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Investigation of production of spare parts in agricultural industry in industry 4.0 through an example system edit

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ABSTRACT

The search for maximum efficiency which was formed as a result of the digital transformation, which was founded in the 1970s, brought Industry 4.0, which means the change of production strategies and business models, in 2011. In this new age which predicts the use of smart factories using unmanned cutting-edge smart robots; it is claimed that resource efficiency will increase, costs will decrease, the speed of product launching will improve and energy savings will be achieved thanks to dark production. It is a fact that the competition in the market will increase with this new age in the world. Turkey's success in holding on to this global market seems to depend on adaptation to newly created technologies, hosting and support processes. Especially the adaptation of SMEs, which constitute a large share of entrepreneurship activities, to this process is important. For this reason, in this study, by examining the production flow of "Kan Metal", which makes small scale production; it has been adapted to Industry 4.0 setup. Thus, by comparing the current system with the predicted one; advantages and disadvantages are identified and changes in the transformation process are revealed.During the examination of the production system, firstly, an information questionnaire was sent to the company, a visit was made to the company, information was exchanged with the company official with the semi-structured interview technique in the light of the information obtained from the questionnaires, and the production line was examined and photographed with the observation method. The current system was analyzed in the light of these data and adapted to the industry 4.0 system with the literature review method and a fictional model was designed.As a result, industry 4.0 means many advantages for the market, such as increased productivity, reduced costs, ease of use of resources and space, tracking the production flow from order to supply, and creating sensitive products. However, the high costs and unqualified personnel of the establishment of new technologies constitute the biggest disadvantages for SMEs. Transition to the new system seems possible only if these companies are supported in terms of infrastructure, education and capital.

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1. Introduction

Until today, 4 different breaks have occurred in the industry and these are called industrial revolutions. The first of the first 3 Industrial Revolutions, which lasted about 200 years, began in the 1780s, with the replacement of mechanical looms by steam engines and the foundation of mechanical production systems, based in England. Thus, there was an extreme increase in productivity in fabric production that moved from private workshops to central factories. [9]. Approximately 100 years later, the period corresponding to the beginning of the 20th century indicates the second Industrial Revolution. In this period, which is also called the technology revolution, production was completely steam-powered and the construction of railways has started. While this situation supports the increase in steel production; on the other hand, it has transformed it into need. In addition, the development of industrial activities has increased the demand for energy resources and started the transition towards oil and electricity by separating resource use from steam power. With the introduction of electrical energy in assembly lines, the development of mass production and division of labor has created high efficiency. In the same way, electrical communication has developed and the possibility of communication by telegraph has emerged[3, 17].

Advances in electricity and information technologies in the early 1970s, brought a radical change based on information technology, communication and energy. Production based on mechanical and electronic technology has begun to change with digital technology, and automation has become widespread. The rapid development of computers and the Internet, along with Digital Technology, has brought about the development of information processing, communication and micro-electronic techniques. In the 3rd industrial period, when developments based on micro-electronic technologies such as atom energy, computers, fiber-optics and chips were experienced, the use of solar energy, wind energy, hydroelectric and geothermal power plants became prominent as the concepts of sustainability and sustainable energy became important [17, 27]. All these industrial revolutions have triggered the formation of new generation technologies, smart objects and factories that can communicate with each other. Thus, in the 2000s, the fourth industrial revolution, called industry 4.0, came to the fore. For this period, which is considered as a transition phase of the world, it is predicted that a production cycle in which much higher productivity is aimed at lower costs will develop and thus a new system and social structure will be formed.

2. Industry 4.0

After first mention of forth industrial revolution in Hannover Fair in 2011, Germany Government build a research group to investigate forth industrial revolution in 2012. The research group published a result report in 2013. According to report, nowadays we have been experiencing the transition process of Industry 4.0 and to success of this process 8 step must be completed: 1st step is detection of reference hardware architecture and providing standardization, 2nd step is administration of complex systems, 3rd step is usage of wide-ranging and high-speed communication infrastructure in industry, 4th step is safety and security, 5th step is organization of study and design, 6th step is permanent education and development of professional education, 7th step is adaptation of current regulation, 8th and last step is providing efficiency of source in application [17]. In new industry era, main aim is usage of all sources including human in optimal level and getting result in the most efficient way. For this purpose, a system that consist of simultaneous usage of all technological developments is conceptualized.

