# Tools of Industry 4.0 on Die Casting Production Systems

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**Abstract.** In Industrial Revolution 4.0 applications the production is increasingly digitized. Moreover, component-driven production is supported. Machines used in production systems exchange very big amounts of process data with one another. The most impressive part is the big amounts of data which can be analyzed for production improvements. Of course, die casting industry has faced these challenges very close. Because each component of an integrated manufacturing system of die casting process requires managing the big data. According to the Industry 4.0, it is possible to adapt various tools and concepts to the manufacturing system with the help of modern information technology and the machine flexibilization. If users can access the process data easily the material flow can be analyzed and optimization along the process can be done. Although there are some challenges in applications, practical potentials of the tools of Industrial Revolution 4.0 especially in die casting production systems offers many advantages especially in management of big data for process improvements.

**Keywords:** Industry 4.0 · Die casting · Integrated manufacturing systems

## 1 Introduction

Industry is the branch of activity in bulk production by changing the nature or form of a substance by means of machinery and the related equipment and tools. The first industrial revolution was based on the usage of water and steam power machines in industry. After that, during the second industrial revolution period, is more known as the mass production period, the most evolving industry has emerged from the need for standardized products. The first mass production line was to manufacture automobiles with serial production lines. This is referred to today as Industry 2.0 and is still the main building block of production. With the third industrial revolution, manufacturing automation has progressed. With computer controlled production, more precise, efficient and better standards have been produced. Of course, the main characteristics of the Industrial Revolutions were technological, socioeconomic, and cultural.

As the last, Industry 4.0 focus of the research policy of the German government in Industry. Their aim was to define scientific targets which shows the current and future


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challenges of society and industry. The main features of this new era, in which the interconnected processes are in communication, the objects communicating over the Internet, collecting data and completely changing the production process, emphasize the interaction of the machines with people. The industrial revolution, manifests itself in the subject of many manufacturing. Today, especially integrated mass production systems benefit from the incomes of the new industrial revolution. The high pressure die casting industry also takes its share from these developments. Because the high pressure die casting industry is one of the best examples of integrated mass production systems with many components [1].

## 2 Smart Factories

Mass production, which was prevailing over the last decades, is increasingly displaced by the production of product variants and of individually customized single parts. A second aspect that comes into play is the lack of utilization of modern information technologies in the manufacturing industry. A "Smart Factory" is intended to be the solution for the challenges of the manufacturing industry. Smart factories contain highly flexible production systems, which are capable of producing single individual parts with the required quality and economic efficiency [2]. A "Smart Factory" is offers a highly digitized and integrated production facilities that relies on smart manufacturing which connects the plant to other entities in the digital supply network, enabling more effective supply chain management. In the course of Industry 4.0 there are well known set of systems and concepts such as "The Internet of Things", "Cyber-Physical Systems" and "The Big Data Analytics" were defined. This paper mentions the common systems and concepts of Industry 4.0 at the frame of die casting production systems. But less known, in general almost unmentioned, are "Flexible Production Systems" and "The Component-Driven Production". Figure 1 shows an Industry 4.0 adapted high pressure die casting smart foundry.

