MEMS IN CONTROL TOWER

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DECLERATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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LIST OF ABBREVIATIONS

BI	Business intelligence
DTS	Downtime Tracking System
ET	Engineering Technician
HPMM	HP Malaysia Manufacturing
IoT	Internet Of Things
KPIs	Key Performance Indicators
MEMS	Micro Electro-Mechanical System
MT	Manufacturing Technician
SAP	System Applications Products
VBA	Visual Basic for Applications

MEMS DALAM MENARA KAWALAN

ABSTRAK

Industri 4.0 ialah sebuah trend semasa dalam automasi dan pertukaran data dalam teknologi pembuatan. Membangun dan melaksanakan papan pemuka adalah perkara biasa dalam kilang-kilang digital yang besar untuk meningkatkan prestasi peralatan dan proses yang produktif. Papan pemuka yang dibangunkan bertujuan untuk meningkatkan prestasi dengan memberikan maklumat yang cekap ke kawasan yang produktif dan menjadikan maklumat ini menjadi pengetahuan, pelan, dan tindakan yang mempromosikan aktiviti talian pengeluaran yang berkesan dan juga untuk mengurangkan masa pengumpulan data dan meningkatkan proses membuat keputusan. Salah satu fasa utama, pembangunan susun atur papan pemuka, dilakukan dengan mempertimbangkan pengurusan visual dan peningkatan yang berterusan dan juga meningkatkan keputusan di semua peringkat. Untuk mencapai papan pemuka yang berkesan, pembangunannya harus mempertimbangkan semua Petunjuk Prestasi Utama (KPI) untuk semua pusat kerja di jabatan MEMS. Hasilnya menggariskan bahawa KPI yang berbeza dipilih untuk papan pemuka pada tahap hierarki yang berbeza dan pusat kerja yang berbeza. Papan pemuka ini dapat meletakkan semua data penting pada satu skrin besar dan pembuat keputusan boleh menganalisis data dan membuat keputusan cepat. Prosedur yang dicadangkan ini membantu kilang digital dalam mencapai papan pemuka untuk meningkatkan prestasi kawasan yang produktif, meningkatkan maklumat dan komunikasi yang produktif dan mempromosikan budaya peningkatan berterusan di barisan pengeluaran.

MEMS IN CONTROL TOWER

ABSTRACT

Industry 4.0 is a current trend of automation and data exchange in manufacturing technologies. Developing and implementing dashboards is common in large digital factories to improving the performance of productive equipment and processes. The developed dashboard intends to improve performance by efficiently providing information to the productive areas and turn this information into knowledge, plans, and actions which promote an effective production line activity and also to reduce the data collection time and improve decision making. One of the main phases, the development of the dashboard layout, was performed considering visual management and continuous improvement and also improve decision making at all stages. In order to achieve an effective dashboard, its development should consider all Key Performance Indicators (KPIs) for all work-center in the MEMS department. The results underline that different KPIs are preferred for dashboards on different hierarchy levels and different work-center. This dashboard is able to put all important data on one large screen and the decision makers can analyze the data and make quick decision making. The proposed procedure assists digital factory in achieving a dashboard to improve the performance of productive areas, improving productive information and communication and promoting a culture of continuous improvement at the production line.

CHAPTER ONE

INTRODUCTION

1.1 HP Malaysia Manufacturing

HP Malaysia Manufacturing (HPMM) (Figure 1.0) was given their Smart Manufacturing project to School of Mechanical Engineering, USM. The project is called “MEMS in Control Tower”. This project is to provide visibility and control in the smart digital manufacturing factory. The manufacturing control tower uses to collect and analyze real-time information data to improve decision making at all stages of the manufacturing process. The requirements of this project are to work with manufacturing team to understand Micro-Electro-Mechanical System (MEMS) operational data and purpose the Control Tower concept in their daily operation. This includes dashboard design, develop the metrics, visual management and delivering the dashboard via mobile devices, large displays, individual workstations, terminal and others.

Figure 1.0: HP Malaysia Manufacturing (HPMM)

1.2 Concept of the manufacturing control tower

Think about the concept of an air traffic control tower, a centralized location where a multitude of aircraft are monitored, directed, and communicated with during both takeoff and landing (Ostdick, 2016). Air traffic controllers at an airport tower ensure for safe and efficient movements of aircraft at the airport and its vicinity. Their decisions always depend on the current situation. To assess the relevant situational aspects information is mostly acquired visually (Manske and Schier, 2015).

The primary responsibility of the control tower in aerospace term is to ensure sufficient runaway separation between landing and departing aircraft. This concept has been used to underscore the point that a similar type of control tower is needed to manage HPMM daily operation in MEMS department. The associated, implicit (and sometimes explicit) message is that you can manage your daily operation simply by looking at a couple of key metrics on a dashboard or spreadsheet (Nandakumar, 2017). The concept was amazing and look systematic to see the overall performance and encounter the problem that can be implemented on the shop floor or production line. The control tower can identify, recognize and control the aircraft speed, direction, and position. This control tower concept is what HPMM trying to implement in their plant.

The main goal of this project is to provide a good visual of real-time manufacturing data to improve decision making at all stages of manufacturing process. The project outcome focuses more on real-time data and the dashboard design that can be view in a large display and be used by all employers in HPMM included managers, work-center owner, engineer, technical specialist, and ET/MT (operators). Big data systems use many machines working in parallel to store and process data, which introduces fundamental challenges unfamiliar to most developers. Big Data shows how to build these systems using an architecture that takes advantage of clustered hardware along with new tools designed specifically to capture and analyze web-scale data (Marz and Warren, 2015). Real-time data will be linking with big data analytics system in this project to make sure the data published in the dashboard will have the high level of integrity.