A research group including The German Research Center for Artificial Intelligence and Siemens and 20 industrial partners run an application about working principles of a smart factory in Kaiserslautern. Soap bottles with radio frequency identification [RFID]. labels are used with the purpose of observation of the interaction between product and machines. These labels give information about colors, size, and volume of the bottles to machines. After giving information, smart machines recognize the bottles and then classify and fill them. In this cyber-physical system working style, information transfer completed by using radio frequencies and transferred information is stored in digital environment in each step [2]. Moreover, these labels create information clouds during production process. These clouds and continuing of the information process will be used to enable the communication between producer and consumer. Using this system consumer will be able to rate the producer performance, give feedback during the working process and producer will be able to follow the process in breakdown situations.

Pioneer technologies of Industry 4.0 are examined in cloud computing system, augmented reality, simulation, autonomous robots, large data, cyber-physical systems, smart factories, integration of system, internet of objects, three dimensional printers categories [26].

Smart Factories: Smart factories are defined as environments which do not include human factor except extraordinary situations, and consist of machines, robots, and equipment which are working in interaction with each other autonomously [23].

Internet of Objects: The network models which connecting internet with help of additional sensors. They are placed in internal system. Purpose of these models is enabling objects to gather and distribute data.

Cyber-Physical Systems: They are defined as interaction systems between physical world and cyber environments with the help of internet. There are sensors in these systems. These whole systems enable us to define the physical movements in cyber environment. Moreover, it enables communication between objects [16].

Cloud-Computing Technologies: The data held by companies stored in a cloud system that defined as virtual server and accessible for share and usage by any devices with internet connection is provided by a technology. The infrastructure that makes mentioned technology useful is defines the cloud computing system using the software and data of the main source and enable the distribution through IT network [22].

Large Data: Gathering and analyzation statistics of internet, social media, kinds of sensors, GSM records, corporate and consumer-based administration data, and similar kind of data is defined as large data. Moreover, to define it as large data, standardization of simultaneous decision process is required. Optimization of task and decision matcher operation modes increases the quality and efficiency of production. In addition, it helps energy-saving, maintenance of equipment [21].

Simulation: Simulation is defined as a three-dimensional virtual model, which is prepared using real time information, of product, material, and production steps during design process. It imitates the process and system in the real world. By using this imitation, it defines the objects and relationships of object [29].

System Integration: It is integration of production and administration of business to each other. This integration enables the parts work with harmony with each other. As a result, consumer, supplier, distribution channels work with harmony with each other. The whole system is defined as system integration. System integration makes it possible to have footprint of machines, components, material that used in production process [8].

Three-Dimensional Printers: They print three dimensional objects in real world using three-dimensional data created computers. Mechanical parts except motors and electronic devices can be produced by them. 3D printers also used to surface improvement and modelling. They are used in medicine, industry, food, town planning, genetics, and IT technologies areas [33]. Another important advantage of them is, they decrease the costs of production which results in an increase of accessibility of products. Application of this process to different materials is continuing.

Augmented Reality: They are technologies which bring together the data of real and virtual objects [15]. An advantage of this technology is it make it possible to virtually adaptation of new features to real objects. By using possible it is easier to save time, workload and do not lose contact with the real world.

Autonomous Robots: They are electro-mechanic devices that can carry out tasks with previously programmed software. They can be controlled by operators or by software. Nowadays, these robots are commonly used and human workload replaced with autonomous robots' day by day [5, 8].

2.1. The Place of Industry 4.0 in the World and Turkey

According to 2020 IFR World Robotics report, with 12% increase, 2.7 million industrial robots are used in the world which is a world record [14]. In last ten years, in especially automotive industry and respectively electronics, metal, machine, plastic, chemical product, and food industries an increase of usage of industrial robots are observed. Two-thirds of the global market of production industrial robots are occupied by new built robots in Asia. The biggest operational stock in the area is announced as China with the 21% increase and 783 000 pieces in 2019. The European market which has Germany as main user, showed 7% increase with 580 000 pieces in 2019. European companies especially which includes SMEs, focus on systems with smart sensors to detect glitch and faults in the production process. Moreover, they also support to educate engineers in that area [10].

While corporation of human and robots has been increasing worldwide, Cobot [collaborative robot]. organization has increased %11 unlike traditional robots. While suppliers of these robots are increasing, application range of them are expand and currently their share in the industrial market is 4.8% [14].

When we check the place of Turkey in the OECD countries and chosen countries, Turkey is 35th in the research and development in 2018 [23]. According to 2019 reports, the share of research and development has increased to 1.06% in gross domestic product [31].

