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Lean Optimization of newly established Assembly Line using Data Analysis of Quality by the feed from Image recognition Industry 4.0 and Jishuken Study

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ABSTRACT

Electric vehicles are emerging and evolving with time future-oriented tend to more automation and data-oriented results which is more near to the accuracy. This leads to taking fast decision-making. Covid -19 pandemic accelerated automation further which is a part of Industry 4.0. with the growing trend of connecting different sectors of industries among each other all activities are associated with both Value Addition (VA) and Non-Value Addition (NVA) traits.

A lean approach can be adopted in order to reduce NVA through waste reduction. Where the data are being collected from the assembly line from operations which automatic or manually performed.

The thesis proposes a technique focusing on optimizing a newly established Assembly line eliminating wastes and quality defects to improve the OEE (overall equipment effectiveness).

Data collected by MES (Manufacturing Execution System) through Images with pattern recognition and process deviation. In case anomalies are being found in the process data which are being further characterized as defects. These defects are further processed for scrap analysis of the overall line, which is being bifurcated to every operation level which provide results for analysis of the outliers.

Whereas Jishuken is more about finding out Lean wastes which result in indicating all the NVA (Non-Value addition) and VA (Value Addition) from time study of operations. By removing NVA's of every operation, it results in an overall reduction of cycle time. With this approach, indications are fetched for the number of activities being scheduled, whereas few are being implemented and some are in progress as per the plan. Improvement is being monitored on the dashboard of the organization to keep a record.

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1) Economic Evolution

The accumulated value of all finished goods and services produced in a country, often measured annually, is the Gross Domestic Product, also known as GDP. GDP is important in assessing the country's economic health, growth and productivity, and is a metric frequently used to compare several countries at a time, most likely to assess which country has seen the greatest success. Over the past decade, global GDP has seen growth every year, except for 2009.

a) Global 10 Years Impact

A high growth rate, however, does not inherently give rise to all positive results and has a negative effect on inflation rates. Extreme GDP growth leads to lower unemployment, but lower unemployment also leads to higher inflation rates due to an increase in demand at a much higher rate than supply and a consequent increase in prices. Unemployment has only slightly changed over the course of 5 years, amid relatively high global GDP growth, and is expected to remain stagnant by 2017. However, unemployment is always hard to forecast, particularly now that most economies are still recovering from the global financial crisis of 2008.

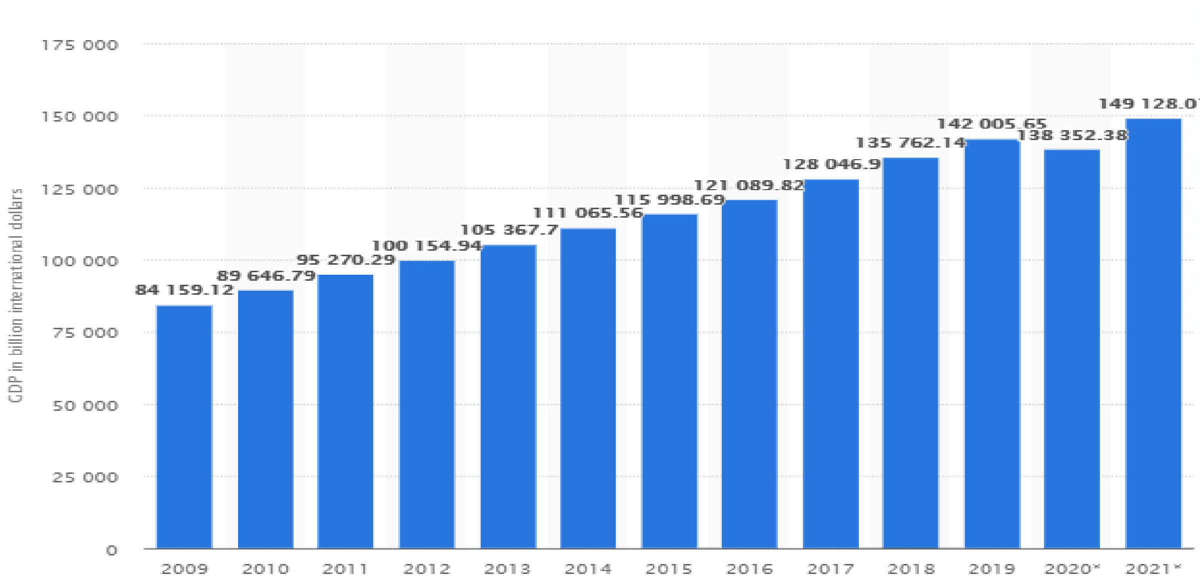


Figure 1.1 Global 10 Years GDP (1)

i) Top 10 countries leading (GDP, DEBT, INFATION, UNEMPLOYMENT)

The United States and China is holding the first two positions in the GDP (Gross Domestic Product) ranking of both approaches worldwide as of 2020. The margin of the US and China falls in the nominal ranking as China's 2020 GDP growth rate (1.85 %) is far higher than the -4.27 percent of the US. On a nominal basis, the US is 6.59 trillion dollars ahead of China in 2020, compared to 6.70 trillion dollars in 2019. China has exceeded the US in 2016 on a PPP (purchasing power parity) basis, and Int. $3.36 trillion, and there is a rising void. Over the next few decades, China will remain the world's largest economy on a PPP basis as the 2nd ranked US is rising slowly and the 3rd ranked India is far behind.

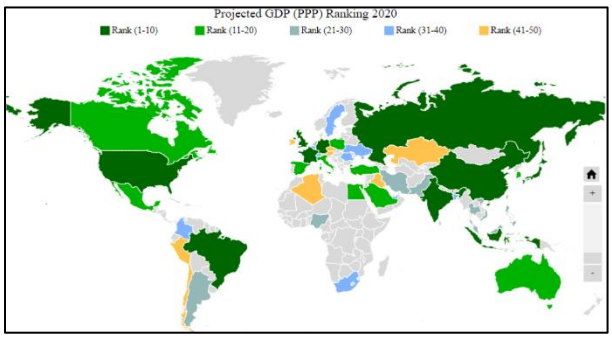


Figure 1.2 Projected GDP (PPP) Ranking (2)

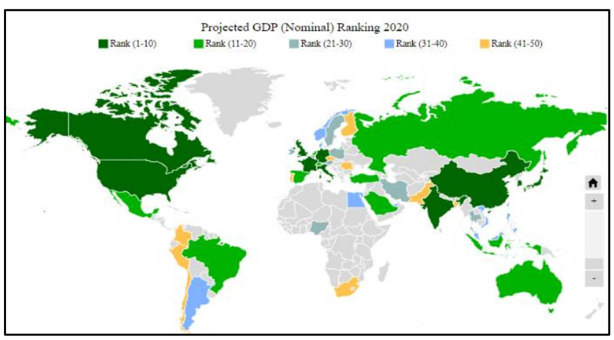


Figure 1.3 Projected GDP (Nominal) Ranking (3)

3rd largest Japan and 4th largest Germany will remain stable in the nominal GDP list. India could be overtaken by the United Kingdom for 5th position. In the top-10 ranking, Korea will replace Brazil. As Canada, Korea, and Russia exceed it, Brazil's rank will be lowered by three positions. Australia overtaking Spain, Indonesia overtaking Mexico, and Switzerland overtaking Saudi Arabia and Turkey will be other improvements in the top 20. Egypt's economic rank would improve by nine positions within the top 50, and the United Arab Emirates would lose five positions.

As per data from the IMF, Asian countries are predicted to make up most of the top 5 countries in the world by size of GDP in 2024, relegating European large economies to lower ranks.

Global Economy										
Country/Economy	**GDP (Nominal) (billions of $)**			**Debt**	**GDP (PPP) (billions of Int. $)**			**Growth (%)**	**GDP per capita (Nominal) ($)**	
	Rank	**2020**	**Share (%)**		**Rank**	**2020**	**Share (%)**	**2020**	**2020**	**Rank**
United States	1	20,807.27	24.8	106.70%	2	20,807.27	16.0 %	-4.27	63,05	5
China	2	15,222.16	18.2	56.36%	1	24,162.44	18.6 %	1.85	10,84	64
Japan	3	4,910.58	6.86	237.54%	4	5,236.14	4.02 %	-6.27	39,05	23
Germany	4	3,780.55	4.51	56.93%	5	4,454.50	3.42 %	-6.98	45,47	15
United Kingdom	5	2,638.30	3.15	86.67%	9	2,978.56	2.29 %	-9.76	39,23	22
India	6	2,592.58	3.09	69.04%	3	8,681.30	6.67 %	-10.29	1,877	148
France	7	2,551.45	3.04	99.20%	10	2,954.20	2.27 %	-9.76	39,26	21
Italy	8	1,848.22	2.20	133.43%	12	2,416.41	1.86 %	-10.65	30,66	27
Canada	9	1,600.26	1.91	88.01%	15	1,809.00	1.39 %	-7.14	42,08	18
South Korea	10	1,586.79	1.89	40.54%	14	2,293.48	1.76 %	-1.88	30,64	28
Russia	11	1,464.08	1.75	13.79%	6	4,021.73	3.09 %	-4.12	9,972	66
Brazil	12	1,363.77	1.63	90.36%	8	3,078.90	2.36 %	-6.80	6,45	88
Australia	13	1,334.69	1.59	41.10%	18	1,307.92	1.00 %	-4.16	51,89	10
Spain	14	1,247.46	1.49	96.96%	16	1,773.36	1.36 %	-12.83	26,83	33
Indonesia	15	1,088.77	1.30	29.29%	7	3,328.29	2.56 %	-1.50	4,038	114
Mexico	16	1,040.37	1.24	54.11%	11	2,424.51	1.86 %	-8.95	8,069	76
Netherlands	17	886.34	1.06	52.04%	27	986.77	0.758 %	-6.40	51,29	11
Switzerland	18	707.87	0.844	39.49%	35	590.90	0.454 %	-6.30	81,87	2
Saudi Arabia	19	680.90	0.812	23.71%	17	1,608.61	1.24 %	-6.44	19,59	44
Turkey	20	649.44	0.775	29.93%	13	2,381.59	1.83 %	-4.99	7,715	78

Table 1.1 – Global Economy (4)

Continental Shift- The World's Biggest Economies Change over the time:

Figure 1.4 Continent shift (5)

As per data from the IMF, Asian countries are predicted to make up most of the top 5 countries in the world by size of GDP in 2024, relegating European large economies to lower ranks.

ii) Top Industries contribution to the economy

Economic growth in China and India has been steep since the 1990s, while Indonesia has recently reached the top 10 of the world's largest economies and is projected to hit fifth position by 2024. In 2024, Japan, a developed economy, is expected to stick to rank 4, with Russia rising to rank 6.

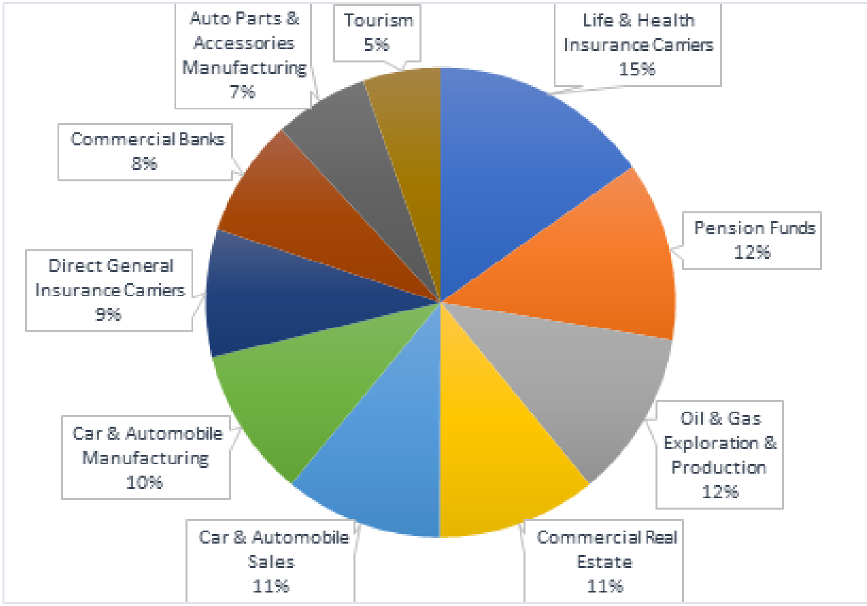


Figure 1.5 Contribution to Economy (6)

From the Economics three main macroeconomic variables are crucial from a policy point of view.

1. GDP is an incomplete measure because it neglects self-production, secret economy, emissions. The well-being of people, apart from consumption, is influenced by other important factors. The goal of governments is to keep GDP as high as possible.

2. Unemployment Resource unemployment is a systemic epidemic. This is clearly seen by the emphasis on people's unemployment. People who are unwillingly unemployed do not have an income on which they can rely to live, so they are typically depressed and dissatisfied, contributing in turn to a potential rise in crime and a vote for a political party that is deterrent from the one currently in government.

3. Inflation is a problem because it interferes with the decision-making of the agents (it is a kind of \noise'), reduces the productivity of the goods and services generated in the country, and penalizes the axed-income individuals as their purchasing power decreases.

b) Industrial revolution

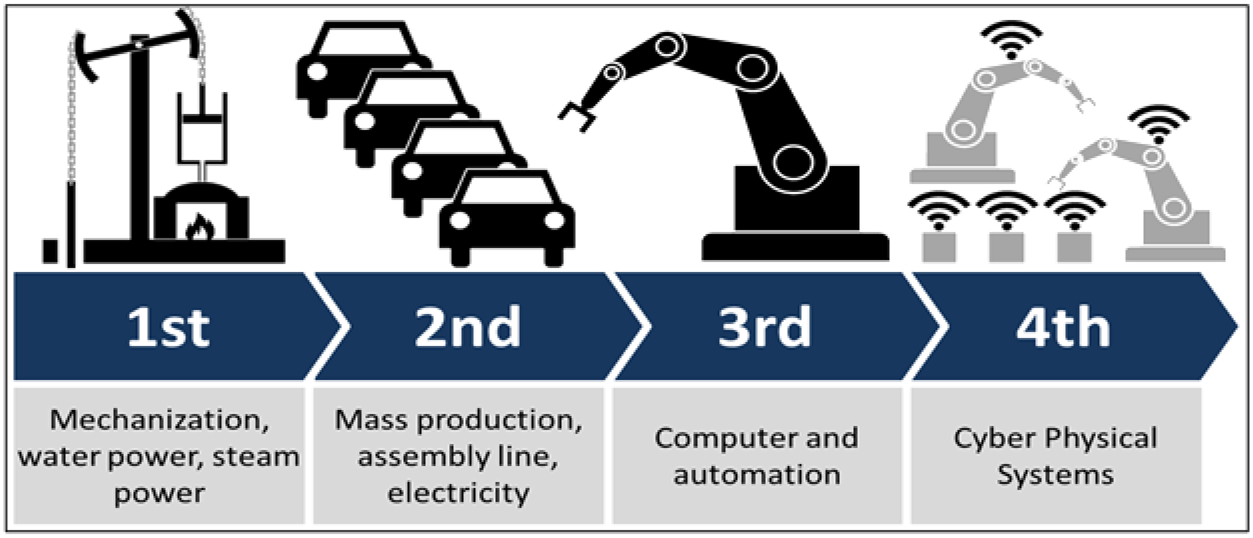


Figure 1.6 Industrial Revolution (7)

“The only constant in life is change”- Heraclitus

Being agile in today’s world which are being followed by several sprints improves the Products indirectly one way or the other impacts our daily life improvising our way of living. As of the industrial revolutions are being concerned revolutions are concerned. Like the steam-powered factories of the *First Industrial Revolution*, the application of science to mass production and production of the *Second Industrial Revolution*, and the beginning of the *Third Industrial Revolution* to digitalization, the technologies of the *Fourth technological revolution*, like AI, genome editing, augmented reality, robotics, and 3-D printing, are rapidly changing the way humming. There are three reasons why the changes of today are not merely a prolongation of the Third Industrial Revolution, but rather the advent of a Fourth and Different Revolution: the effect of tempo, scale, and systems. There is no historical precedent for the pace of current breakthroughs. The fourth is progressing at an exponential rather than a linear rate relative to previous industrial revolutions. Moreover, almost every industry in every country is disrupted by it. With unprecedented computing power, storage space, and access to information, the possibilities of billions of people connected by mobile devices are endless. Emerging technological breakthroughs in areas like AI, robotics, the web of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing would multiply these possibilities. Artificial intelligence is all around us, from self-driving vehicles and drones to virtual assistants and translation or investment apps. In recent years, AI has made impressive progress, powered by exponential increases in computational capacity and by the availability of vast quantities of knowledge, from software used to discover new medicines to algorithms used to forecast our cultural interests.

i) Paradigm shift impact on the economy (focusing on industry 4.0/CPS)

The contributions of Industry 4.0 to eight value drivers in manufacturing are illustrated:

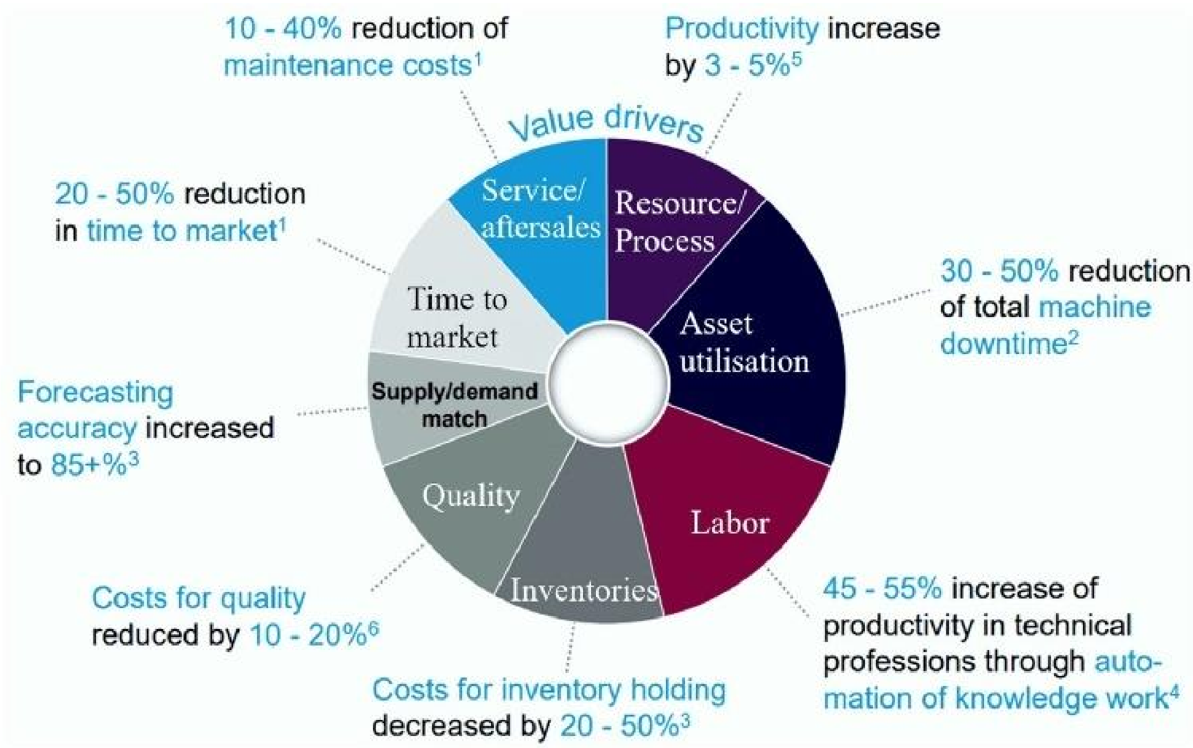


Figure 1.7 contributions of Industry 4.0 to eight value drivers (8)

As it can be seen from the Pie chart that all will contribute to the 3 factors of the Macroeconomics and huge chunk is being the contributor to the Labor market (45 - 55 %). The use of owned robotics app stores further supports this desired versatility, where brands can tap into software to increase their robotics hardware's purpose, build their own app stores to continuously change what their hardware can deliver. This will enable all businesses to plan for the highest and lowest demand levels, accurately integrate their robotic workforce, and be prepared for any unavoidable necessities. Relatively low downtime in the best and worst of times. Robots will benefit from the productivity of a community, just like our own society. Working together, our strengths can also be amplified, and we can hide individual weaknesses. Known as swarm robotics, this will keep the assembly line's strengths active, ensuring productivity for both man and machine with a multi-skilled workforce.

This change in paradigm tends to more unemployment, where there are mainly:

1. **Frictional unemployment:** Frictional unemployment occurs as a result of people voluntarily changing jobs within an economy.
2. **Cyclical unemployment:** Cyclical unemployment is the variation in the number of unemployed workers over the course of economic upturns and downturns, such as those related to changes in oil prices.
3. **Structural unemployment:** Structural unemployment comes about through technological change in the structure of the economy in which labor markets operate.
4. **Institutional unemployment:** Institutional unemployment is unemployment that results from long-term or permanent institutional factors and incentives in the economy.

Among this four Structural unemployment is being raised due to the difference in the skill level of the labor market. As the technological paradigm is being disrupted and the demand of labors with multiple or hybrid roles are in demand towards dynamic roles and more agility in the working culture. Its can be seen that countries are more moving toward the digitally oriented devices driven by data gathered from devices such as mobile phones, smart watches, tablets. The more mobile the device are the more likely to be taken to the places where it would have been unable to reach for the people to get the information (eg. Devices from living room to bedroom such as smart watch etc.) Attention economics is an approach to the management of information that treats human attention as a scarce commodity and applies economic theory to solve various information management problems. Attention is focused mental engagement on a particular item of information. Items come into our awareness, we attend to a particular item, and then we decide whether to act.

ii) COVID crisis accelerates Industry 4.0

First half of 2020 was like other some companies are dealing with dramatic losses or transforming a new way to support doing business. Few industries while managed to move along at a snail's pace while others where some are sky rocketing. In many respects, the automotive industry is very conventional, which has historically shielded it to a large extent, but due to COVID-19, systems that have operated effectively for over 100 years have and will continue to face major disruptions. There needs to be a fresh look at potential solutions in vehicle production for the sake of business and in order to retain regional and global economies. Many organizations will look at how future-proof they can be, and this lies in the introduction of new automated vehicles. Manufacturing of automobiles has traditionally revolved around the assembly line process, which was first implemented in 1913 by Henry Ford. Not only has it transformed the automotive sector, it has totally changed production and remains dominant in many operations worldwide, with a blend of automated and manual approaches. The performance of the assembly line cannot be questioned, but for some time, automobile manufacturers and factory planners are now looking at alternatives to this highly effective but often intransigent technology. When a catastrophe arises and people are totally excluded from the framework, everything comes to a virtual standstill. And the sector itself including raw materials, the production and transport of the finished product to be sold, is basically a type of assembly plant. So, if at any point there's a problem, only one, there is automatically a knock-on effect. This means a real paradigm shift, considering how long these frameworks have been relied on by the industry to this day. But though there was a thinking about how to adjust the policy before, this would have been multiplied exponentially by the crisis. There is also a need to manufacture vehicles that are less dependent on people in direct touch with the assembly line, and the process needs to be much more flexible, agile and versatile. A more robotics-led approach is clearly called for, which will allow businesses to realign and retrain workers in supervisory positions. Robots who no matter the crisis faced, will keep going. In principle, it sounds fantastic, but how do we interrupt anything at all and safely put robots in at the end of the ad?

Figure 1.8 Impact Analysis Covid-19 (9)

Open source for sharing the technology and to reduce the cost of production: Traditionally, new technologies in the automobile industry have proven to be extremely decentralized when looking at what goes through the vehicle itself with auto companies preferring patented technology and in-house innovations to maintain as much comparative edge as possible. In the modern connected vehicle age, as this method becomes outdated, we find that this trend applies to the processes that still go into production. New technologies, such as robotics and the software that supports them, create complex environments that would struggle to be implemented and managed on their own by a single company. Together the industry must take steps. More widely, however a heterogeneous ecosystem of many diverse groups, each an authority in their own niche, collaborating to advance shared production growth targets is what the landscape needs. These cross-industry coalitions cultivate a culture of collaboration and identify shared principles aimed at accelerating the production and implementation of emerging technology for manufacturing.

Linux and ROS (Robot Operating System) have therefore become the go-to platforms for innovation in robotics and now also in the automotive industry. This has permitted more experts to contribute to progress and has made it possible for auto manufacturers to harness superior economics, faster software cycles, and more reliable open-source codebases. The large percentage of robotics are ROS-based. Its versatility and help alleviate make it ideal for a wide range of robotics applications, large - scale production, and is a natural fit for those seeking to roboticide their automotive approach. Progress and recovery come from disaster. A large part robotized assembly line would alter the roles of human beings as workers. We can discover new innovations within manufacturing and the industry by moving into supervisory and/or created out of thin air roles, much of which can be accessed remotely. This will also enable automotive companies to become more flexible and able to move quickly moving in new directions when confusion arises and without the need for too many boots on the ground.

c) Impact and contribution of automotive industry to the economy

The 10 Global Biggest Industries by Revenue in Billions ($)			
Rank	**Industry**	**Revenue for 2020**	**Weight**
1	Life & Health Insurance Carriers	$ 43,843.00	15%
2	Pension Funds	$ 35,644.00	12%
3	Oil & Gas Exploration & Production	$ 33,254.00	12%
4	Commercial Real Estate	$ 31,678.00	11%
5	Car & Automobile Sales	$ 31,386.00	11%
6	Car & Automobile Manufacturing	$ 29,766.00	10%
7	Direct General Insurance Carriers	$ 25,352.00	9%
8	Commercial Banks	$ 23,410.00	8%
9	Auto Parts & Accessories Manufacturing	$ 18,728.00	6%
10	Tourism	$ 15,410.00	5%
	Total	$ 288,469.00	100%

Table 1.2 The 10 Global Biggest Industries by Revenue in Billions ($) Reproduced (10)

Below are the market share of the all sectors present. Where we can see that automotive sector 7%+10%+11% = 28 % out of 100 %.

