GF Machining Solutions: Real-Time Manufacturing Process in a Cloud Environment

Andreas Rauch

1 *GF* Addressing the Market Trends in Manufacturing

GF Machining Solutions is a world leading manufacturer of milling, electric discharge machining, laser texturing and cutting and additive manufacturing and automation systems and devices, servicing a wide spectrum of industries ranging from specialized aerospace, automotive, medtech, ICT and electric connectors to traditional mould and die segments. One of the new key strategic developments supporting this wide portfolio is an industrial IoT infrastructure, delivering solution applications, based on edge processed and OPC UA standardized machine data, from a cloud environment: the Digital HUB. This infrastructure focuses on real-time, remote service delivery and advanced process optimization, augmenting machine capabilities and simplifying the use of the technologies by the customers. The main driver for such a transformative development has been the increasing pressure on those customers regarding productivity, costs and resource efficiency, at a varying degree for the market segments of attention.

Mould and die manufacturing has been historically the major target for *GF Machining Solutions*, and the company has provided dedicated innovations for improving the corresponding process performance, in particular with

A. Rauch (✉)
Georg Fischer AG, Schaffhausen, Switzerland
e-mail: andreas.rauch@georgfischer.com

O. Gassmann, F. Ferrandina (eds.), *Connected Business*,
https://doi.org/10.1007/978-3-030-76897-3_16

Electric Discharge Machining, which enables a high-precision profile and cavity shaping independently of material hardness. More recently, conventional and advanced manufacturing devices have been integrated in the portfolio, which, together with automation systems, provide the most efficient framework for modern demanding applications extending to production markets.

The high-precision capabilities of those technologies have been pulled, on one side, by the miniaturization trend of the various products manufactured out of moulds and dies: ICT devices, sensors, connectors, IC circuits, etc. On the other hand, performances have been pushed by the growing capacity of numeric controllers in terms of digital data handling and real-time feedback loops adapting to changing process dynamics. These advances implied a quantum leap in terms of stability at higher productivity rates independently of part complexities (Suh et al. 2008).

For production markets like aerospace and medtech, additional requirements for surface quality and traceability are met thanks to the development of appropriate advanced sensor networks and post-processing data analytics, which results in optimum machining strategies. These require, however, external machine learning or AI processing capabilities, and offline adjustments, often performed by domain experts, who converge only gradually to the desired operational efficiencies (Caggiano et al. 2015).

2 Production Efficiency Through 5G Process Manufacturing

The current context makes necessary a new framework for sustaining the improvements required by industries, as end-product's lifetime becomes shorter and functionalities demand increasingly diverse features and new materials. 5G manufacturing in a cloud environment presents here a great potential for delivering high-performing process stability and productivity as it responds to the quest of real-time transfer of multiple sensor data at high rates, amplified processing capabilities and low latency-secure feedback to machine controllers and automated systems for monitoring and optimization at new levels. Table 1 summarizes the different new features and advantages of the 5G framework with respect to traditional CNC frameworks.

Eventually such capabilities will lead to the implementation of full Digital Twins, where prediction capabilities incorporate all the relevant asset information for the most accurate control of manufacturing towards any required, possible KPI for the real system.

Table 1 Comparison between traditional CNC and 5G IoT augmented process manufacturing, author's own illustration

Feature	Traditional CNC	5G IoT augmented CNC
Sensors	– Fixed	– Wireless, mobile and secure
Data process and aggregation	– Bounded to local computer capacity	– Expandable through cloud infrastructure
Process control	– Real time: limited to single sensor data and relatively linear domains	– Possible sensor fusion and non-linear machine learning modelling in real time
	– Pre-processing needed for high-frequency sensors	– Raw data process able even for high-frequency sources
Knowledge management	– Information silos, bounded to machine or personnel	– Open, shared between machines and personnel
Flexibility	– Static, dependent on redesign or offline re-programming	– Dynamic, smoothly adaptive and customizable online
Business model	– Product oriented	– Service oriented

3 *GF* New Digital-5G-Enabled Industrial IoT Infrastructure

The new *GF* digital foundation infrastructure, Digital HUB, has been built up around GFMS devices following a dedicated industrial IoT architecture, based on OPC UA standards for machine-to-machine communication and a common EDGE environment collecting and structuring machine data for delivering business applications with different solution targets. The vision of the corresponding, future, 5G-enabled infrastructure is represented in Fig. 1. Based on new features from Table 1, the advantages of such a framework are the following:

- Remote services and real-time information from machines: 5G brings unlimited capacity for data transfer and processing so that full fleet information is available for condition monitoring of all the machine functional components, providing live remote assistance, readily enhanced with augmented/virtual reality.
- Process monitoring from multiple sensors which can be arbitrarily located inside the machine or cell, close or attached to process parts for maximum sensitivity and aggregated for sensor fusion and holistic regulation of manufacturing processes, this in order to deliver the highest accuracy and productivity framework.
- Process and service analytics using machine learning and artificial intelligence at cloud level, using modern data science approaches, with distributed and high-speed computing which are necessary for new real-time control of current complex systems (multi-axes cutting, laser machining and additive manufacturing).

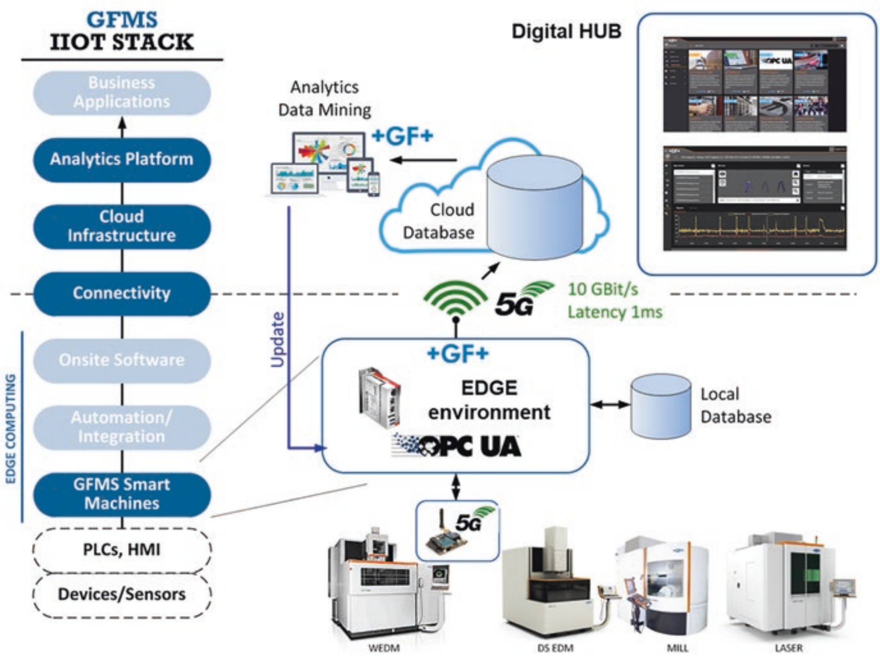

Fig. 1 GF Machining Solutions—5G industrial IoT infrastructure vision, author's own illustration

- Manufacturing process and services control: able to reach loop time dynamics of the order of 1 ms thanks to new 5G latency possibilities in an industrially secure environment, either on private or encrypted public networks.

Finally, in aggregate, those advantages around a cloud environment allow to envision a real-time, seamless available, delocalized manufacturing, with remote monitoring, service and control of all components of the manufacturing processes along their lifecycle, as they clearly establish the virtual teleportation capability of those manufacturing assets in complete information systems.

4 Creating Value in Manufacturing with a New 5G IoT Infrastructure

The new 5G framework offers different opportunities against current challenges in manufacturing for critical aerospace and automotive components, medical implants and instruments as well as high-precision moulds and dies, at single machine or automated robotized cell level, along the full lifecycle of the process.

5 A Use Case for 5G Manufacturing: Real-Time Process Monitoring

In collaboration with *Fraunhofer IPT* and *Ericsson*, *GF Machining Solutions* has implemented the first pilot for 5G-enhanced manufacturing of high-quality components, by integrating real-time wireless sensors attached to the part, during a 5-axis machining process, into the IoT framework, for seamless visualization and real-time analytics. This innovative approach allows simultaneous quality control and optimizes the efficiency of the full process. The system and results are represented in Fig. 2.