When we look at the perception of sector to fourth industrial revolution in Turkey, results indicate that there are legal loopholes, shortage of qualified workman and problems at research and development necessity, learning necessities, problems in system designs, financial difficulties, and dependency to abroad. In addition, with the industry 4.0 there might be disadvantages for Turkey due to cultures of business, the situation of industry in Turkey, working conditions, high costs, and comprehensive software. According to reports, often used applications of industry 4.0 are system integrations, big data, internet of objects, cloud computing systems and another result is that there is an awareness of new technologies in the companies which use advanced technology [13].

SME are very important in transition to industry 4.0. In 2019, the share of SMEs is99.8% in new business attempts in Turkey. 72.4% of employment is encountered by SMEs. According to classification of SMEs; although 56.9% of SMEs are working with low technology, the rate of large-scale initiatives is 49% [32]. According to predictions, SMEs are very important in the process of adaptation of advanced technology to production if conditions are suitable.

3. Aim and method

The main aim of the study is the detection of the tendency of the transition of industry 4.0 and especially to observe the effects of the SMEs' advanced technology integration to production. To achieve this aim, a questionnaire which is about company information, strategies, structure of organization, sources, information systems, and culture of organization are e-mailed to Kan Metal which is a company in Ostim, Ankara (cf. Annex-1). According to data taken from questionnaire additional questions about production and mechanism directed to companies (cf. Annex-2). Finally, by visiting companies, production mechanism is observed, photographed, and semi-structured interview technique, which is one of the qualitative data collection techniques, was carried out. At the end of the research, production mechanism at Kan Metal, and steps of production are examined and edited with the technologies which are predicted to be used with industry 4.0 by using the literature review method.

4. Findings and application

4.1. Company Info

Kan Metal, which is a company built to produce automotive spare parts and marketing in 1958 in Ostim-Ankara, produces spare parts of agricultural machinery since 1982. The company consist of 1 engineer, 2 bachelors, 11 workers and the company is a relatively small SME. They participate fairs in Germany and Italy twice in a year for advertising activity, and they export agricultural machines to Italy, Spain, Germany, Greece, Bulgaria, Serbia, Russia, Ukraine, Hungary, Azerbaijan, Uzbekistan, Iran, Taiwan, and more countries. While the company takes accounting services from outside of the company, they handle their web service. They own 7 machines which can be controlled manually and numerically, and they take painting and baking services from outside of the company.

In 2016, they bought their neighbors' place and their place doubled. In 10 years, they are planning to move a 4-storey factory in Ankara-Kazan. According to this plan, settlement plan of machines will change and painting, baking services will be added up to production process.

The product range of Kan Metal, which produces to order, consists of two groups as vibrating crank and drum blade. In this study, the production stages of the vibrating crank are examined.

4.2. Production Line

The steps of the production of the vibrating crank are explained respectively.

Work order and design: Due to the production to order method, material control is carried out according to the product chosen by the customers from the catalog. 6 meters long round steel solid shafts with diameters ranging from 25 to 42 mm are supplied as raw material. Since the priority is the delivery time, if they do not have the material, an order is placed from a supplier from Ankara and Istanbul who will deliver the material first regardless of the cost.

If the customer requests a special non-catalog vibrator crank production, the part is sent as a sample. After the sample is measured and the technical drawing is created, it is sent back to the company.

Raw Material Warehouse: 6-meter shafts are kept in the entrance that has a maximum capacity of 75 tons. Materials and storage times vary according to diameters. The purpose of storage is stated as shortening the supply time and meeting the demand during busy periods. Stock control is done manually with Excel program based on orders.

Picture 1. *Raw material storage area and Saw*

Saw: The 6-meter shafts are cut according to the dimensions of the ordered product.

CNC lathe: Center holes are drilled on one end of the cut shafts to be used in the lathe machine in the next stages.

Picture 2. *CNC lathe - raw material - lathed product*

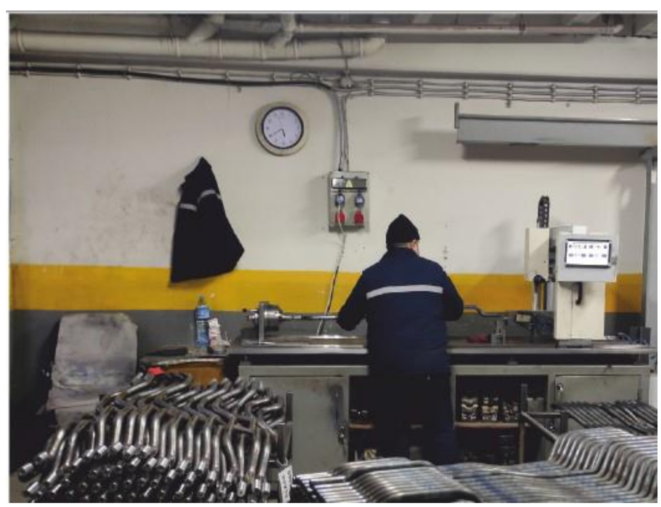
Twisting: Due to the costs of special production machines, the fourth generation twisting machine designed by Kan Metal, twists the shafts according to the desired details.