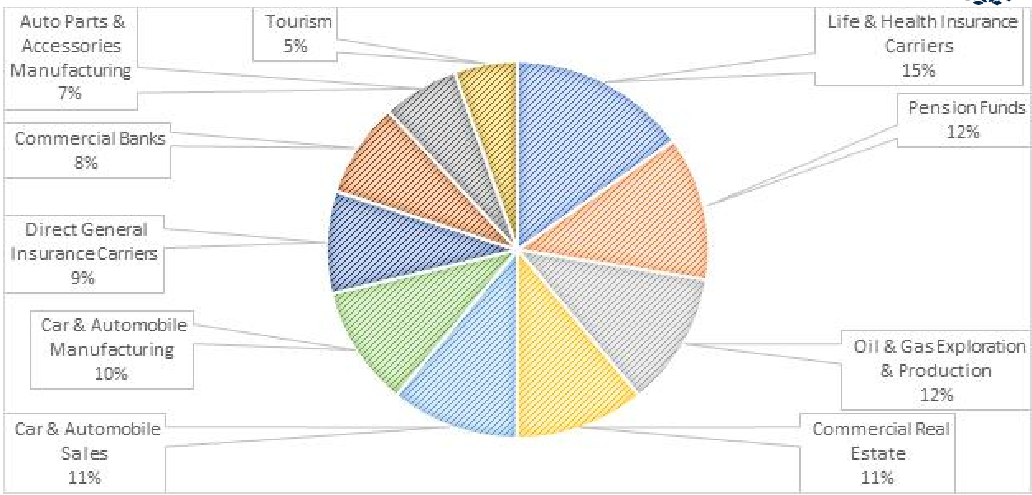


Figure 1.9 Global Biggest Industries by Revenue 2020 (11)

According to the International labor organization (ILO) and its latest report on *(Geneva, 4–8 May 2020)* its been seen that the automotive industry adds substantially to jobs in global manufacturing. The number of workers in the 'Motor Vehicles, Trucks, Semi-Trailers' sector has risen by 35% since the global financial crisis, according to the UNIDO Industrial Statistics Database. Global jobs in the industry was estimated at almost 14 million employees in 2017.

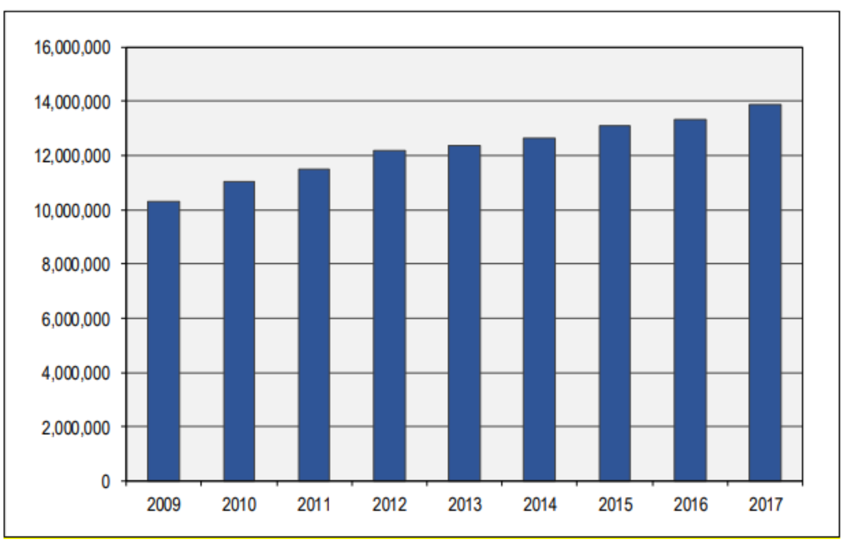


Figure 1.10 Global employment estimate in the “Motor vehicles, trailers, semi-trailers” sector, 2009 –17 (12)

d) New innovations and Projects in progress (Automobile)

Evolving Car industry

An automotive car is the biggest creation in the past for allowing fasting mobility in the world. In the past, before the car invention, it had transportation as carts and horse carriages for people and goods. but engineers worked on that same design horse carriage then improved the frame of the vehicle.

It was the first model produced as a type of toy in 1672. It was a steam engine with a Chinese emperor's 65 cm long scale model. In the 20th century, automobiles were used in the world market because developing countries relied on that market. In 1806, it was the first car with an internal combustion engine as gasoline. In 1886, as per Benz's Motorwagen patent, German inventor Karl Benz brought modern cars into the market, so Germany is the birthplace of cars and he gave the world a four-stroke petrol cycle engine. In 1888, Karl Benz and his wife took their first road trip by car and proved the first invention for automobiles.

Numerous innovations were aligned and now moving towards digitization may companies are trying to take a leap by exploiting to their competitive advantage strategically such as Google in 2010 introduced an innovation called Google X as a self-driving vehicle. In 2011, the Chevrolet Volt electric hybrid car was launched by General Motors. In 2014, Tesla added the first model S to offer autopilot, which can handle car steering and change lanes on the way. In 2014, the 4G Wi-Fi hotspot system added new technologies to link passengers to the Internet.

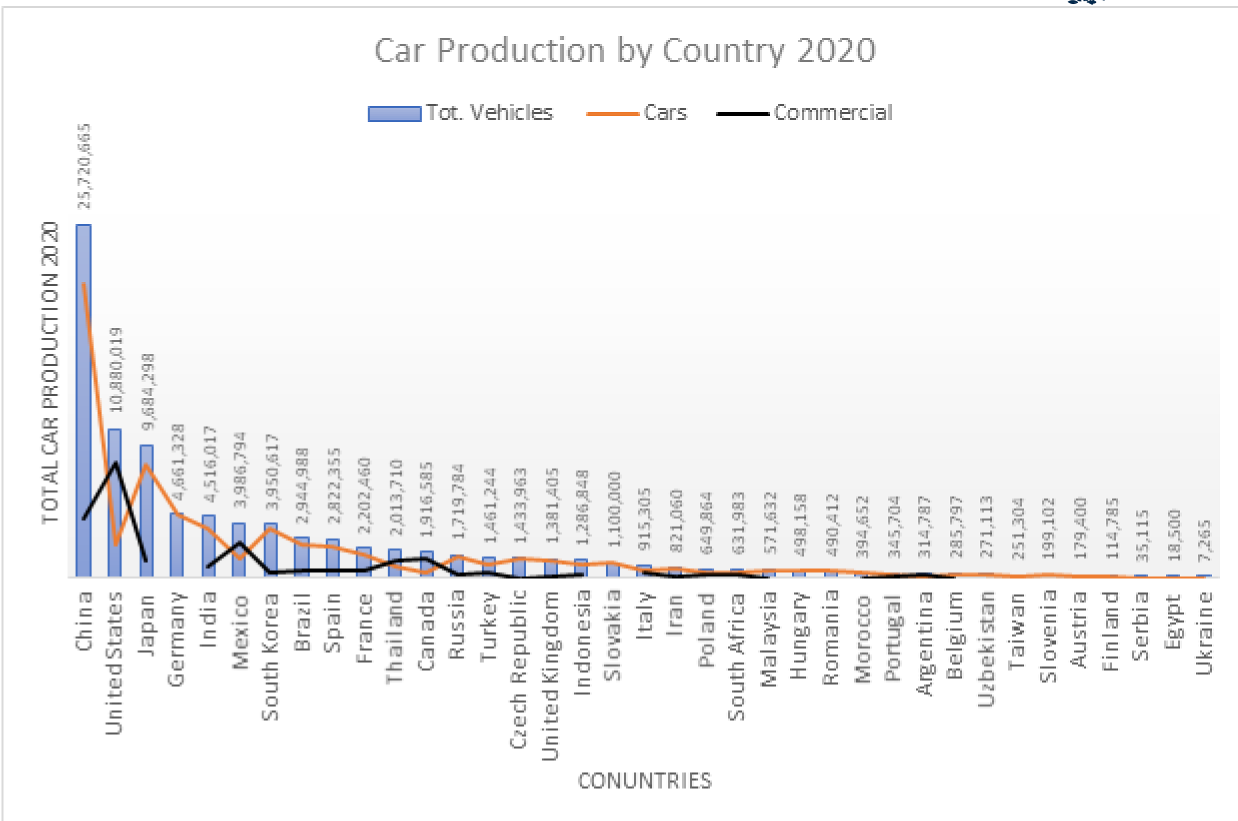


Figure 1.11 Car production by country 2020 reproduced (13)

MEB Modular electric drive matrix (MEB): The future I.D. family's models are now being developed on the new Modular electric drive matrix (MEB). These are Volkswagens in various classes that have been designed as fully electric vehicles with ranges of up to 500 kilometers and beyond. The MEB's architecture will profoundly alter electric vehicles and automobiles in general.

The Modular Electric Toolkit, which has been built specifically for electric vehicles, jettisons all of the fossil age's baggage. This results in significant changes to the body, interior, packaging, and powertrain characteristics of electric Volkswagens.

Figure 1.12 MEB Modular electric drive matrix (MEB) (14)

Fiat Chrysler (FCA) – BEV:

During the event dedicated to the new Ducato MY2020, the evolution of the Best-Seller that has been satisfying the entire spectrum of business needs for 38 years, the Fiat Professional brand gave the world its first glimpse of the Ducato Electric – an all-electric BEV (Battery Electric Vehicle) version – which will go on sale in 2020 and pair with the natural gas Ducato Natural Power.

Figure 1.13 Fiat Chrysler (FCA) – BEV (15)

i) Top Child part manufacturers (Products and market)

Table 1.3 TOP 10 auto part companies and the competitive parts in the world (16)

Rank	Companies	Competitive products
1	Robert Bosch	Powertrain solutions; chassis systems controls; electrical drives, car multimedia, electronics, steering systems & battery technology
2	Denso Corp	Thermal, powertrain control, electronic & electric systems; small motors, telecommunications.
3	Magna International Inc.	Body exteriors & structures; power & vision technologies; seating systems & complete vehicle solutions
4	Continental AG	Advanced driver assistance systems, electronic brakes; stability management, tires, foundation brakes, chassis systems, safety electronics,telematics, powertrain electronics, injection systems & turbochargers
5	ZF Friedrichshafen	Transmissions, chassis components & systems, steering systems, braking systems, clutches, dampers, active & passive safety systems, driver assist systems including camera, radar & lidar
6	Aisin Seiki Co.	Body, brake & chassis systems, electronics, drivetrain & engine components
7	Hyundai Mobis	Automotive electronics, infotainment, ADAS, EV systems, module systems, lighting, airbags & brakes
8	Lear Corp.	Seating & electrical systems (E-Systems)
9	Faurecia	Faurecia seating & interiors; Faurecia Clarion Electronics & Faurecia clean mobility
10	Valeo	Micro hybrid systems, electrical & electronic systems, thermal systems, transmissions, wiper systems, camera/sensor technology security systems, interior controls

2) Brake System Evolution: A History

The first methods for stopping the momentum of a vehicle and preventing motion were tested in the 1890s, Wooden block brakes became obsolete when rubber tires were introduced by the Michelin brothers. Today, more than a hundred years later, the braking mechanism has developed into a dynamic system designed to respond to varying road conditions. The evolution of brakes has been tremendous, and over the years it has included several innovative ideas. In all the latest innovations in the brake system, enhancing auto safety and performance is the number one priority.

The kinds of braking systems used over the years include:

1. Wooden block brakes

2. Mechanical drum brakes

3. Expanding internal shoe brakes

4. Hydraulic brakes

6. Disc brakes

6. Anti-lock brakes

7. Four-wheel brakes

8. Power-assisted brakes

9. Self-adjusting brakes

Figure 2.1 Types of brakes (17)

b) Types of Brakes

i) DISC BRAKE:

The disc brake is a device for slowing or preventing a wheel's rotation from moving. A disc brake is usually made of cast iron, although composites such as carbon-carbon or ceramic-matrix composites are also made in some cases. The wheel and/or the axle are connected to this. Friction material in the form of brake pads is pressed against both sides of the disc in order to stop the wheel. Generated friction, slowing or stopping on the disk wheel.

ii) DRUM BRAKES:

A drum brake is a traditional break in which the friction is caused by a set of shoes or pads that press against a rotating drum-shaped part called a brake drum. The term \"drum brake\" usually means a brake in which shoes press on the inner surface of the drum. Where the drum is pinched between two shoes, similar to a standard disk brake , it is sometimes called a \"pinch drum brake\", although such brakes are relatively rare.

c) Market Analysis and future forecast

Automotive Brake System Market Statistics – 2026:

The market size of the worldwide automotive brake system was estimated at $22.03 billion in 2018 and is expected to hit $38.48 billion by 2026, with a *CAGR of 7.5% from 2019 to 2026*. In 2018, Asia-Pacific accounted for the highest share and is projected to retain its lead during the forecast period in the global market.

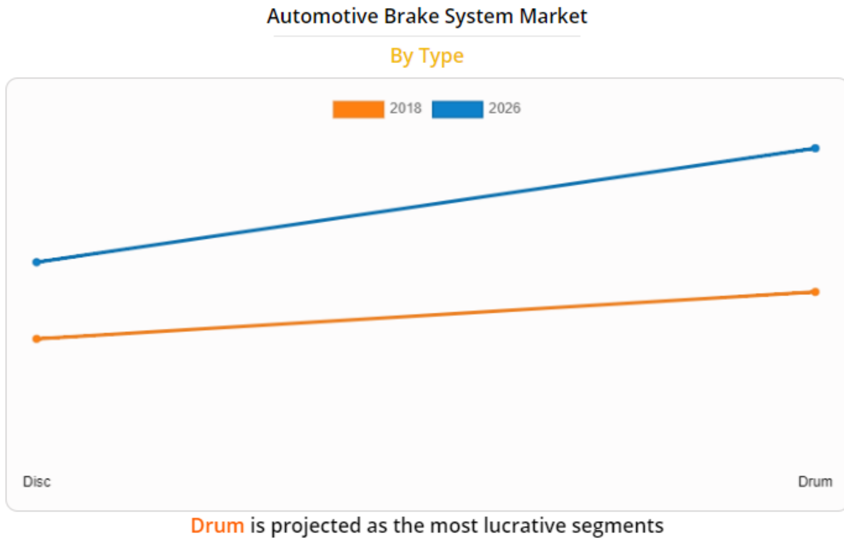


Figure 2.2 Automotive Brake system market by type (18)

On the basis of type, technology, sales channel, and area, the global automotive brake system market is segmented. It is divided into discs and drums by form. It is bifurcated by technology into the antilock braking system (ABS), traction control system (TCS), electronic stability control (ESC) and electronic distribution of brake forces (EBS) (EBD). It is categorized into passenger cars, commercial vehicles, and hybrid vehicles by the distribution channel.

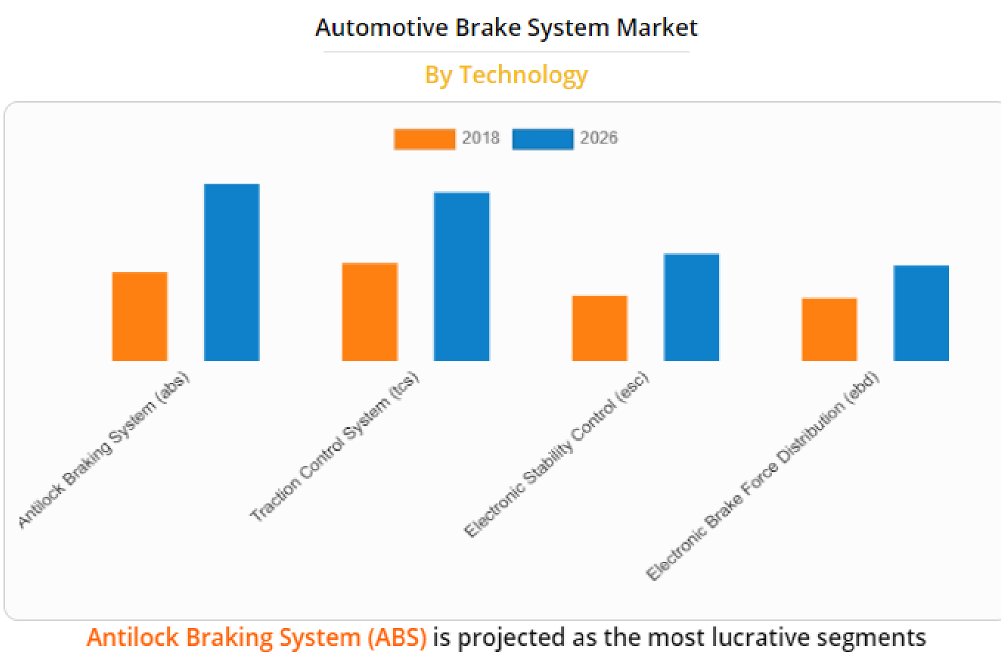


Figure 2.3 Automotive Brake system market by Technology (19)

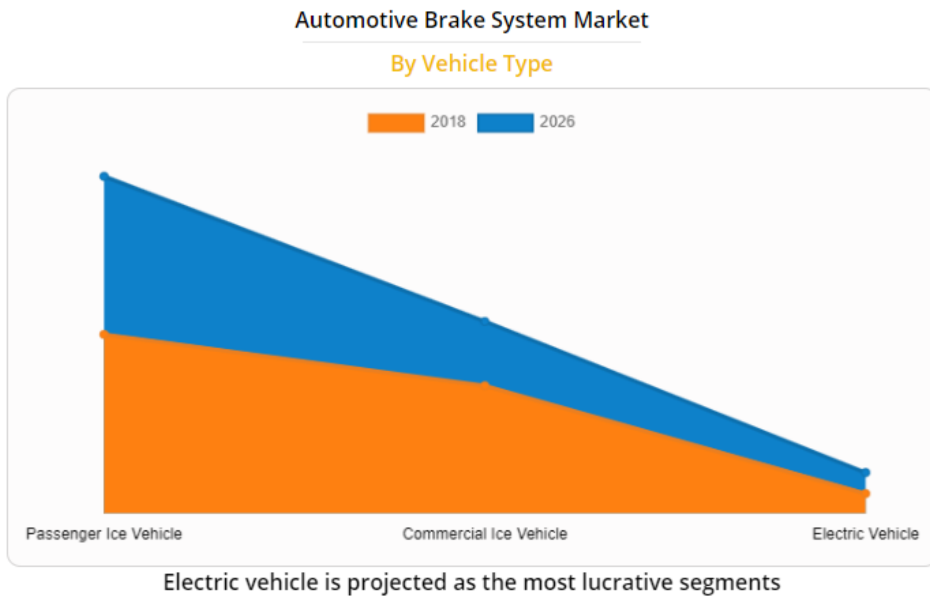


Figure 2.4 Automotive Brake system market by Vehicle type (20)

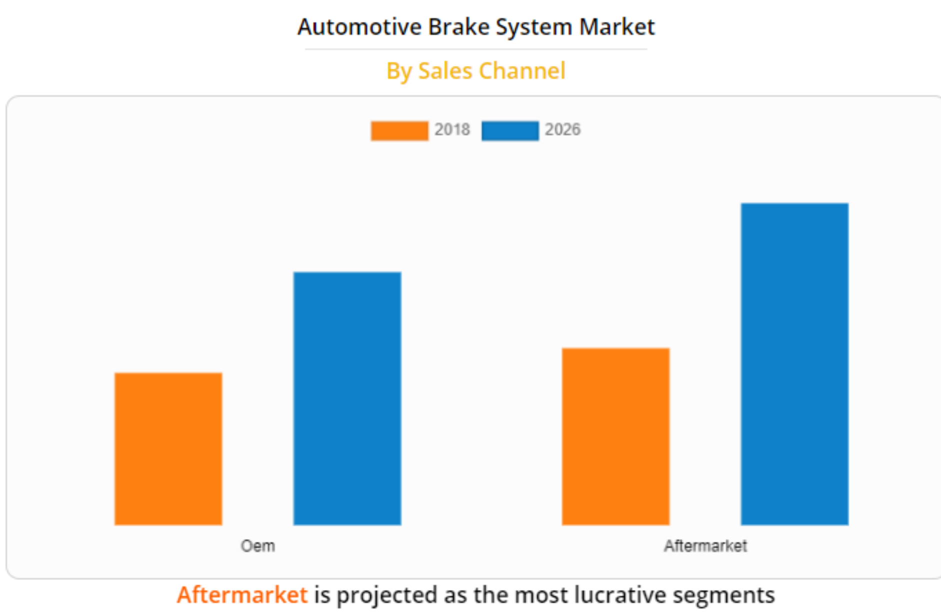


Figure 2.5 Automotive Brake system market by sales channel (21)

d) Major companies

1. Continental AG
2. Robert Bosch GmbH
3. Brembo S.p.A.
4. LSP Innovative Automotive Systems GmbH
5. Aptiv PLC (Delphi)
6. Disc Brakes Australia (DBA)
7. Hitachi Automotive Systems
8. Advics Co. Ltd.
9. Performance Friction Corporation (PFC)

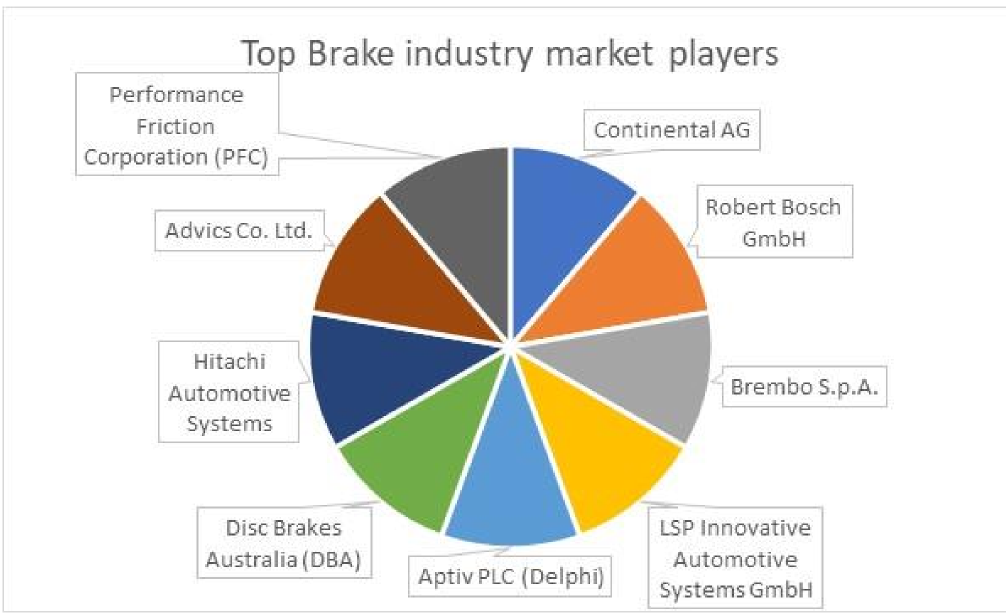


Figure 2.6 Top Brake Industry market player (22)

3) Concepts and mind map (Focusing on industry 4.0)

Fourth Industrial Revolution better known as Industry 4.0 aligns well with the digitization methodology which goes hand in hand with Lean Six Sigma where it helps an organization to proceed towards the Continuous improvement and to have 360 view with a radical innovation.

For sustained adoption, adding Industry 4.0 must occur in a way that aligns with the lean six sigma culture. Kaizen is a Japanese coined meaning Continuous improvement which emphasizes to raise quality, to shorten delivery time and to increase customer satisfaction. In VSM (value stream mapping) identifying the real opportunities for improvement with the involvement of the team members who are responsible of work in the machine or in that area.

Getting support while doing the Gemba walk with the line leaders and auditors helps to get out of the box view while, sometimes, this could include a thorough re-evaluation of the entire map, such as when replacing paper-based processes with mobile solutions. In a nutshell the idea is to make operations smooth with removal of 3M (Muda, Muri, Mura). Under Muda in Lean manufacturing 7+1 wastes are being followed such as (TIMWOOD-S) Transport, Motion, Inventory, Waiting, Over production, Over process, Delivery, + Skills underutilized. Likewise, Lean, Industry 4.0 is being focalized on business processes, and in operations. Business process automation and data exchange are being involved using the Internet of Things (IoT), cloud computing, analytics, machine learning and artificial intelligence. Comparing Continuous improvement (considered as more of Organic) and radical change (considered more of new processes and new business models) which involves risk.

a) Lean and industry 4.0.

The industrial environment for smart production lines & smart machines I4.0 will be able to connect with each other in real time and make successful decisions. In this respect, the integration of the Lean Framework & Industry 4.0 (Lean Business 4.0) technique would provide the development phase with the next level of excellence. Latest reports suggest that successful implementation of Lean Industry 4.0 would boost conversion costs by about 40 percent. For 5 years or 10. In this review, the Lean Manufacturing & Company 4.0 interplay will be discussed. On the other hand, Lean six sigma is a mathematical approach to quality optimization which deals with differences in processes of production.

Industry 4.0's production approach will generate vast volumes of data. This wide data sets obtained by Industry 4.0 technologies can be exploited with powerful data analysis techniques. Good decisions can then be taken by using these analysis strategies in each six-sigma time period.

Lean integration is a management system that emphasizes creating value for customers, efficiency development, and waste avoidance as a radical data integration and system integration strategy. Lean integration, including lean manufacturing, lean IT, and lean technology execution, is parallel to other lean disciplines. Integration strategies may be characterized generally as either Process Integration or Data Integration.

The predominant organizational model is the Integration Competency Center Integration Competency Center (ICC), also referred to as the Integration Center of Excellence (COE), which is a shared service function providing methodical data integration, system integration, or business framework integration within organizations, especially large companies and public sector agencies.

Corporate systems integration enables the efficient exchange of information and the automation of company processes across multiple computing technologies in a cohesive way. From one-off projects to the repeatable, sustainable structure of an Integration Competency Base, the topic of integration has expanded. As the early years of automobile manufacturing have progressed from custom staff to assembly lines by incorporating best practice integration technologies, standardization and ICC technological resources, they have greatly improved the success and lowered the cost of their integration projects.

Any part of the industry has evolved further than anyone. There is a step (product data sharing standard) in the manufacturing industry, for example, which can be used to share product models between CAD (computer assisted design) systems.

The Automotive Competency Hub, to assist our industrial customers with their Industrial Competency Center (ICC) with robotic arms like Kuka, ABB, etc., NXPs newly released.

Lean integration is a data-driven methodology that focuses on continuous change and elimination of duplication to maximize customer benefits. The total range of lean integration is two-fold. Lean "Lean" 'Integration' refers to the formation of a formal, symbiotic relationship between different systems. For lean integration, the product or service lifecycle does not stop until the contract with a customer is complete. In fact, in order to maximize potential loyalty and reduce the probability of errors, Lean integration integrates user feedback. "bottom-up" feedback is heavily imported by lean convergence, unlike traditional, siloed office systems.

Lean integration	**Other methodologies**
Experience and data-driven	Experience-driven
Sustainable and holistic	Tackles only part of the problem
Ongoing	One-time
Simple	Unnecessarily complex
“Bottom-up” input	Input exclusively from IT

Table 3.1 Lean integration with data (23)

b) Six lean integration principles

Lean incorporation has some basic principles that are essential to fostering substantial, continuous change:

i) Team empowerment

To fully integrate lean integration, you need motivated, varied, and guided teams. Companies need to build a community that understands staff of different sets of skills. Each person should accept his or her role and responsibilities, but they should also have the ability to innovate without fear of failure.

ii) Remove waste

Waste is something that in lean integration does not offer customer advantage. Companies must be tuned to internal or external customer needs in order to recognize areas of excess. It is necessary to eradicate all operations that do not improve the service of the customer.

iii) Plan for change

There is no constant, as someone once said, except transition. When a company plans to adapt, it will respond and embrace improvements much sooner. Effective lean integration requires developing systems that will allow incremental changes without market disruption.

iv) Automation

Automation systems help teams to tackle problems quickly and can convert large projects of execution into bite-sized chunks. In a brief period of time, such minimal deployments are expertly handled to generate high value. Interdependencies between systems can also be removed by automation.

v) Quality

Lean integration helps a company to interweave best practices through its activities. Consistency audits may consist of structured measures that can detect issues early and regularly. By these consistency metrics, development towards a solution can also be measured.

vi) Continuously improve

Ongoing change is one of the main tenets of lean integration. In order to repair end-to-end processes, it is difficult to achieve it all at once. Instead, Lean integration proposes a process of hypothesis, validation, execution, and reflection to ensure projects go in the right direction.

c) The cloud and the future of lean integration

The growth of the cloud and big data processing has made enterprises accountable for supplying their consumers with full value goods in the least viable period. How can this demanding feat be achieved? This topic has contributed to the emergence of various methodologies for operational efficiency, including lean integration.

