Case Study 1: Metallic Powder Processing

Case study host:

MBN Nanomaterialia spa – Treviso - Italy.

Brief description of process unit(s) of interest for intensification and motivation:

The case study aims at solving the classification task of the high-density particles produced by ball milling at MBN Nanomateralia. The particles are used in the production of wear-resistant thick coatings.

The material must be sprayed by thermal spraying and for this reason needs to be selected in the narrow particle size range of 10 – 38 µm. Hence, **the main target of the PI for MBN is to put in the production line the different classification steps after the ball milling with a recirculation of the coarser fraction.** This, per se, will constitute a big advancement in the intensification of the process. To do this, some powder classification technologies should be changed (i.e. sieving) and in-line monitoring of the overall process should also be implemented to manage the process.

Currently MBN is classifying the particles in separated steps, with standard sieving and classifying equipment available for powder metallurgy sector that have limits regarding the processing due to the wear and the safety issue of the specific material used. **The aim is to move to a continuous or semi-continuous process to decrease the process costs and increase process yields.** Moreover, **limiting handling operation will decrease the risk of exposure to cobalt (Co) which is carcinogenic, for instance, sieving is a simple and easy process but requires substitution of the meshes that are often broken by this hard material. Due to the risk of exposure to Co, this maintenance work is not easy and would be limited as much as possible.**

Brief description of PI technology chosen:

The chosen PI technology is the Elbow Air-Jet Classifier (hereafter, EJAC). It can classify particles of different size and has the advantages of not using water, magnetic fields, heating, etc. Hence, it is a quite simple element that just needs air streams. The main design difficulty is its shape (curvature to enter in the different channels and lengths between them).

Currently this classification system is available in the market from a few manufacturers outside Europe, and applied by toner producers to separate the smallest particles.

The EJAC working principle has been revised and applied to the separation of the broad particle size distribution in four different ranges: (1) the finest particles, (2) the product for Thermal Spraying, (3) medium sized particles used in other product and (4) bigger particles to be fed back to the milling plant.

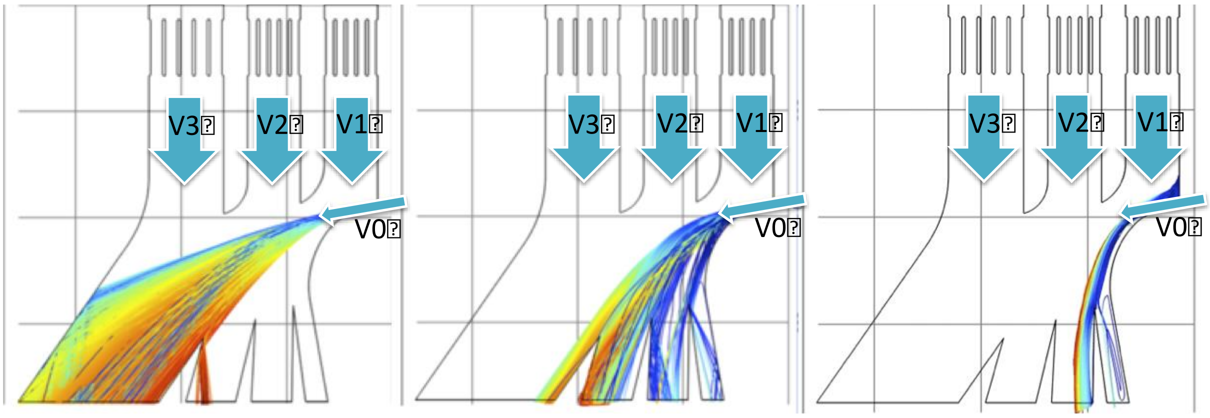


Figure 1 Simulation of particle trajectories in the EJAC, the optimal solution is obtained acting on inlet air velocities (V0 to V3)

Brief summary of results:

The EJAC unit has been realized from scratch, after a complete modelling of the powder dynamic in the classification chamber in response to the velocities V0 to V3 (Figure 1) and in different geometrical configurations.