Picture 3. *Kan Metal twisting machine*

Cut to length machine: The twisted products are cut from the ends according to the final length measurement.

Picture 4. *Cut to length machine*

Dimension control: The dimensions and oscillations of all products are individually measured and controlled.



Picture 5. Bench for dimension control

Universal lathe: 1 mm of the end parts of the cranks are removed from the diameter in order to obtain more precise measurements in CNC lathes.

Picture 6. *Universal lathe*

CNC lathe: The ends of the cranks where the bearings will be seated are turned according to the bearing tolerances.

Picture 7. *CNC lathe*

Attachment assembly: The cranks are divided into 4 groups at this step. Screwing, pressing and welding processes are performed according to the order. If the order is requested without attachment parts or if the product is manufactured for stock, no action is taken to the part.

Picture 8. *Types of vibrating cranks – Press machine – screw and welding workbench*

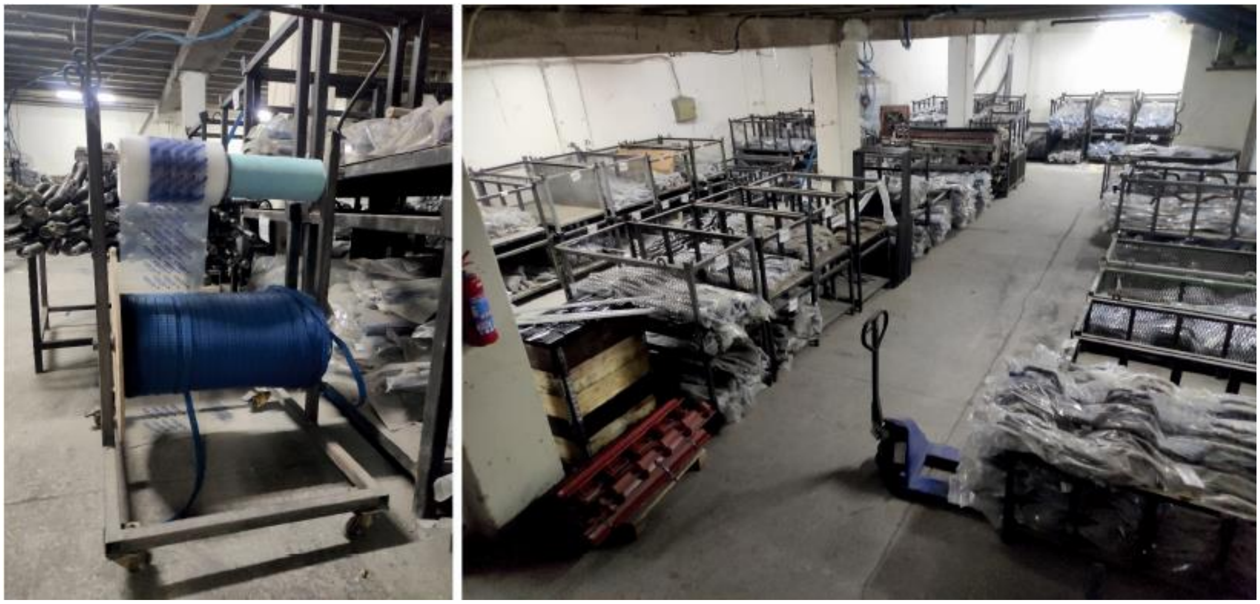
Machining center: Wedge channels are opened to turned parts in the machining center so that they can fit into the machine.

Picture 9. *Machining center*

Painting and firing: At this step, the parts are taken by forklifts to another company located on the same street and undergo static painting and firing processes.

Packing: Tops of the parts are wrapped with nets to prevent damage to the parts and the parts are dressed with logo nylon films.

Product warehouse: It is the last step where intermediate and final products are stored until the order is received or until the shipment date. As indoor transportation is not convenient forklifts cannot be used in this area, and parts can only be stored in a single or double storeys with of pallet trucks.