The cloud and its dynamics just keep rising over time, and along with it, consumer aspirations can rise. Lean incorporation helps organizations to resolve this problem. Lean incorporation allows for market intelligence that is organized, and scalable. Or more significantly, lean integration concepts keep workers driven to deliver optimum support.

d) Three lean integration best practices

Lean integration is important for keeping track with emerging innovations. So how does an enterprise implement and execute Lean Integration concepts on a daily basis? A variety of best practices exist here:

i. Keeping the customer in mind

It is easy to forget about the customer when a team is actively interested in reaching their individual goals. Lean integration encourages workers to take a step back and take a look at the whole picture. Questions such as, "Do I directly add client value to what I do?" or "Did I deliver all that the customer needed to do their job?" are beneficial in framing the focus of a lean squad.

ii. Standardized metrics and processes

Well-defined, repeatable processes are the hallmark of a lean, structured organization. Companies should establish a happy compromise between needless bureaucracy that speeds down a process and no organization's confusion at all. A visible way to monitor each phase of a process would need to be inaugurated by Lean teams. This not only helps to detect errors but is also a motivator for workers to meet the goals.

iii. Not reinventing the wheel

Although totally separate tasks may be done by different sections of an organization, many of the information or function they request is similar. Instead of starting from scratch on any new project, groups will identify patterns, validate the correct approach, and hit the ground running. Recognizing and reusing activities saves companies resources and resources, while curbing continued maintenance efforts.

e) TPM

i. TRADITIONAL TPM:

The traditional approach to TPM was developed in the 1960s and consists of 5S as a foundation and eight supporting activities (sometimes referred to as pillars).

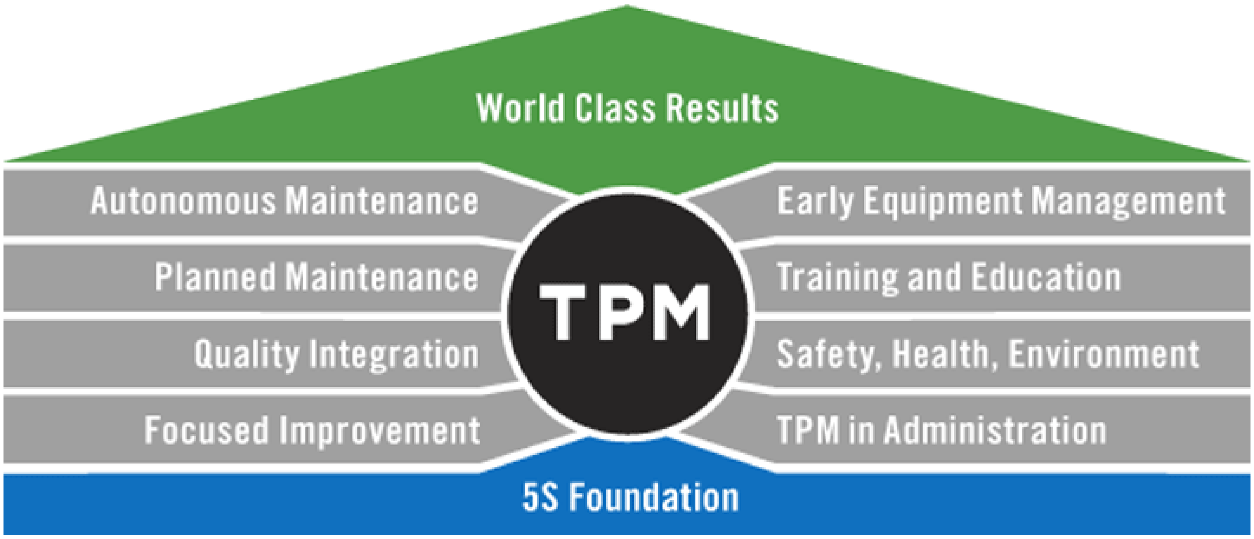


Figure 3.1 Traditional TPM (24)

1. **Autonomous Maintenance:** Operators are responsible for routine maintenance such as cleaning, lubrication, and inspection.
2. **Planned Maintenance:** Schedules maintenance tasks based on failure rates that have been forecasted and/or measured.
3. **Quality Maintenance:** Incorporate error detection and prevention into your manufacturing processes. To remove recurrent sources of quality faults, employ Root Cause Analysis.
4. **Focused Improvement:** Encourage small groups of staff to collaborate proactively to enhance equipment operating on a regular basis.
5. **Early Equipment Management:** TPM-acquired practical knowledge and understanding of industrial equipment is used to improve the design of new machinery.
6. **Training and Education:** Fill in the knowledge gaps required to meet TPM objectives. Operators, maintenance employees, and supervisors are all affected.
7. **Safety, Health, Environment:** Maintain a safe and healthy workplace.
8. **TPM in Administration:** Apply TPM techniques to administrative functions.

4) Thesis focus

It's a Lean framework which shows overview of Lean Organization along with the link to other counter methodologies and the studies.

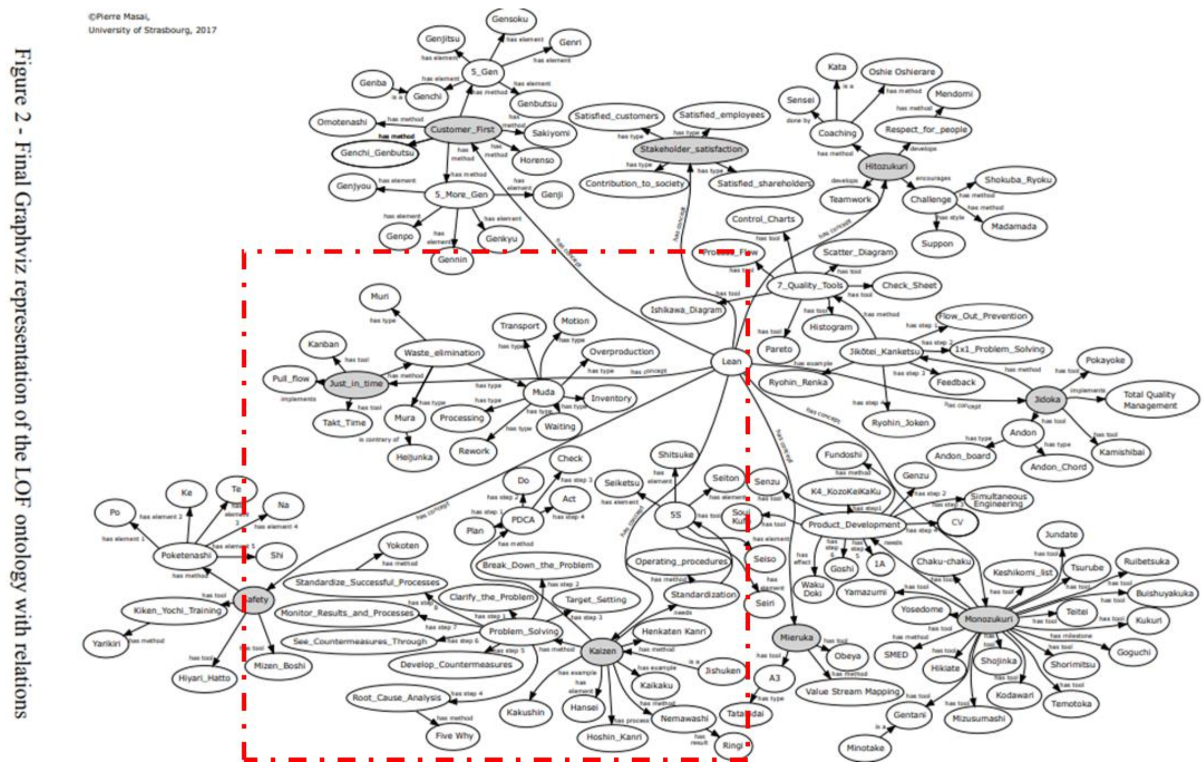


Figure 4.1 LOF (Lean Organization Framework) (25)

In this thesis the focus is quality and improving the performance of the operations at micro level which is being shown below.

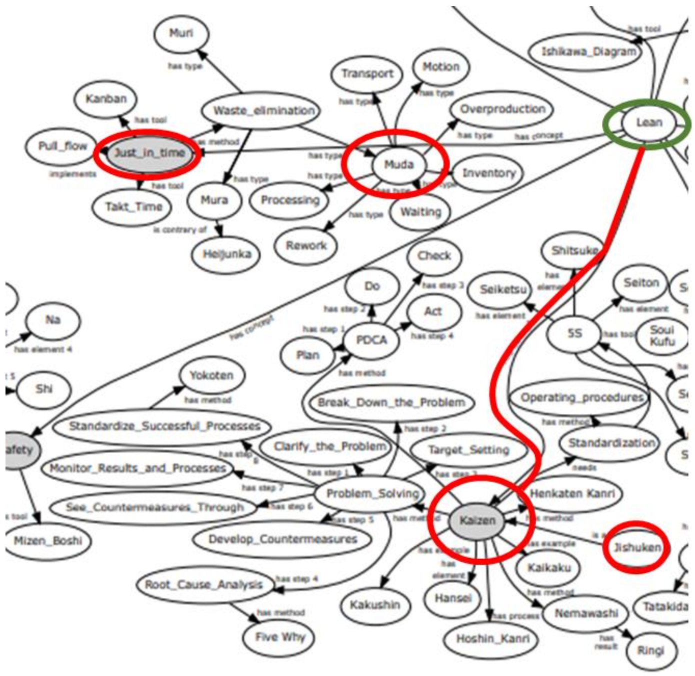


Figure 4.2 LOF (Lean Organization Framework) Focused part (26)

5) Continental AG History

Continental AG, generally referred to as Continental or Conti, is a German multinational manufacturer of automobile parts specialized in braking systems, indoor electronics, automotive protection, powertrain and chassis components, tachographs, tyres and other automotive and transport parts. It is headquartered in Hanover, Lower Saxony. Continental is the world's fourth-largest tire manufacturer.

In 1871, as a rubber producer, Continental-Caoutchouc und Gutta-Percha Compagnie, Continental was established. Continental began the manufacture and manufacturing of automobile tires with a single sole in 1898, which was the brand's biggest breakthrough. In 1904, Continental became the first company to produce grooved automobile tyres worldwide. The detachable wheel tire made for touring vehicles was another major product developed by Continental (1905). Continental joined with many other major companies in the rubber industry in the late 1920s to create Continental Gummi-Werke AG, Germany's largest rubber company.

According to a survey funded by PricewaterhouseCoopers, Continental was ranked third in global OEM automotive parts revenues in 2012, after purchasing Siemens AG's VDO automotive subsidiary in 2007.

Through its integration of VDO, Continental looked overextended in 2008 and had since lost almost half of its market capitalization when it found itself to be the hostile takeover target of the family owned Schaeffler AG. By 2009, at the helm of Continental, Schaeffler successfully installed the head of its engine division.

On 6 September 2012, after a 45-month absence, Continental returned to the benchmark DAX index of 30 selected German blue-chip stocks. The majority shareholder is the IHO Group (Investment Holding of the Schaeffler family) which currently holds 46 percent of Continental stock.

It was revealed on 13 November 2020 that Nikolai Setzer would take over as CEO following Elmar Degenhart's short-term resignation.

a) Cairo Montanotte (Description)

Located in CAIRO MONTENOTTE, SAVONA, Italy, CONTINENTAL BRAKES ITALY SPA is part of the Car Parts Manufacturing Industry. The CONTINENTAL BRAKES ITALY SPA business family consists of 1,442 firms.

In **Continental AG** to follow TPM, (Total Productive maintenance) number of pillars are followed as where Quality management, office TPM and Safety health & environment are being integrated with 5 pillars. TPM/ Lean and NPL (New Product Line) under the umbrella of CBS (Continental business system). In contrast to traditional TPM 3 pillars are being integrated with five pillars. Each pillar follows 7 steps (0-7) to achieve the motive of every pillar.

b) 5 pillars are

- **Pillar 1: Elimination of Central Problems (CIP / EOCP)**
- **Pillar 2: Autonomous Maintenance (AM)**
- **Pillar 3: Systematic Maintenance (SM)**
- **Pillar 4: Training & Qualification (T&Q)**
- **Pillar 5: Preventive Asset Management (PAM)**

Use VSM to identify practical applications of advanced technologies. After creating the "as is" version of the graphical map, the team looks to identify waste and eliminate it.

i) Quality, service improvement and redesign (QSIR) tools:

This is a comprehensive collection of proven quality, service improvement and redesign tools, theories and techniques that can be applied to a wide variety of situations. You can search the collection alphabetically for a specific tool or browse groups of tools using one of four categories. Use VSM to identify practical applications of advanced technologies. After creating the "as is" version of the graphical map, the team looks to identify waste and eliminate it.

House of TPM (CBS)

	Fundamentals			Steps		
Organization	TPM Organization			0. Preparation All Pillars	All Pillar	
	TPM Responsibility			0. Preparation Pillar1	Elimination of Central Problems	Pillar No. 1
	TPM Resources / Budgets			1. Identify sources of loss		
	TPM Communication			2. Determine focal points		
	TPM Actions			3. Setup improvement		
	TPM Roadmap	Advanced steps	Execution of Activities	4. Analyze causes		
	TPM Controlling		Elimination of Losses			
	TPM Information Material		Priority	5. Elaborate measures		
	Initial Information		Costs of Losses			
	Regulary TPM Information	Operational excellence	Responsibility/ Controlling	6. Implement measures		
	Special Activities / TPM		Interdiciplinary			
	TPM Auditors		Knowledge Management	7. Carry out success controls		
				0. Preparation Pillar2	Autonomous Maintenance	Pillar No. 2
				1. Conduct initial cleaning and inspection		
				2. Eliminate sources of contamination and inaccessible areas		
				3. Develop and test provisional standards for		
		Advanced steps	Skill Matrix	4. Conduct training for inspection and develop		
			One Point Lesson			
			Visual Management			
			Improvement of Standards	5. Autonomous inspection		
			Reduction of Losses			
		Operational excellence	OEE Improvement	6. Organize and manage the workplace		
			Automomous Repair			
			Automomous Maintenance	7. Ongoing autonomous maintenance		
				0. Preparation Pillar3	Systematic Maintenance	Pillar No. 3
				1. Maintenance priorities		
				2. Stable starting point		
				3. IPS system (information planning and control		
		Advanced steps	Control	4. Process-referred maintenance		
			Execution of Activities			
			Improvements			
			Root Cause Analysis			
			Targets			
			Visual Management	5. Process optimization		
			Autonomous Maintenance			
		Operational excellence	Life Cycle Cost	6. Improving maintenance		
			KPI Improvement			
			Improvement Material	7. Planned maintenance program		
			Improvment Standards			
				0. Preparation Pillar4	Training & Qualification	Pillar No. 4
				1. Awareness		
				2. TPM-Basics		
				3. TPM-Tools		
		Advanced steps	Execution	4. Elimination of central problems		
			Trainer			
			Materials	5. Autonomous Maintenance		
			Budget and Plan (including resources)			
		Operational excellence	Roll Out	6. Systematic Maintenance		
			Incentive system			
			Target	7. Manufacturing		
Standard / 5S	Order / Sort			0. Preparation Pillar5	Preventive Asset Management	Pillar No. 5
	Informationen			1. Product development		
	Standards to set in order			2. Plant/Equipment		
	Cleanliness			3. Plant/Equipment construction		
	Cleanliness Standards	Advanced steps	Target Costing	4. Plant/Equipment manufacturing		
	Tag System		Knowledge Management			
	Standard Operations (for Operator)		Improvement			
	Standard Operations (for Machines)		Visual Management	5. Installation		
	Information Standard		Multiple PAM			
	Respect of Standard		PAM Teams			
	Improvement of Standards	Operational excellence	Improvement	6. Start-up / Ramp-up		
	Responsibility of Standard		Respect of Standards			
	Audit		KPI	7. Operation		
	Targets / Goals		Supplier Development			

TPM Pillars and steps used in Continental AG

Figure 5.1 House of TPM (CBS – Continental Business System) (27)

6) Product description and quality analysis

As described in the segment of MEB and BEV these two are being produced held by the client Volkswagen and FCA.

Line 12 Simplex

a) Line & description

Line Fundamentals		
Line Assy	Linea 12 SImplex	
Client	VW+FCA	
Volume	1104000	Car Units annualy
Shifts	4	
OEE Actual	25.27%	
OEE target	80%	
Takt time	21.50	sec
Target cycle time	15.05	sec

Table 6.1 Line description (28)

i) Line Layout and product flow

OP	Descrizione lavoro	OP	Description	CT AVG MES	
10	Housing load	MGU_OP10_BASIC		22,94	Loop 1
		MGU_OP10_MIRROR		22,59	
15	US membrane welding	MGU_OP15_BASIC		21,64	
		MGU_OP15_MIRROR		22,49	
20	Worm insertion + motor in housing	MGU_OP20_1_BASIC	Pos	21,55	
		MGU_OP20_1_MIRROR	Pos	21,40	
		MGU_OP20_2_BASIC	Piant	21,87	
		MGU_OP20_2_MIRROR	Piant	21,82	
30.1	Ball Bearing load	MGU_OP30_1_BASIC		17,73	Loop 2
		MGU_OP30_1_MIRROR		17,72	
30.2	Carico Driven Wheel	MGU_OP30_2_1_BASIC	Posaggio	16,75	
		MGU_OP30_2_1_MIRROR	Posaggio	16,41	
	Driven Wheel insertion	MGU_OP30_2_2_BASIC	Pressa	16,81	
		MGU_OP30_2_2_MIRROR	Pressa	16,79	
	Driven Wheel axial greasing	MGU_OP30_2_3_BASIC	Ingrassaggio	17,42	
		MGU_OP30_2_3_MIRROR	Ingrassaggio	17,43	
30.3	Washer #1 load	MGU_OP30_3_1_BASIC	Posaggio	17,52	
		MGU_OP30_3_1_MIRROR	Posaggio	17,48	
	Washer #1 greasing	MGU_OP30_3_2_BASIC	Ingrassaggio	17,58	
		MGU_OP30_3_2_MIRROR	Ingrassaggio	17,55	
30.4	Axial bearing load	MGU_OP30_4_1_BASIC	Posaggio	18,10	
		MGU_OP30_4_1_MIRROR	Posaggio	18,22	
	Axial bearing greasing	MGU_OP30_4_2_BASIC	Ingrassaggio	18,75	
		MGU_OP30_4_2_MIRROR	Ingrassaggio	18,89	
30.5	Washer #2 load	MGU_OP30_5_1_BASIC	Posaggio	19,03	
		MGU_OP30_5_1_MIRROR	Posaggio	19,20	
	Washer #2 greasing	MGU_OP30_5_2_BASIC	Ingrassaggio	19,12	
		MGU_OP30_5_2_MIRROR	Ingrassaggio	19,30	
30.6	Spring + Spring (x2) + cap	MGU_OP30_6_BASIC	Posaggio	19,02	
		MGU_OP30_6_MIRROR	Posaggio	19,16	
30.8	Spindle load + greasing	MGU_OP30_8_1_BASIC	Pos.	20,12	
		MGU_OP30_8_1_MIRROR	Pos.	19,96	
30.8	Spindle screwing	MGU_OP30_8_2_BASIC	Avv.	20,29	
		MGU_OP30_8_2_MIRROR	Avv.	20,55	
40	Actuation device in housing (+grease + check)	MGU_OP40_2_BASIC	Ingr.	20,32	
		MGU_OP40_2_MIRROR	Ingr.	20,46	
		MGU_OP40_3_BASIC	Piant.	21,32	
		MGU_OP40_3_MIRROR	Piant.	21,00	
50	Leadframe welding	MGU_OP50_BASIC		23,59	Loop 1
		MGU_OP50_MIRROR		23,40	
70	Cover load	MGU_OP70_1_BASIC	Ingr.	24,32	
		MGU_OP70_1_MIRROR	Ingr.	24,13	
70	2nd greasing	MGU_OP70_2_BASIC	Pos.	24,54	
		MGU_OP70_2_MIRROR	Pos.	24,35	
80	Cover Laser Welding	MGU_OP80_1_BASIC	Prel.	24,62	
		MGU_OP80_1_MIRROR	Prel.	24,75	
		MGU_OP80_2_BASIC	Salda.	26,56	
		MGU_OP80_2_MIRROR	Salda	25,97	
		MGU_OP80_3_BASIC	Ingr.	25,81	
		MGU_OP80_3_MIRROR	Ingr.	26,44	
110	Spindle release	MGU_OP110_BASIC		26,47	
		MGU_OP110_MIRROR		27,23	
120	Leakage test	MGU_OP120_1_BASIC		50,63	
		MGU_OP120_1_MIRROR		50,49	
		MGU_OP120_2_BASIC		51,51	
		MGU_OP120_2_MIRROR		51,37	
125	3rd greasing	MGU_OP125_1_BASIC	Ingrassaggio	29,30	
		MGU_OP125_1_MIRROR	Ingrassaggio	29,48	
		MGU_OP125_2_BASIC	Visione	42,74	
		MGU_OP125_2_MIRROR	Visione	26,21	
131	Cut + peeling + crimping spindle 1	MGU_OP131_BASIC		30,02	Loop 3
132	Cut + peeling + crimping spindle 1	MGU_OP132_MIRROR		30,66	
141.1	Gaiter positioning 1	MGU_OP141_1_1_BASIC	Ins.	30,35	
141.2	Gaiter positioning 2	MGU_OP141_1_2_MIRROR	Ins.	30,01	
142.1	Peeling 1	MGU_OP142_1_BASIC		28,26	
142.2	Peeling 2	MGU_OP142_2_MIRROR		26,44	
151	Nipple crimping 1	MGU_OP151_BASIC		27,62	
152	Nipple crimping 2	MGU_OP152_MIRROR		28,41	
160	Gaiter insertion	MGU_OP160_BASIC		27,63	
		MGU_OP160_MIRROR		28,18	
170	EoL Test	MGU_OP170_BASIC		28,08	
		MGU_OP170_MIRROR		28,92	
180	Laser marking	MGU_OP180_BASIC		27,78	
		MGU_OP180_MIRROR		27,68	
190	Unload	MGU_OP190_BASIC		26,93	
		MGU_OP190_MIRROR		26,82	

Table 6.2 Line layout with cycle time (29)

ii) Product flow

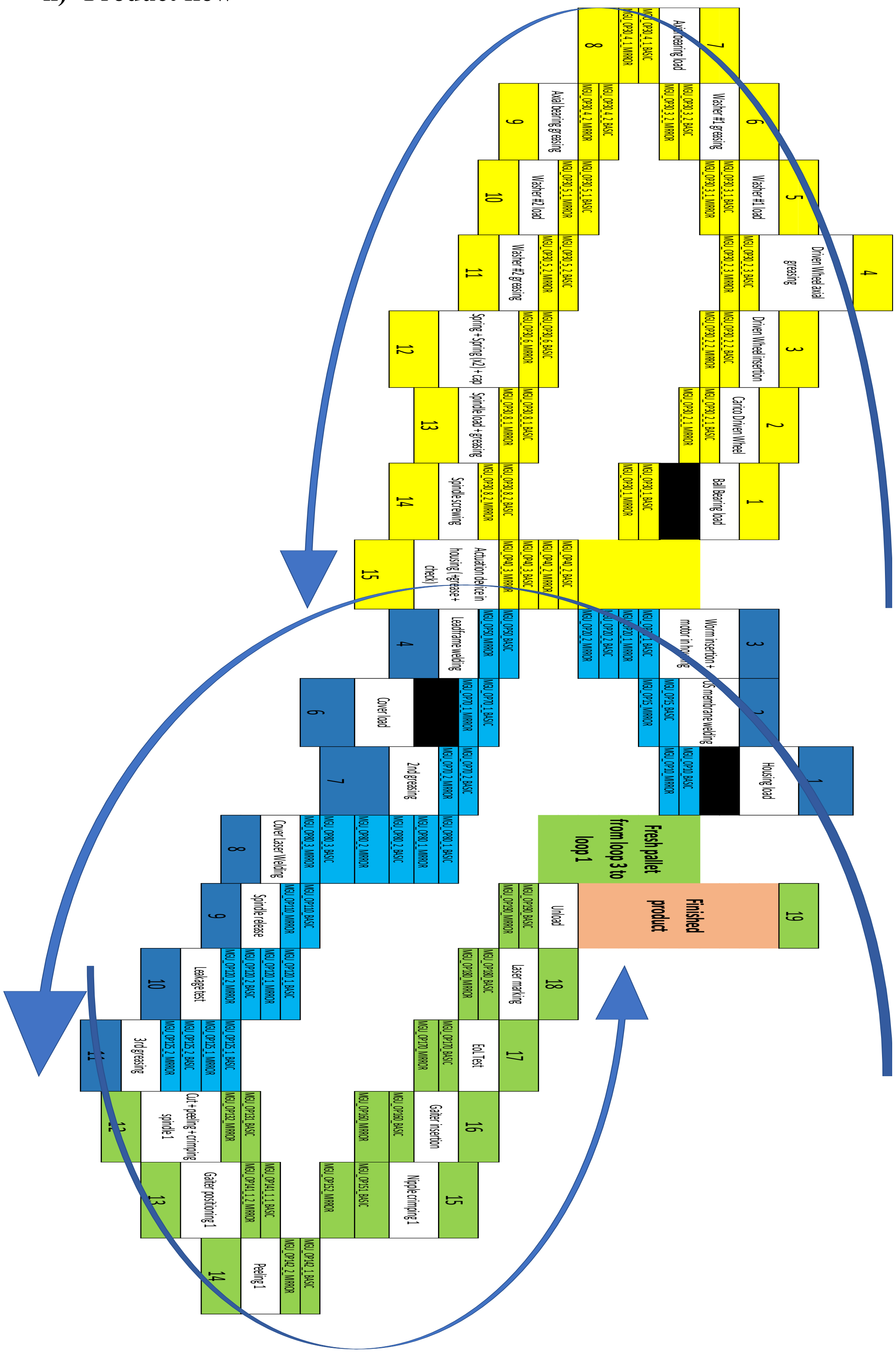


Figure 6.3 Product flow (30)

iii) MES DATA Production Quality

Daily Analysis of fail rate Calendar week wise.
Below are equipment failure rates of line 12 simplex which are taken for every day where its is being cumulatively taken in order to trace and take actions.