The validated design has been realized in transparent plastic to evidence particle flows and points of most wear. Three air blowers have been installed to provide the necessary air to curve the particle trajectories in the four outlet.

Two cyclones have been installed for the medium fraction and the product fraction, collecting drums with filters has been chosen for the coarse fraction and the smaller fraction.

The operation is controlled by an external PLC that drives the blowers and collect the data form the installed sensors that measure air flow, pressure, material flow and collected product amount.

Figure 2 From the left: main chamber with analogue pressure control, the installed blowers, the cabin for test confinement

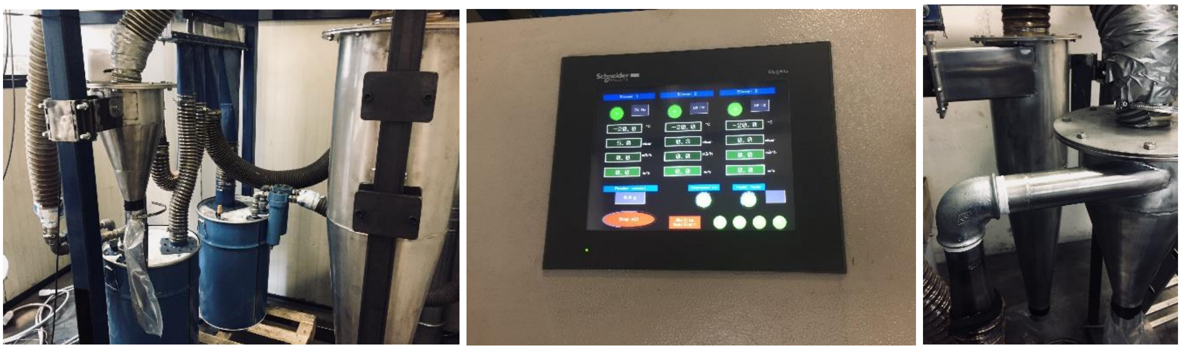
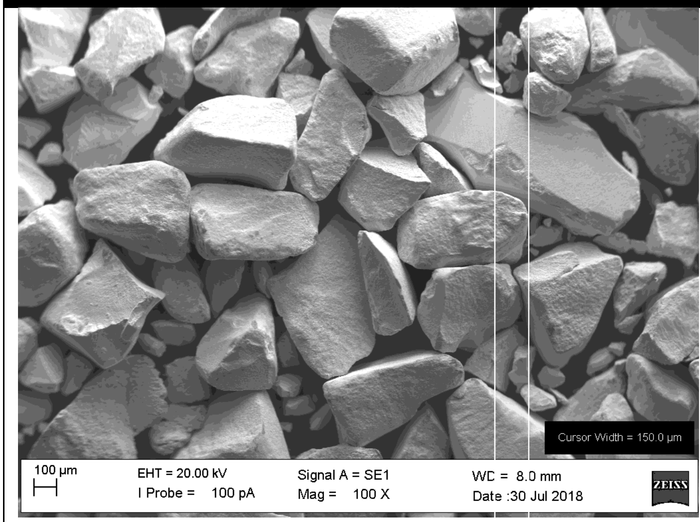
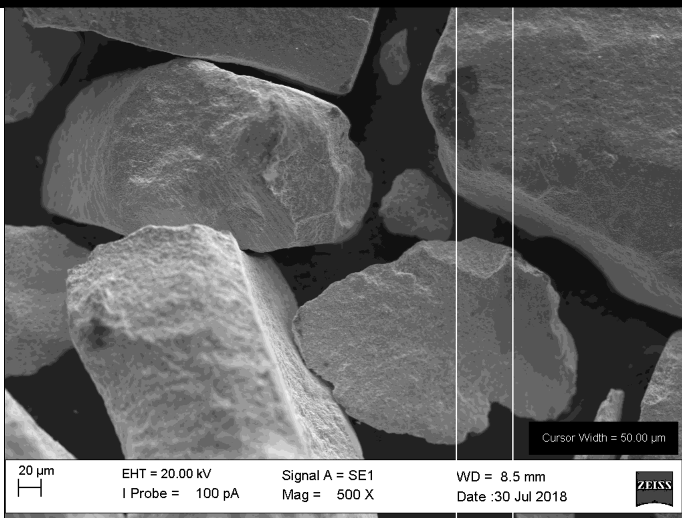
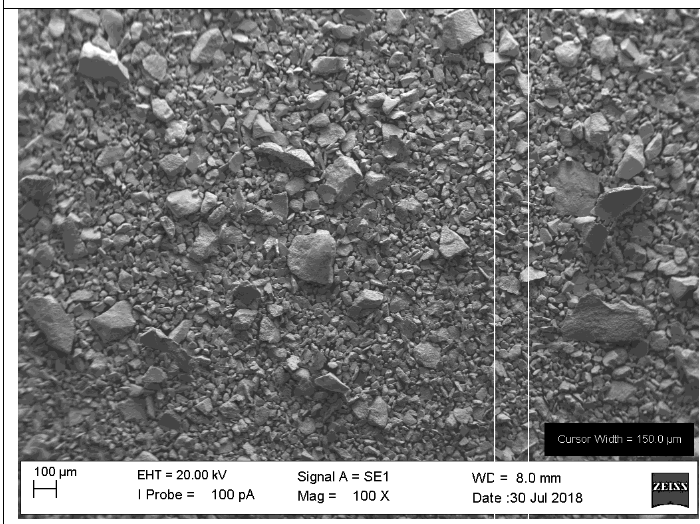
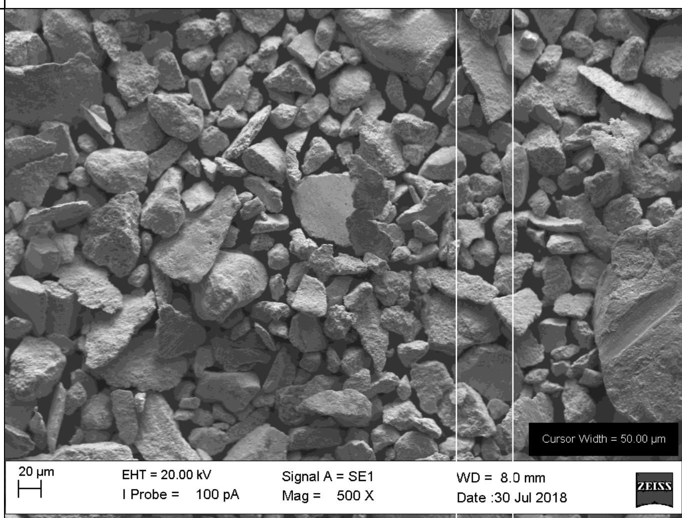
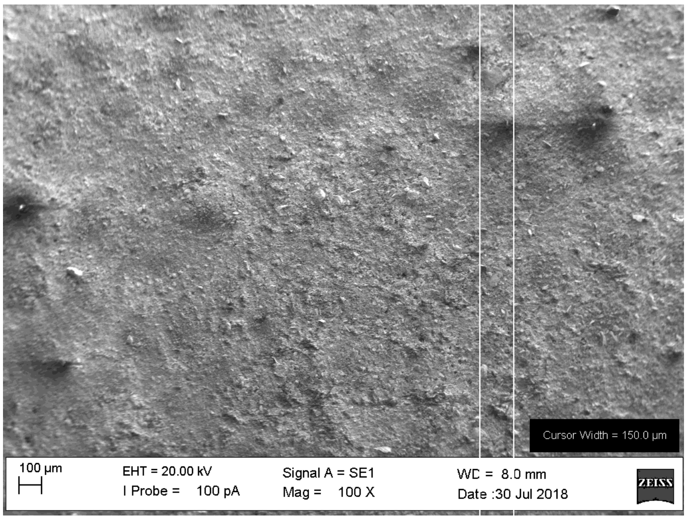