1.3 Industrial 4.0 Big Data Analytics in manufacturing company

The advances in the internet technology, internet of things (IoT), cloud computing, big data, and artificial intelligence have profoundly impacted manufacturing. The volume of data collected in manufacturing is growing. Big data offers a tremendous opportunity in the transformation of today's manufacturing paradigm to smart manufacturing. Big data empowers companies to adopt data-driven strategies to become more competitive (Tao et al., 2018). The smart factory is an important feature of Industry 4.0 that addresses the vertical integration and networked manufacturing systems for smart production (Kagermann et al., 2013).

For a smart digital manufacturing factory to be implemented, it should combine the smart objects with big data analytics (Wang et al., 2016). In MEMS department in HPMM, the System Applications Products (SAP) data come out raw from four basic process that is Barrier, Drill, Attach, and Platting. So, the data was coming from a various machine in all four process.

Smart manufacturing aims to convert data acquired across the product lifecycle into manufacturing intelligence in order to yield positive impacts on all aspects of manufacturing(O'Donovan et al., 2015). The systematic computational analysis of manufacturing data will lead to more informed decisions, which will, in turn, enhance the effectiveness of smart manufacturing(Shao G, 2014). This project is trying to implement this big data analysis so that it can increase HPMM daily, weekly, and monthly yield, output, and target. This can help HPMM to transform their business process in MEMS department in future. Based on the extant research, by academician and industry shows that retailers can achieve up to 15-20% increase in ROI by putting big data analytics.

1.4 MEMS process flow

The function of MEMS department in HPMM is responsible for fabricating the Integrated Print head (Engine) of all Inkjet printers. In MEMS department consist of four main process or work-center that is Barrier, Drill, Attach and Platting.

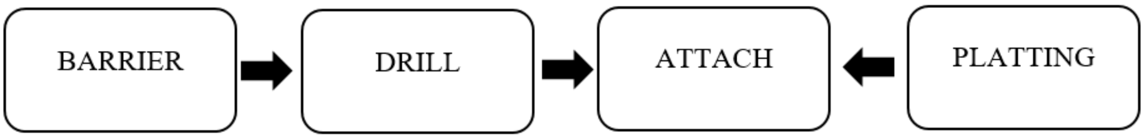

Figure 1.2: MEMS process flow

1.4.1 Barrier

Barrier is the first process in MEMS department. The name is from ‘ink Barrier’. There is three main function of Barrier that defines the firing chamber volume, defines the ink inlet channel, and act as an adhesive between the Thin Film and Orifice Plate.

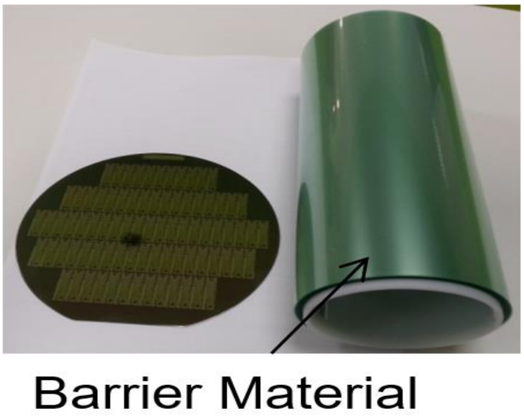

Figure 1.3: Example of Barrier material

1.4.2 Barrier process flow

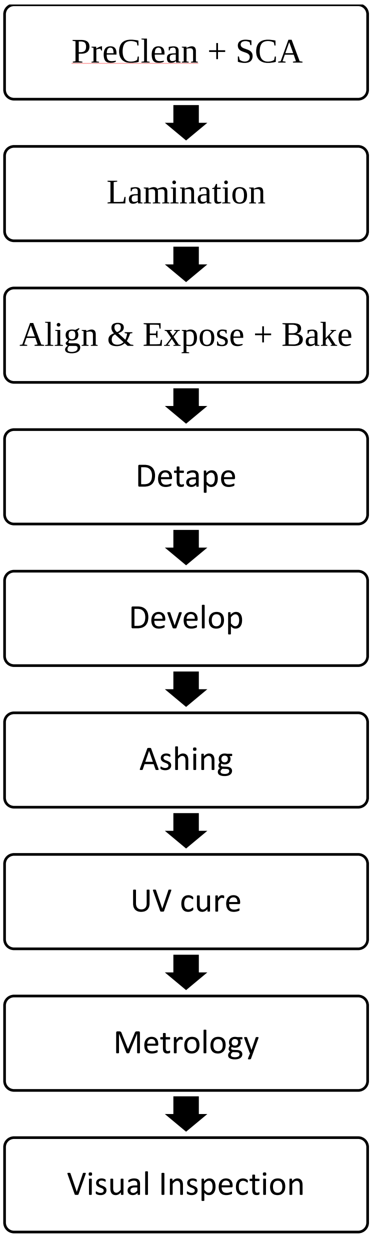

Figure 1.4: Barrier process flow

1.4.3 Drill

Drill is a second process after Barrier and has the main function that creates slots that allow ink to flow from pen body through print head to firing chambers. Slotting start from the back of the wafer to minimize damage to the Thin film circuit and Barrier architecture on the front of the wafer.

