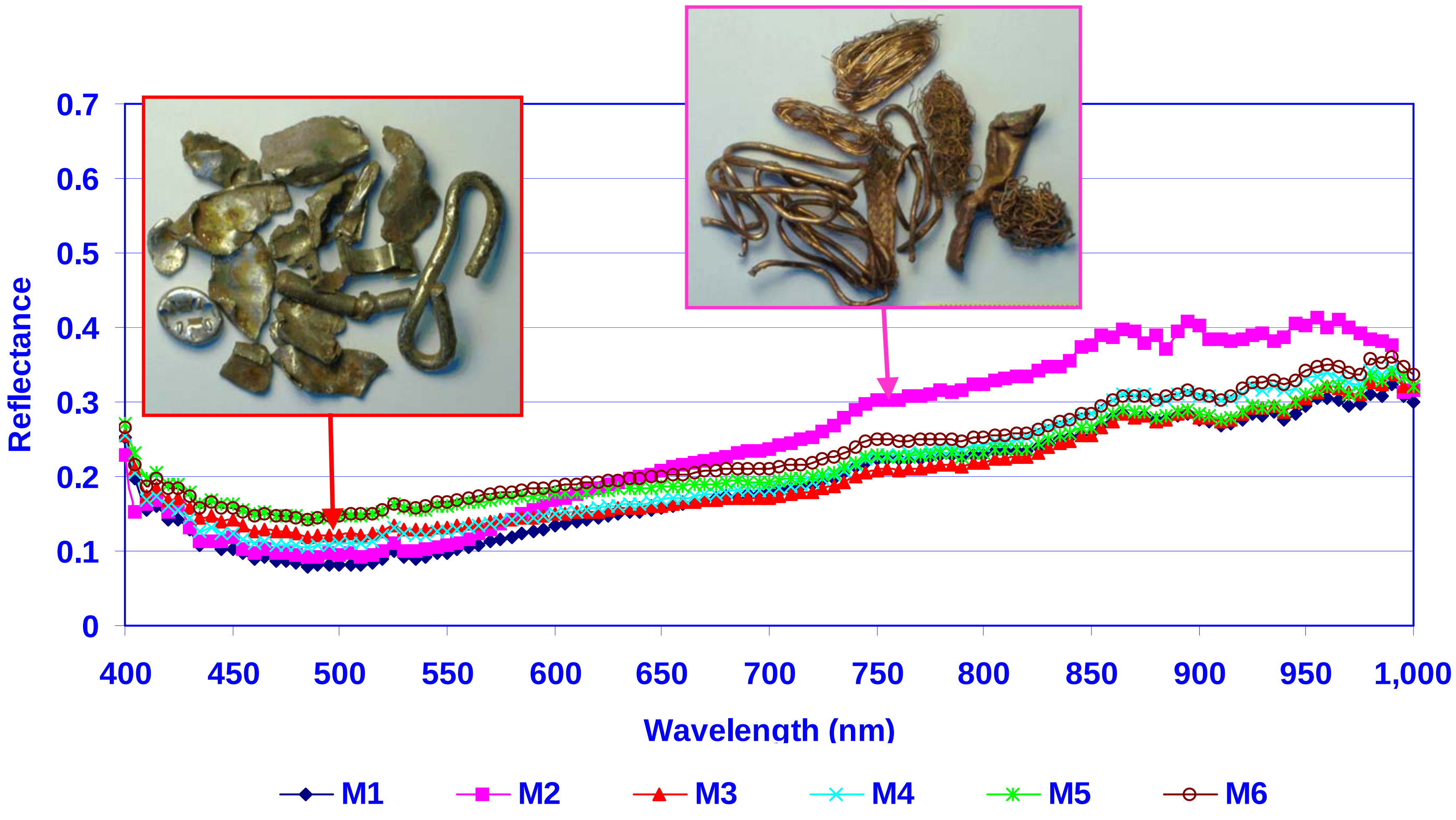
Experimental results

Reflectance spectra of metals



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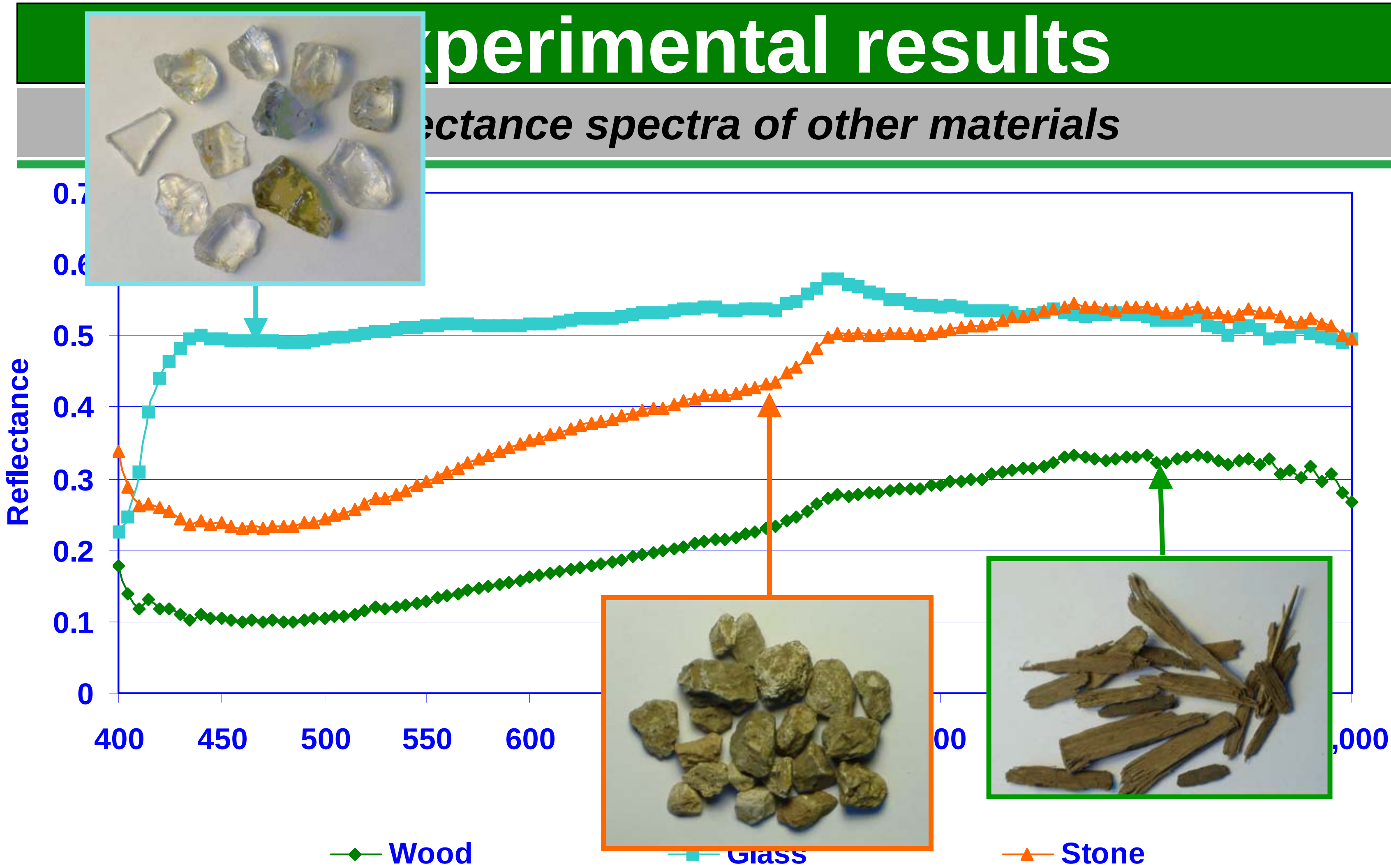
xperimental results

ectance spectra of other materials



Glass, wood and stone spectral signatures show different shapes and reflectance levels, either among them or compared to those of plastics and metals.

