# The Optional Facilities for the Low Pressure Cold Spray

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**Abstract**

Being the convenient and simple tool to spray localized coatings of any thickness to any metal substrate, the portable DYMET systems have become popular in restoration applications. Elimination of various defects at parts, rolls, moulds is widely used both at plants and work shops. Industrial applications are still limited by the demands to the prolonged nozzle wear and powder feeder long term stability.

The latest development of the optional long-live nozzles and stable non-pressurized powder feeder for the low pressure cold spray process are the next steps to establish it in the production processes. Brief descriptions of the ceramic nozzles for the DYMET equipment and the vibrating-rotating non-pressurized powder feeder are presented.

## Introduction

Gas dynamic spray or cold spray process has passed realization decade. Several types of commercial equipment are presented in the practice now. Powerful high pressure systems with high productivity and deposition efficiency are utilized in mass production and at large objects. Low pressure systems find a use for various local applications.

The characteristic property of the low pressure cold spray systems are radial downstream of the nozzle throat injection of metal - ceramic powder blends (Ref 1, 2). The powder blends are supplied by non-pressurized open powder feeder. The need of only ordinary compressed air at pressures of 5–8 bars with 400 l/min rate and power consumption of about 3.5 kW allow the use of equipment at small plants and repair shops.

Despite of rather small value of powder deposition efficiency 20–30 %, low pressure cold spray systems become convenient tool to build up metal without high temperature input. Most of all applications are connected with the restoration (Ref 3, 4). Nevertheless there are numerous attempts to apply DYMET equipment to serial production. The nozzle wear and powder feed stability turn out to be the restricting factors for some manufacturing applications.

## Typical Low Pressure Cold Spray Application

Being the method of applying the metal with minimal substrate heating the low pressure cold spray equipment is effectively used to eliminate the defects at massive metal objects. Whereas the sealing up the leakages in cyclotron or nuclear object walls was the exotic works, the local defects at huge rolls elimination became the typical procedure.

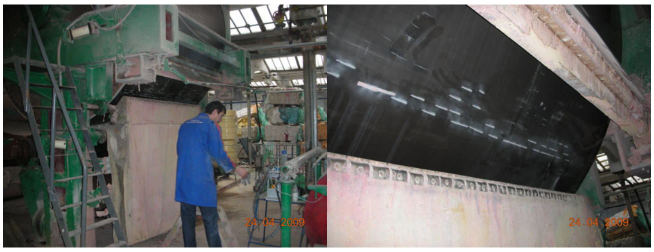

*Figure 1: Defects at huge rolls repair.*

The restoration of defects at casting moulds and casting templates is widely used by industry. Metals sprayed are aluminum, nickel, copper or copper and zinc blend.

*Figure 2: Elimination of defects at casting moulds.*

Restoration of bearing seats, metal building up at corrosion and mechanical damages, through holes sealing up are the customary works at repair shops.

Several hundreds of customers apply DYMET for various automotive parts restoration. The cylinder blocks, cylinder block heads, crankcases, radiators, wheel disks and other parts of modern and antique cars are restored by the cold spray technique.

*Figure 3: Automotive parts restoration.*

The possibility of part restoration attracts attention of manufacturing companies. The casting and machining defects correction by cold spray is often used in small-batch manufacturing.

*Figure 4: Casting and machining defects correction.*

Along with the restoration application low pressure cold spray is applied to local coatings deposition for various technological processes. Thin layers of copper, aluminum, nickel or tin are sprayed by DYMET in electric engineering to create local contact pads at various metal, glass or ceramic substrates.

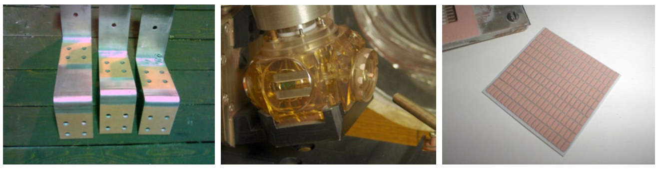

*Figure 5: Contact pads at metal, glass and ceramic.*

Cold spray turned out to be convenient process to create thin anti-seizure coatings at screws of marine equipment and oil-well tubing.

*Figure 6: Anti-seizure coatings at screws.*

In spite of the limited deposition efficiency and production rate of the low pressure cold spray process the variety of industrial application continues to rise. The main problems to those applications become the limitations in nozzle life time and in powder feeder volume and stability.

**Nozzle Wear Rate Modification**

DYMET spray gun consists of light weight air heater and supersonic nozzle. The radial powder injection downstream of the nozzle throat allows the avoidance of the throat erosion or clogging. Only the nozzle profile downstream the powder injection point is the subject of erosion by ceramic component of powder blend. This part of the nozzle is constructed as a changeable insert element.