Picture 10. *Packaging and warehouse*

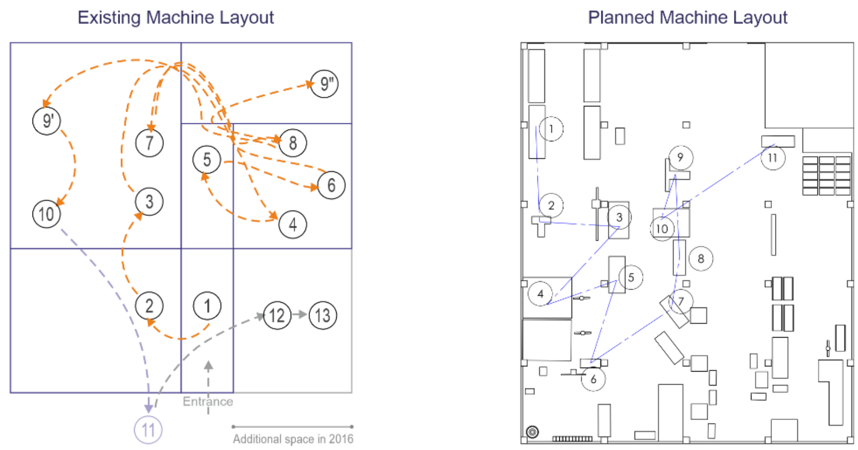
4.3. Current Production Line Evaluation

When the production stages of the shaking crank were examined, it was observed that there were no fully automatic machines included in the process and the production mainly relied on manpower. When the advantages of this mode of production are examined, it is observed that improvements can be made with low capital, and flexible working can be achieved by shifting workers from line to line according to work load. In addition, the company does not have difficulty in meeting the demand and can apply overtime during busy order periods.

The disadvantages of the current production line can be listed as follows:

- Insufficient raw material warehouse space,
- Irregular charges of supply,
- Inventory tracking is not actively conducted,
- Unnecessary circulation time between production machines,
- Accumulating parts in each process step and switching to a new process,
- Dependency to operators,
- Since the final product warehouse is on the lower floor, there is no forklift, only one-floor material can be stored.

In the production of vibrating cranks Kan Metal constantly employs 2 personnel and additional 4 personnel who are shifted from other productions based on the need. Considering that the existing conditions of the enterprise, where the daily production rate is maximum 30, will be improved, it is foreseen to add another one of the CNC lathe machine in Step 8, which determines the daily production amount. In this case, the speed of the twisting machine, which has a daily production capacity of 40-60 pieces in the 4th step, can be slow.



Picture 11. *Production flow available and planned machine layouts*

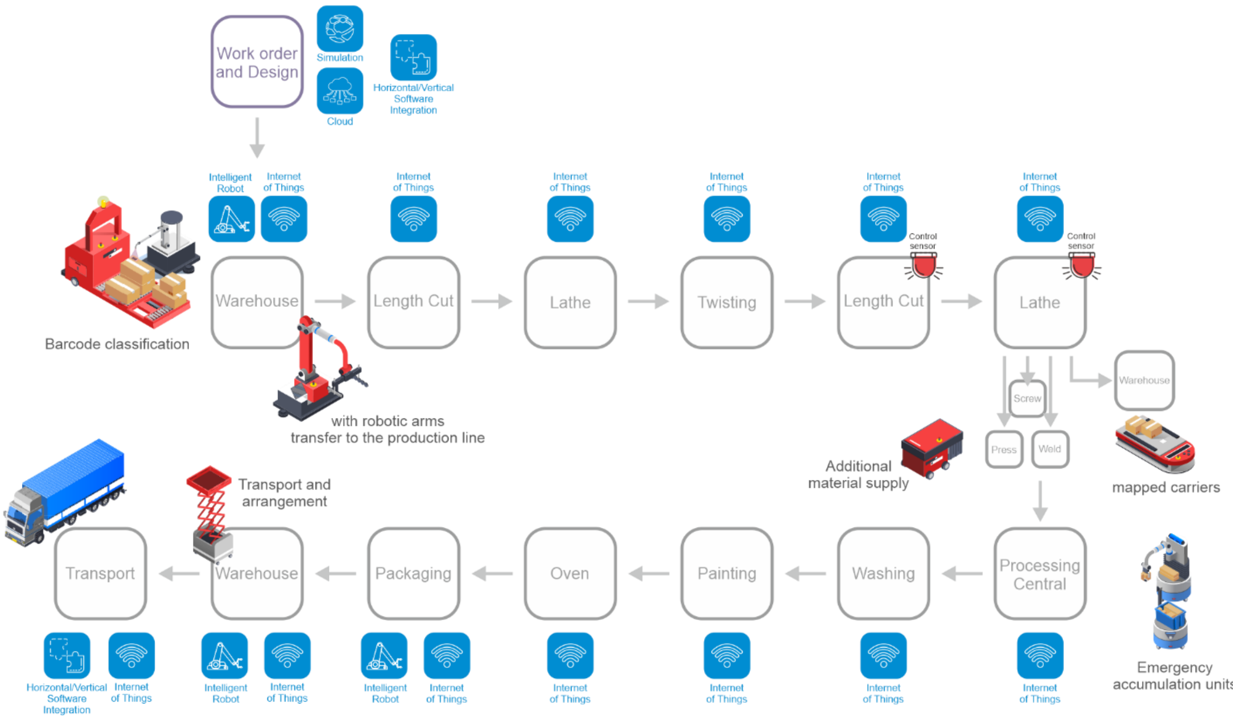
It is contemplated that the production can reach the maximum level of its own conditions by doubling the production if dyeing and firing units are added to a vibrating crank line, which is thought to have pairs of CNC lathe and twisting machines at the factory that is located on a larger area as planned in Picture 13. In this case, if 2 people are added to the new machines, 2 people are added to the painting and packaging steps, 1 person is added as support to the additional parts assembly and processing center, and 1 person is added as accounting, a total of 6 people will be included and the production line will be able to work at full capacity as planned.