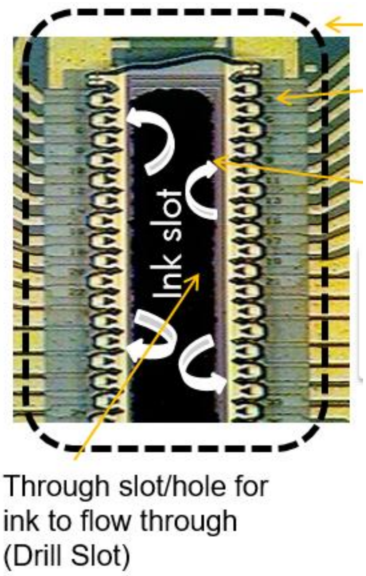

Figure 1.5: Top view of the die (with OP plate removed)

1.4.4 Drill process flow

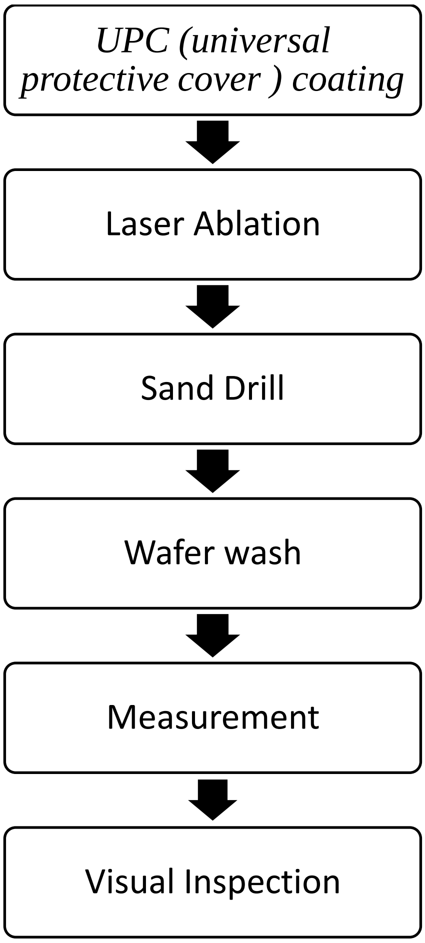

Figure1.6: Drill process flow

1.4.5 Platting

Platting is a process to create the ‘orifice’ where ink is ejected. Platting was prepared after we have done mandrel process. But mandrel process will not be discussed in this project since HPMM did not manufacture it. Platting process can easily be understood by using sketching in Figure 1.7.

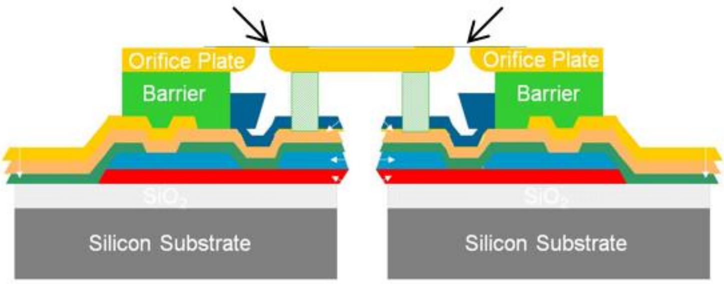

Figure 1.7: Platting process

1.4.6 Platting process flow

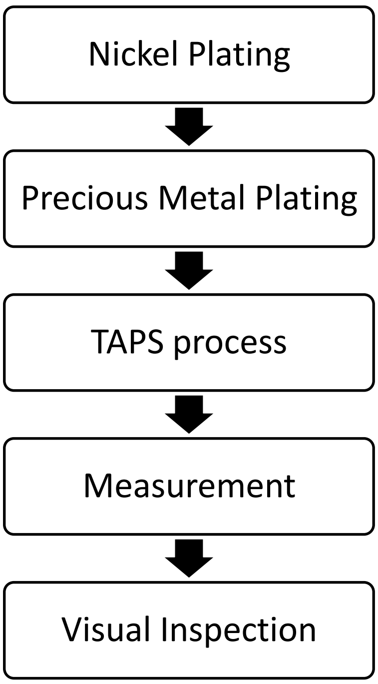

Figure 1.8: Platting process flow

1.4.7 Attach

Attach is the final process for MEMS department. MEMS are considered as a brain for HP printers. Attach process is to attach a 'Good' OP plate on each good die with the required alignment. Figure 1.8 shows the illustration of the good attach process.