Until recently cheap stainless steel replaceable inserts was manufactured. Such insert wear life averaged about 2 kilograms of powder blend. With the 0.5 g/s powder jet load the nozzle continuous operation time lasts about 1 hour. Quick change of the insert is not a problem in repair works, but becomes limiting factor for the line production.


*Figure 7: Portable gas dynamic spray system DYMET-423.*

The simple increase of the nozzle insert walls thickness can't prolong insert life time. The erosion changes the nozzle profile and the through hole in the wall appearance is the simple direct indicator of the wrong nozzle profile.

The use of hard metals instead of stainless steel as the nozzle inserts material was confronted with the dilemma of wear rate and cost consistency. The harder is the material, the more difficult is its machining. The same time the material wear mechanism is changing with the material hardness increase from surface abrasion to surface chipping.

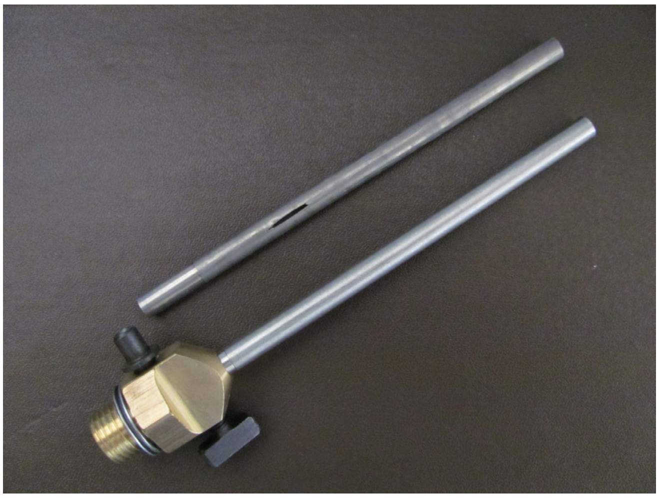

*Figure 8: Nozzle with the steel insert and the eroded insert.*

The success in resolving this problem was achieved by the development of ceramic nozzle inserts. The inserts became rather expensive, but the life time increased more effectively. The last tests demonstrate life time increase up to 20 kilograms for the cheapest ceramic and more then 200 kilograms for the special type ceramic.

Those nozzles with ceramic inserts designed to date have the same jet parameters as former nozzles and can operate in the same temperature range up to 600 °C with the same efficiency.

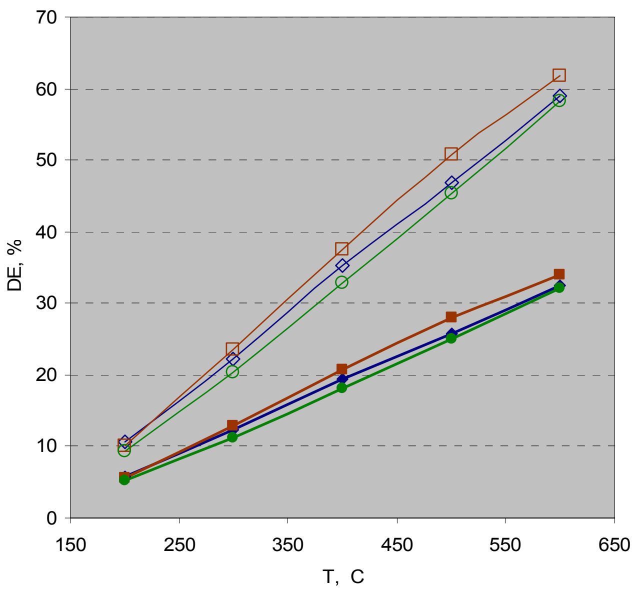


*Figure 9: Deposition efficiency of copper – alumina blend sprayed by the nozzle with steel insert (filled diamonds) and by the nozzles with wear proof inserts (filled circles and squares) at air stagnation pressure 0.50 MPa with various air stagnation temperatures. The same data recalculated to metal content in the blend are in empty symbols.*