Equipment FAIL RATE CW	12/10/2020	13/10/2020	14/10/2020	15/10/2020	16/10/2020	17/10/2020	Total CW 41
MGU_OP15_BASIC	9.4%	14%	9%	7%	8%	10%	9%
MGU_OP180_BASIC	22.2%	11%	7%	3%	4%	7%	9%
MGU_OP30_8_2_MIRROR	6.6%	11%	12%	5%	9%	10%	9%
MGU_OP30_2_1_MIRROR	6.7%	5%	4%	15%	4%	2%	6%
MGU_OP30_3_2_MIRROR	3.6%	7%	5%	5%	5%	3%	5%
MGU_OP30_2_2_MIRROR	2.1%	0%	0%	4%	7%	7%	3%
MGU_OP160_MIRROR	1.7%	2%	5%	4%	5%	2%	3%
MGU_OP40_2_BASIC	2.5%	2%	2%	3%	7%	3%	3%
MGU_OP15_MIRROR	1.7%	4%	3%	2%	3%	6%	3%
MGU_OP40_2_MIRROR	1.0%	1%	1%	3%	7%	6%	3%
MGU_OP30_5_2_MIRROR	2.5%	2%	3%	5%	3%	2%	3%
MGU_OP30_2_2_BASIC	2.4%	1%	5%	6%	2%	0%	3%
MGU_OP152_MIRROR	3.5%	4%	3%	1%	1%	3%	3%
MGU_OP30_8_2_BASIC	2.8%	3%	2%	2%	2%	4%	3%
MGU_OP20_1_MIRROR	7.7%	0%	1%	1%	1%	3%	2%
MGU_OP40_3_BASIC	2.8%	3%	2%	1%	1%	2%	2%
MGU_OP151_BASIC	0.7%	2%	6%	0%	2%	1%	2%
MGU_OP20_2_BASIC	1.4%	3%	3%	1%	1%	2%	2%
MGU_OP30_5_2_BASIC	0.1%	1%	2%	7%	0%	0%	2%
MGU_OP20_1_BASIC	6.0%	0%	1%	0%	1%	2%	2%
MGU_OP180_MIRROR	0.8%	2%	2%	0%	3%	2%	2%
MGU_OP40_3_MIRROR	1.3%	1%	1%	1%	2%	3%	2%
MGU_OP80_2_MIRROR	0.0%	5%	3%	1%	0%	0%	1%
MGU_OP125_2_MIRROR	0.0%	4%	3%	1%	0%	0%	1%
MGU_OP170_MIRROR	1.1%	4%	1%	1%	0%	0%	1%
MGU_OP110_BASIC	0.1%	0%	1%	0%	5%	2%	1%
MGU_OP170_BASIC	1.4%	1%	2%	1%	3%	1%	1%
MGU_OP141_1_2_MIRROR	0.1%	0%	1%	3%	1%	2%	1%
MGU_OP160_BASIC	1.1%	1%	2%	1%	1%	1%	1%
MGU_OP30_8_1_MIRROR	1.1%	0%	0%	0%	0%	5%	1%
MGU_OP120_1_BASIC	0.3%	1%	1%	1%	1%	2%	1%
MGU_OP30_6_MIRROR	0.0%	0%	1%	1%	2%	0%	1%
MGU_OP30_6_BASIC	0.0%	0%	1%	1%	2%	0%	1%
MGU_OP30_3_2_BASIC	0.3%	0%	1%	1%	2%	1%	1%
MGU_OP141_1_1_BASIC	0.1%	0%	1%	2%	0%	0%	1%
MGU_OP120_2_MIRROR	1.0%	1%	1%	0%	0%	0%	1%
MGU_OP30_4_2_MIRROR	0.1%	0%	0%	3%	0%	0%	1%
MGU_OP125_2_BASIC	1.1%	0%	0%	1%	1%	1%	1%
MGU_OP20_2_MIRROR	0.1%	1%	1%	0%	1%	1%	1%
MGU_OP10_BASIC	0.4%	1%	0%	1%	0%	1%	1%
MGU_OP80_2_BASIC	0.0%	0%	1%	1%	1%	0%	1%
MGU_OP10_MIRROR	0.1%	1%	0%	1%	0%	0%	0%
MGU_OP131_BASIC	0.7%	0%	0%	0%	0%	0%	0%
MGU_OP30_8_1_BASIC	0.3%	0%	0%	0%	1%	1%	0%
MGU_OP120_2_BASIC	0.4%	0%	0%	0%	0%	0%	0%
MGU_OP120_1_MIRROR	0.1%	0%	0%	0%	0%	0%	0%
MGU_OP142_1_BASIC	0.0%	0%	0%	0%	0%	0%	0%
MGU_OP132_MIRROR	0.3%	0%	0%	0%	0%	0%	0%
MGU_OP30_4_2_BASIC	0.0%	0%	0%	0%	0%	0%	0%
MGU_OP50_MIRROR	0.0%	0%	0%	0%	0%	0%	0%
MGU_OP50_BASIC	0.0%	0%	0%	0%	0%	0%	0%

Table 6.3 Weekly % of defects (31)

The above has been graphically represented in a pie chart. To have get main contributor to the quality defects with respect to the production.

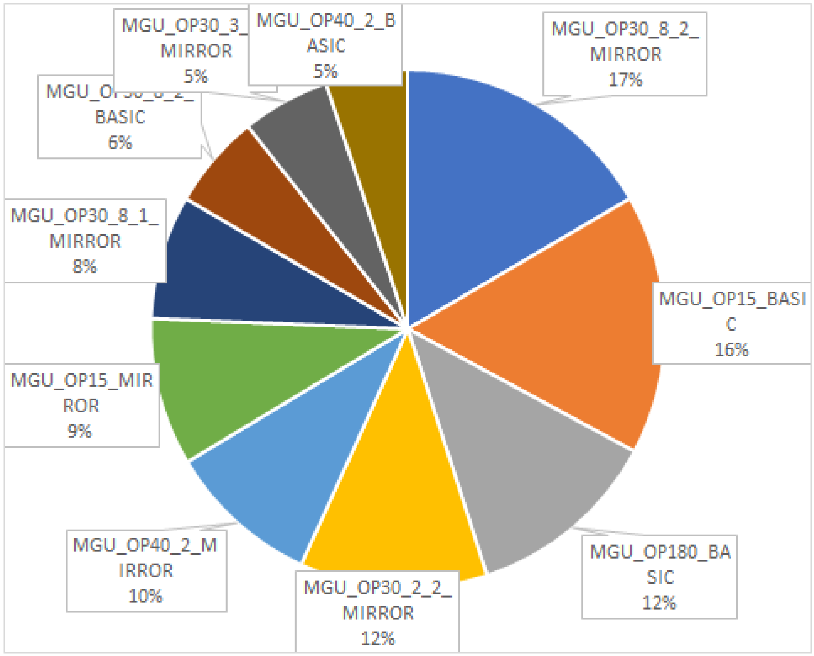


Figure 6.4 Weekly defect rate in Pie chart (32)

Waterfall chart to understand the impact:

MGU_OP30_2_2_BASIC		
	02/11/2020	7,3%
	03/11/2020	11,4%
	04/11/2020	8,3%
	05/11/2020	12,5%
	06/11/2020	13,7%
	07/11/2020	13,4%
TOTAL		66,5%

MGU_OP15_BASIC		
	02/11/2020	5,74%
	03/11/2020	10,80%
	04/11/2020	10,41%
	05/11/2020	16,61%
	06/11/2020	8,18%
	07/11/2020	9,03%
TOTAL		60,78%

MGU_OP160_BASIC		
	02/11/2020	4,00%
	03/11/2020	5,92%
	04/11/2020	7,73%
	05/11/2020	10,01%
	06/11/2020	6,35%
	07/11/2020	4,24%
TOTAL		38,25%

MGU_OP30_8_1_BASIC		
	02/11/2020	14,51%
	03/11/2020	3,52%
	04/11/2020	7,07%
	05/11/2020	2,83%
	06/11/2020	10,19%
	07/11/2020	0,00%
TOTAL		38,13%

Figure 6.5 Weekly defect rate in Waterfall chart (33)

iv) Cycle time and quality performance

Cycle time and quality performance of the operations from the MES which are being analyzed and performed.

MGU_Operations	QTY performance	CT Performance	Overall average sec	23/12	28/12	29/12	30/12
MGU_OP120_2_BASIC	99,54%	23%	51,51	35,58	36,53	35,75	37,32
MGU_OP120_1_BASIC	98,76%	24%	50,63	36,88	36,40	35,56	41,49
MGU_OP125_2_BASIC	99,08%	28%	42,74	19,87	19,92	18,80	21,32
MGU_OP141_1_1_BASIC	99,40%	40%	30,35	20,13	19,72	18,99	21,24
MGU_OP131_BASIC	99,63%	40%	30,02	20,23	20,15	18,74	21,63
MGU_OP125_1_BASIC	100,00%	41%	29,30	19,96	19,92	18,94	20,96
MGU_OP142_1_BASIC	99,83%	42%	28,26	21,22	21,29	21,36	21,44
MGU_OP151_BASIC	99,26%	43%	27,62	20,46	19,97	19,05	20,57
MGU_OP170_BASIC	98,52%	43%	28,08	25,73	25,73	25,73	25,73
MGU_OP160_BASIC	97,71%	43%	27,63	21,00	20,37	18,94	20,31
MGU_OP180_BASIC	98,00%	43%	27,78	22,06	21,88	19,68	21,93
MGU_OP110_BASIC	99,67%	45%	26,47	18,80	19,01	18,76	20,56
MGU_OP190_BASIC	99,82%	45%	26,93	20,69	20,81	19,07	20,81
MGU_OP80_2_BASIC	99,62%	45%	26,56	19,06	19,23	19,06	55,14
MGU_OP80_3_BASIC	100,00%	46%	25,81	19,01	18,93	18,83	19,84
MGU_OP80_1_BASIC	100,00%	49%	24,62	18,73	18,90	18,73	19,76
MGU_OP70_1_BASIC	99,58%	49%	24,32	18,48	18,77	19,00	19,90
MGU_OP70_2_BASIC	99,95%	49%	24,54	18,44	19,01	19,05	19,96
MGU_OP50_BASIC	99,59%	51%	23,59	18,66	18,73	19,12	18,97
MGU_OP10_BASIC	98,43%	52%	22,94	18,31	18,28	16,64	19,27
MGU_OP20_2_BASIC	98,65%	55%	21,87	18,18	18,70	19,14	17,76
MGU_OP40_3_BASIC	97,73%	56%	21,32	18,32	18,57	18,52	18,38
MGU_OP30_8_1_BASIC	96,78%	60%	20,12	17,60	17,13	17,70	16,84
MGU_OP20_1_BASIC	99,35%	56%	21,55	18,12	18,89	19,25	18,00
MGU_OP15_BASIC	94,50%	55%	21,64	18,77	18,43	17,63	18,89
MGU_OP30_8_2_BASIC	97,14%	59%	20,29	17,36	17,24	17,76	16,97
MGU_OP40_2_BASIC	98,77%	59%	20,32	18,04	18,27	18,22	17,85
MGU_OP30_5_2_BASIC	99,29%	63%	19,12	17,74	16,20	19,72	17,09
MGU_OP30_6_BASIC	99,61%	63%	19,02	17,27	17,74	18,69	16,82
MGU_OP30_5_1_BASIC	100,00%	63%	19,03	16,52	16,25	16,84	15,31
MGU_OP30_4_2_BASIC	99,69%	64%	18,75	16,47	16,36	16,89	15,43
MGU_OP30_4_1_BASIC	100,00%	66%	18,10	16,50	16,34	16,95	15,50
MGU_OP30_2_2_BASIC	97,04%	71%	16,81	16,23	16,53	16,79	15,95
MGU_OP30_3_2_BASIC	98,70%	68%	17,58	16,32	16,13	16,76	15,44
MGU_OP30_1_BASIC	99,96%	68%	17,73	16,78	17,12	17,22	16,66
MGU_OP30_3_1_BASIC	99,91%	69%	17,52	16,35	16,17	16,77	15,36
MGU_OP30_2_3_BASIC	99,99%	69%	17,42	16,29	16,23	16,86	15,39
MGU_OP30_2_1_BASIC	99,25%	72%	16,75	16,23	16,66	16,96	16,02
MGU_OP120_2_MIRROR	99,43%	23%	51,37	35,59	36,66	35,62	38,55
MGU_OP120_1_MIRROR	99,22%	24%	50,49	36,85	36,51	35,30	42,24
MGU_OP170_MIRROR	98,10%	41%	28,92	27,55	27,55	27,55	27,55
MGU_OP180_MIRROR	99,53%	43%	27,68	21,41	21,67	19,17	21,68
MGU_OP190_MIRROR	99,86%	45%	26,82	20,65	20,84	18,96	21,07
MGU_OP160_MIRROR	97,65%	43%	28,18	20,66	20,38	18,57	20,50
MGU_OP142_2_MIRROR	99,81%	45%	26,44	20,10	19,50	18,99	19,02
MGU_OP152_MIRROR	98,60%	42%	28,41	20,35	19,93	18,52	19,87
MGU_OP141_1_2_MIRROR	99,37%	40%	30,01	20,00	19,53	18,84	20,67
MGU_OP132_MIRROR	99,76%	39%	30,66	20,13	19,56	18,67	20,99
MGU_OP125_1_MIRROR	100,00%	41%	29,48	19,97	19,88	18,94	21,11
MGU_OP110_MIRROR	99,93%	44%	27,23	18,95	19,04	18,79	20,83
MGU_OP80_3_MIRROR	100,00%	45%	26,44	18,98	18,77	18,70	20,15
MGU_OP30_8_2_MIRROR	96,13%	58%	20,55	17,49	17,42	17,88	17,29
MGU_OP10_MIRROR	99,25%	53%	22,59	19,15	17,97	16,58	19,21
MGU_OP80_2_MIRROR	99,65%	46%	25,97	19,09	19,33	19,03	20,46
MGU_OP125_2_MIRROR	99,37%	46%	26,21	19,06	19,34	19,02	20,42
MGU_OP40_3_MIRROR	98,47%	57%	21,00	18,27	18,56	18,50	18,36
MGU_OP30_8_1_MIRROR	96,78%	60%	19,96	16,88	16,98	17,76	17,08
MGU_OP70_2_MIRROR	99,99%	49%	24,35	18,48	19,06	19,03	19,85
MGU_OP20_2_MIRROR	99,46%	55%	21,82	18,18	18,70	19,14	17,71
MGU_OP70_1_MIRROR	99,43%	50%	24,13	18,51	18,77	18,88	19,85
MGU_OP50_MIRROR	99,80%	51%	23,40	18,67	18,68	19,17	19,06
MGU_OP20_1_MIRROR	99,07%	56%	21,40	18,14	18,89	19,27	17,80
MGU_OP15_MIRROR	96,05%	53%	22,49	18,87	18,26	18,04	19,26
MGU_OP40_2_MIRROR	98,63%	59%	20,46	18,04	18,28	18,23	17,85
MGU_OP30_4_2_MIRROR	99,19%	64%	18,89	16,47	16,41	16,93	15,55
MGU_OP30_4_1_MIRROR	100,00%	66%	18,22	16,40	16,36	16,96	15,53
MGU_OP30_5_2_MIRROR	99,42%	62%	19,30	17,77	16,42	19,80	17,38
MGU_OP80_1_MIRROR	99,99%	48%	24,75	18,74	18,96	18,74	19,72
MGU_OP30_5_1_MIRROR	100,00%	62%	19,20	16,57	16,40	17,03	15,49
MGU_OP30_6_MIRROR	99,51%	63%	19,16	17,33	17,95	18,91	17,12
MGU_OP30_3_1_MIRROR	99,97%	69%	17,48	16,35	16,13	16,75	15,37
MGU_OP30_2_3_MIRROR	99,99%	69%	17,43	16,29	16,17	16,86	15,48
MGU_OP30_3_2_MIRROR	97,15%	68%	17,55	16,31	16,13	16,76	15,44
MGU_OP30_1_MIRROR	100,00%	68%	17,72	16,80	17,12	17,22	16,67
MGU_OP30_2_2_MIRROR	96,74%	71%	16,79	16,24	16,54	16,80	15,96

Table 6.4 Cycle time Vs Quality rate analysis from MES (Manufacturing execution System) (34)

v) Analysis of Impacting to OEE / Jishuken study

1) Actual OEE VS Forecast and trend

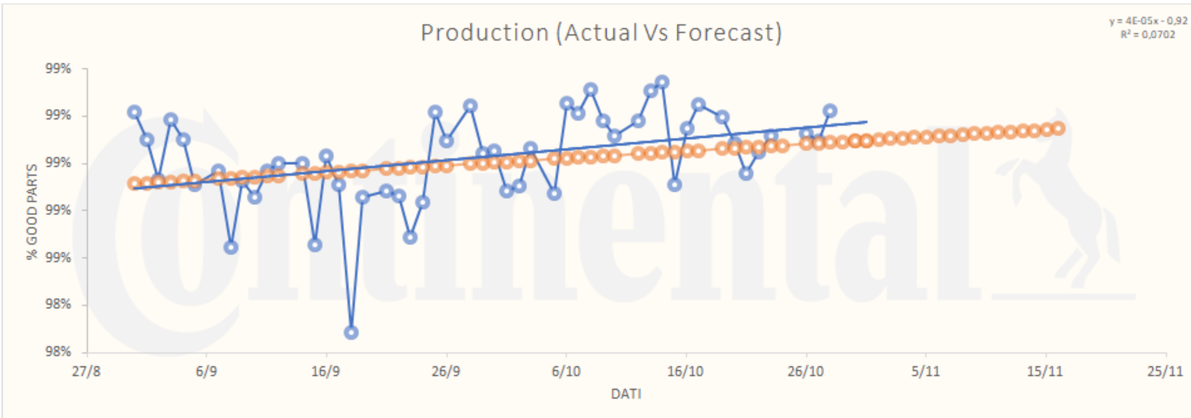


Figure 6.6 Actual OEE VS Forecast and trend (Calculated) (35)

Slope = 3.03083E-05

Intercept = -0.346671896

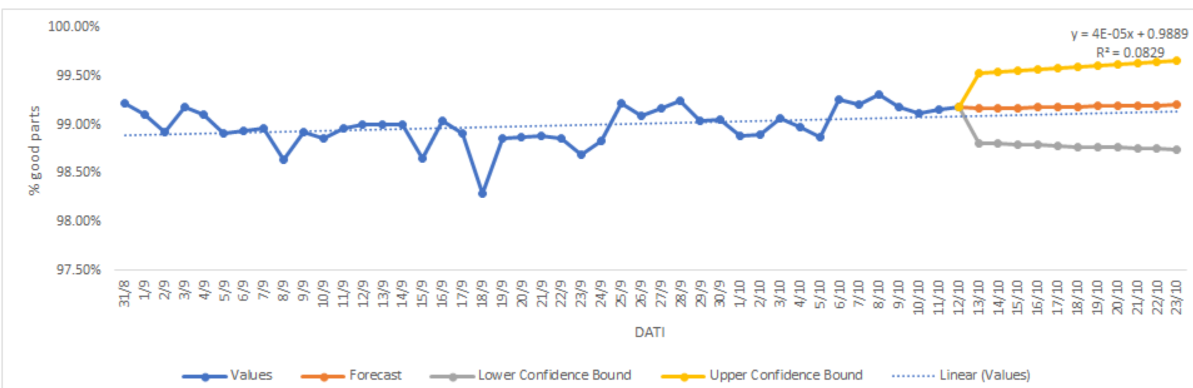


Figure 6.7 Actual OEE VS Forecast and trend (Excel) (36)

2) Variation between Actual and predicted forecast

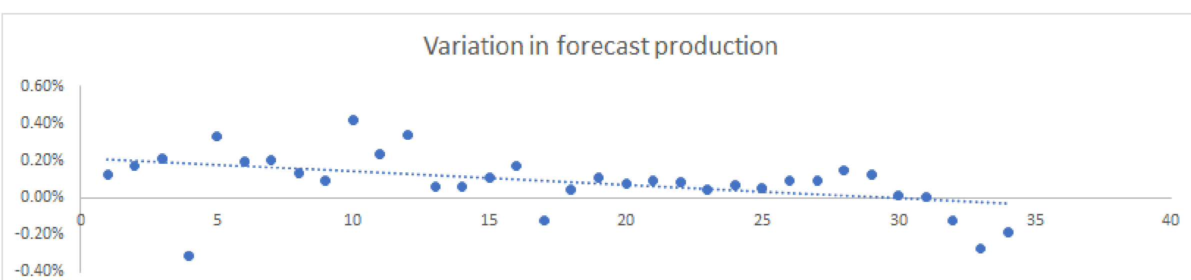


Figure 6.8 Variation in Actual and predicted forecast Forecast (37)

3) *Forecast Defective parts*

Trends with respect to production

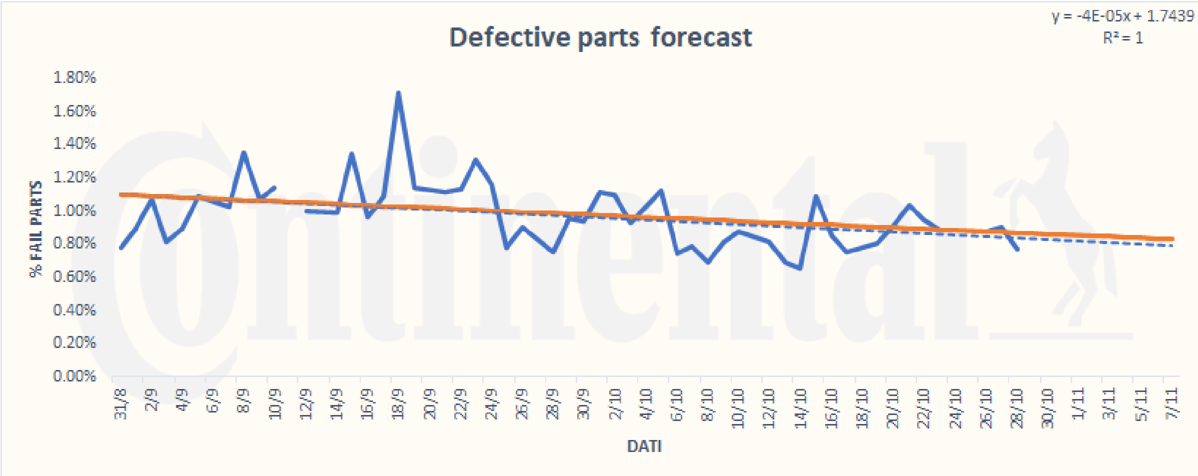


Figure 6.9 Defect rate Forecast and trend (Calculated) (38)

Slope = -3.93181E-05,

Intercept = 1.743892431

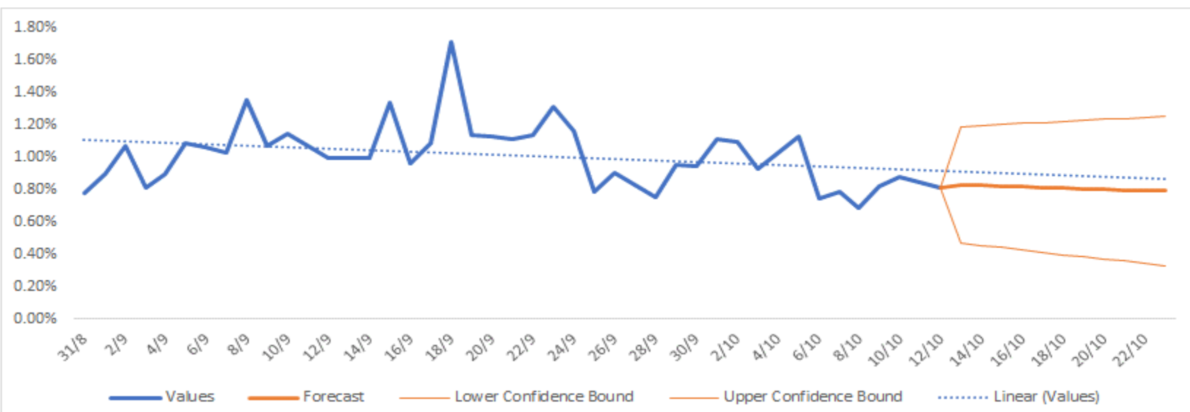


Figure 6.10 Defect rate Forecast and trend (Excel) (39)

4) *Variation between Actual and predicted forecast*

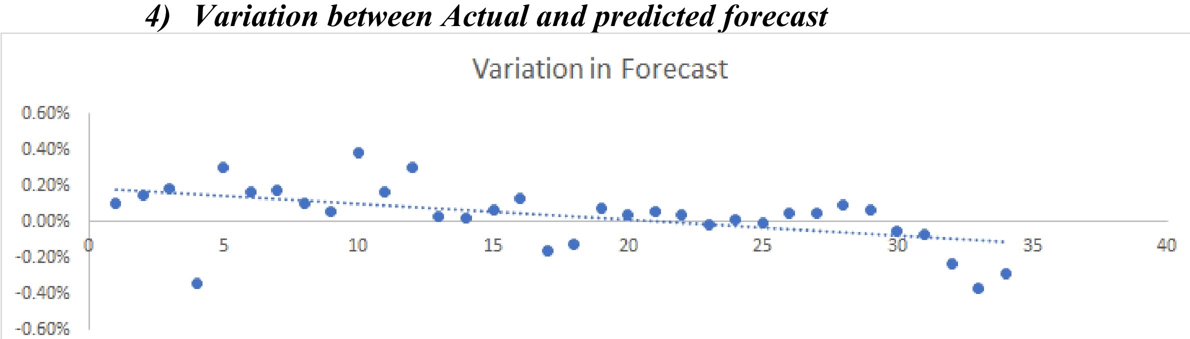


Figure 6.11 Variation in Actual and predicted forecast Forecast in Defects (40)

b) Assembly Line quality study

Line 12 (Simplex)

(i) Overall weekly scrap analysis

It can observe from the graph below that overall trend of scrap analysis is being reduced weeks 41 and 42 were outliers due to new experimentation.