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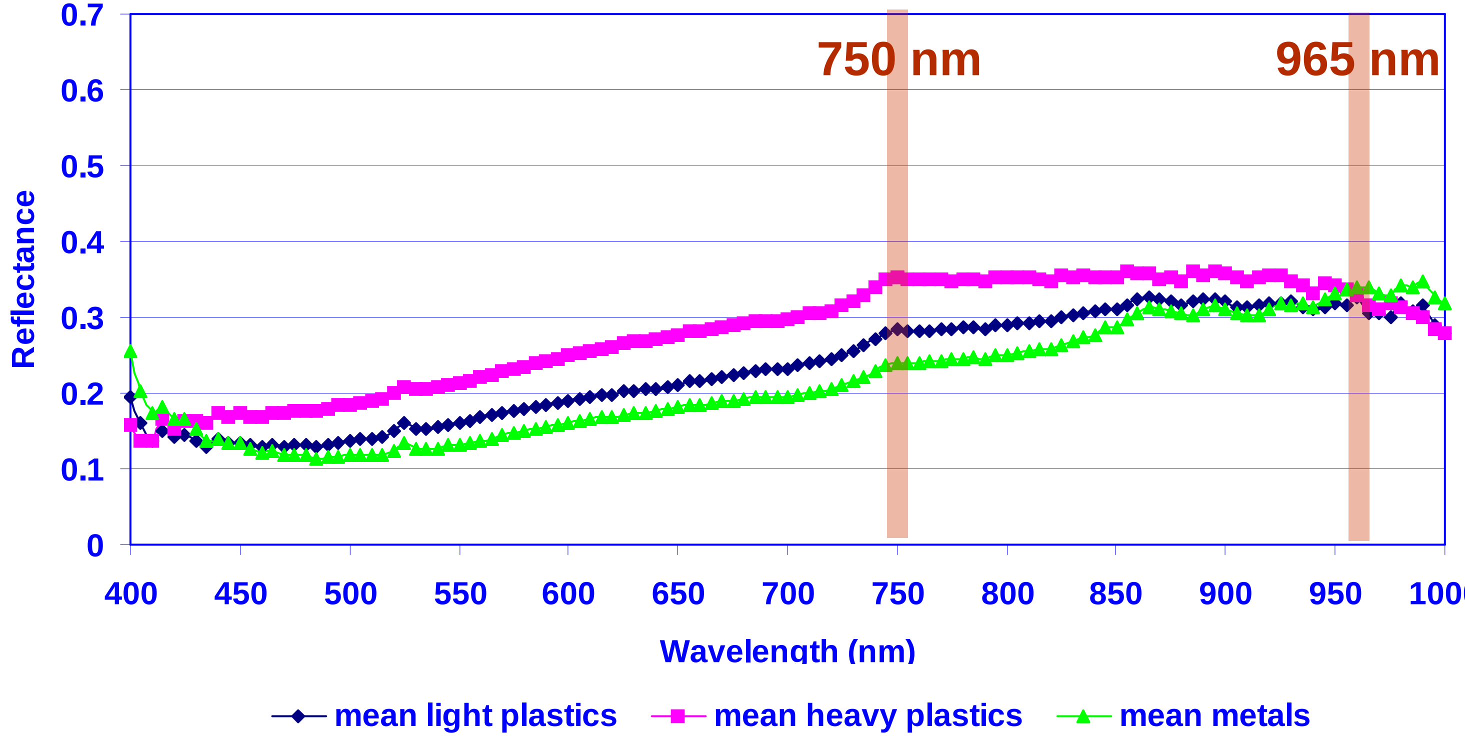
Experimental results

Average reflectance spectra comparison



In an automated sorting system, the speed of data processing, due to the high feed rate, is an essential goal, considering the short time allowed to perform sample recognition and its eventual ejection. A "*wavelength threshold logic*" was applied to perform the fluff particles recognition. The wavelengths ratio W_{R1} = 965/750 nm has been computed.