An analysis of benefits of such a system is presented by *Fraunhofer* and *Ericsson* (Fraunhofer IPT 2018), for the particular case of aerospace component manufacturing. The production of such components involves high-strength Ni and Ti alloys; complex geometries requiring multi-axes, high-speed milling, resulting in special manufacturing strategies from the point of view of parameter design; long machining times and dedicated quality control; and high costs parts and relatively high level of rework and scrap rates. Defected part levels can be as high as 25% for some critical components as turbine blades and disks, as they require achieving the highest surface quality standards for ensuring secure turbomachinery performances.

Thereby vibration analysis is with wireless sensor data integrated into the *GF* industrial IoT Digital HUB infrastructure. Vibration spectra can be correlated with surface quality on the part 3D model, allowing real-time follow-up of process quality, defining a new business model with simultaneous online analytics capabilities of the system.

The 5G industrial IoT-enabled manufacturing allows in this case to first reduce the development time of the machining strategies as extended trial times can be shortened when parameters appear to create chatter phenomena putting at risk the surface quality. Secondly, the system can provide real-time warnings during the production process so this can be managed in a way to reduce resource waste or accelerate the quality control process in a final stage. Eventually, the framework will allow the real-time control of manufacturing so that control parameters are adjusted online for constraining vibration values to required tolerance bands while keeping the process stable and performing.

6 IoT Infrastructure Benefits and Business Models

While the previous methodology and system can be conceived in a traditional CNC environment, it will be far from efficient in terms of costs and performances. Only a 5G industrial IoT infrastructure will allow such a solution by

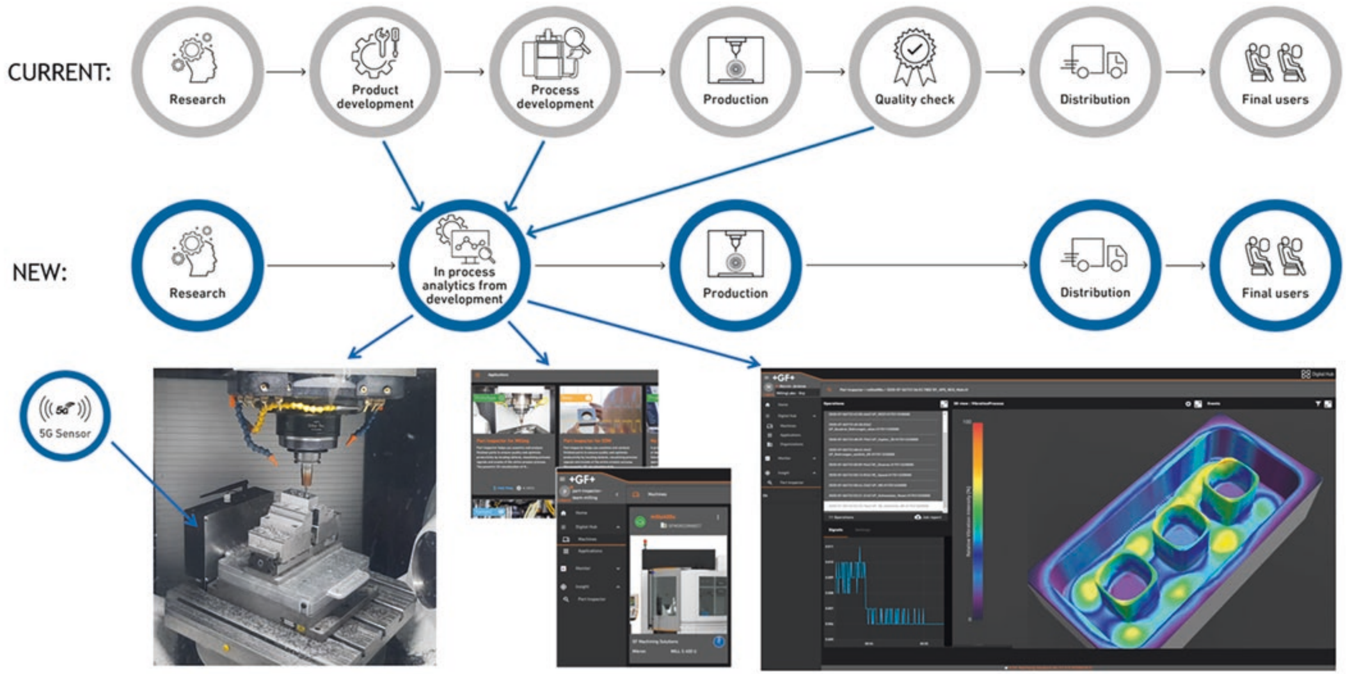

Fig. 2 5G real-time process monitoring system and test use case for part, author's own illustration