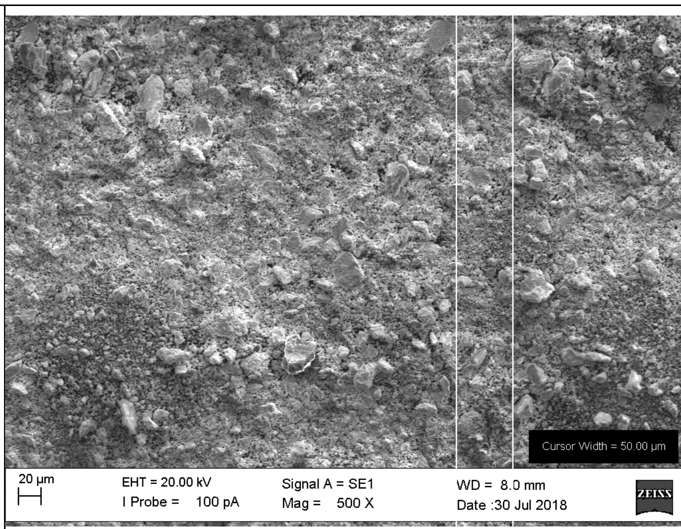
Figure 3 From the left: the cyclones and collecting drums, the PLC running the project, detail of the installed cyclones

The EJAC principle works with the heavy Ceramic-Metal composites tested, the images below are examples of the particles obtained as a result of the classification.

Magnification **100X**	Magnification **500X**
	
Coarse Fraction – 4^{th} outlet	Coarse Fraction – 4^{th} outlet
	
Medium Fraction –3^{rd} outlet	Medium Fraction –3^{rd} outlet



Product Fraction –2nd outlet



Product Fraction –2nd outlet

Final conclusions from case-study:

The PI is a success and it will be certainly adopted permanently among the powder classification systems used for industrial production mainly for its high throughput capacity, cleanness, very limited maintenance and total absence of moving parts and meshes that normally get clogged soon or later.

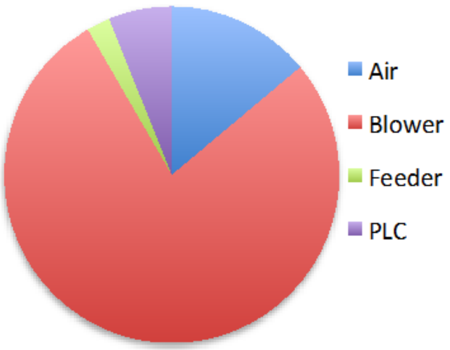
The drawback of the PI is in the limits in particle size resolution that hinders the adoption of the EJAC as it is with the current design. But its effectiveness in separating bigger particles (500-150 range) and medium sized particles (150-50) from the smaller ones is of great advantage in facilitating the overall sieving step and substituting the air-classification for particles below 10µm.

The system throughput has been tested with different powders and fully satisfies the requirements. In the current installation the feeder has been tested with WCCo powder, with particles <500µm, able was able to deliver from 21 to 38 kg per hour. The Throughput capacity was actually limited by the coaxial venturi used to accelerate and inject the particles in the classification chamber, therefore throughout in the range of 20 to 80 kg/h are expected with small hardware upgrades.

The capital expenditure cost of the realized EJAC are in line with those of sieving and classifying technologies utilised for the same purpose, while the operative costs has to be carefully evaluated considering the manpower costs and the benefits from the reduced HSE issues: As evidenced by the histogram graph (Figure 4), although the overall energy consumption is much higher with the new PI solution (about +60%) there is a substantial decrease in manpower needed to operate the plant (about -85%).

