Zero-Defect Manufacturing: The next era after Total Quality Management

A Policy Brief prepared by the Zero-Defect Manufacturing group of Projects.
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Executive Summary

Manufacturing represents approximately 21% of the EU’s GDP and 20% of its employment, providing more than 30 million jobs in 230,000 enterprises, mostly SMEs. Europe has embraced and has become a world leader in Industry 4.0, an initiative to bring a quantum leap in manufacturing efficiency and effectiveness. As Industry 4.0 has matured, the concept of Zero-Defect Manufacturing (ZDM) has become a subject of interest, both for single-stage and for multi-stage manufacturing systems improve the process efficiency and product quality, minimizing, eliminating or compensating defects and process errors. The ZDM cluster coordinates a series of innovative, yet consistent R&I approaches to the essential challenges of ZDM, each from its own perspective and in representative critical domains. However, some gaps identified in European policy formulation are impeding the full achievement of European ZDM leadership. ZDM research and development involves long temporary horizons that could be better addressed with innovative R&D funding approaches. Policy level support for the dissemination of a ZDM standardisation culture could help the latter in better taking root within the European industry. Finally, targeted communication and outreach initiatives at the European level could help raise awareness of the strategic contribution of ZDM to the overall goal of continued European manufacturing excellence and worldwide leadership. These recommendations are the result of the direct experience of the projects involved in the ZDM cluster and are based on the activity that projects carried out within the Common Dissemination Booster.
1. Zero-Defect Manufacturing: The next era after Total Quality Management

Industry 4.0 refers to the concept of factories in which machines are augmented with connectivity, possibly wireless, and sensors – becoming Cyber-Physical Systems (CPS) – and connected to a system that can visualise the entire production line, control single processes and group of processes, and make decisions on its own. Within the industry 4.0 concept, Zero-Defect Manufacturing (ZDM) has the goal to improve the process efficiency and the product quality while minimizing and eliminating defects and process errors.

Europe is pursuing as a strategic priority the adoption of new technologies and methodologies in the industrial field and therefore marches towards the integration of industry 4.0 best practices.

Awareness on the ZDM approach for multi stage manufacturing – its potentiality and the benefits in terms of sustainability, process optimisation and innovation – should therefore be improved, especially towards specific industrial stakeholders at a European level.

Moreover, EU projects active within the ZDM field, often face a progress interruption in their R&I activities due to their lifespan. The uptake of the EU projects’ results could be hindered by the lack of standardisation initiatives that could serve to involve industrial players.

This document aims at proposing recommendations at a policy level in order to fulfil the gaps that are slowing down the full achievement of the ZDM approach and impeding a potential European ZDM leadership.
Europe has embraced and become a world leader in Industry 4.0. As Industry 4.0 has matured, the concept of ZDM become a subject of interest. ZDM is driven by the need to minimize and eliminate product quality defects and process errors. Traditional quality control methods, such as Statistical Process Control or the Six Sigma method, require more resources than actually available for the SMEs case; senior management time and resources may be limited, resulting in improvement projects that are underfunded and under prioritized. Furthermore, reports have shown serious limitations in highly changeable production contexts characterized by customized batches, small quantities (or even unique products) and in-line/on-line product inspections and multi stage production environments. Moreover, statistical process control shows limitations, because it does not allow a real time control of the process, is limited in providing data for feed-back and feed-forward control of interacting processes, does not allow real time correlation of data originating from different processes, fails to track a single product and provide associated information. This is where the ZDM cluster of projects comes in. This cluster coordinates a series of innovative yet consistent approaches to the essential problems of ZDM, each from its own perspective and in representative critical domains.
The Z-Fact0r approach introduces production strategies targeting early defect detection, followed by prediction of how the defect will be generated in production and avoiding this through recalibration of the production process, and finally the utilisation of emerging additive and subtractive 3D technologies to rework the product. Addressing the same core issues from a different perspective, STREAM-0D utilizes leading edge simulation technologies coupled with real-time production feedback data once again to identify defects before they enter irrevocably into production and adjust the production parameters to eliminate the defects. An important component of this approach is Reduced Order Modelling, which strips down the complexity of the simulation models to the extent that they can literally be handled by a smartphone. The GO0DMAN project aims at developing ZDM strategies in multi-stage production systems through the integration of quality and process control using agent-based Cyber Physical Systems, smart inspection systems, and advanced data analysis tools. As a result, it is possible to achieve earlier, real-time detection of defects, at the single process level as well as inter-stage processing at the global level, triggering mitigation actions and avoiding defect propagation to downstream processes. Finally, the ZAero project focusses on ZDM in an aerospace context. In the aerospace industry high-quality standards have to be met. In-situ visual inspection is used for quality control, which is currently causing huge productivity losses during lay-up and has become a real bottleneck in carbon fibre parts manufacturing. ZAero targets inline quality control methods for the key process steps, utilising sophisticated system level decision support systems to assist human decision-making and enhancing efficiency.
1.2 Policy challenges