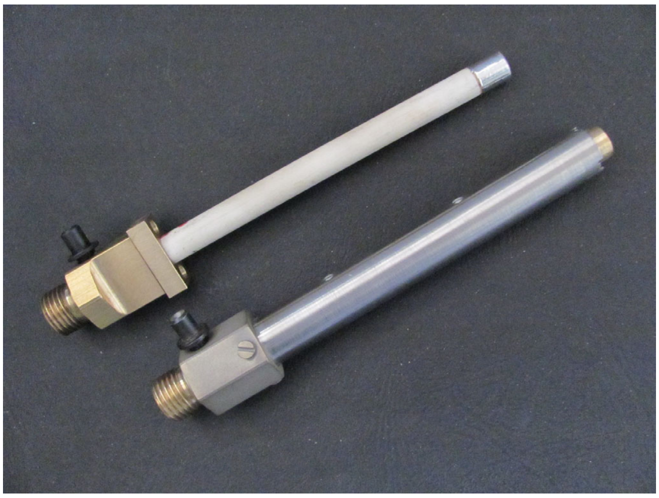

*Figure 10: The nozzles with ceramic inserts.*

The deposition efficiency was calculated as the ratio of the coating mass deposited at mild steel substrate to the weight of the sprayed powder blend. The metal copper mass portion in the blend sprayed is 55 %. The maximum alumina volume inclusions into the coating do not exceed 5 %. Those values make it possible to recalculate the metal copper deposition efficiency for the sprayed copper – alumina blend.

The life time of the nozzles with ceramic inserts is prolonged to more then 10 hours of operation time. Nozzles with ceramic inserts may be easily installed instead of the usual nozzle and are supplied to customers as optional facility.

**Powder Feed Rate Stabilization**

Ordinary vibratory powder feeders mounted at portable DYMET equipment dose powder by vibrating valve. The dosing is rather stable in the powder load range from 50 g to 400 g. The powder supply rate increases at the load below 50 g and decreases at the loads above 400 g. The powder conglomeration at long stops may cause the change of the supply rate. Ambient temperature variation in the range of 10 – 40 °C also influences upon the dosing. The total feed rate deviation under all those reasons could rich up to 20 %. This deviation value is allowable for the local restoration processes but restrict the manufacturing application.

Sophisticated powder feeder is designed to reduce powder feed deviation below 5 % and to increase the powder load volume. Because of the highly dispersed powders easily aggregates, conglomerates and sticks to the walls and dosing elements, both vibration and rotation were used for powder dosing.

The feeder includes several stages of powder preparation and supply. The vibration of the bottom layers of powder volume provides the uniform powder density in discrete volumes. The stream of powder batches by those discrete volumes is supplied to the averaging module. The batch stream frequency is controlled by the rotation rate of the powder transport disk. The rotation rate regulates the powder dosing.

*Figure 11: The external view of the rotationally vibratory powder feeder.*

The averaging module transforms the sequence of batches to continuous powder flow. This flow is poured out through the vibrating funnel to the flexible pipe, connected to the nozzle injection unit.

The powder feed rate depends on the initial powder density and powder properties. The rate is regulated from 0.1 g/s to 1.5 g/s by discrete steps. Thus acceptable for DYMET equipment applications jet load of 0.4 - 0.5 g/s may be achieved for the most of powder types.

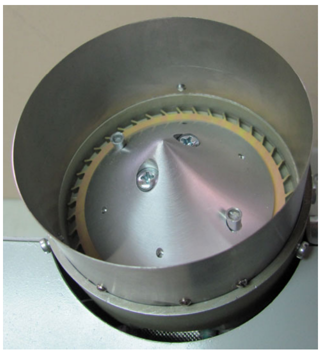

*Figure 12: The vibrating powder transport disk.*

The powder feeder designed has 2 liters volume. This is much enough for the continuous operation more then 1 hour. The powder may be added to the feeder tank just when in operation. The minimal load value is about 50 - 80 g of powder. Stable feed after the initial powder load is reached in 10 seconds.

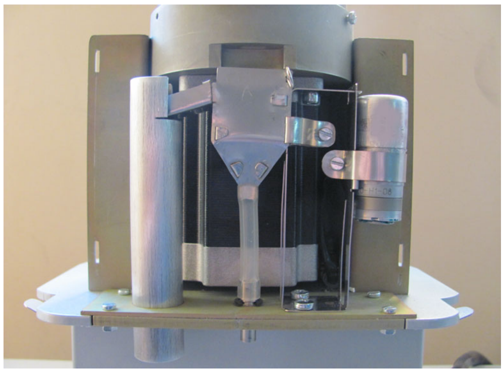

*Figure 13: The averaging module.*

This edition of the rotationally vibratory open powder feeder may be used for the tests or other purposes without sucking out powder of the funnel. Without the pipe the vibrating funnel exit becomes open and the powder fall out by continuous flow.

**Summary and Conclusion**

Being the convenient tool for metal parts restoration, portable low pressure cold spray equipment DYMET has met restrictions in manufacturing applications. Adopting the limited deposition rate and efficiency the production required improved processes duration and stability.

The design of ceramic nozzle inserts enables to prolong continuous operation time to more then 10 hours. Rotationally vibratory open powder feeder provides high stability powder supply for a production environment. The optional facilities developed enhanced process duration and stability in manufacturing applications.

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