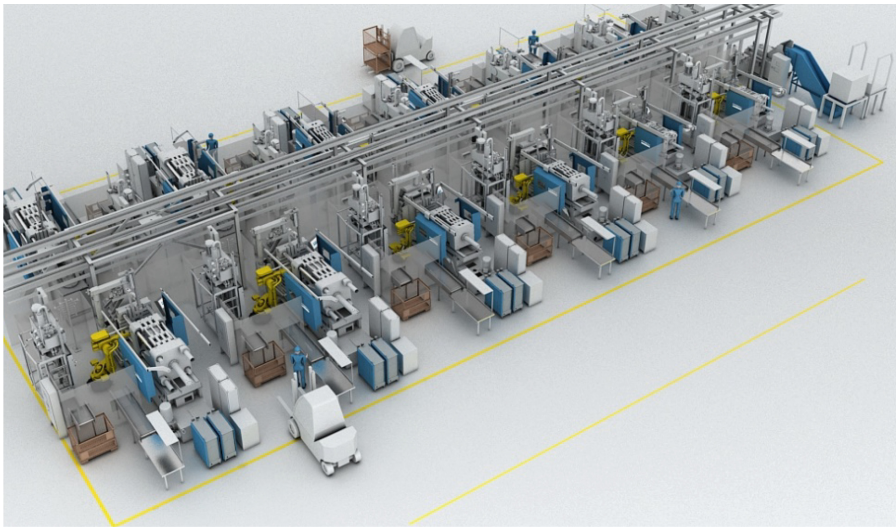

**Fig. 1.** Industry 4.0 adapted smart foundry

## 3 Die Casting Production Systems

High pressure die casting is a unique casting method for manufacturing fully automatic, high efficiency and high quality parts with a large scale of weight. An integrated mass production system can be established with a die casting machine, a melting furnace, a molten metal transfer system and a mold heating/cooling system. Such an integrated system allows continuous high quality and efficient production by a well-designed operating conditions. An Industry 4.0 adaptable pressure die casting system offers very important and economic advantages that other casting methods cannot provide. The crucial manufacturing parameters like gate velocity and intensification pressure for better quality parts can be collected as the big data about manufacturing and be analyzed as computer aided quality parameters which were used for continuous improvement of the process. The obtained big data from manufacturing process could be used to increase the product quality expectations like high density and satisfactory mechanical specifications [3].

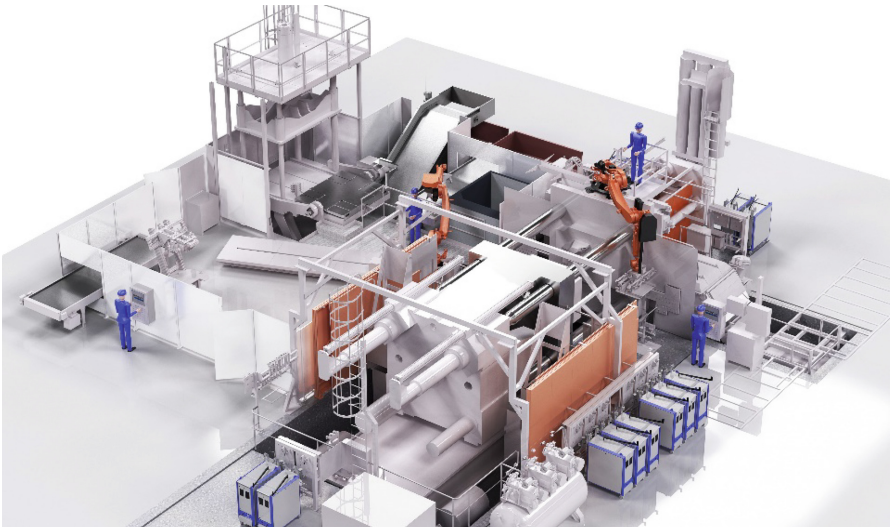

**Fig. 2.** Production system of an industry 4.0 adapted high pressure die casting cell

The information technology that is used for production machines should be modern IT technology to drive such big amount of data. One of the core aspects of Industry 4.0 is the use modern IT technology in manufacturing systems [4]. The use of modern information technology and the flexibilization of foundry machines and foundry processes are necessary. Figure 2 shows a very good example of a mass production system of an Industry 4.0 adapted high pressure die casting cell.

## 4 Tools of Industry 4.0 on Die Casting Production Systems

In this paper, the well-known set of tools used for die casting production systems in industry 4.0 basis such as "The Internet of Things" important especially in data collection, "The Big Data Analytics" important especially in data analysis and "Cyber-Physical Systems" were respectively defined (Fig. 3).