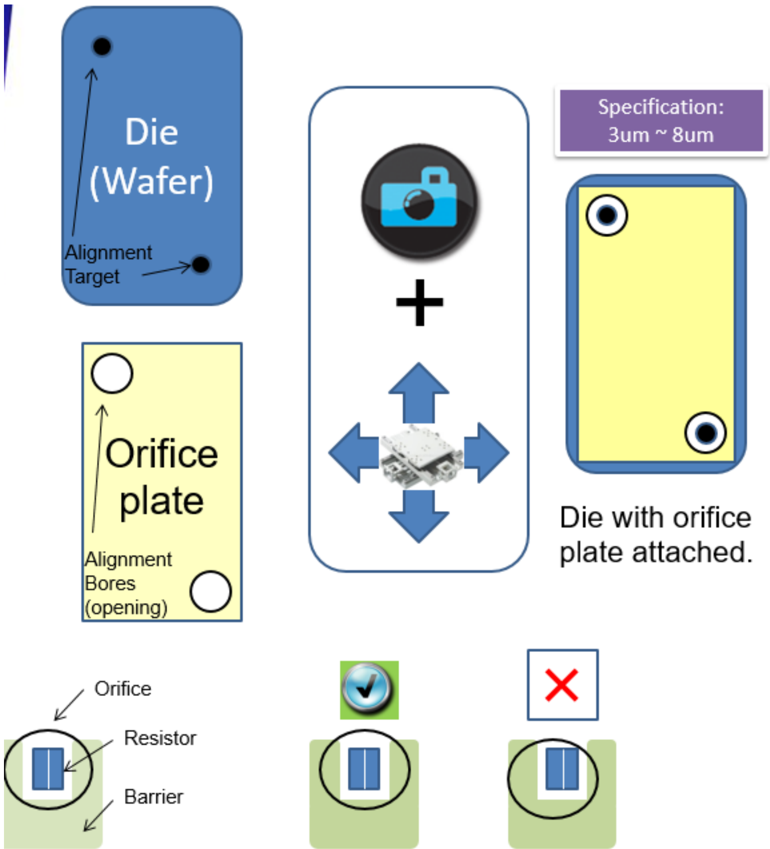

Figure 1.9: Attach illustration process

1.4.8 Attach process flow

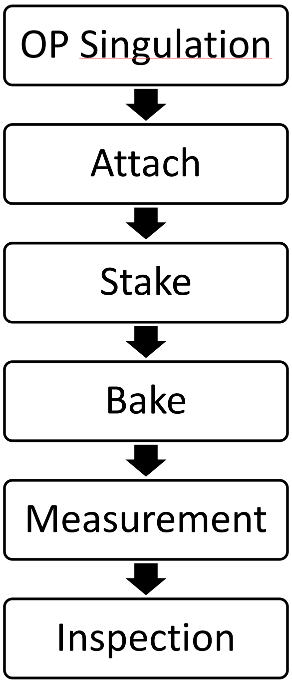

Figure 1.10 Attach process flow

1.5 Dashboard

Business intelligence (BI) is what we want after we analyze raw data and turn that data information into actionable informative knowledge. By using BI HPMM can identify cost-cutting opportunities, uncover new business opportunities, recognize changing business environments, identify data anomalies, and create widely accessible reports.

A dashboard is a visual interface that provides at-a-glance views into key measures relevant to an objective or business process. We want this BI concept to turn impossible amounts of data into useful knowledge. Dashboards are ideal mechanisms for delivering this targeted information in a graphical, user-friendly form. Most of the data analysis and reporting did in business today is done by using a spreadsheet program. In this project, we will use Excel dashboard as the platform for dashboards and reports.

1.5.1 Excel dashboard

HPMM is in corporate America, they are conversant in the language of Excel. With an Excel dashboard, the users spend less time figuring how to use the tool and more time viewing the data.

In Excel, features such as pivot tables, drop-down lists, and other interactive controls (such as a checkbox) don’t lock your audience into one view. And because an Excel workbook contains multiple worksheets, the users have space to add their own data analysis as needed.

Excel can help to automate certain processes and even connect with various data sources. With a few advanced techniques, our dashboard can practically run on its own. In most companies, funding for new computers and servers is limited, let alone funding for expensive dashboard software packages.

Excel contains so many functions and features that it is difficult to know where to start. We can go from reporting data with simple tables to creating meaningful and informative dashboards sure to please everyone.

1.6 Problem statement

This project is being proposed to have a good visibility and control in the digital factory. Therefore, the main objectives of this project are to collects and analyses real-time information or data to improve the decision making at all stages of the MEMS manufacturing process. There three main problems that need to be solved in this project.

There are a lot of manufacturing data available in each process in MEMS department and some of them did not make sense to the decision maker. The decision maker needs only a few engineering performance metrics to view their everyday performance. Every day they need to filter the raw data and select a few one to show them their current process performance.

The decision makers need a dashboard design that has eye-catching visualizations. Some of them feel that the dashboard looks messy and not easy to understand. The current dashboard design was combined all four-manufacturing process in MEMS department that is barrier, drill, attach, and platting. So, the dashboard design needs to look simple and user-friendly and get better visibility into data from different perspectives.

The real-time manufacturing data need longer time to collect and engineers need to collect and analyze the data. The data collection time takes a longer time for the decision maker to decide. By implementing this project, the data collection time can be reduced and can lead to a good decision making.

Among the journals about real-time manufacturing data collection was discussed how to collect the data and make sure that the data was relevant and make sense for the decision-making stage. The journal did not specify how to make the machine communicate with the system to triggered malfunction or defect in the production line. Almost all the current research was trying to figure out how to transform the factory to become smart factory based on industrial 4.0 specification. The recent research was trying to use Big Data and IoT platform to transform the factory.

1.7 Objectives

1. To create design a dashboard that shows the overall performance of the process
2. To analyze the real-time manufacturing data in MEMS department.
3. To reduce the data collection time and improve decision making at all stages of MEMS manufacturing process.

1.8 Scope of study

In this study, Analysing large amounts of data and report those results in a meaningful way is the main goal. Current MEMS dashboard is using the number and it is not easy to understand so this project will get better visibility into data from different perspectives and easy to all work-center to understand.

Adding interactive controls to show various views is very important in this project because this will add more value to the Excel dashboard. Creating eye-catching visualizations also the main goal of this project since this dashboard will be using a lot of managers and engineers.

Concepts such as table structures, filtering, sorting, and using formulas will show a lot in this project since we play with many raw data from HPMM server. Building customized charts that fit into HPMM distinct needs.

CHAPTER TWO

LITERATURE REVIEW

2.1 What is Industry 4.0?

The "Industrial 4.0" concept appeared first in an article published by the German government in November 2011, as a high-tech strategy for 2020. After mechanization, electrification, and information, the fourth stage of industrialization was named "Industry 4.0". In April 2013, the term "Industry 4.0" appeared again at an industrial fair in Hannover Germany, and quickly rose as the German national strategy (K. Zhou, 2015).

The concept of Industry 4.0 is based on the integration of information and communication technologies and industrial technology and is mainly dependent on building a Cyber-Physical System (CPS) to realize a digital and intelligent factory, in order to promote manufacturing to become more digital, information-led, customized, and green.