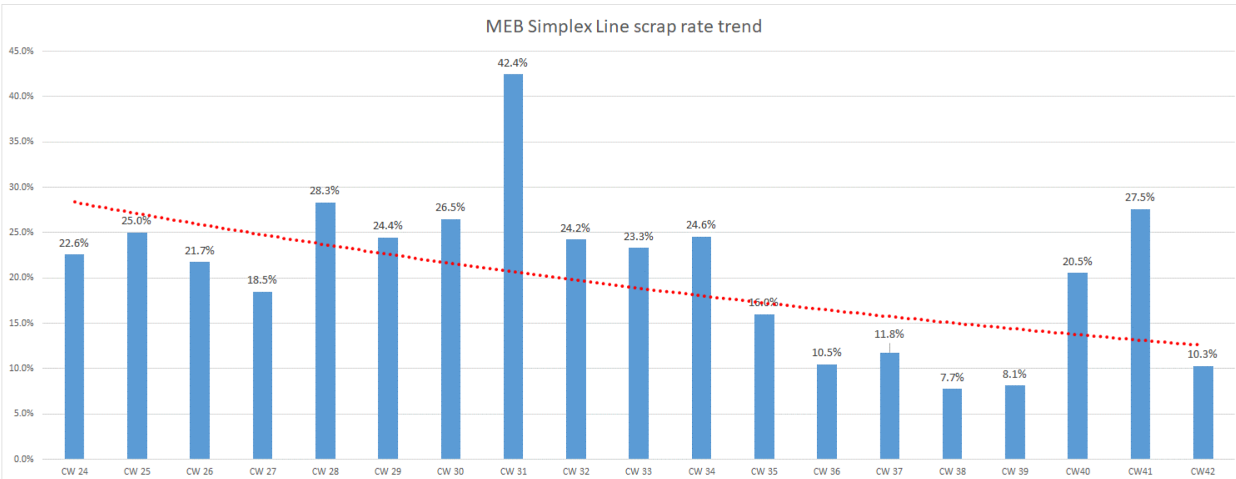


Figure 6.12 Overall weekly scrap analysis (41)

(ii) Operation wise weekly Scrap

The below table along the graph shows the data collection of the above which are being represented on weekly basis and to show the trend of the operation wise ups and downs of the defect rate.

Station	Description	Scrap rate report CW34	Scrap rate CW 41	Scrap rate CW42	Trend report CW34	Trend CW41
PBO OP34_3_1_2	Scragging , performance check and set diameter	11.46%	16.05%	4.36%	-7.10%	-11.69%
OPX	Safe Launch	10.00%	3.38%	3.29%	-6.71%	-0.09%
PBO OP22	Automatic bracket loading and fixation	3.26%	9.55%	3.26%	0.00%	-6.29%
LBO OP08	Greasing vision check	6.20%	3.10%	2.34%	-3.86%	-0.77%
LBO OP04	Automatic screwing	1.57%	1.87%	1.93%	0.36%	0.07%
PBO OP37	Visual chek overview	3.70%	1.59%	1.86%	-1.84%	0.27%
LBO OP10	Brakes unloading (DM shoes reading)	1.82%	2.11%	1.32%	-0.50%	-0.78%
PBO OP33	Hooking cable vision chek	4.54%	2.47%	0.87%	-3.67%	-1.60%
LBO OP03_2	Hook bracket fixation check	5.48%	0.03%	0.31%	-5.17%	0.27%
LBO OP11_2	Clips Check	0.28%	0.51%	0.29%	0.01%	-0.22%
PBO OP24	MGU fixation	1.05%	1.01%	0.24%	-0.81%	-0.77%
PBO OP35	Chek gap betwen HBL pin and web	0.20%	0.54%	0.17%	-0.02%	-0.36%
LBO OP05	Bushing press	0.06%	0.07%	0.05%	-0.01%	-0.02%
PBO OP26	Unload docking loop 1	0.16%	0.05%	0.01%	-0.15%	-0.04%
PBO OP31	Load docking loop 2 and check label	0.14%	0.02%	0.00%	-0.14%	-0.02%
PBO OP23	Manual MGU loading and fixation	3.51%	0.00%	0.00%	-3.51%	0.00%
PBO OP32	Hook cable	1.37%	0.00%	0.00%	-1.37%	0.00%
LBO OP03_1	Backplate manual loading	0.01%	0.00%	0.00%	-0.01%	0.00%
LBO OP01	Reaction block and bushing ,automatic loading	0.00%	0.00%	0.00%	0.00%	0.00%
LBO OP02	WC automatic loading	0.00%	0.00%	0.00%	0.00%	0.00%
LBO OP06	180° rotation	0.00%	0.00%	0.00%	0.00%	0.00%
LBO OP07	Backplate and cable guide greasing	0.00%	0.00%	0.00%	0.00%	0.00%
LBO OP09_1	Match between shoes sub assy and backplate	0.00%	0.00%	0.00%	0.00%	0.00%
LBO OP09_2	Spring check	0.00%	0.00%	0.00%	0.00%	0.00%
LBO OP11_1	Clips insertion	0.00%	0.00%	0.00%	0.00%	0.00%
PBO OP21	Load brakes on Docking loop 1 and chek labeling	0.00%	0.00%	0.00%	0.00%	0.00%
PBO OP36	Visual chek for orphan parts	0.12%	0.00%	0.00%	-0.12%	0.00%
PBO OP38	MGU plug insertion	0.00%	0.00%	0.00%	0.00%	0.00%

Table 6.5 Operation wise weekly Scrap (42)

(iii) Defect Classification

Below are operations were having number of scrap rates where according to Continental AG Standards are as below:

Class A: 10 % and above (weight with respect to the production rate)

Class B: 4 % - 10 % (weight with respect to the production rate)

Class C: 0 % - 3.99 % (weight with respect to the production rate)

Station	Description	Produced Parts Pcs	Good Parts Pcs	Fail Parts Pcs	Scrap rate	Weight	Cum	Class
PBO OP34_3_1_2	Scragging , performance check and set diameter	10779	10309	470	4.36%	22.87%	22.87%	A
OPX	Safe launch	7417	7173	244	3.29%	11.87%	34.74%	
PBO OP22	Automatic bracket loading and fixation	10889	10534	355	3.26%	17.27%	52.02%	
LBO OP08	Greasing vision check	10659	10410	249	2.34%	12.12%	64.14%	
LBO OP04	Automatic screwing	10507	10304	203	1.93%	9.88%	74.01%	B
PBO OP37	Visual chek overview	10278	10087	191	1.86%	9.29%	83.31%	
LBO OP10	Brakes unloading (DM shoes reading)	10424	10286	138	1.32%	6.72%	90.02%	
PBO OP33	Hooking cable vision chek	10899	10804	95	0.87%	4.62%	94.65%	
LBO OP03_2	Hook bracket fixation check	10121	10090	31	0.31%	1.51%	96.16%	C
LBO OP11_2	Clips Check	10359	10329	30	0.29%	1.46%	97.62%	
PBO OP24	MGU fixation	10486	10461	25	0.24%	1.22%	98.83%	
PBO OP35	Chek gap betwen HBL pin and web	10297	10279	18	0.17%	0.88%	99.71%	
LBO OP05	Bushing press	9959	9954	5	0.05%	0.24%	99.95%	
PBO OP26	Unload docking loop 1	10468	10467	1	0.01%	0.05%	100.00%	
LBO OP01	Reaction block and bushing ,automatic loading	10593	10593	0	0.00%	0.00%	100.00%	
LBO OP02	WC automatic loading	10627	10627	0	0.00%	0.00%	100.00%	
LBO OP06	180° rotation	10295	10295	0	0.00%	0.00%	100.00%	
LBO OP07	Backplate and cable guide greasing	10424	10424	0	0.00%	0.00%	100.00%	
LBO OP09_1	Match between shoes sub assy and backplate	10408	10408	0	0.00%	0.00%	100.00%	
LBO OP09_2	Spring check	10406	10406	0	0.00%	0.00%	100.00%	
LBO OP11_1	Clips insertion	10377	10377	0	0.00%	0.00%	100.00%	
PBO OP21	Load brakes on Docking loop 1 and chek labeling	10970	10970	0	0.00%	0.00%	100.00%	
PBO OP23	Manual MGU loading and fixation	10484	10484	0	0.00%	0.00%	100.00%	
PBO OP31	Load docking loop 2 and check label	10461	10461	0	0.00%	0.00%	100.00%	
PBO OP32	Hook cable	10849	10849	0	0.00%	0.00%	100.00%	
PBO OP36	Visual chek for orphan parts	10279	10279	0	0.00%	0.00%	100.00%	
PBO OP38	MGU plug insertion	10090	10090	0	0.00%	0.00%	100.00%	

Table 6.6 Classification of defects (43)

Classification helps to segregate and to point out the main contributors in scrap analysis.

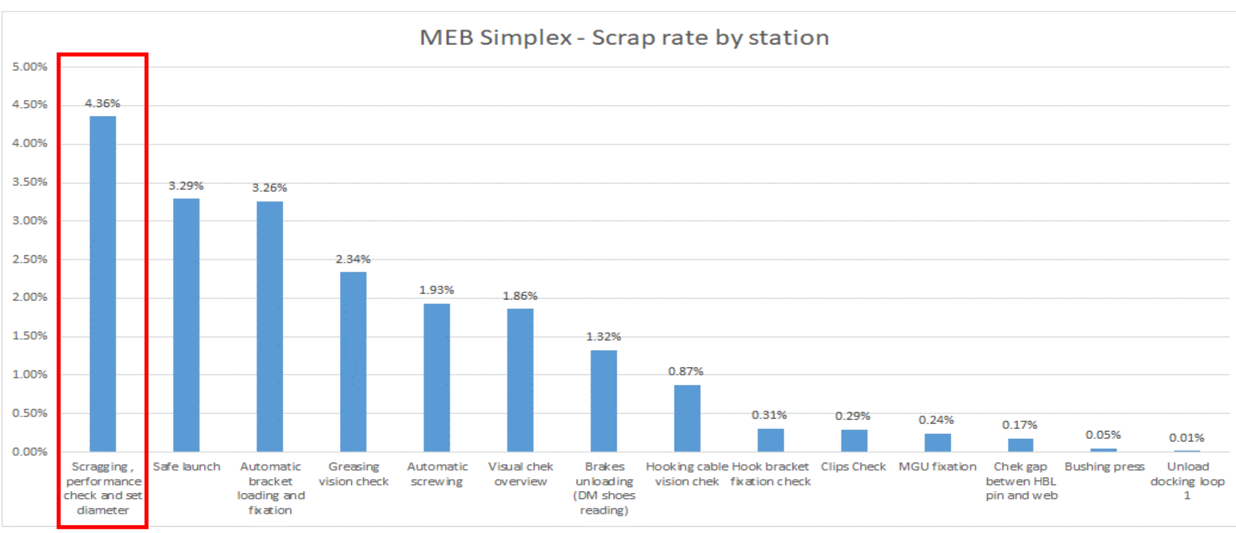


Figure 6.13 Highest defect (44)

Applying Pareto chart of 20- 80 rule classifying according to the operations. From the graph below it can be seen that 3 operations are the main contributors constituting 80 % of the defect rate.

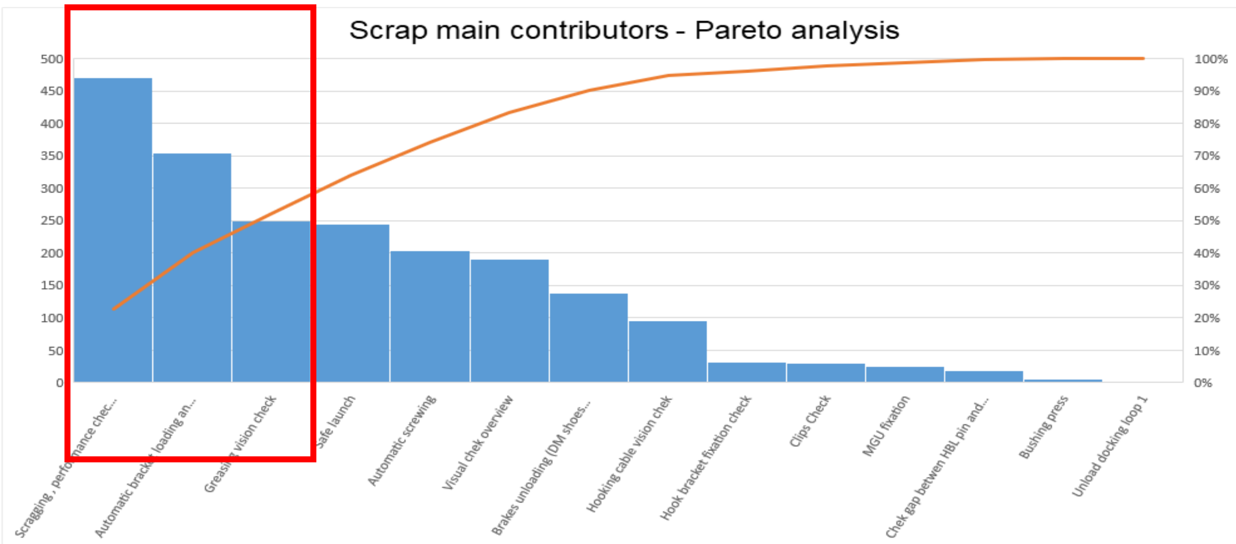


Figure 6.14 Pareto chart (45)

Class A

As Class A were main contributors of scrap analyzing as below:

Explaining top contributor: PBO OP34: 1, 2 and 3- Scragging , performance check and set diameter.

i. Scragging defect Classification

In Scragging, performance check and set diameter, several Defects are contributors where few are being highlighted as below with graphical representation and percentage in the scrap contribution.

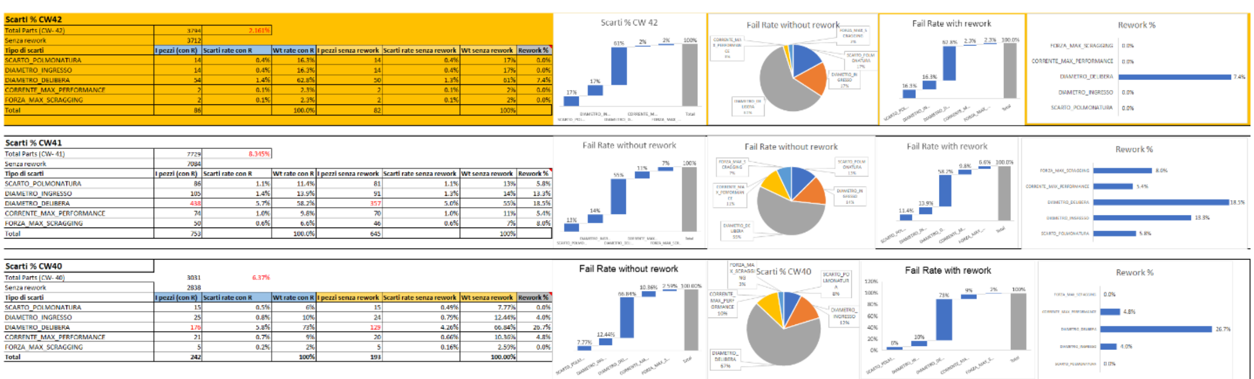


Figure 6.15 Dashboard Scragging (Highest defect rate station) (46)

Above is the dashboard of Scragging which are explained as following:

Types of the defects are which are the main contributors:

1. SCARTO_POLMONATURA
2. DIAMETRO_INGRESSO
3. DIAMETRO_DELIBERA
4. CORRENTE_MAX_PERFORMANCE
5. FORZA_MAX_SCRAGGING

Scarti % CW20							
Total Parts (CW- 20)	10864	0.341%					
Senza rework	10827						
Tipo di scarti	I pezzi (con R)	Scarti rate con R	Wt rate con R	I pezzi senza rework	Scarti rate senza rework	Wt senza rework	Rework %
SCARTO_POLMONATURA	1	0.0%	2.6%	1	0.01%	2.70%	0.0%
DIAMETRO_INGRESSO	28	0.3%	73.7%	28	0.26%	75.68%	0.0%
DIAMETRO_DELIBERA	0	0.0%	0.0%	0	0.00%	0.00%	0.0%
CORRENTE_MAX_PERFORMANCE	8	0.1%	21.1%	7	0.06%	18.92%	12.5%
FORZA_MAX_SCRAGGING	1	0.0%	2.6%	1	0.01%	2.70%	0.0%
Total	38	0.3%	100.0%	37	0.3%	100%	12.5%

Figure 6.16 Types of Scragging defects (47)

The above are being shown weekly basis with the scrap rate in Scragging 1,2,3 where it could be seen as an example that DIAMETRO_INGRESSO is the main contributor for calendar week (CW-20) which is 73.7% with rework and without rework is 76.68 % with respect to the rate of production.

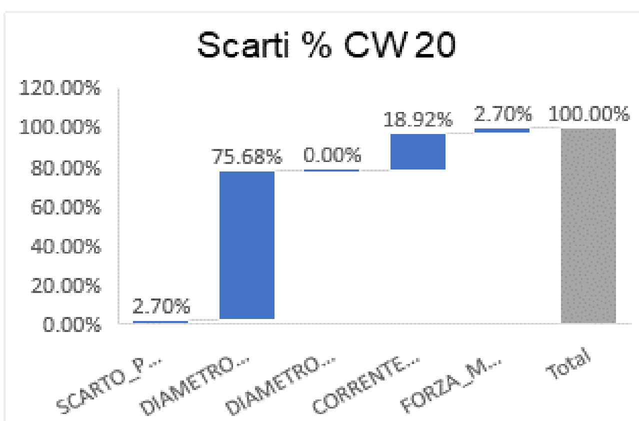


Figure 6.17 (i) Micro analysis Scragging (48)

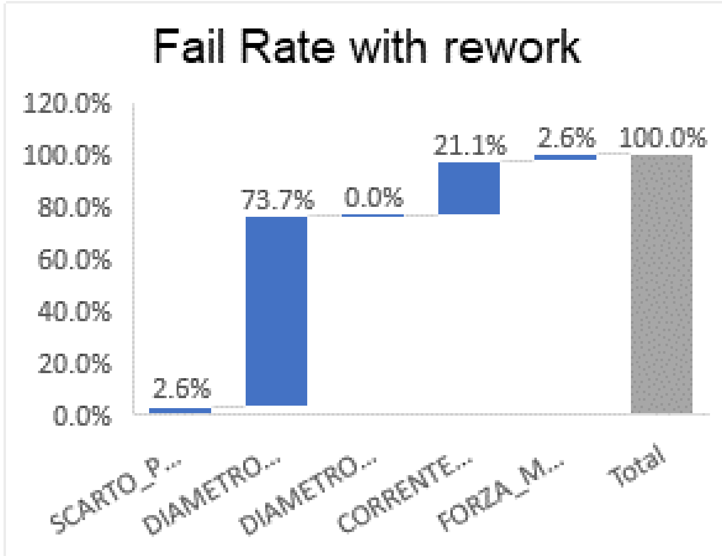


Figure 6.18 (ii) Micro analysis Scragging (49)

Every part passes through each station but scragging station contains 3 stations where the parts get toggled so to segregate which part crossed through which one to pinpoint stations and to take the specific action so take the corrective actions and to reduce percentage of defects.

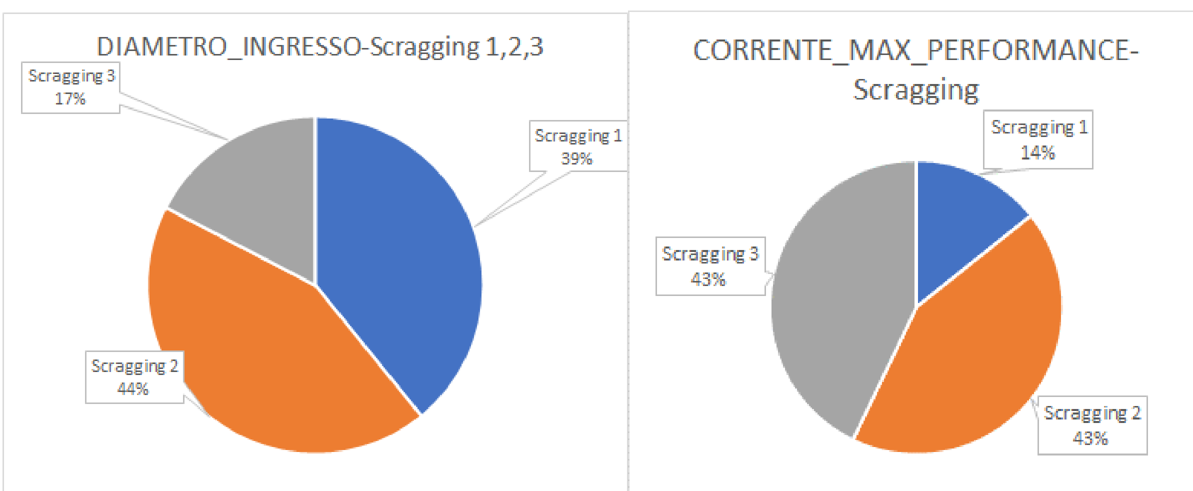
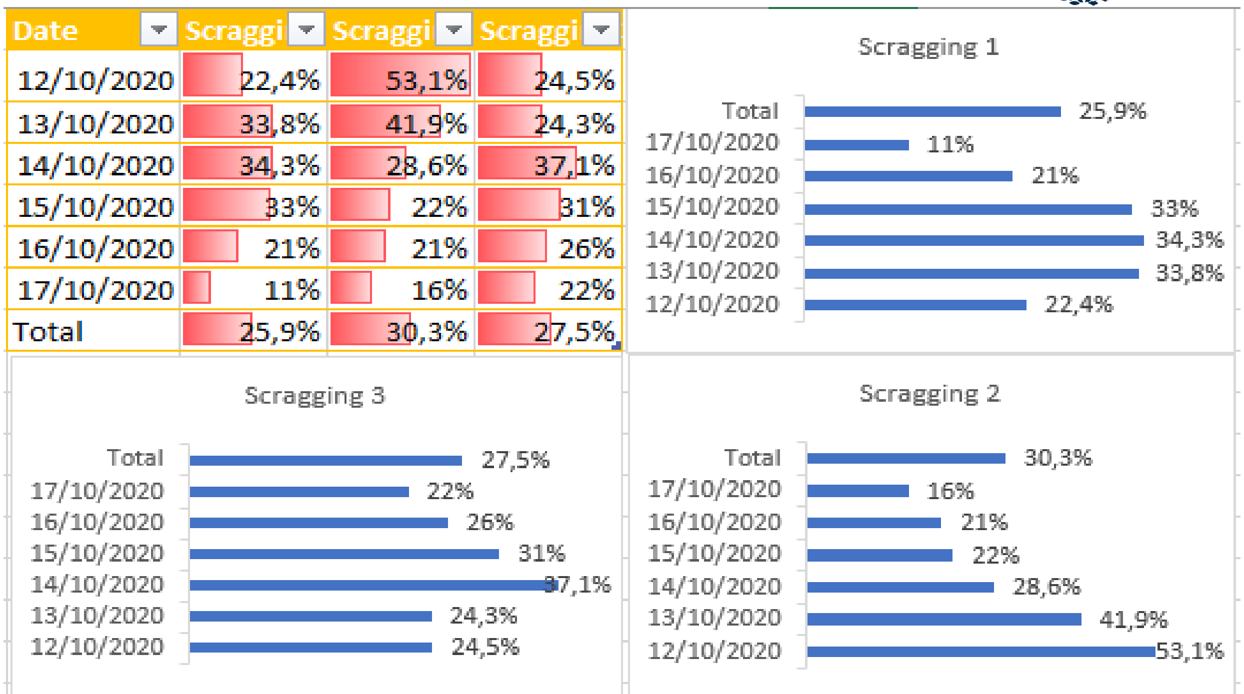


Figure 6.19 (iii) Micro analysis Scragging 1,2,3 station wise (50)

The above steps are being followed which are being impacted to reduce the scrap rate resulting quality rate increment and OEE improvement.



Date	Scraggi	Scraggi	Scraggi
12/10/2020	22,4%	53,1%	24,5%
13/10/2020	33,8%	41,9%	24,3%
14/10/2020	34,3%	28,6%	37,1%
15/10/2020	33%	22%	31%
16/10/2020	21%	21%	26%
17/10/2020	11%	16%	22%
Total	25,9%	30,3%	27,5%

Figure 6.20 (iv) Micro analysis Scragging (51)

7) Performance Study / Jishuken study

a) Scope of Content

The Automotive Manufacturing Jishuken methodology describes the standard process for the continuous improvement on a targeted area in the shop floor, selected before by the management, which must be recovered or prepared for a safety and quality improvement or productivity increase.

This standard will explain the necessary process steps, to apply a certain methods and tools, to reach the defined target, by identifying the areas where we have deviation to standards. It is as well describing the tools that are suitable to be used by the Jishuken team members during the workshop's activity.

This document is applicable to all shop floor area like Surface Mouthing Technology (SMT), Printed Circuit Board Assembly (PCBA), Final Assembly (FA) and as well to the Supply Chain Management (SCM) areas, were the required improvement was identified.

b) What is JISHUKEN?

JISHUKEN is a type of „learning by doing "workshop with the target to identify weaknesses (MUDA) and to drive improvement (KAIZEN) with a systematic approach in any kind of area of operations driven by management.

A JISHUKEN workshop can be run for some days up to 1 year. It`s devided in several workshops (normally ~ 4 main workshops which take about 1 week each). Between the workshops there is the improvement and consolidation phase. It is part of the Toyota Production System (TPS) and will cover the three basic pillars, (1) people, (2) process and (3) parts/product.

(i) Purpose of the Jishuken activity

The reason of such an activity is to make a deep analysis of the actual condition at the Gemba (men, machine, method and materials) and bring employees from different areas of production to work together according to a sequence to increase safety, quality, efficiency and maximize customer value creation. Based on the chosen to target the mindset of the participants is trained to bring changes, optimizations and ideas how to decrease or eliminate waste (7 waste) from the process to reach the final aim. This activity supported by the Jishuken tools described below in this standard.

		OUTPUTS				
		TIME			Quality	Parts
	Process steps	Transport →	Store △	Setup ▭	Check ◇	Assembly ▭
INPUTS	Man/People	Motion		Waiting		
	Machine					Over Processing (too much)
	Method					Over Production (too many)
	Materials	Handling	Inventory		Rework (too bad)	

Figure 7.1 Input Vs Output (Jishuken Manual Book- Continental) (52)

The way to do this is to study, to describe and understand the running process to be able to generate and apply the continuous improvements. This activity identifies and visualize waste which can contribute to low productivity, quality and delivery concerns. As well this activity is linked to different gaps identified in the production processes.

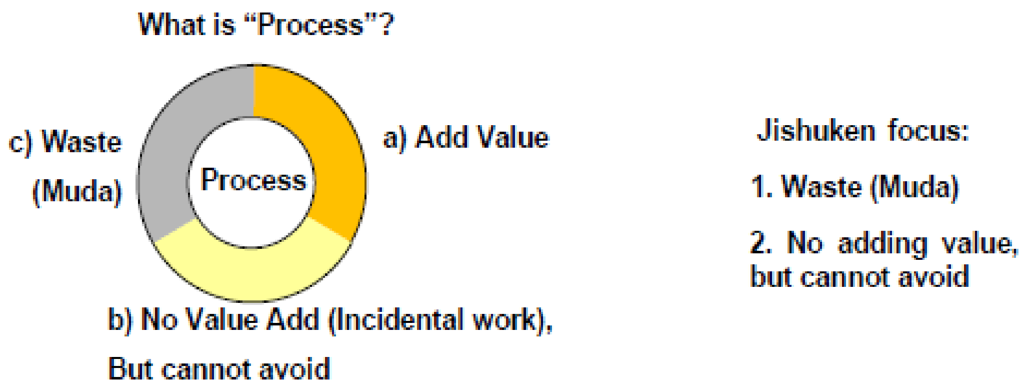


Figure 7.2 Process (Jishuken Manual Book- Continental) (53)

The workshop will support also the top management to coach and develop employees to identify waste and focus on opportunities in the production stream where they can reduce or even eliminate the losses. By doing this, they will be able to understand the production system and to empower their employees to generate changes that will lead to increase of efficiency.