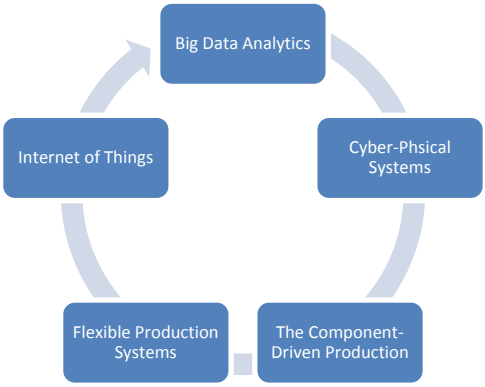


**Fig. 3.** Tools of industry 4.0

### 4.1 Internet of Things

Over the past years we have heart of several project and many applications and cases related to the Internet of Things. They were maybe about a series of technologies or devices, maybe were about platforms and applications that are connected to a network or devices. Data collection and analyses is the subject of the big data concept. However, the collection of this data even it is a big one, is directly related to the internet of things. If we think about the die casting process, there are hundreds of thousands process data come from each shot belongs to several process parameters like gate velocity and intensification pressure. Of course, the users receive value from the ability to collect data from connected devices (Fig. 4). Information about each processing step can be transferred internally and externally between the single processes of the process chain allowing to individually adjusting machines and processes to achieve quality and economic efficiency.


**Fig. 4.** Internet of Things

### 4.2 Big Data Analytics

In integrated high pressure die systems mostly produce a significantly greater number of data sources and higher information density which will lead to an enormous increase in significance of data driven analysis and control systems. Smart foundries uses analyzing algorithm and software tools and control tasks for many years like other manufacturing industries. The problem in data acquisition is requiring high effort and cannot be automated. The other problem is the mystery in the history of the part. They need to be marked with unique codes for identification. Because of the economic concerns of this application, knowledge-based approach will be necessary to include data-driven systems into the control of casting processes [2].

### 4.3 Cyber Physical Systems

The virtual or digital representation of an object or a process can be supplied by a cyber physical system. For instance, in die casting industry many manufacturers uses simulation programs in different variations of process parameters already. Differently, a cyber physical system represents digital interaction of the part with the virtual representation. Although many modern machines have Programmable Logic Controllers and have digital interfaces for automation and data transfer. The data is stored in the machines or section controllers but is not present for a comprehensive analysis. However, an integration of computation with physical processes need to be defined by both cyber and physical parts of the system. So that, optimize the production and adjusts machines, processes and planning towards a multi-criteria would be possible (Fig. 5).

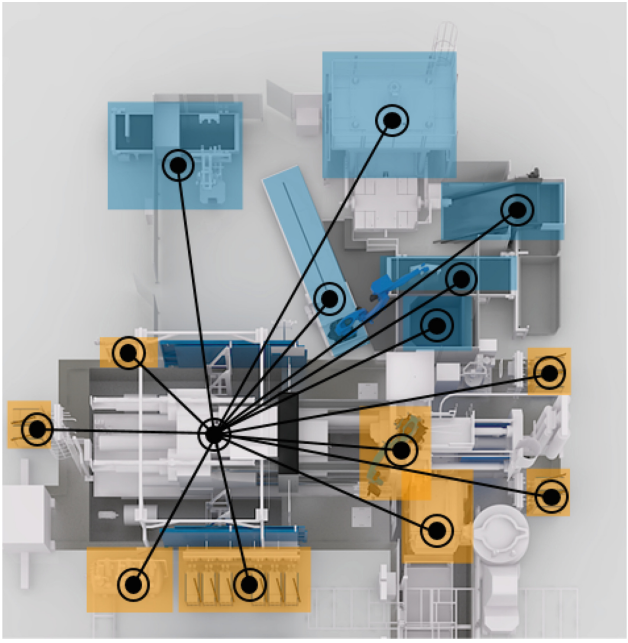

**Fig. 5.** Cyber and physical parts of a die-casting system

## 5 Conclusions

The major task of Industry 4.0 is to realize a highly flexible production system that is capable to produce casting parts even with small and/or specialized lot sizes. The Internet of Things, Big Data Analytics and Cyber-Physical Systems are the main supporting systems to archive this goal. The use of modern information technology and the flexibilization of machines and/or processes are necessary to be succeeded. If machine and process data are accessible without barriers, there are lots of possibilities to link these and to carry out comprehensive optimization along the process chain of die casting. The ability to interact with data and to expand the capabilities of the physical world through computation and communication are the key renders for future technology developments.

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