4.4. Fictional Industry4.0 Factory Model

In order for the vibrator crank part used in combine harvesters to be healthy and long-lasting, it is important that it does not make any secretions while turning, and therefore it requires sensitive production. In the current flow, machining parts in the universal lathe before CNC turning lathe in steps 7 and 8 are an extra step to achieve greater precision. Considering this sensitivity and the machines used, the company is seen as having a very convenient production flow for the application of Industry 4.0 technologies.

In case of transition to Industry 4.0 model, it is foreseen that simulation, smart robots, internet of things, horizontal/vertical software integration and cloud technologies will be included in the system. In this case, the flow is set up as in Picture 14.

According to the Industry 4.0 setup, with the horizontal/vertical software integration that can be included in the system, raw material order and stock control, which is one of the most priority problems of the enterprise, will be resolved according to the production flow. In addition, the delivery time will be determined and customers will be able to control the order, production and delivery processes of the products and provide feedback. By creating a simulation of the part instead of sending a sample, additional shipping charges and extra workload will be avoided. Part drawings, quality control documents, company documents and inter-company contracts can be stored in the cloud and used when needed.



Picture 12. *Production flow available and planned machine layouts*

While the raw materials that arrive at the company are loaded into the warehouse via smart robots, they can be classified according to their diameters thanks to smart barcodes. In addition, it is foreseen that the internet of things will enable entering the raw material stock system that arrives and a warning can be sent for the order in case the products decrease on the shelf. After the raw materials are transferred to the production line by the means of robot arms, thanks to the internet of things, each product will be able to move on to the next process after completing its process.

In cut-to-length and turning steps where quality control is important, intermediate products will be checked before proceeding to the next step through control sensors, and if there is any mistake, transfer will be provided after fixing it. In the lathe step that requires precise processing, after the first measurement is done, it will be controlled and reduced to a fine tolerance, so that the two processes will be combined to ensure that the dimensions are suitable for the final product.

In the additional processing stage, intermediate products will be processed according to the order with the help of the internet of things, and if the product is to be stored as an intermediate product, it can be taken to the warehouse by means of mapped carriers.

Products will progress with the help of even the same technologies, including paint and oven, and when it comes to the packaging step, it will be done with the help of smart robots. After this step, the final products will be transported to the shipment or warehouse thanks to their smart tags. In case the shipment takes place, thanks to the software integration, the carrier company will be notified and the products will be sent without losing time. The customer will receive information that the products are ready and on the way.
In the case of a malfunction in the machines within the system flow, it is designed that support can be provided with smart emergency material suppliers and the machines can repair themselves. In addition, it is foreseen that the production line can be prevented from stopping by creating emergency accumulation units.

4.5. Advantages and Disadvantages of the Fictional Industry 4.0 Factory Model for Kan Metal

The proposed technologies are fundamental innovations, not remedial methods for the company. Re-establishing a factory with these technologies requires large capital, as it will be costly. but Kan Metal, a small-scale SME, aims to develop itself by investing its resources in technology in a balanced way.

When the current production flow is examined, it has been determined that the stage that slows down the daily production amount is the CNC machine specified in Step 8. The fact that there is only one of these machines, which has a daily production capacity of 30, causes the company's daily production capacity to be 30. For this reason, one more CNC machine was added to the new diagram. Thus, assuming that the production rate will remain constant, the number of products to be sent to the twisting machine with a daily production capacity of 40-60 units and the total production amount are expected to be doubled.