delivering a high-fidelity Digital Twin of the process dynamics, by integrating various data sources at high frequency in a cloud environment, able to aggregate and process it with analytic tools in real time. Additionally, the framework provides unlimited, low-cost capacity for storing this information in data lakes or warehouses, which, with appropriate information models and ontologies, will enable to integrate learnings from other similar systems and update particular ones in automated way (Cho et al. 2018). This as long as data can be shared between stakeholders by taking into account their concerns for data protection and legal regulations.

Finally, such dynamic framework will enable switching to new business models by lowering barriers for PaaS and SaaS in manufacturing, as it will convey the implementation of Digital Twins, through which costs can be under the full control of machine tool manufacturers. These can thus provide advantageous contracts including continuous improvement packages as well as maintenance and quality guarantees, and OEMs can further lower investments by enabling data sharing within the new network. For instance, it is estimated that up to 70% of costs during machine tool lifecycle arise in the maintenance area (Mourtzis et al. 2016). As most of these costs are due to unexpected failures and quality issues, implementing 5G industrial IoT-enhanced control will therefore eliminate those risks and provide a unique tool for a sustainable, economic manufacturing. *GF* will use the industrial IoT infrastructure to implement the strategic ESG (environmental, social and governance) goals.

7 Conclusion

As the leading provider of complex manufacturing systems involving diversity of technologies and manufacturing applications, *GF Machining Solutions* can provide unique advantages for dealing with current manufacturing challenges in mould and die and production industries. A new 5G industrial IoT infrastructure in place provides the best framework for implementing those solutions by extending the capabilities of traditional numeric controls in such a way that they can delegate the pre-processing, post-processing and data analytics of multiple, appropriate data sources to a cloud environment. The new framework opens the door to Industry 4.0 integration of smart sensors, machines and human expertise into a common, seamless available, source of optimization of processes and services as quality monitoring and predictive maintenance, and to new advantageous business models for all involved stakeholders and the global sustainable environment.

Lessons Learned for Implementing Real-Time Manufacturing via Cloud

- Assess and document your manufacturing process chain in terms of data, information flow and functional objectives.
- Map your costs and related relevant business and technical KPIs.
- Design a Digital Twin for your process delivering the previous information needs.
- Identify sensor gaps in order to enable process data collection automation for your Digital Twin.
- Assess data network needs in terms of data velocity, veracity and variety in order to specify the best transmission channels and protocols.
- Design or adjust requirements for cloud infrastructure architecture, from connectivity to process analytics and business application availability levels.
- Implement pilot data collection and the required, secured Digital Twin monitoring applications.
- Collect insights and deploy analytics applications.
- Launch large data collection and deploy digital twin intelligent solution.
- Learn and improve.

References

Caggiano A et al (2015) Wire EDM monitoring for zero-defect manufacturing based on advanced sensor signal processing. Procedia CIRP 33:315–332

Fraunhofer (2018) Fraunhofer IPT, Ericsson and GF to present 5G manufacturing solution for the first time in the US Press release Fraunhofer IPT, September 11

Mourtzis D et al (2016) A cloud-based approach for maintenance of machine tools and equipment based on shop-floor monitoring. Procedia CIRP 41(2016):655–660

Andreas Rauch is Head of Digital Business at GF Machining Solutions and is responsible for digital strategy, the development of digital business models, and sales. He fosters the implementation of IoT with a focus on standardization, machine-to-machine communication, big data management, analytics platforms, legal frameworks, and customer experience. Born in Zürich, Switzerland, he graduated in Mechanical Engineering and postgraduate studies in business administration and software development. Andreas founded his own company in 1998, specialized in Design to Manufacturing processes, and sold it in 2010 to a leading company in the turbomachinery environment. Before joining GF Machining solutions, he was GEs Head of Advanced Works in Europe and responsible for Digital Twin implementation projects and Brilliant Factory Systems.