Recycling of thermal spray waste in sintered products

Cristina Siligardi
Dipartimento di Ingegneria Enzo Ferrari
Università di Modena e Reggio Emilia

LIFE+12 ENV/IT/678

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Aim of work

✓ Demonstrate the feasibility of valorizing and recycling thermal spray waste of different nature: mainly zirconia, NiCoCrAlY and other powders (i.e. alumina)
✓ To realize demonstrative products like frits, glazes, glazed sintered tiles and sintered samples containing up to 100% of spent thermal spray powders.
✓ Development of demonstrative pilot line for new frits and glaze

Melting $\rightarrow$ glasses, frits and glazes

Sintering $\rightarrow$ ceramic substrates, engobes
Thermal spray process

75 Weight %
Overspray!!!
Waste Powders

- APS5
- APS5SW
- APS6
- APS6SW

- CORINDONE
- CORINDONE-W

- HVOF - INT
- HVOF - EST
- LVPS - EST

ZrO₂
Al₂O₃
MCrAlY

Final Products

- K4SINT
- ING MODENA
- FONDOVALLE
- Turbocoating
- Fritta
Zr sand price Historical trend

Source: TZMI (TZ Minerals International Pty Ltd)

Zr sand production by region (2014 - 1.1mt)

Source: Iluka
Industrial GLAZE

100% substitution
Industrial PIGMENTS

100% substitution
**AP6** suitable for coloured bodies

**CORINDONE-W** suitable for coloured bodies

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<td><strong>ΔE=3,35±0,08</strong></td>
<td><strong>ΔE=1,28±0,27</strong></td>
<td><strong>ΔE=0,38±0,38</strong></td>
<td><strong>ΔE=0,30±0,10</strong></td>
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<td>Recycled Powder</td>
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Final Products

A → Coloured body
B → White Engobe
C → Final product grey
D → Final product black

A+B+Decoration=C or D
LIFE12 ENV/IT/678 “LIFE ReTSW-SINT”

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<tr>
<th>Engobe</th>
<th>L*</th>
<th>a*</th>
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<tr>
<td>A4</td>
<td>87.73±0.23</td>
<td>-0.53±0.03</td>
<td>3.99±0.08</td>
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<td>Industrial Engobe</td>
<td>88.21±0.38</td>
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**Morphology (SEM)**

- GOOD AGREEMENT WITH STANDARD
- ACCEPTABLE AGREEMENT WITH STANDARD
- BAD AGREEMENT WITH STANDARD
The purpose of this action is to assess the environmental impact of the use of spent feedstock powders recovered at the end of various thermal spray processes as secondary raw materials for the production ceramic glazes.

In particular it has been considered that the recovered and pre-treated powders are added to the raw materials mixture for the production of quenched glass (“frit”) normally added to the raw materials mixture of a ceramic glaze.

Analysis has been conducted with the Life Cycle Assessment methodology (LCA), in order to consider the whole life cycle of the products, from the raw materials extraction, to the end of life phase, obtaining a “cradle to grave” overview.
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LCA

Thermal spraying: Internal Sieving

Thermal spraying: External Sieving

16.77%

Comparing 27,000 kg "Funzionalizzazione di una pala per turbine (con coprodotti)" with 27,000 kg "Funzionalizzazione di una pala per turbine (senza coprodotti)"

Methods: IMPACT 2002+2002+13 The4d13 Indoor.1d.2.1 / IMPACT 2002+ / Single score
LCA

![Graph comparing APS5 frit and Traditional frit in terms of environmental impact categories: Human health, Ecosystem quality, Climate change, Resources, Energia rinnovabile, and Costi interni. The graph shows a significant reduction in certain impact categories with APS5 frit.}

13.48% decrease in a specific impact category.
LCC

The reduction of energy consumption in the manufacturing phase of APS5 is 73.7%.

The reduction in the energy cost associated to APS5 frit is 60.5%

The reduction of raw material cost is therefore 24.16 %.

The reduction of manufacturing costs per unit of product is 80.22%.

The improvements about workers’ health and safety amounts to 17.45%
Conclusion

• YSZ thermal spraying waste cannot be re-used for thermal spraying process because of morphology and particle aggregation;

• APS5 YSZ thermal spraying waste sieved can replace zircon raw material in variable percentages up to 100 wt.% for white tile production and for sintered products (K4SINT);

• APS6 YSZ and CORINDONE-W thermal spraying waste sieved can replace zircon raw material in variable percentages up to 100 wt.% for coloured products;

• NiCoCrAlY thermal spraying waste cannot be employed due to the presence of chromophore ions that lead to colour the glazes;
2014

S. Barbi, C. Siligardi, Recycling of yttria-stabilized ZrO2 (YSZ) thermal spray waste in tile ceramic glazes, Italian Speech Contest, Parma, ICERS, 16/12/2014

2015

S. Barbi, G. Bevini, R. Casini, C. Siligardi, T. Manfredini, Recycling of yttria-stabilized ZrO2 (YSZ) for ceramic tile glazes and pigments, X National conference on materials science and technology, Favignana, INSTM, 01/07/2015


S. Barbi, C. Siligardi, Recycling of yttria-stabilized ZrO2 (YSZ) thermal spray waste in tile ceramic glazes, Welcome to the life programme, Padova, 28/05/2016

S. Barbi, C. Siligardi, LIFE12 ReTSW-SINT, Firenzuola, 30/06/2016


2017

Coordinator
Ceramica Fondovalle - Vito Remigio

Partners
Turbocoating - Luca Tagliaferri
Fritta - Roberto Casini
K4Sint - Luca Girardini
UNIMORE - Cristina Siligardi
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http://www.elle3.it
GRAZIE PER L’ATTENZIONE

Per ulteriori informazioni:

cristina.siligardi@unimore.it
059-2056236
https://personale.unimore.it/rubrica/dettaglio/siligardi