The purpose of Industry 4.0 is to build a highly flexible production model of personalized and digital products and services, with real-time interactions between people, products, and devices during the production process (J. Wan, 2014). The basic principle of Industry 4.0 is the core of IoT and smart manufacturing (L. Research, 2014): work in progress products, components and production machines will collect and share data in real time. This leads to a shift from centralized factory control systems to decentralized intelligence.

The future of manufacturing will see industrial production systems become more intelligent through use of digital systems. Within the first three industrial revolutions, humans have witnessed and created mechanical, electrical and information technology, which were aimed at improving the productivity of industrial processes (K. Zhou, 2015)

2.1.1 History of Industrial Revolution

The first industrial revolution improved efficiency through the use of hydropower, increased use of steam power and development of machine tools. The second industrial revolution brought electricity and mass production (assembly lines); the third industrial revolution further accelerated automation using electronics and information technology, and now the fourth industrial revolution is emerging which is led by CPS technology to integrate the real world with the information age for future industrial development. Figure 1 displays the four stages of the industrial revolution (Luo, 2014).

In order to better transform from Industry 3.0 to Industry 4.0, Germany has developed a strategic plan to implement Industry 4.0. The main points of this plan can be summarized as building a network, researching two major themes, the realization of three integrations, and achievement of eight planning objectives (Luo, 2014).

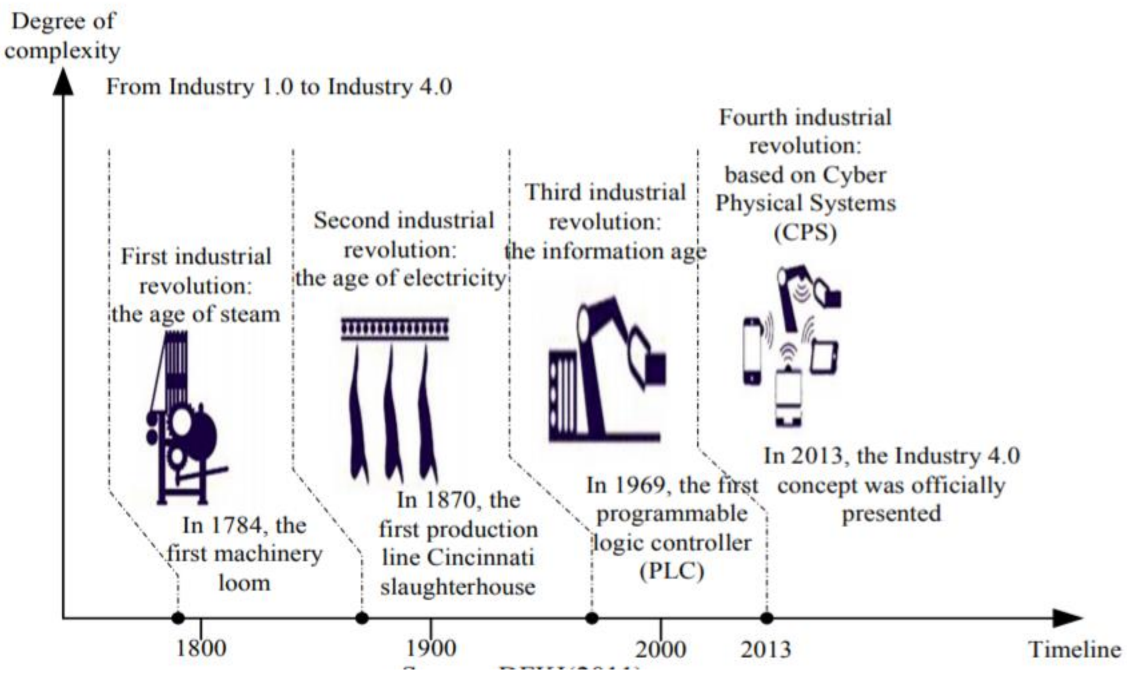

Figure 2.1: The four stages of the industrial revolution (Luo, 2014)

The smart factory and intelligent production are the two themes under research. The "smart factory" is a key component of future intelligent infrastructure, which focuses on intelligent manufacturing systems and processes, and implementation of networked distributed production facilities (K. Zhou, 2015).

2.1.2 Smart manufacturing factory in Industrial 4.0

Industry 4.0 is a complex and flexible system involving digital manufacturing technology, network communication technology, computer technology, automation technology and many other areas.

The smart factory is a manufacturing cyber-physical system (CPS) that integrates physical objects such as machines, conveyors, and products with information systems such as MES and ERP to implement flexible and agile production. In this section, a framework for the smart factory is proposed and its operational mechanism is investigated (Wang et al., 2016). The concept of CPS was first defined in 2006 by Dr. James Truchard, who introduces the concept that the virtual world and the physical world can be merged by CPS. In fact, a CPS is an integrated system of computing, communications, and control (Lee, 2008).

Industry 4.0 makes use of CPS technology to build a CPPS platform (as shown in Figure 2), which connects virtual space with the physical world, to enable equipment in a smart factory to be more intelligent, thus creating better production conditions enabling smart production (B. Vogel-Heuser, 2014).