In the pie chart of Figure 4 is reported the contribution of the different components of the EJAC to the electrical consumption: in this initial design the Air Blowers are the components that lead the overall PI energy consumption, but those are also the components for which there are more possibilities for optimization.

This estimation of operative costs does not include the maintenance costs, that are more difficult to estimate for the new PI although the new PI is envisaged to require less maintenance, due to the absence of moving parts as well as the absence of filters/meshes that normally have to be periodically substituted and disposed of.



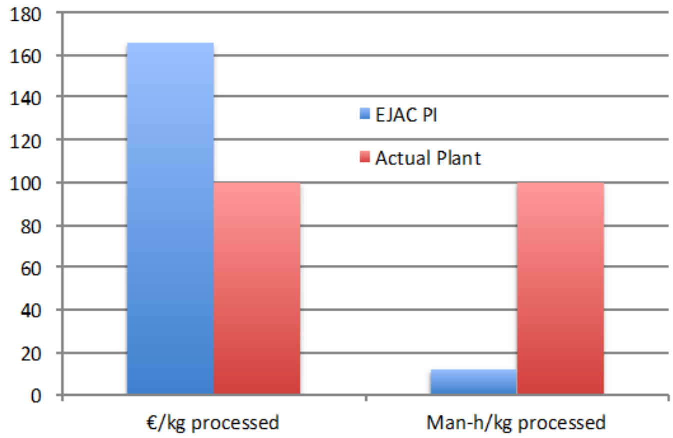


Figure 4 On the left: contribution of the different component of the EJAC to the overall electricity consumption, on the right a comparison with the current solution of classification and sieving

TRL of PI Technology:

The Elbow-Jet-Air-Classifier installed in MBN nanomaterialia is in use for the classification of Tungsten-Carbide Cobalt grit obtained from the recycling of CerMet cutting tips by ball milling, the prototype is operating and its functionalities have been demonstrated in the operational environment. The EJAC can be considered TRL 7 for the multiple classification of ceramic and metal powders.

Summary of the Expected Impact

The expected impact is analysed in the following different aspects:

- **Energy savings:** No major savings are expected in the current configuration due to the high volume of air required, this could be solved with different designs of the PI (i.e. thinner chamber) or using a more specific classification system with less outputs.
- **Time savings/production increase:** The major savings are expected from the lead production time and reduced manpower. Moreover, the PI can be easily integrated with in line with the milling process, thereby removing most of the powder handling and idle times
- **Safety improvements:** The EJAC works in a completely confined environment and can be integrated downstream with an automated packaging equipment. This is of paramount importance when dealing with hazardous materials either for their toxicity or flammability.
- **Cost savings**: An overall cost saving is expected by the reduction of the manpower involvement associated with the simultaneous separation in the EJAC of different particle size ranges and the continuous processing.
- **Environmental impact:** No major improvement is expected in relation to the environment since all the possible releases of material in the environment were already tackled and minimized with the standard classification and sieving equipment. Particles can be released in the atmosphere only if the ventilation system is malfunctioning.

The EJAC process is economically viable in more focused and specific uses. Its high throughput and pure pneumatic principles make it ideal for a first screening of the particles, that could be refined with multi-step EJAC installations, while a single unit with 4 outlets gives not enough resolution in separating the fractions. The optimal scenario consists in having the EJAC installed directly at the milling plant allowing a continuous separation of the powder in the different product lines. Different designs of the EJAC should lead to simple and compact units that could be installed in cascade to enhance the resolution of classification.

More dedicated designs would allow one to reduce the overall cost of the equipment:

Projected figures for capital expenditure are:

Current conventional system – Euro26000
The EJAC systems as currently installed (prototype) - Euro24850
Estimate for a production system at MBN - Euro13200