The company, which has a production capacity of 60 vibrating cranks with a daily working time of 9 hours, will increase its capacity to 160 products (60 pieces x 24 hours / 9 hours) considering that the production will be uninterrupted for 24 hours under the new conditions. While 180 items (6 days x 30 items) are produced per month in traditional production, it is calculated that the weekly production (7 days x 160 items) will be 1,120 items in the case of 7 days of uninterrupted production with Industry 4.0. Thus, when the new situation is compared with the existing production capacities, it is observed that the production rate will increase by 622.2%.

More production means either more product than demand or the necessity of finding new markets. This means that the company gains approximately 6 times more customers compared to its customer portfolio. The necessity of reaching new markets and customers brings with it the necessity of increasing the number of personnel or their skills working in the company.

It is thought that 7 machine equipment in the company will evolve into 11 machines and mapped carriers, emergency accumulation units and robotic placement units if Industry 4.0 is adopted. In this case, it is foreseen that there will be no business areas where 11 blue-collar workers out of 14 working in the company can work. Considering that the accounting services are outsourced, it has been determined that 2 people who are partners of the company and the only engineer in the company will adapt to the new system and deal with processes such as order approval, advertising activities and emergency controls, so that the company's production can be carried out with a total of 3 people.

Establishing a staff of 20 with the plan to include 6 more personnel, which was observed in the company's short-term development plan, will also increase personnel costs and the margin of human error. According to the newly calculated situation, the profitability rate of the company will increase with a total of 3 people and standard quality products will be obtained.

In order to include new parts in production, the company requests sample parts from its customers and starts production by measuring on each part. Thanks to the developing 3D scanning technologies, the samples will be saved to the cloud system before they are sent, and they will be delivered, edited and stored. This will both increase the company and customer communication, reduce transportation costs and create a platform where the company can securely store and share production details and drawings and make arrangements interactively with the customer. In addition, 3D printers will enable the production of samples that can be checked and sent to the customer before the parts go into mass production. Thus, in the current system, the interaction of the international company with the customer will increase, and the company will easily reach new customers and increase its market share, with the ease of designing customer-specific parts with reduced shipping costs.

One of the biggest advantages of the new model is that the company will find solutions to the problems that cause inefficient use and cost losses, such as forgetting materials in the storage area, which is currently experiencing difficulties, with the help of smart tags, smart carriers with maps and elevators, and moving lines.

Thanks to the technologies brought by Industry 4.0, shaky cranks will be produced uninterruptedly despite the current or planned new order in Kan Metal, and the factory will have used its resources in the most efficient way. Thanks to the control of the production flow with the internet of things and the horizontal/vertical system integration, raw material arrival-end product output and producer-customer balances will be able to be adjusted according to the order without any problems. In addition, stock follow-ups will be kept up-to-date and the cost will be reduced by making the raw material orders at the right time. In addition, the necessary additional material and material support in the production line will be kept under control automatically, thus preventing the disruptions in the workflow.

Since there is a minimum use of manpower in the dark factory system, the negative effects of the employees and the environment in production will be minimized. In addition, all data from order to distribution will be pulled from the cloud and system assurance will be provided in the data flow.

5. Conclusion and recommendations

In the study, the the vibrating crank production methods of Kan Metal, a small-scale SME company located in Ankara, were examined and applied to Industry 4.0. It is foreseen that the company, which produces 30 pieces with 9 hours of work per day, will produce twice [60 items in 9 hours]. in the same time by adding one more CNC lathe, which determines the production amount under new conditions. In addition, since uninterrupted production will be started throughout the day, the daily production amount will increase to 160 units. Working 6 days a week, the company can produce a total of 180 products, while in the new fictional system, it will be able to produce 1120 vibratory cranks 7 days a week. In this way, it has been calculated that approximately 622.2% efficiency will be achieved with Industry 4.0. In addition, it has been revealed that there will be no need for blue-collar stuff as the worker-dominated production style is replaced by faultless production.

In current studies the implementation of Industry 4.0 in

Turkey is seen as a process that will bring a lot of efficiency, especially for SMEs [6, 34]. While the final products of the companies are perfected in many aspects such as products that require precise measurement, supply costs, production continuity, efficient use of storage units, worker defects and safety, uninterrupted data flow, the production flow will be designed at an optimum level. In addition, it is foreseen that internal and inter-firm communication will be provided at a high level thanks to system integrations.