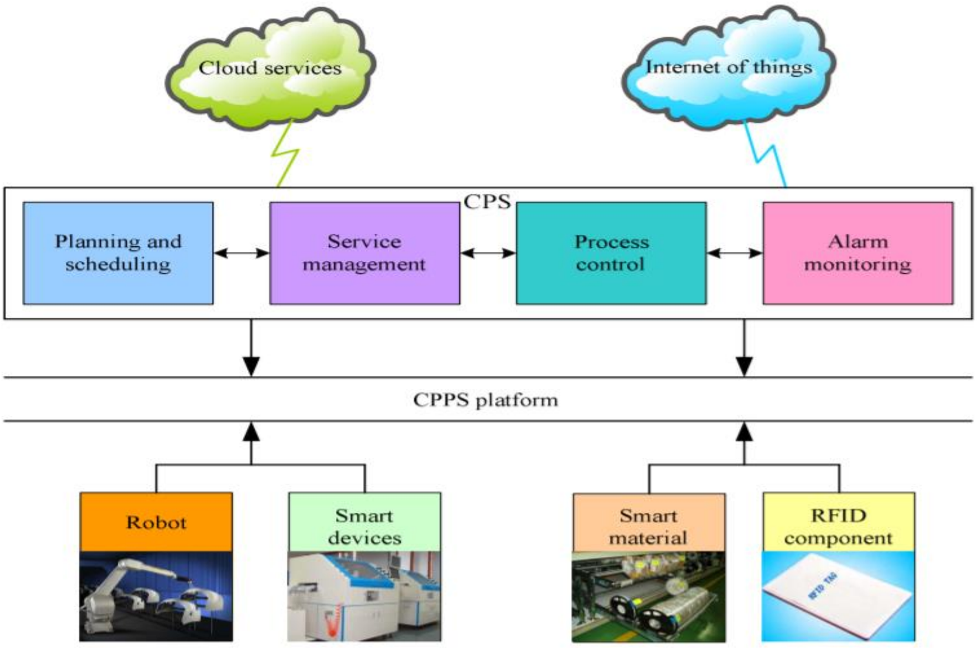

Figure 2.2: CPPS platform in Industry 4.0

2.1.3 Big Data in Manufacturing Industries

The manufacturing industry is currently in the midst of a data-driven revolution, which promises to transform traditional manufacturing facilities into highly optimized smart manufacturing facilities. These smart facilities are focused on creating manufacturing intelligence from real-time data to support accurate and timely decision-making that can have a positive impact on the entire organization. To realize these efficiencies emerging technologies such as the Internet of Things (IoT) and Cyber-Physical Systems (CPS) will be embedded in physical processes to measure and monitor real-time data from across the factory, which will ultimately give rise to unprecedented levels of data production (O'Donovan, 2015).

Modern manufacturing facilities are data-rich environments that support the transmission, sharing, and analysis of information across pervasive networks to produce manufacturing intelligence (Davis, 2012). The predicted exponential growth in data production will be a result of an increase in the number of instruments that record measurements from physical environments and processes, as well as an increase in the frequency at which these devices record and persists measurements. The technologies that transmit this raw data will include legacy automation and sensor networks, in addition to new and emerging paradigms, such as the Internet of Things (IoT) and Cyber-Physical Systems (CPS) (Lee, 2015). The low-level granular data captured by these technologies can be consumed by analytics and modeling applications to enable manufacturers to develop a better understanding of their activities and processes to derive insights that can improve existing operations (O'Donovan, 2015).

"How are big data technologies being used in manufacturing?". The focus on big data technologies in manufacturing environments is a relatively new interdisciplinary research area which incorporates automation, engineering, information technology and data analytics. Table 1 shows candidate search terms identified through the exploration of paper abstracts that were returned by the search query using both 'big data' and 'manufacturing'.

Main terms	Candidate terms
Manufacturing	Smart manufacturing, Advanced manufacturing, Industry 4.0, Cyber-Physical System, Supply chain, Factories, Factory, Production, and Process
Big data	Large-Scale data, Cloud computing, Machine learning, Big-data analytics, Data virtualization, and Master data management

Table 2.1: Main and candidate search terms for big data in manufacturing

2.1.4 Mobile Internet and Internet of Things Technologies

Since the birth of the Internet, the interconnection between computers has become a reality. The mobile Internet has achieved communication and contact between people across large distances. Both have changed the way that people interact, and the Internet and the mobile Internet have quickly infiltrated and influenced modern industrial systems. Germany's Industry 4.0 strategy has observed that we will make more use of the Internet and Internet of things for interactions between human and machines enabling intelligent manufacturing and producing the fourth revolution.

As computing power and the storage capacity of smart mobile devices increases, mobile terminals and mobile APP will be used in the near future to design, manufacture and manage the industrialization process, and will become the “new normal” for the industry. As shown in Figure 2.3, smart mobile terminal applications in industry (D. Gorecky, 2014) can easily control and monitor intelligent processes in factories (Zhu, 2015).

Figure 2.3: Smart mobile terminal applications in industry (D. Gorecky, 2014)

As network communication technology develops, there is a vision that things will be able to “talk” to each other, blending the virtual world with the physical world, which has emerged as the Internet of things (IoT). The IoT includes radio frequency identification (RFID) devices, infrared sensors, global positioning systems, laser scanners and other information sensing devices and other arbitrary objects, which can be connected to the Internet according to an agreed protocol, for information exchange and communication, in order to realize intelligent identification, location, tracking, monitoring, and management (Miao, 2014). The role of IoT in Industry 4.0 is also indispensable.

2.2 Building Basic dashboard components

The dashboard allows users to interact with the whole platform and obtain required information (Chien et al., 2017). The visual representation of relational data is very important for researchers in many application domains. Static or dynamic graphs are typically visualized by either node-link diagrams and adjacency matrices (Burch, 2018).

In the current Industrial 4.0 era, most aspects of life depend on and driven by data, information, knowledge and user experience. The quality of data, information, and analysis of such entities from past to its projected future activities. Information Visualization, Visual Analytics, Business Intelligence, machine learning and application domains are just a few of the current state of the art developments that effectively enhance understanding of these driving forces (Banissi and Huang, 2018).