The scientific description of the study will show how the production process is running (the flow) and how should run to prevent waste by minimizing losses. Following a certain sequence, the participants will easily describe the process visually in such a way to find easily the gaps to improve.

It is recommended that all departments from a plant to participate in this activity, leaded by the Jishuken leaders in Gemba. The management role is crucial to create the purpose and to explain the importance to the team members in the way that they are starting to buy into it.

The necessary Jishuken loops can be applied, to enable the team to continue working on a specific task, until the defined target is reached.

Jishuken is a great method to develop people capabilities at the Gemba by identifying important and sustainable changes to the production system that drives improvement results.

Creating an environment where the employees can express themselves by generating improvements will enable the organization to achieve the Operational Excellence.

(ii) Focus points for the Jishuken activity in the shop floor area

1. Capacity improvement
2. Continuous flow – work in takt time
3. Capability improvement of a single process, one zone or overall line/area
4. Improve Standard work – create sequence
6. Productivity losses
6. Operators balancing – Yamazumi
7. Maintenance lead time analysis
8. Down time reduction – Focus on Availability
9. Andon system - reaction time improvement
10. Material and information flow in the whole plant including SCM areas
11. Micro stops and minor losses decrease – Performance improvements
12. WIP/Buffer management on the production line for continuous flow
13. FPY improvement - false calls, visual inspection rejects
14. Visual management improvement
16. Improvement Quality and Analysis flow

(iii) Specific elements for the Jishuken activity

a. Focus and objectives

During the Jishuken activity the main objectives should be focused on safety and quality to create productivity by describing all the process elements steps for a better visualization and to assure the transparency of the process study. To be able to reach and generate the Kaizen within a process the group must use gather all the details by applying the visualization tools based on their scope. Since waste is not visible all the time the tools below should allow the team members to discover them, to see through different processes what is the value add or non-value add elements that describe the process.

Based on the identified gaps or the target setup at the beginning of the Jishuken activity the group can link the purpose of the workshop to one of the 3 defined objectives below. Choosing one of the categories below the team members should use the needed tools to reach and generate the kaizen actions to be able to reach the target or close the defined gap.

Objective	**Visualisation Tools**	**Kaizen Method**
Just in Time • Lead time Reduction	• Material and Information Flow diagram or any similar methods • Lead Time map	a) Frequent Conveyance b) Buffer Management c) Change Over Kaizen; small lot;
Abnormality Management • Eliminate Abnormality and Fluctuations • Increase Performance • Create Availability	• Pulse Camline • Output Measurement Tool • Abnormality tracker • Tagging board	a) Line Fundamentals b) Abnormality elimination / Fluctuation reduction c) Preventative maintenance
Efficiency Improvement • Labour Depending Cost (LDC), Capacity improvement (Takt Time reduction)	• Standard Work documents • Zone Capacity and Capability Sheet • Yamazumi Chart • Keshikomi Chart	a) Motion kaizen Temotoka b) Man/Machine cycle time reduction c) Layout Design

b. Roles of the participants

Jishuken local PM:

- Is the driver for the activity preparation (invitations, line/process availability, agenda)
- He ensures the schedule during the activity
- Links the teams/ builds synergies
- Coaches the team during the activity
- He is the contact person for management
- He can request additional resources
- He follows-up/Yokoten results or open items
- He moderates the team and the whole activity

Jishuken leaders:

- If there is the need that the activity requests multiple teams due to the complexity of the topics to be approached
- Coordinates the teams
- Contact person for the Jishuken local PM
- Presents the findings and the results in front of management or at each review during the activity
- Leads the team to reach the targets
- Highlights the risks in the team

Plant management team (L1):

- Supports and commits to targets
- Is available during the activity
- Reviews the process and take decisions
- Allocates proper resources and ensures their availability
- Removes barriers and obstacles during the activity
- Attends and drive the activity wherever is scheduled
- Congratulate and rewards the teams based on their achievements

c. Jishuken principles

In order to distinguish between different improvement methods or tools available in the market or in our organization the Jishuken activity is defined by the following principles:

- Target focus workshop – link it with the organizational KPI's.
- Self-study approach by each participant
- Short and intense working time frame for each participant
- Customer First – protect the customer with all changes.
- Use data at the source – collect data from Gemba.
- Kaizen based on facts – describe and quantify the possible benefits.
- Understand the purpose of work.
- Transparency – visualize the losses (Muda)

- Quick and low-cost improvements
- Trial and test changes – confirm Kaizen during the Jishuken activity in Gemba.
- Standardizing solution and check the possibility for Yokoten
- Involve all stakeholders – activity leaded by management.

d. Definition of target for the Jishuken activity

The scope of the continuous improvement activities is to create an environment where everybody can contribute everywhere to the wellbeing and prosperity of the organization anytime. To reach that goal the management must constantly work to create and develop their organizational culture for all employees by defining the proper targets to enable the organization to move forward.

By creating the goal or the target, the team purpose during the Jishuken activity will become clear by aligning the organizational needs to the objectives of the workshop. All targets must be Specific, Measurable, Achievable, Relevant, Time frame (SMART) defined to facilitate the visualization of the gap. As well it is recommended that all of them to be linked to the organizational strategic targets in the way that every such Jishuken activity can contribute to the wellbeing of the organization.

From the scope of the targets we can identify two categories that are defining the gap within the process:

The caused gap is defined as a gap to an already defined targets such the budget or standard target. This require a reactive attitude to visualize the problems and to work on them to define and solve the root causes to close the gap. The recovery is needed immediately to secure the customer requirements (products, quality and deliveries). This can trigger a Jishuken activity to eliminate the losses, to reach the budget or the standard target.

The created gap is defined as gap to the organizational strategy goals (long term perspective goals). This require a preventive work from the management and their capability to create challenges based on the previous achieved results. By continuously raising the target (step by step) the organization will accelerate their moving forward steps and increase the capability to sustain and find other opportunities for improvements. This attitude of the organization's members must also be supported by the development and coaching abilities of the management to their employees.

Example of how different types of gaps can trigger a Jishuken activity:

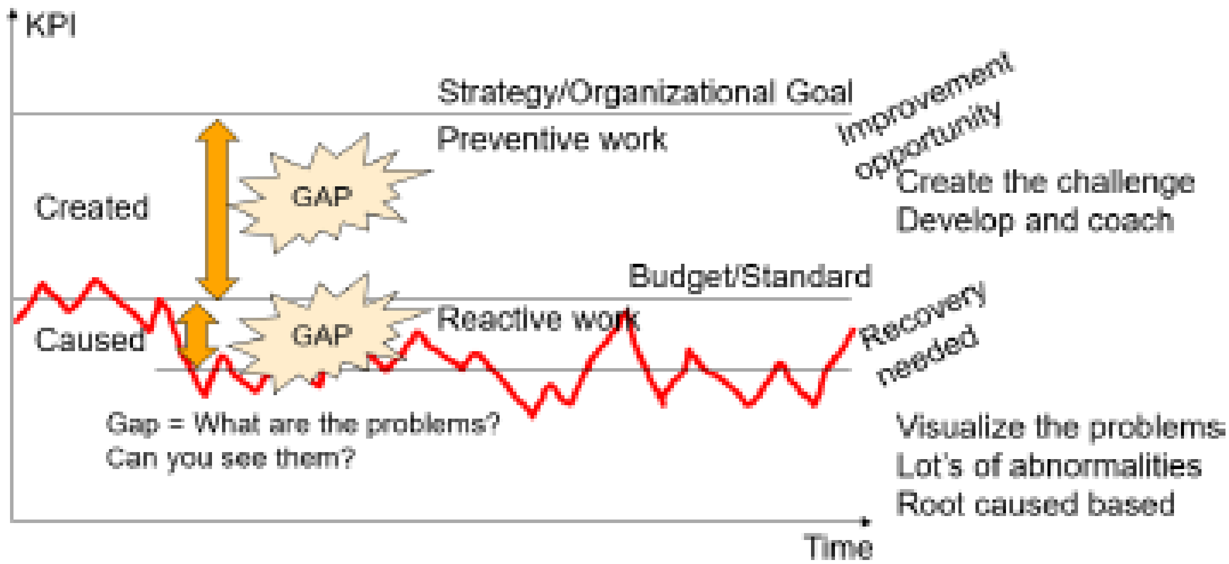


Figure 7.3 KPI Vs Time- Jishuken Book (Continental AG) (54)

In both cases the role of management is to communicate and explain the targets to their employees to engage them in the journey of the continuous improvement activity. Any additional questions must be clarified at the beginning of the Jishuken activity to ensure a smooth kaizen process. By doing this the whole organization will develop a close and long-term working relationship between management and their employees.

e. Target group of participants for the workshop

Interaction between people to reach a common sense and to meet the target can increase the cooperation between plants, Business Units (BU), Automotive Manufacturing (AM) and different departments, suppliers and customers.

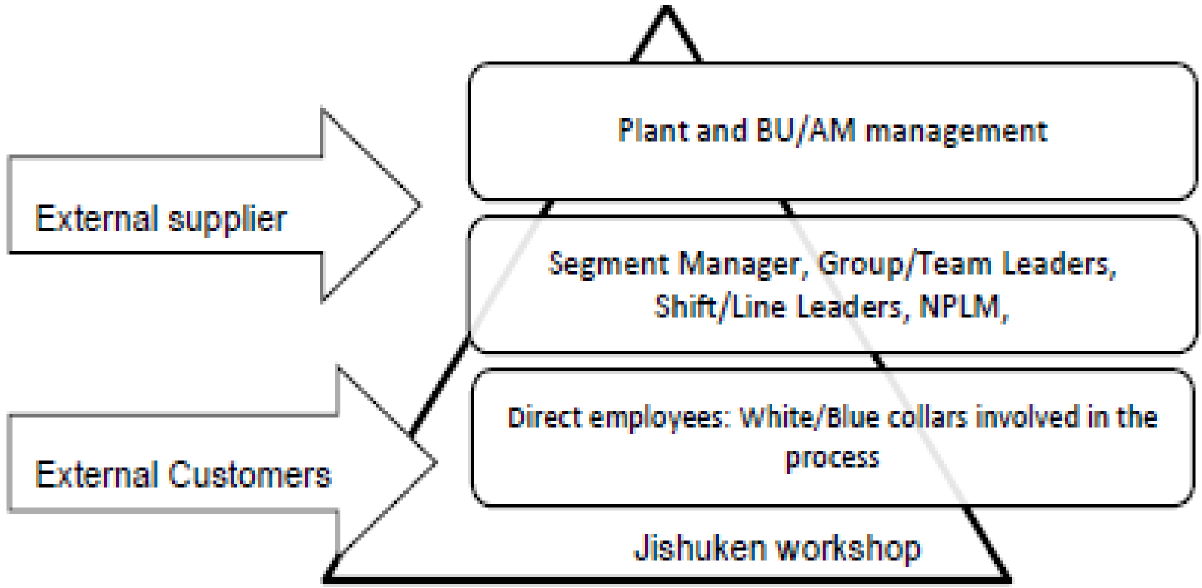


Figure 7.4 Jishuken Workshop - Jishuken Book (Continental AG) (55)

Example of participants:

› Focus Factory Manager
› Segment/Value Stream Manager
› Production Manager
› CBS Coach
› NPL, SLM, MP
› QMPP
› IE process and test
› Maintenance
› Line leader
› Line Technicians
› HR, Controlling
› Facility etc.

The foundation of every improvement process is represented by the living standard which describe the process. Without a standard there is no improvement. The sustainability of each improvement must be described in the new defined standard.

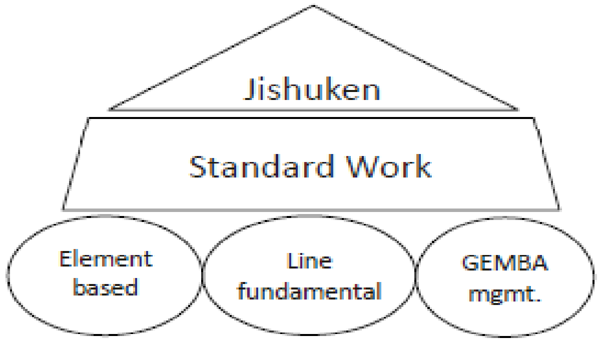


Figure 7.5 Jishuken Workshop resulting - Jishuken Book (Continental AG) (56)

f. Jishuken general phases

Proper sequence to organize this activity must be respected. The success of the Jishuken workshops must be followed to cover all steps from the planning phase. Those steps describe the way to run a Jishuken activity from planning to the best practice standardization process:

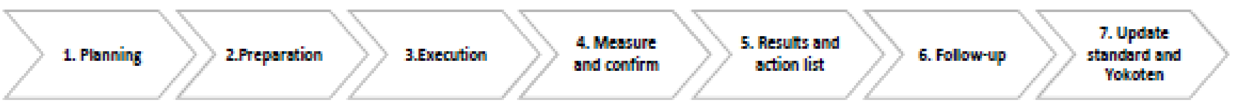


Figure 7.6 Phases of Jishuken (57)

Multiple Jishuken events can be organized in the same area by using the same improvement team. This is a way to ensure the effective development of people by returning to the same improved area and to allow Jishuken team members to continue to look for new and better ways of carrying out the work. Another important reason why is recommended to repeat the Jishuken activities in the same production area is to confirm and sustain the improvements done in the previous Jishuken workshops. Participants need to confirm that the improvements are implemented, and the work can be sustaining over the time.

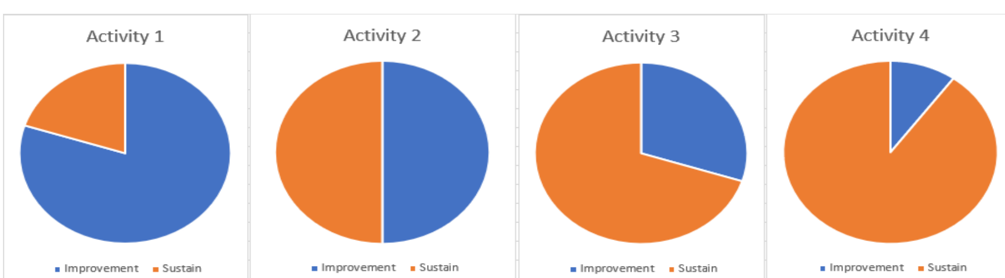


Figure 7.7 Analysis of activities (Continental AG) (58)

After every improvement process the team must evaluate all changes first and after if the implemented changes can be sustained than the change must become the new standards. As well all the process improvements or production line design improvements should be included in the new standard process equipment specifications, shop floor standards or line design guidelines to reflect how the learning activity inside of the organization.

Process flow that describes the link to improvement Jishuken activities, standardization and the Yokoten activities:

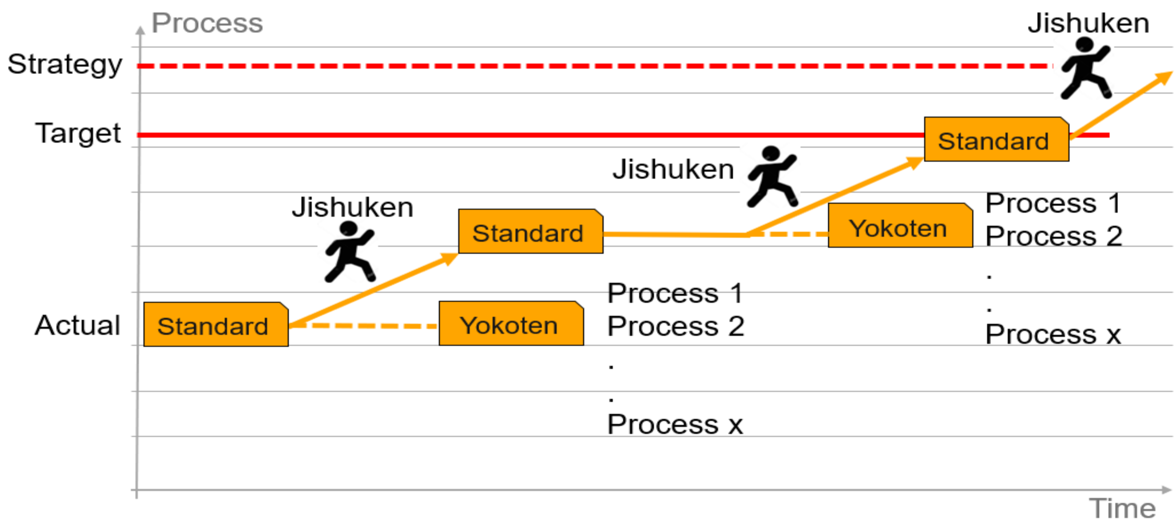


Figure 7.8 Process Vs Time Jishuken Book (59)

g. 6 Description of steps, tools and key elements

A. Plan, define and start preparation for Jishuken (1,2)

The Jishuken team leaders are already assigned during process No.2 (Define the focus area of the activity).

1. Kick-off meeting with the core team: Jishuken team leader, Line/shift leader, NPL, MP, QMPP, Production planner, Production manager, Production segment, FFM
2. Data analysis must be calculated or measured during the preparation phase based on the following inputs: Standard work instruction, Output target, EDI/CDP volumes,

Standard operation sheet, FPY, down time, shift pattern including breaks, NCC, OEE etc.

3. Tools that must be taken in consideration: collecting data from the production data base (MES, Pulse); using output measurement to get the confirmation of the actual output and deviations on the line; VSM; Internal reports and documents that could support the analysis.
4. Setup the focus points based on the analysis. Extract the topics that jeopardize and affect the targets of the area.
5. Schedule agenda taking in consideration and avoiding the following activities maintenance shift, big change overs (more than 2h), new products introduction or any customer visits in production.
6. Take in consideration that applied changes during the Jishuken workshop can create interruptions in the production schedule.
7. Define the complete team and split it in sub teams. Pay attention to the availability of participant's during the workshop and external resources like R&D or suppliers of equipment.
8. The result of the preparation phase must be completed when the Jishuken local project manager (PM) is ready to send out the agenda and Jishuken schedule to the complete organization.
9. The preparation activity must consist of organizing the materials needed during the Jishuken activity (documents, rooms etc.). Taking video - if is needed - to highlight the process before the activity. Organizational stuff is recommended to be done before the Jishuken activity: documents, forms, papers, whiteboards etc.
10. Additional preparations that bring value to the Jishuken activity before this will take place are best practice examples from previous Jishuken or improvement processes. Lesson learned from similar activities/processes/locations are intended to bring clarifications and alternatives to the team.

i. What are Line Fundamentals?

Set of basic rules and standards that describe the safety conditions for the products and for the production employees, quality key elements and output of the production areas. These fundamental elements are linked to the customer need (Takt Time, Customer volumes, product ration/variation, flexibility according to workplace) and will impact the productivity of the area as well.

During the pre-analysis phase the assigned Jishuken team is recommended to check and confirm in Gemba the Line Fundamentals checklist of the standard process. The team must check the written available standards and confirm them in Gemba near the production environment. The recommended processes that can be part of Line.

1. Fundamental's checklists are listed below

- Takt Time, Target Cycle Time, Targets Parts Per Hour, Number of needed operators. Supporting documents: Standard Operation Sheet (SOS)
- Standard work. Supporting documents: SOS, Standard Work Instructions, Cycle Time Diagram, Material handler work instruction, Change Over (C/O) work instruction. Can be confirmed by using Standard Work Check template described in Deviation management procedure, Six standard questions or any other available method.
- 5S Instructions together with the 5S check or any other confirmation of the 5S standard
- Maintenance work instructions and daily maintenance plan
- Buffer management on the line. Supporting documents: SOS, Value Stream Mapping, Material and Information flow sheet
- Instructions regarding how to remove or insert the analyzed products from and back to production line or to each process
- Instructions how to exchange the operators between their workplaces during the shift
- Safety requirements on production line or on critical processes. Supporting documents: SOS
- Safe Launch Concept instructions for the new product introduction
- Fire Wall local instructions for quality inspections processes
- Andon and Jidoka guidelines and instructions (check responsibilities and reaction time)

- Micro Logistic instructions for that focus area. Supporting documents: Value Stream Mapping, Material and Information flow sheet, Material Handler Work Instruction

2. Activity execution

The Jishuken activity is an intensive workshop that could take a couple of days to reach the initial targets. The aim is based on the targets that were defined on the Pre-analysis phase. To be able to generate improvement activities the teams needs to study the actual conditions and to understand the need and the source of improvements. All the Kaizen will be generated based on each team study and will approach the defined targets by reaching each of them. The following items describe the structure the workshop.

Day 1:

• Introduction round with plant management and Jishuken teams (schedule, target, rules)
• Calculate Line Fundamentals cycle time at the beginning of the workshop to setup and connect the mindset of the people with the customer expectation (volumes, quality and time).
• Start with review of data which was prepared during the Preparation phase (best practice sharing, results from previous Jishuken activities, Lesson learned)
• Train and explain to the teams how to use the tools during the Jishuken activity
• Define steps to reach the final target/s. Add as many details as possible

Line Fundamentals - Cycle Time calculation

To calculate and to understand the line speed needed to match with the customer needs (volumes). The participants to the Jishuken activity must do this exercise, in pen and paper to setup the correct expectation for the workshop, based on the customer behavior. Is a theoretical calculation that needs to be confirmed in Gemba.

Example of Line Fundamentals calculation (Takt Time, Target Cycle Time, Targets

Parts Per Hour, Number of needed operators):

1.	**Working Time**
Available production time/week (hours)	168
Number of shifts/weeks	4
Number of shifts/days	3
Planned stops time/week (hours)	8
Planned breaks/shift (hours)	0.5
Planned Total breaks/week (hours)	10.5
Available time/shift (hours)	7.5
Net Available time/week	149.5
Product variation ratio (Actual P/N)	50%
Allocated time for this P/M (hours)	74.75
Flexibility, Sprint capacity	15%
Customer volumes/week (pcs)	8000
Customer volumes/week (pcs) + Sprint	9200

2.		**Takt Time (TT)**		= Available Weekly Working Time (Actual P/N) * Weekly Volume	
=	269100	sec	/	9200	parts
Takt Time =		**29.25**		**sec**	

3.			**Target Cycle Time (TCT)**		
OEE budget (%)			85%		
Availability losses (D/T)			10%		
Performance losses (minor stops)			3%		
Quality losses (Line Rejects)			2%		
Target Cycle Time			= Takt Time x OEE budget		
=	29.25	sec	x		85%
Target Cycle Time =	**24.86**			**sec**	
4			**Targets Parts Per Hour (PPH)**		
=	3600	sec	/		Target Cycle Time
=	3600	sec	/	24.86	sec
@ 100% capacity =	**144.80**			**PPH**	

5			**Number of operators (DEF)**		
Sum of actual manual work time (sec)			= Σ CT manual work		
= CT workplace 1 + CT workplace 2 + …...					
Actual Σ CT manual work =	150			sec	
Number of needed operators (DEF)			= Σ CT manual work / TCT		
=	150	sec	/	24.86	sec
No. of DEF =	**6.03**			**HC**	

- Communicate and explain the target of the Jishuken activity – by management
- Calculate Line Fundamentals
- Analyze activities in shop floor using tools
- Create the study
- Create/generate the Kaizen
- Trial/implement Kaizen
- Review (PDCA) cycle
- Bring the team together and perform wrap-up of the activities
- Present the next day's schedule with plant management

Day 2:

- Start-up meeting with teams
- Setup activities for each team
- Repeat activities steps from day 1:
- Compare actual status/point in the activity with the target

Day 3:

- Start-up meeting with teams
- Setup activities for each team
- Repeat activities steps from day 1:
- use Temotoka check sheet to evaluate the impact of all changes on each workplace
- Build and summarize the results versus targets
- Prepare for presentation/Create Yokoten
- Present the study and the solutions in front of the management
- Create follow-up, define the next Jishuken if the target was not reached, but the teams see further possible improvements
- Create and distribute the Problem-Solving sheet that describe the Jishuken project

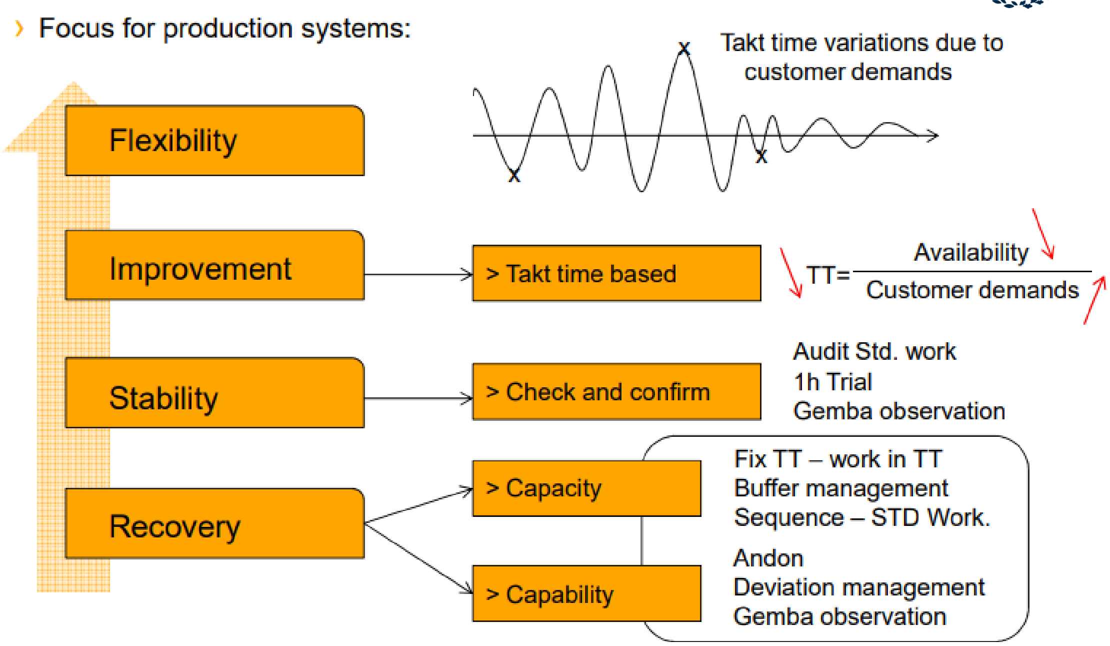


Figure 7.9 Jishuken Process and Impact (Continental AG) (60)