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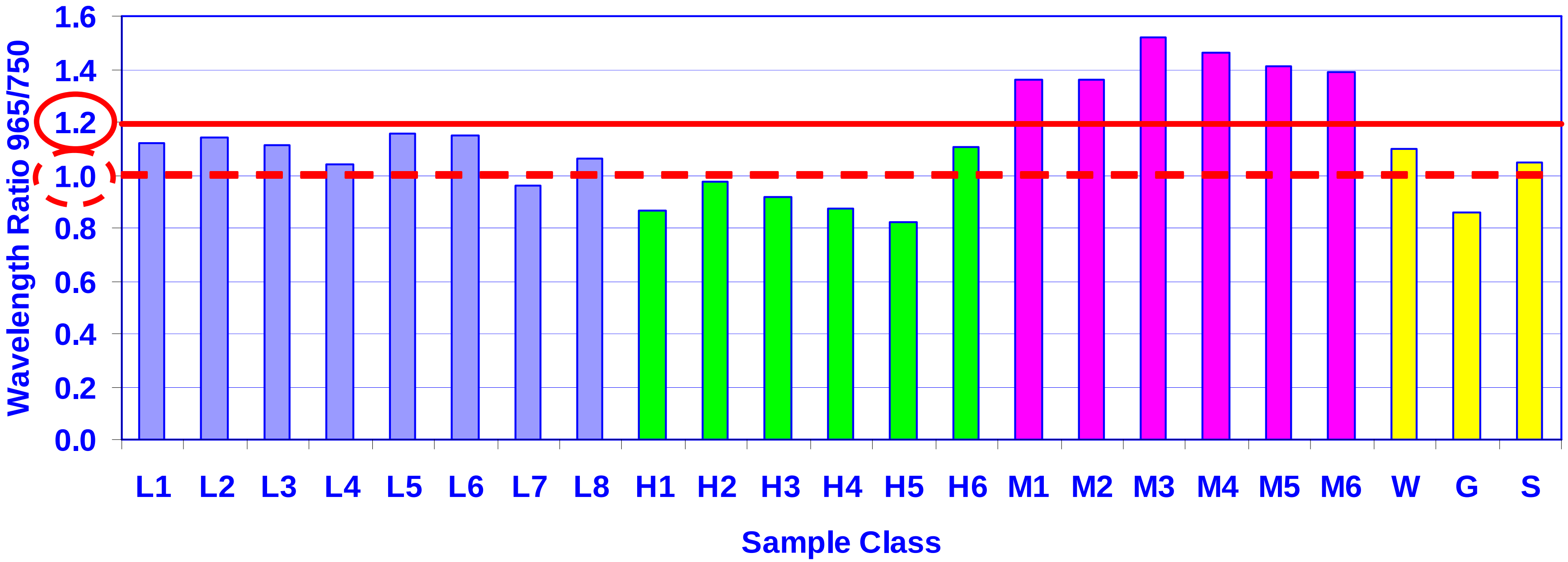
Experimental results

Wavelength Ratio WR1 (965/750 nm)



2 different W_{R1} thresholds can be assumed: the first one, corresponding to 1.2, allowing to identify metal contaminants ($W_{R1} > 1.2$) and plastics ($W_{R1} < 1.2$) and the second one, corresponding to 1, allowing to identify light plastics ($W_{R1} > 1$) with one exception (class L7) and heavy plastics ($W_{R1} < 1$) with one error (class H6).

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Experimental results

Correctness of classification

Real Class	Predicted Class	
	Plastics	**Metals**
Plastics	**0.610**	**0.019**
Metals	**0.009**	**0.362**

Applying the W_{R1} with threshold at 1.2, just 0.9% of metals are not correctly recognized being attributed to plastics. The implementation of such a procedure, inside a fluff separator working on-line will be able to eject more than 99% of metal scraps.

Concerning plastics, just 1.9% of fragments will be misclassified as metals and would be ejected by an on-line sorting system, that means a loss of useful material < 2.0%.

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Conclusions

Achieved Results

- The possibility to apply hyperspectral imaging (VIS-NIR field) to recognize metals contaminants in fluff to be recycled for co-combustion processes has been investigated.
- Results demonstrated as recognition of plastics and metals can be obtained adopting an easy and fast selection strategy, based on the ratio of two selected wavelengths in the NIR field: W_{R1} = 965/750 nm, with low classification errors.
- The development of an on-line control/sorting system, based on the proposed approach, could allow to reach two important goals:
  - Metal contaminants sorting, reducing costs related to fluff disposal and environmental impact and increasing energy production;
  - Control of the separation efficiency of the jigging stage in the industrial recycling plant.

Conclusions

Further Developments

- **More detailed investigations are needed in order to validate the preliminary results obtained in this study, in terms of number of analyzed samples.**
- **The characteristics of the devices and the related analytical techniques allow to utilize such an approach to set-up innovative, flexible and low cost on-line sorting/control strategies that can be easily integrated, at industrial level, inside existing processing plants layouts.**

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