2.2.1 Formatting dashboard to your way of visualizations

The main goals of data visualization are to communicate the data and ensure that it is understood (Lea et al., 2018). Examples of data visualization tools include Tableau, Google charts, SAP Lumira, QlikView, SAS JMP and Visual Analytics, MicroStrategy, Microsoft PowerBI, and so forth.

Data visualization involves creating and studying the visual representation of data that has been abstracted in some schematic form, including attributes or variables for the units of information to facilitate the identification of patterns in the data. This allows the data to be presented in a format that is easier to explore, analyze, and use to support hypotheses (Bačić and Fadlalla, 2016, Gu et al., 2017).

2.2.2 The pivotal pivot table

Data analysis at the descriptive stage and the eventual presentation of results requires the tabulation and summarization of data. Pivot tables and pivot charts are one of Excel's most powerful and underutilized features, with tabulation functions that immensely facilitate descriptive statistics (Grech, 2018a).

Pivot tables permit users to dynamically summarise and cross-tabulate data, create tables in several dimensions, offer a range of summary statistics and can be modified interactively with instant outputs (Dobashi, 2017). The dashboard focuses on operational and tactical aspects by monitoring the core operational processes that drive the business on a day to day basis, so pivot tables are very important to organize all the data (Bastas and Liyanage, 2018).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Date/Time	Year	Date	Month	Time	Hour	Minute	Day of the week	User full name	Enrollment	Affiliation	Affected user	Event context	Component
2	25/05/16, 14:29:40	2016	16/05/25	2016/05	14:29:40	14:00	14:29	Wed.	Student-01	2015	Econo	-	File: 演習課	File
3	25/05/16, 14:29:23	2016	16/05/25	2016/05	14:29:23	14:00	14:29	Wed.	Student-02	2013	Law	-	Course: 社	System
4	25/05/16, 14:29:06	2016	16/05/25	2016/05	14:29:06	14:00	14:29	Wed.	Student-03	2016	Law	-	File: 6.4 度	File
5	25/05/16, 14:29:01	2016	16/05/25	2016/05	14:29:01	14:00	14:29	Wed.	Student-03	2016	Law	-	File: 6.2 Ex	File
6	25/05/16, 14:28:36	2016	16/05/25	2016/05	14:28:36	14:00	14:28	Wed.	Student-03	2016	Law	-	File: 6.3 度	File
7	25/05/16, 14:28:34	2016	16/05/25	2016/05	14:28:34	14:00	14:28	Wed.	Student-04	2016	Econo	-	File: 演習課	File

Table 2.1: Example of data integration in the pivot table (Dobashi, 2017)

2.2.3 Chart that shows trending

The plotting of data into graphs should be a mandatory step in all data analysis(Grech, 2018b). Excel will "fit" nonsense trend lines to data presented on column and line charts, and can report an inadequate number of significant digits for polynomial trend lines. (Hargreaves and McWilliams, 2010).

Applying creative label management is needed when we build up a trending chart. For example, when month names look and feel very long but it needs to be on the dashboard. Words place on their sides inherently cause a reader to stop for a moment and read the labels. (Liengme and Ellert, 2009).

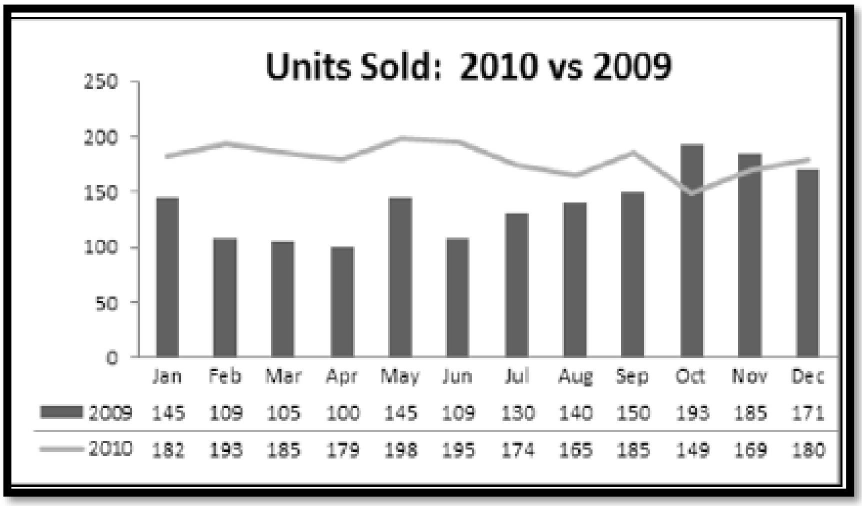

Figure 2.4: Example of trending chart in Excel (Alexander, 2014)

2.3 Building advanced dashboard components

2.3.1 Performance against a target

A trend is a measure of variance over some defined interval typically time periods such as days, months, or years (Li et al., 2015). Line charts are the kings of trending. In business presentations, a line chart almost always indicates movement across time. Even in areas not related to business, the concept of lines is used to indicate time consider timelines, family lines, bloodlines, and so on (Alexander, 2014).

Although the name is fancy, comparative trending is a simple concept. You chart two or more data series on the same chart so that the trends from those series can be visually compared. In this section, you walk through a few techniques that allow you to build components that present comparative trending (Alexander, 2014).

A thermometer-style chart offers a unique way to view performance against a goal (Alexander, 2014). A good example could be while analyzing revenue performance of regions or sales reputation as shown in Figure 2.6 (Liengme and Ellert, 2009).