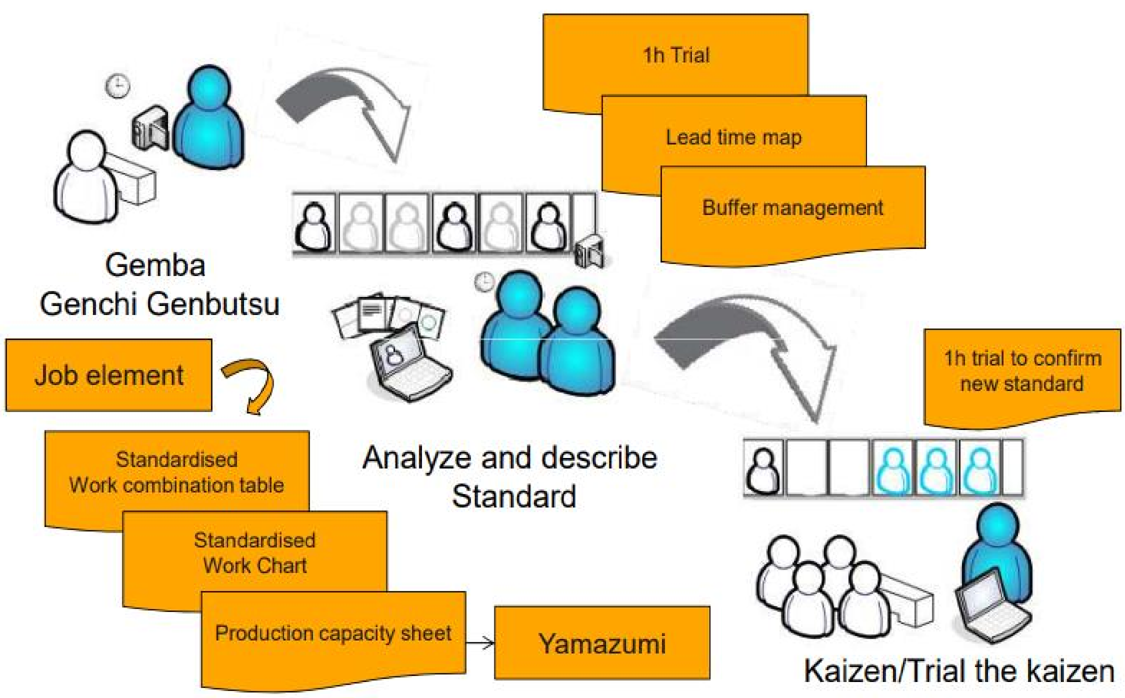


Figure 7.10 Jishuken sequence (Continental AG) (61)

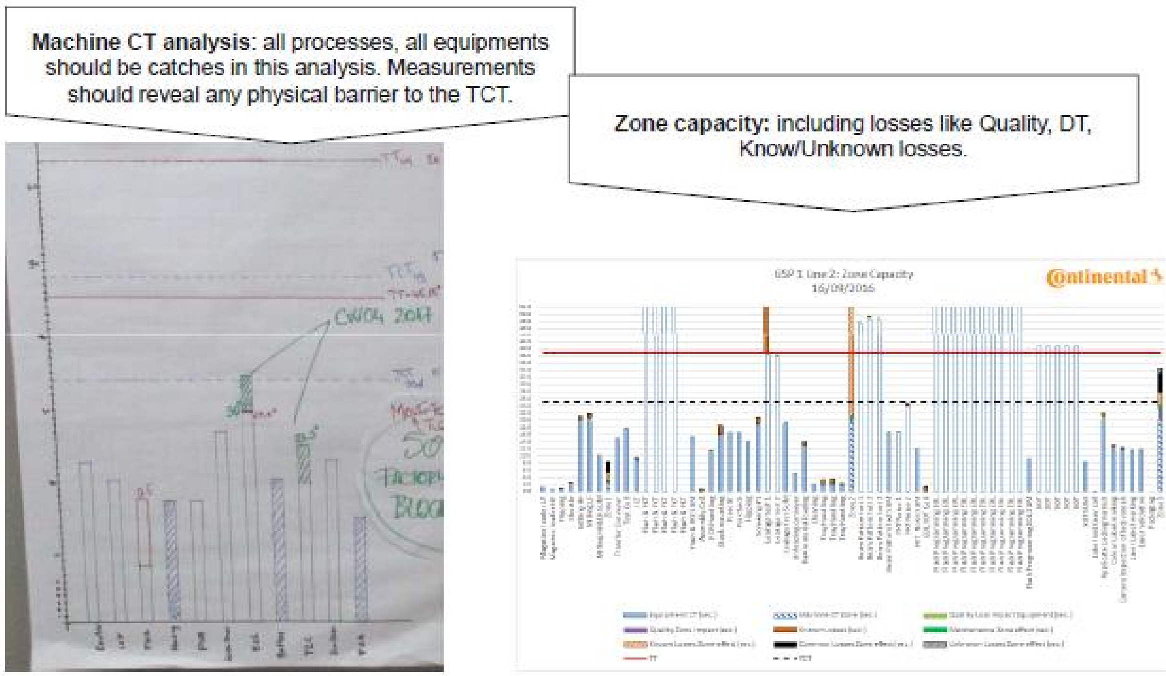


Figure 7.11 Machine cycle time (Continental AG) (62)

Time recording (OPM - Output Measurement Tool)

- General information

Define timekeeper:

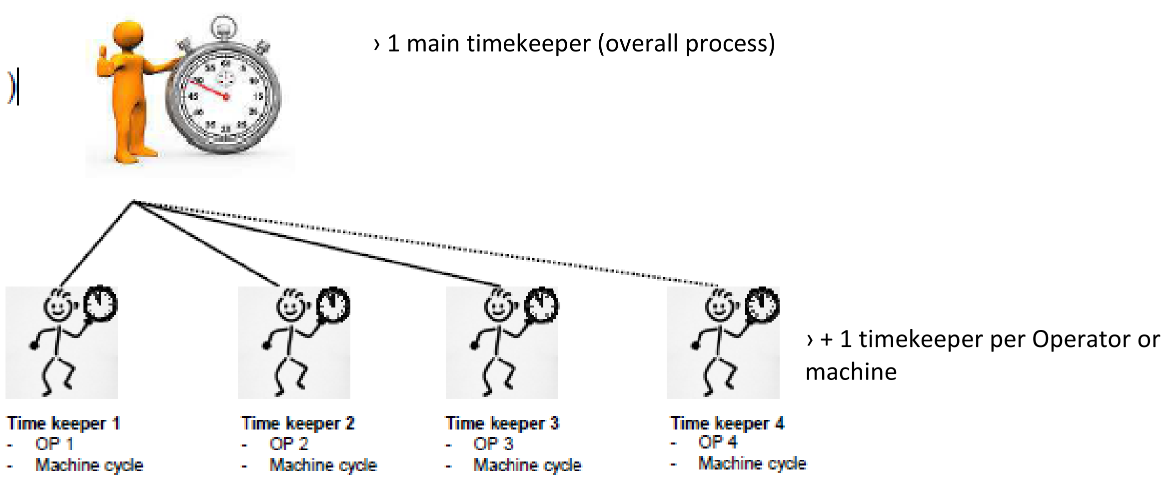


Figure 7.12 OPM measurement management (Continental AG)(63)

- Tasks main Timekeeper

Tasks & rules:

› Stop time for a pre-defined period (e.g. 1h)

› time keeps running until this period is finished

› Counting of finished goods (good/n.g. parts)

› Monitors abnormalities/deviations

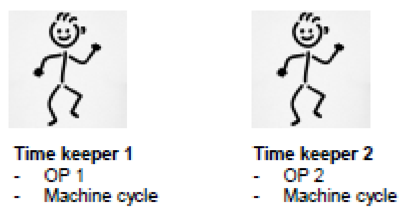
› *Position of timekeeper: outside of line, close to final test*

- Tasks sub timekeeper

Tasks & rules:

› Start time together with main timekeeper (0h/m/s)

› Starts first measurement after > 5mins



› records time after each finished cycle

› Start: defined starting point

› End: when cycle is repeated (defined starting point)

› Note down timing of each cycle but do not stop the watch

› Position of timekeeper: outside of line, close to dedicated operator or machine

› Note down timing of each cycle but do not stop the watch

› Exception 1: there are no parts from the previous process step available

› Exception 2: the finished part cannot be placed on next workstations (e.g. handover buffer is full; machine stopped)

Important: This stoppage is not part of the standard word of the operator

Time recording will continue as soon as operator continue cycle according standard

Note down all abnormalities/deviations in the corresponding cycle line of your sheet

The overall timing will not be stopped

- Abnormalities / Deviations

Typical abnormalities / deviations:

› Machine stopping (downtime)

› Fail part handling

› Discussions between operators

› Problems with unwrapping of parts

› No parts

› Waiting time

› No material

Work is being carried out with the team formation:

The team consisted of 5 members supported by other departments such as SCM , Production, Quality team.

c) Jishuken Activity

(1) OPM- Output Measurement Tool

Output Measurement Tool - tool to measure the output pitch of a certain process. It is used to visualize the fluctuations and variations to the different output cycles. The results of this measurement highlight: number of parts produced in a timeframe (output pitch), fluctuation between cycles and if each part produced is in the target;

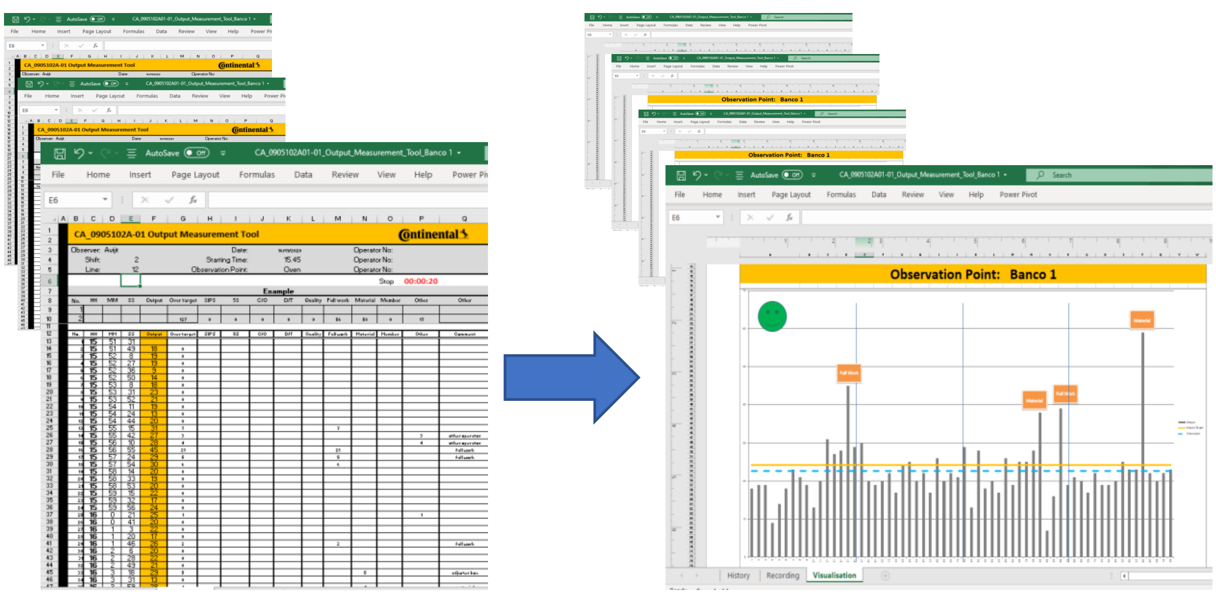


Figure 7.13 OPM (Output Measurement Tool) Continental AG (64)

1. *Issues for stoppage*

5S = activities related to 5S

C/O = Change over process

D/T = Downtown (Unplanned, Technical)

Quality = activities that involve quality loss (Process failure, rework, inspection)

Full work = buffer full after the process, no space for future parts

Material = Raw material is missing or not available in time

Other = other reason why the deviation occurs

Comment = comment from the user to highlight the deviations

Below is the bifurcation of the time analysis where operation stoppage occurred.

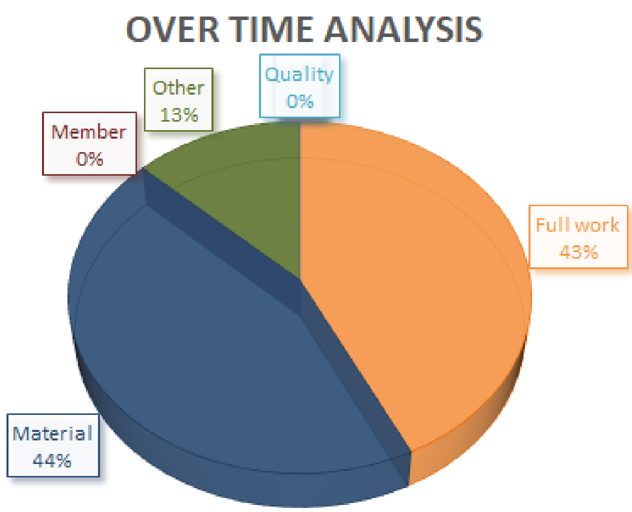


Figure 7.14 Over time analysis (65)

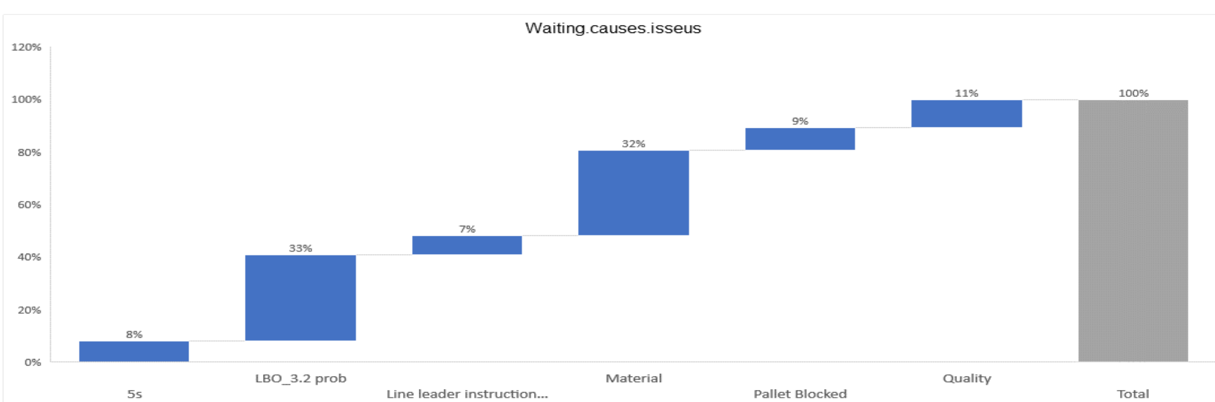


Figure 7.15 Over time analysis Waterfall analysis (66)

Each Operation is being carried up to min 30 min to 1hr minimum 30- 50 clean cycles. This is being carried out for all operations so in this case 70- 72 Operations + 6 Operators manual work. With the above clean cycle has been further bifurcated to get micro level understanding

(2) 6 Standard Question Assessment Sheet

6 Standard Questions:

Date:
Process/Workplace: FORNI
Observer:

Continental

	Result	Remark
(1) Does a standard exist / is it available ? Can you find / Get it ? Up to date (based on CA)?	O	
(2) Is the standard appropriate ? If you follow the Std. will you achieve the target ?	O	
(3) Are the members aware of the standard ? Can the members tell you where it is ?	X	OPERATORE NON HA RICEVUTO ISTRUZIONI
(4) Do the member understand the standard ? Can they explain the key point, the key point reason ? (what, how and why) ?	O	
(5) Do the member follow the standard ? Check abnormalities (actual vs. std) !	X	
(6) Is the standard confirmed ? Is there an audit --> Can you grasp the result ?		

Evaluation

Result	Remark (Check People – Process – Parts)
O	Keep and review regularly
Δ	Action(s) need(s) to be defined (deviation against std.)
X	Immediate action(s) necessary (major deviation or no std.)

Figure 7.16 Standard Question Assessment Sheet (67)

(3) Temotoka Check Sheet

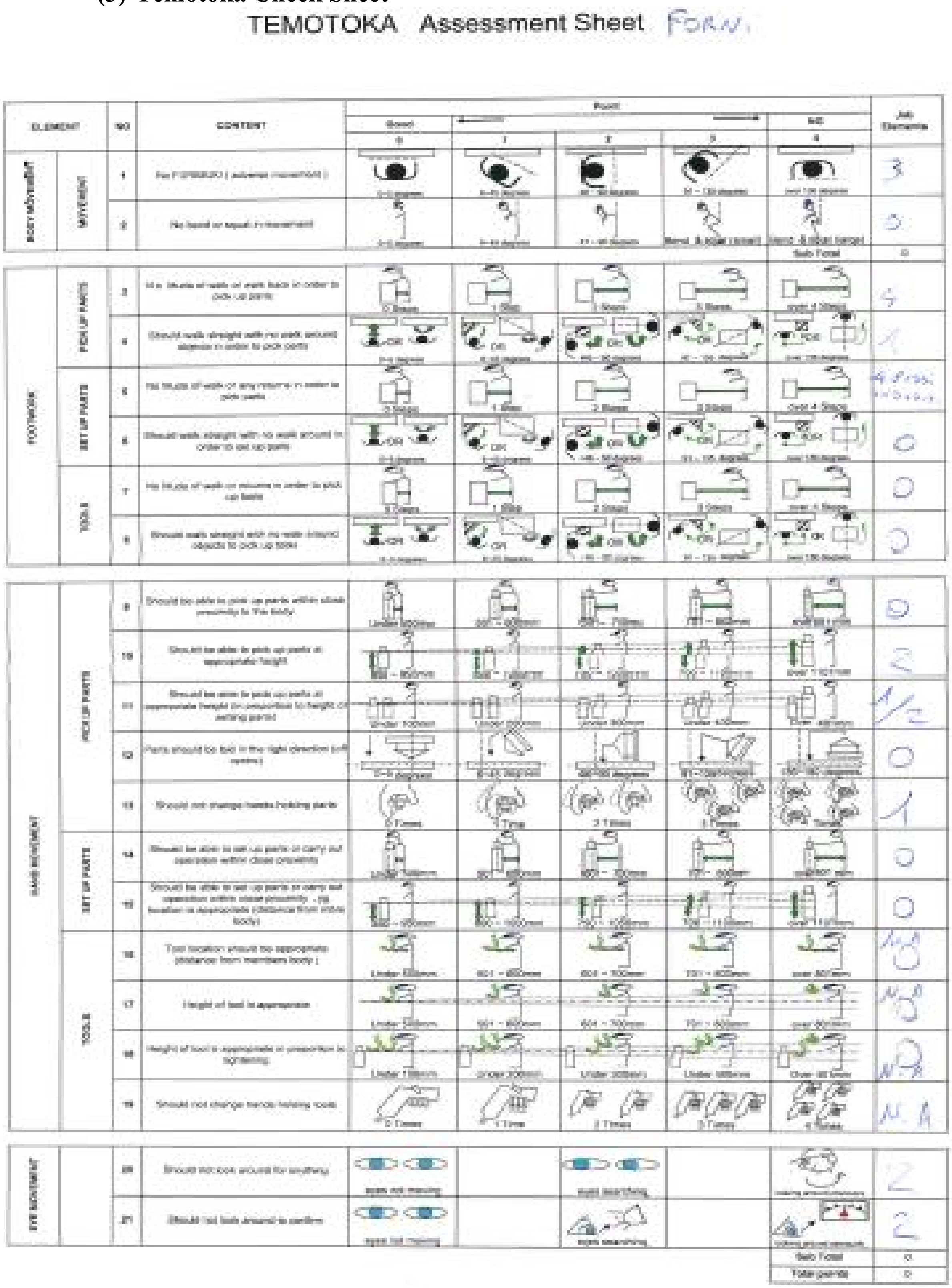


Figure 7.17 Temotoka Check Sheet (Continental AG) (68)

(4) Standard Work Recording Chart + Yamazumi

Video analysis– use a simple tool that is available and accepted by the local organization, to record the needed cycles and details for the operation which need to be described later. It can be used to record the machine or the robot movements, the workplaces standard and as well any other process that needed to be improved. Before starting to record the Jishuken team leader must explain it first to the Shift Line Leader and get their acceptance that the Jishuken team can record. Common tools to be used: Time Prism, Kinovea etc.

What is the Standard Work Recording Chart + Yamazumi?

› Is used to take over and break down the results from the video time studies and create the Yamazumi directly.

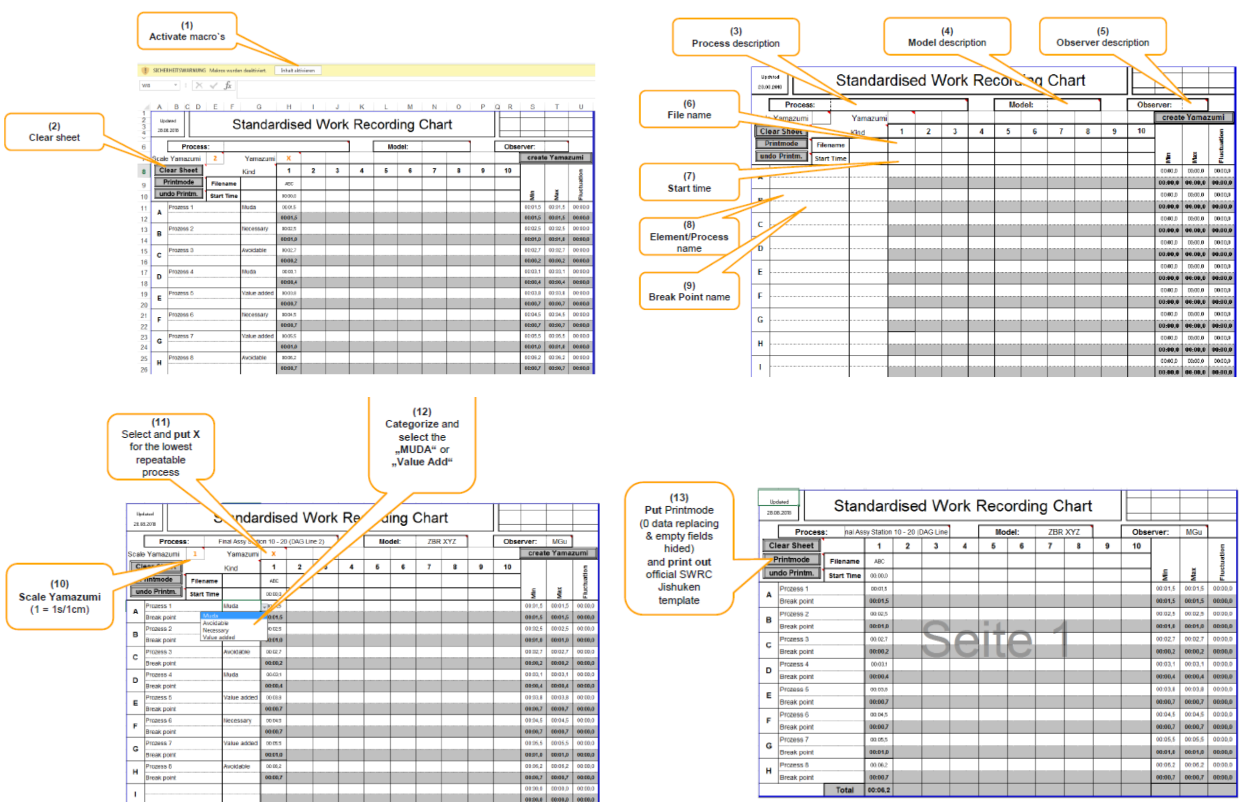


Figure 7.18 (i) Temotoka Check Sheet (Continental AG) (69)

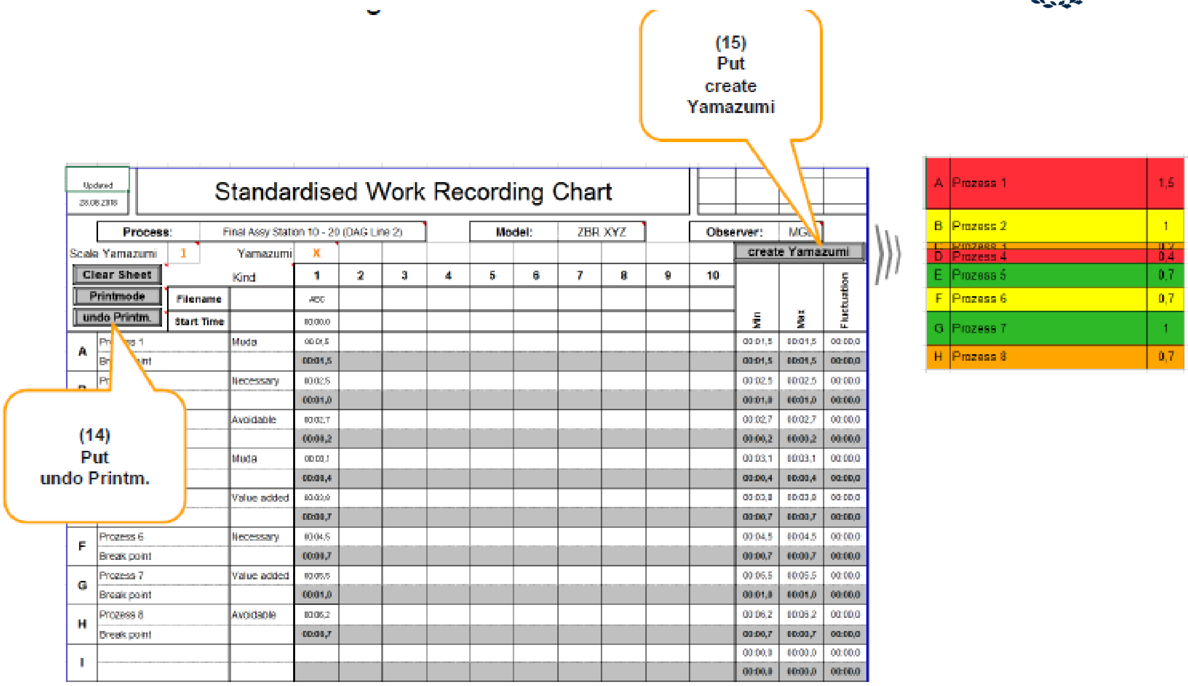


Figure 7.18 (ii) Temotoka Check Sheet (Continental AG) (70)

Standard Work Recording Chart + Yamazumi (Actual wok)

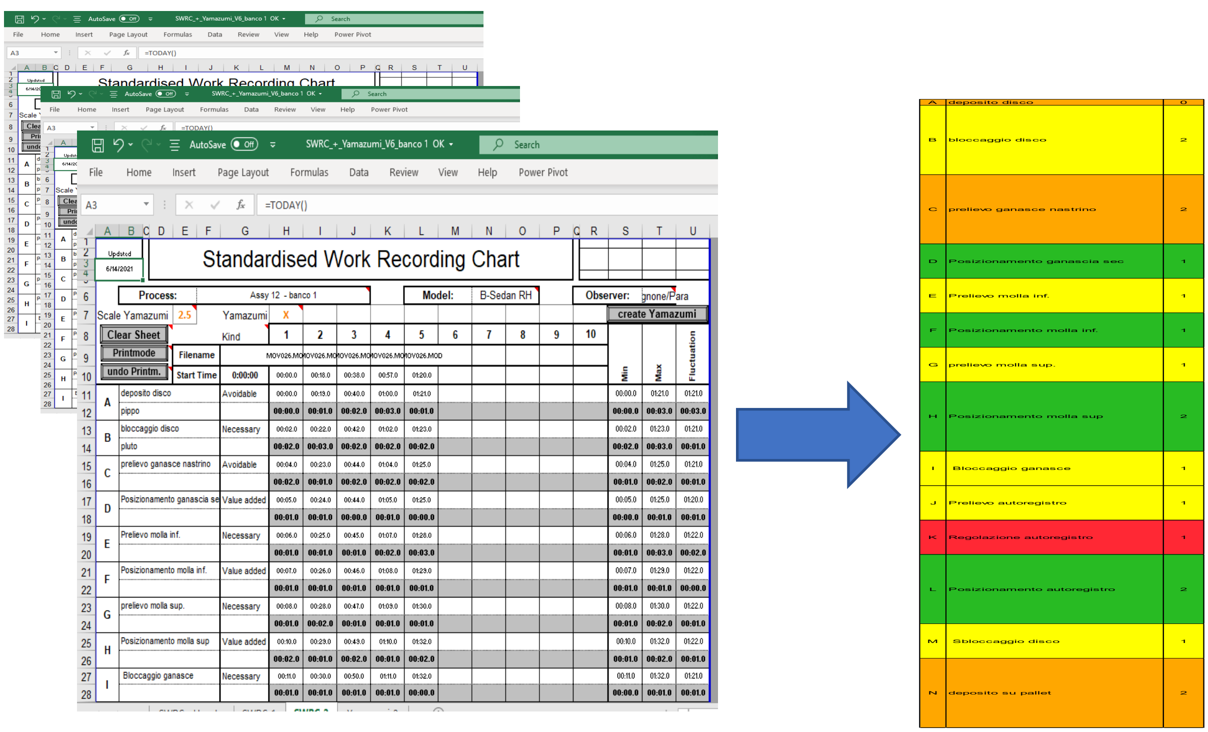


Figure 7.19 - Standard Work Recording Chart + Yamazumi (Actual wok) (71)

In line 12 is divided in 2 parts

1. Machine Operations
2. Mannual Operations

The below graph shows cycle times of machine and manual operations which was before the intervention which occurred for technical rectification of the operations. These rectifications are issues faced during time recording of the operation.