Manufacturing represents approximately 21% of the EU’s GDP and 20% of its employment, providing more than 30 million jobs in 230,000 enterprises, mostly SMEs. Moreover, each job in industry is considered to be linked to two more in related services. European manufacturing is also a dominant element in international trade, leading the world in areas such as automotive, machinery and agricultural engineering. The strategic importance of Europe’s manufacturing leadership was acknowledged in the “Manufacturing 2030” report that the European Commission published for the “Factories of the future” section of the Horizon 2020 program. Thus, it is critical that European policy supports the continued excellence of European manufacturing, and ZDM is one key component.

However, some gaps identified in European policy formulation are impeding the full achievement of its goals of ZDM leadership. Current Research and Innovation policy in the major research programmes such as H2020 foresees structuring of R&I projects with temporal horizons that are aligned with general funding horizons according to generic technological considerations. Taken that ZDM involves long temporal horizons that are met with difficulty by current funding policies, there is a risk of progress interruption and compromising of achieved results. ZDM is intrinsically multi-disciplinary and requires homogeneous progress in all its technological pillars, including measurement systems, process automation, signal acquisition and processing, network connectivity, industrial informatics, data analytics and knowledge management.
Furthermore, whereas some strategic technological domains (such as 5G) have received significant support at the European R&I policy level for standardisation initiatives, ZDM is not yet a beneficiary of this type of policy support, with the result that the standardisation need in ZDM has yet to be fully embraced by companies, hampering its diffusion in industry. In a similar vein, EC policy has yet to provide for the dissemination at EU level of awareness-raising communication initiatives, likewise inhibiting the development of a consistent, effective European-wide strategy for ZDM leadership.
2 Recommendations
2.1 Continuation of Horizon2020 research projects, Technical Orientation of Research

The required timeline of ZDM Research and Development projects is longer than the funded Horizon2020 period, with the majority of Horizon2020 ZDM projects ending with results at TRL 6 or 7. Consequently, a lot of effort is still needed to bring those results to the market and to fully validate the methodology and concepts defined. Although the existing funding process does provide unique opportunities for further research, it doesn’t fully utilize the dynamics of an already established team that could work to bring those results to the market.

Innovative R&D funding approaches would drastically shorten the required time and effort towards marketable results, thus bridging the valley of death to improve the EU’s commercialization activity. As has been already done by the Commission for the advanced materials research sector, it would be particularly relevant to fund ZDM research projects with pilot lines as a continuation of projects, as ZDM is more relevant to the system approach that is applied to the entire manufacturing units. In this way, the ZDM approaches developed in the initial projects will be fully validated, showing the real improvements that will guarantee a higher commercial take up of the project results.

The continuation of Horizon2020 projects would also be beneficial for the organisations involved, as this action would decrease the time needed for innovation delivery or uptake. Furthermore, the action would be beneficial as it would decrease unwanted mobility of researchers and the risk of progress interruption.

The establishment of a European-wide interconnected network of ZDM Pilots could also be foreseen to facilitate knowledge exchange, stakeholders’ engagement and, in the long term, the growth of customer base.
2.2 Standardisation

Although a lot of effort has been done by the active projects in order to record and promote the standardisation needs in Zero-Defect Manufacturing, this remains a funded research goal and has not yet been embraced by companies. The ZDM working groups’ outcomes regarding standardisation need to be communicated through the communication means described in Recommendation No 3. In that way, industry groups can provide important insight and help accelerate the formation of pre-standardisation groups.
2.3 : Dissemination & Communication actions

When dealing with the ZDM concept, it would be effective to use EC channels to implement appropriate actions able to trigger interest from stakeholders in the industrial field, through dedicated actions towards specific segments and not just the general public. Specifically, EC could use its channels (and database of contacts) to disseminate EU ZDM projects’ results towards academic and/or scientific associations in a quite regular manner (for instance: Universities and Research Centres, Scientific Societies and Scientific Committees of Technical Chambers). European Universities can be also enrolled in alerting the public on the Zero-Defect Manufacturing concept.

EC could also use its channels and database to create awareness around the ZDM paradigm and the projects which are involved in the cluster (for instance towards: boards of industrial players, representatives from industrial associations, their contacts with the industry and policy makers, their experience, and their communication channels and activities).

These communications could rely on a consistent communication message able to highlight the benefits of the ZDM approach towards sustainability, a better use of resources, the optimisation of the production process, innovation, increased competitiveness for the industry, waste reduction, etc. This, in order to convey an idea of ZDM as the next era after Total Quality Management.
3  Project Group

www.z-fact0r.eu

www.go0dman-project.eu/

www.zaero-project.eu/

www.stream-0d.com

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