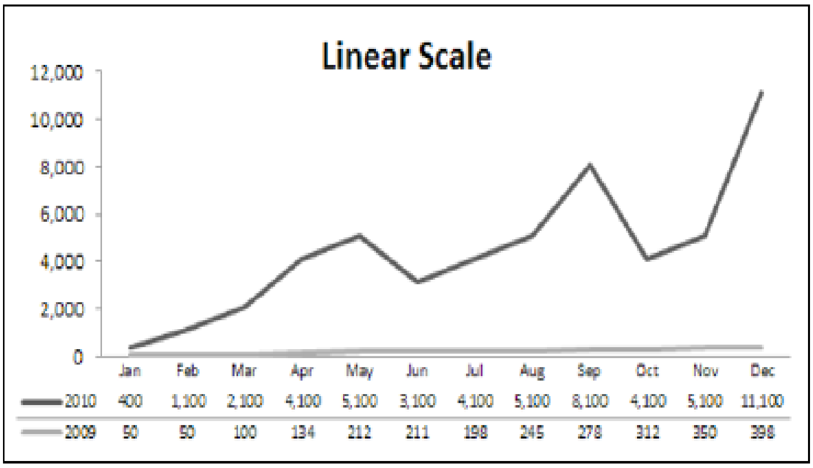

Figure 2.5: Example of trend chart

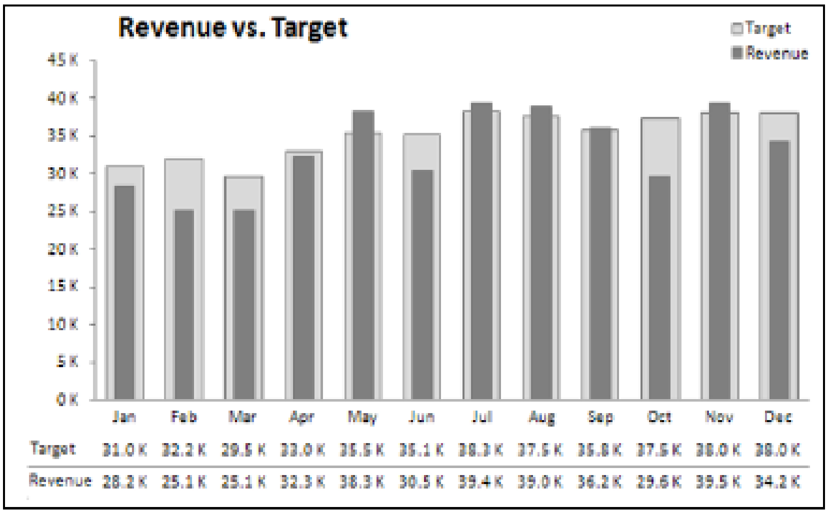

Figure 2.6: Example of thermometer graph

2.4 Dashboard reporting technique

2.4.1 Macro charged dashboarding

Recording a macro is like programming a phone number into your cell phone. You first manually dial and save a number. Then when you want, you can redial those numbers with the touch of a button (Alexander, 2014). This concept would be beneficial for the dashboard to reduce selection time.

Excel's macro recording functionality is a useful way of quickly writing VBA code to perform simple repetitive tasks. This feature of Excel can also assist you when you are writing more complex macros (Hargreaves and McWilliams, 2010).

2.4.2 Macro navigation button

The most common use of macros is navigation. Workbooks that have many worksheets or tabs can be frustrating to navigate. Macro navigation Figure 2.7 shows how the button looks like (Alexander, 2014).

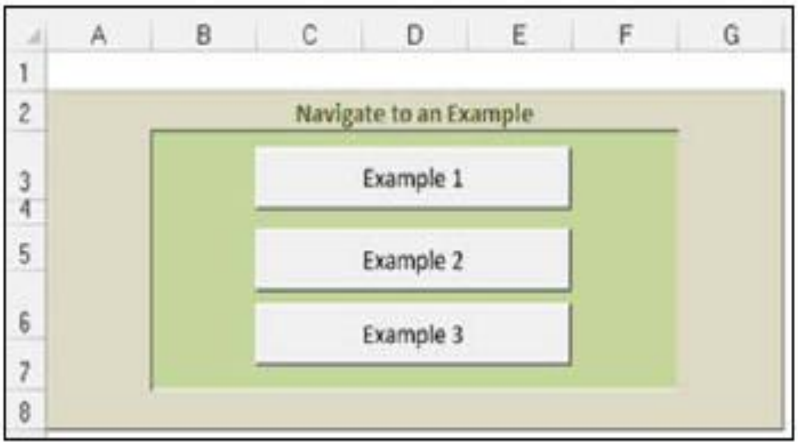

Figure 2.7: Example of the macro navigation button.

2.5 Dashboard concept

2.5.1 Dashboard design principle

Excel makes charting so simple that it's often tempting to accept the charts it creates no matter how bad the default colors or settings are. Remember that a dashboard is a platform to present your case with data. Why dress up your data with superfluous formatting when the data itself is the thing you want to get across? Avoid fancy formatting dashboard. (Elias and Bezerianos, 2011, Gröger et al., 2013).

There may be situations in which it's valuable to show all the data values along with the plotted data points. However, you've already seen how data labels can inundate your users with chart junk. So use data tables instead of data labels (Alexander, 2014).

2.5.2 Feedback from dashboard users

Dashboard main aim is to propose an infrastructure which will allow a manufacturing information system to anticipate which information is important and relevant and then to serve it to the appropriate user (Nadoveza, 2013). The developed dashboard intends to improve performance by efficiently providing information to the productive areas and turn this information into knowledge, plans, and actions which promote an effective shop floor activity (Vilarinho, 2018).

The survey needs to be done to measure project performance (Tokola et al., 2016). The foundations of all the best survey projects are laid long before the first responses come rolling in; they start during what we call the Need phase of survey design, and that's what we'll be covering here (Vilarinho et al., 2018).