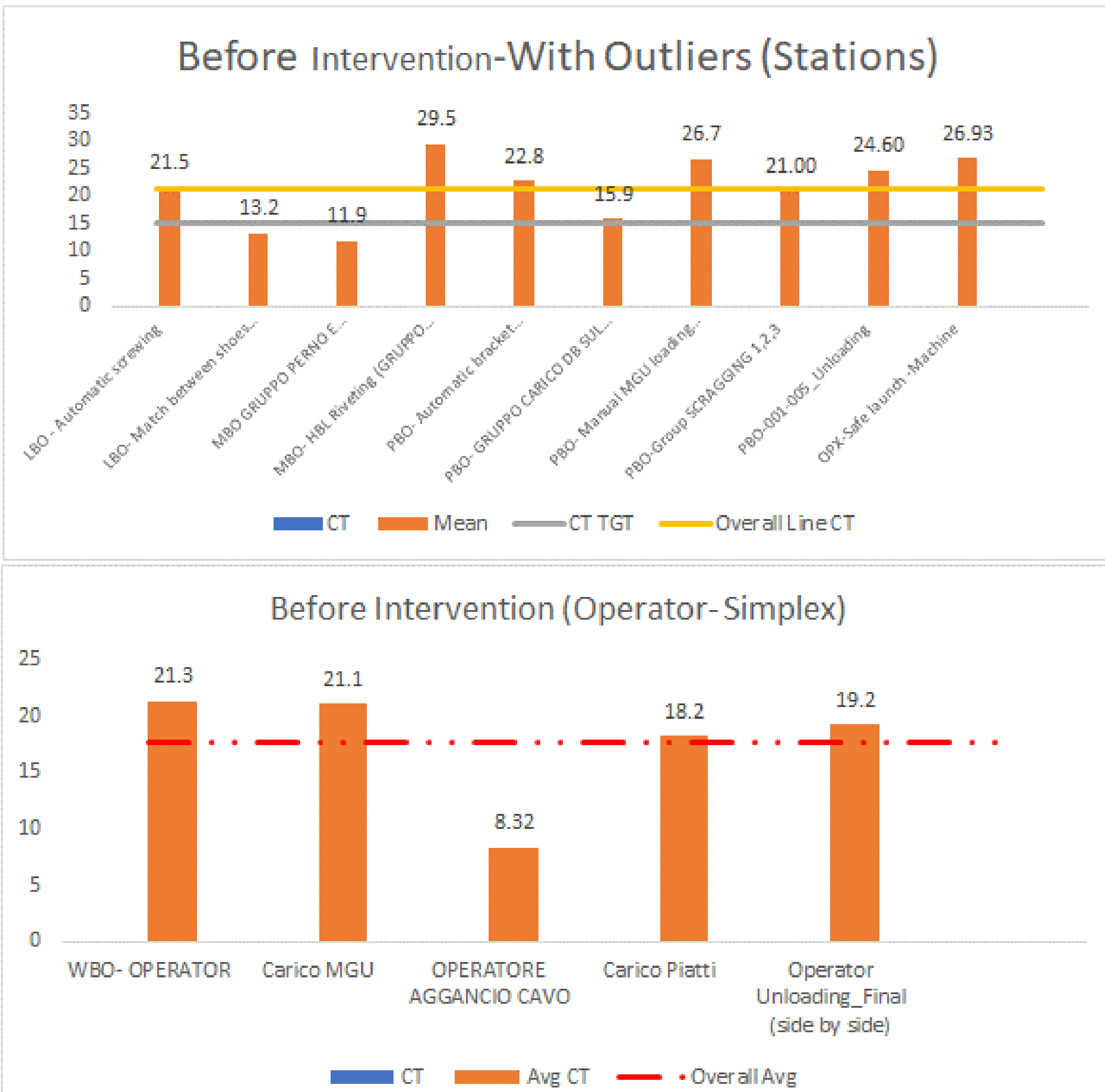


Figure 7.20 Robotic operation and Manual Operation (72)

From the graph below it can be seen that all the issues are being identified and analyzed.

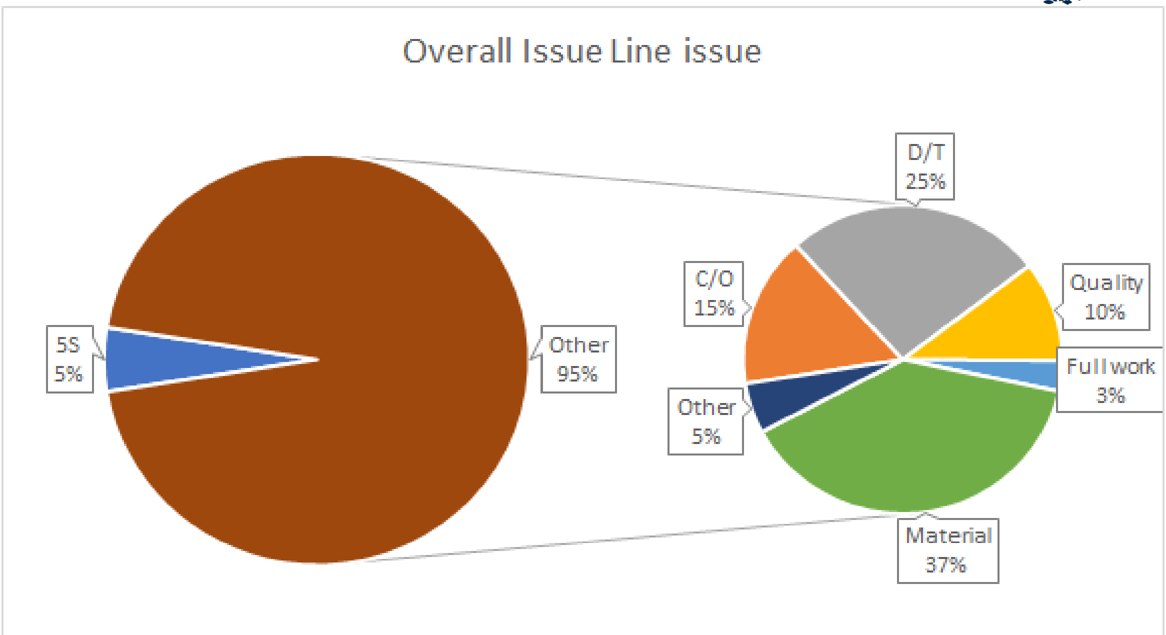


Figure 7.21 Overall issue – Line issues Bifurcation (73)

Each Operation is being further bifurcated for micro analysis for the dedicated activities with respect to departments.

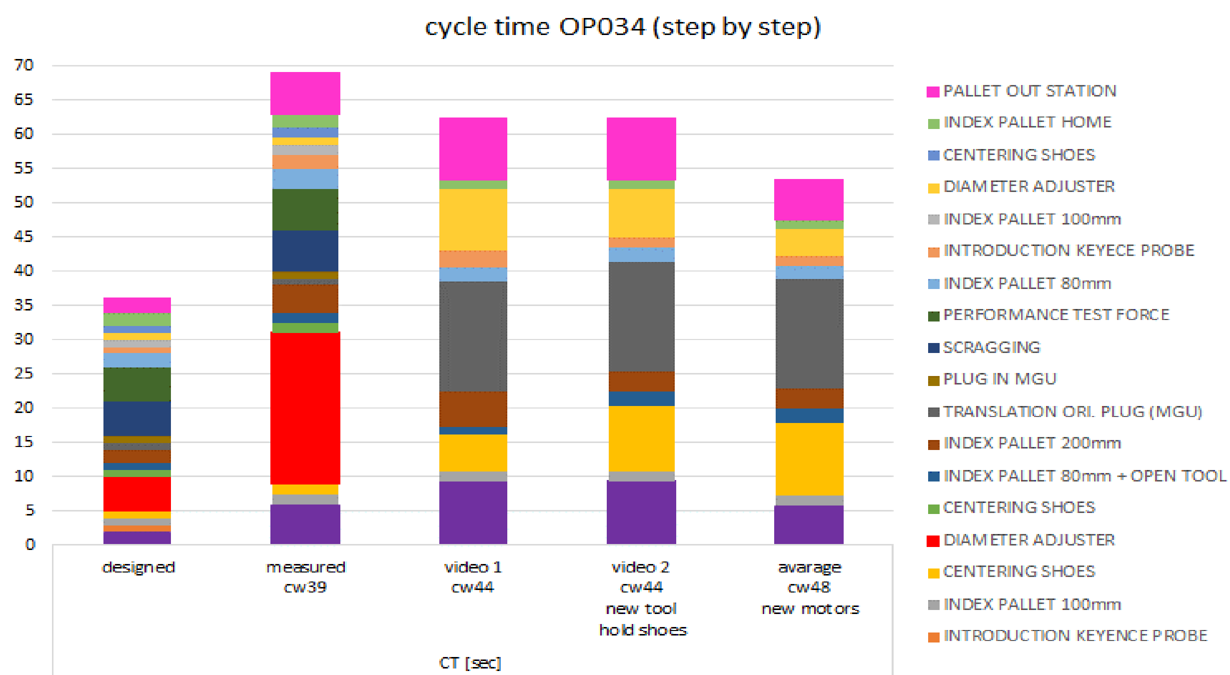


Figure 7.22 Cycle time step by step operation (Micro Analysis) (74)

Operator manual work bifurcation

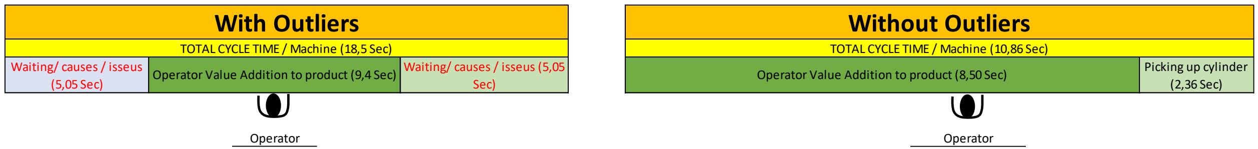


Figure 7.23 Manual work bifurcation with and without outliers (75)

Below is the micro analysis of the mannual analysis of the operations

Where 12.82 sec is machine time taken to complete the operation and 7.50 sec is mannual operation taken by the operator. 6.2 sec is the value addition time by the oparator.

Here 50 cycles are being taken.

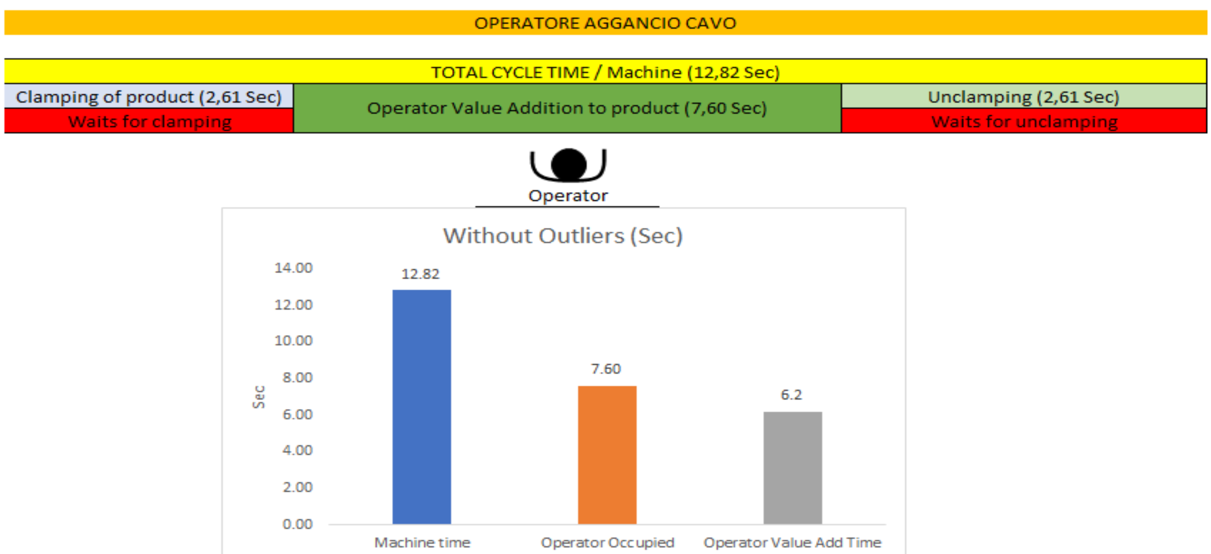


Figure 7.24 Graphical representation of manual Operation (76)

Concern and Improvement list (Action List)

OP Nr.	Category	Topic	Action	Responsible department	Current state	Comments
030.6	quality	spring pot supply (missing components due to purge not registered)	purge to be analyzed (non included in MES)	I.E.	closed	station present on MES but not active SAIE + IT to perform the acitvity -> actions to be defined with SAIE and IT (station connected to MES but counting must be checked) 23.11.: intervention planned on 23/11 (1 week monitoring necessary) 26.11.: alignment MES/PLC done but physical counting is not matching SAIE intervetion done , to be validated by Conti 04.12.: misalignment MES/PLC still present (7pcs difference in 4,50 h) 18.12: MES/PLC counting is aligned.
030.2.2	quality	Scrap rate is increasing cw 50 BU 1,5% MU 10,4% cw 51 BU 0,99% MU 2,31% cw52 BU 0,47% MU 0,62% cw1 BU 0,68% MU 1,16% cw2 BU 0,18% MU 0,32%	to investigate the scrap reason	R&D/Q	ongoing	Root cause found: under monitoring (MU 0,5%, BU 1,5%) 26.10.: RC: washer on the pallet behind ball bearing) - to be monitored 30.10.: scrap parts measured and NOK because out of tolerance (BU ext. profile) 11.11.: new batch measured and out of specification (8d provided) - feedback from SFS expected end cw 46 23.11.: high scrap on BU side -> new batch arrived from SFS - parts to measured and tested on line 04.12.: new batch to be delivered on 4.12 and to be measured by Q 11.12: batch received and measured, NOT in capability (MU is worse than BU). New batch to be delivered on 11.12, to be measured - insertion window to be enlarged? 14.12: new batch delivered but still NOK after measurement @CAI. Measurement output Conti/SFS are DIFFERENT, comparison with SFS is ongoing. next meeting on 16.12. 16.12: new batch under measurement.
030.8.2	quality	screwing scraps cw48 BU 12%, MU 1,5% cw50 BU 2,02% MU 2,83% cw51 BU 2,12% MU 3,75%	to be investigated	Q	ongoing	scraps analysis ongoing: mostly related to first screwing phase (cw 42 MU 4.87% BU 1,34%). Proposal: additional turn to eliminate interference is feasible next step to modify the sw 26.10.: sw modified -> scraps decreased in CW43 to be monitored for new intervention waiting for new screwer 29.10.: sw intervention done, scrap trend to be monitored 04.11.: MU side 2%, BU < 1% 11.11.: new station will arrive in cw46-2020 (potential delay of some components) to check with Comau 13.11.: 2 weeks delay to be confirmed - waiting for new timing by Comau (topic escalated to management) 02.12.: high scraps of cw49 due to missing rotation of the DG Comau to find the right set up 16.12.: scraps are decreasing to the former values after intervention 18.01: new clamps in 3D printed to be tested
030.8.1	quality	PUMP Scrap rate is increasing scrap cw 46 BU 2,9%, MU 6,9% scrap cw 47 BU 9,2%, MU 7,6% scrap cw 48 BU 2,0%, MU 5,7% cw1 BU 0,16% MU 3,54%	monitor the scrap during cw43 and find root cause	I.E.	closed	one possible root cause is the shape of grease box (conic) - to be further investigated with supplier of grease pump DAVTECH - plate of pump to be replaced, waiting from supplier feedback 16.11.: scrap cw 46 BU 2,9%, MU 6,9% 23.11.: supplier feedback received - PO in 23.11. Lead time 3 weeks, installation cw2 13.01.: new pump installed on 11.01 (on 1st tank), waiting for first results in cw3 22.01: both pump working well
030.6	quality	spring pot supply (missing components due to purge not registered)	scrapped spring pot (but OK parts) to be recovered	Q	ongoing	18.12.: Massimo to define a procedure to recover the spring pot buffer which is now automatically scrapped by the station
131/132	**mechanical**	cable unfolding	installation of BU side	I.E.	closed	Comau in delay of 2 weeks 2.10: installation done - to be verified 7.10: vedere mail Fleck su osservazioni loop 3
131/132	**mechanical**	breakdown	to be investigated	I.E.	ongoing	04.12.: breackdown analysis ongoing 07.12.: monitoring ongoing 08.12.: breakdown analysis done, to be shared with IE

Figure 7.25 Action Plan for implementation

Below are cycle time of all operations after all the interventions which were being carried out from the action plan list and few are still to be implemented.

Figure 7.26 after implementation of actions (Jishuken study) (77)

The above analysis helped in reducing the cycle time of operations resulting in overall cycle time of the assembly line which can be seen in the OEE of the line.

8) Conclusion

Let us begin with entire time. This is often referred to as time that is available 24 hours a day, seven days (it includes every minute of every day).

TEEP (Total Effective Equipment Performance) is a performance statistic that reveals your manufacturing operation's full capabilities. It accounts for both equipment and schedule losses (as assessed by OEE) (as measured by Utilization).

TEEP = Availability X Performance X Quality X Utilization.

Subtract Schedule Loss from entire time, which includes all time that should be excluded from OEE analysis since no production is planned during that time (e.g., plant shutdowns, breaks/lunches, or periods with no orders). TEEP includes Schedule Loss (Total Effective Equipment Performance). It isn't covered by OEE.

We will now look at the three OEE components, each of which considers a distinct form of loss. Availability, Performance, and Quality are the three factors. Planned Production Time is the time remaining.

OEE starts with Planned Production Time and examines all efficiency and productivity losses that occur throughout that time in order to reduce or eliminate them.

The ratio of Fully Productive Time to Planned Production Time is the simplest approach to compute OEE. Manufacturing just Good Parts as quickly as feasible (Ideal Cycle Time) with no Stop Time is referred to as Fully Productive Time. As a result, the calculation is:

OEE = (Good Count × Ideal Cycle Time) / Planned Production Time

Although this is a perfectly acceptable OEE computation, it excludes the three loss-related factors of availability, performance, and quality. We adopt the preferred method for this.

OEE (overall equipment effectiveness): A (Availability) X P (Performance) X Q (Quality)

- Availability (A) = Run Time / Planned Production Time

  Run Time = Planned Production Time − Stop Time

All occurrences that interrupt scheduled production for long enough that it makes sense to track a reason for being down are considered in availability (typically several minutes).

Run Time equals Scheduled Production Time minus Stop Time, where Stop Time refers to all time when the manufacturing process was supposed to be running but wasn't owing to unplanned (e.g., breakdowns) or planned (e.g., maintenance) stops (e.g., Changeovers).

- **Performance (P) = (Ideal Cycle Time × Total Count) / Run Time**

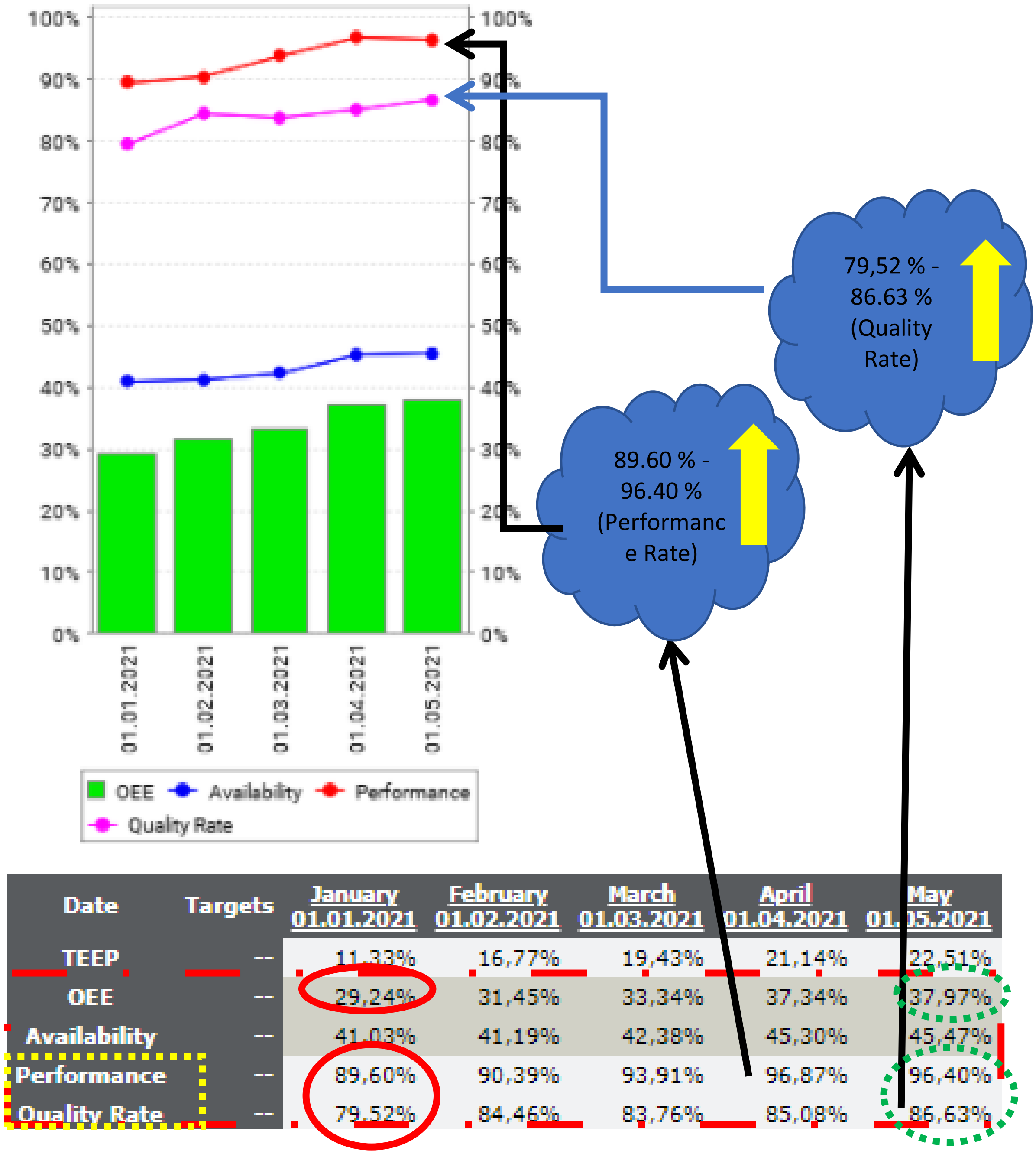
Anything that causes the manufacturing process to run at less than the maximum feasible speed when it is running is considered performance (including both Slow Cycles and Small Stops).

The Ideal cycle time that your process can accomplish under ideal conditions is called Ideal Cycle Time. As a result, when you multiply it by Total Count, you get Net Run Time (the fastest possible time to manufacture the parts).

- **Quality (Q) = Good Count / Total Count**

Quality considers manufactured items that do not meet quality standards, such as those that need to be reworked. Remember that OEE Quality is similar to First Pass Yield in that it defines Good Parts as parts that successfully pass through the manufacturing process without requiring any rework the first time.

The ratio of Fully Productive Time (only good parts made as quickly as feasible with no stop time) to Net Run Time is the same (all parts manufactured as fast as possible with no stop time).



Date	Targets	January 01.01.2021	February 01.02.2021	March 01.03.2021	April 01.04.2021	May 01.05.2021
TEEP	--	11,33%	16,77%	19,43%	21,14%	22,51%
OEE	--	29,24%	31,45%	33,34%	37,34%	37,97%
Availability	--	41,03%	41,19%	42,38%	45,30%	45,47%
Performance	--	89,60%	90,39%	93,91%	96,87%	96,40%
Quality Rate	--	79,52%	84,46%	83,76%	85,08%	86,63%

Figure 8.1 OEE impact (MES) (78)

Hence as per the internal calculation in MES, **OEE = 29.24 %** in the month of January 2021 and in the month of **May 2021 is 37,97 %** after action plans are being implemented.

Politecnico di Torino

9) Reference table

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