When the results of the survey and the results obtained in the research are compared with similar studies [20, 34], it is observed that SME companies do not have enough information about Industry 4.0, do not support personnel training in this direction, and provide a shy attitude due to the technical knowledge and cost necessary to create the system. In addition, factories and therefore countries must have certain infrastructures such as internet, electricity, water and communication. However, despite these negativities, the advantages that come with the technologies that will be implemented in the long term are of great importance for both capital owners and the country's industry. These advantages are mainly envisaged as follows:

- With the discrete production method, production will become uninterrupted and productivity will increase due to unit product cost, in factories that work only during working hours or in shifts and where mass production is not possible.
- Information storage and processing processes during the design and ordering stages of the products will be provided by cloud systems and the internet of things, samples can be measured with 3D scans and approval from the customer can be obtained by simulation method, and easy sample creation will be possible thanks to 3D printers. Thanks to these steps, shipping costs will decrease and customer satisfaction and trust will be ensured. Thus, small firms will be able to compete with large enterprises and it will be easier to open up to new markets.
- Raw material supply and storage will be controlled thanks to horizontal/vertical integration, so that negative situations such as order delays will be eliminated.
- By minimizing human use, human errors will decrease, personnel expenditures will decrease, production will accelerate and occupational health and safety violations will be prevented.
- Accessibility and transparency of production processes will facilitate remote control for managers and will be important for customers for monitoring and reliability.
- Thanks to digitalized machines and cloud storage, new product types and revisions will be included in production at low cost as soon as possible, and products will be produced with minimum waste and standard quality.

Considering the costs of transition to Industry 4.0 and the shortage of qualified personnel, it is necessary for Turkey to increase the share of the budget spent on R&D and to train qualified personnel in order to compete with the enterprises in the world. In addition, technology departments and robot laboratories in universities should be given importance, and robot development should be supported with TUBITAK projects. Legal, infrastructural, financial and educational support should be given to SMEs and the transition to the new system should be facilitated with state support.

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Annex-1:

COMPANY INFORMATION SURVEY
What is your company's NACE code?
What is the total number of employees in your company?
How is the differentiation of employees in your company according to their education level?
Doctorate : .... Post graduate: .... Licence:................................ Associate degree: .... High school: .... Vocational high school: .... Primary education: ....
How many engineers are working in your company?
Do you have an R&D department in your company? Yes ☐ No ☐
Do you have R&D employees? If yes, indicate how many staff there are.
Do you have an engineer or employee who works/can work in the field of Industry 4.0? (software, electronics, mechatronics etc.) Please explain if any.
What is your company's industry?
☐ Agriculture ☐ Tourism ☐ Plastic Machine Metal ☐ Energy ☐ Mine ☐ Food ☐ Health ☐ Forest Products ☐ Other
What is the scope of activity of your company?
☐ Local / Regional Scale ☐ National Scale ☐ International Scale ☐ World Scale ☐ Other
1. STRATEGY
1.1.What is your company vision?

1.2. What is your company mission?

1.3. Do you have a company strategy (written, unwritten, short/long term goals)? Please specify if any.

1.4. Do you have a defined R&D and Innovation strategic goal(s)? Please specify if any.

1.5. Is a defined Industry 4.0 strategy among your target(s)? Please specify if any.

1.6. If you have defined strategic goals, are they known to your top and middle managers and employees? If your answer is yes, please explain

2. ORGANIZATIONAL STRUCTURE

2.1. Do you employees have applicable job descriptions (written, verbal, defined, master-apprentice relationship)? Please specify if any.

Current state						Importance for the Firm				
Often.......... Never						Important .Unimportant				
5	4	3	2	1	**2.2**. How often do your employees take part in project-based interdisciplinary work within the scope of business objectives? How important is it for your employees to engage in project-based interdisciplinary work?	5	4	3	2	1
5	4	3	2	1	**2.3**. How often do your employees work in different departments and develop competence? How important is it for your employees to work in different departments and develop competence?	5	4	3	2	1
High............ Low						High............ Low				
5	4	3	2	1	**2.4**. What is the decision/initiative level of your employees in operational processes in your business?	5	4	3	2	1
5	4	3	2	1	**2.5**. What is the effect level of these decisions on central government decisions?	5	4	3	2	1
5	4	3	2	1	**2.6**. What is the impact level of your employees' mistakes on business operations?	5	4	3	2	1
5	4	3	2	1	**2.7**. What is the level of knowledge of company managers on concepts such as smart factory / product / production?	5	4	3	2	1

2.8. Does your organization provide training on new technologies?

2.9. Do you have feedback mechanisms (customer, employee, market, competitor, etc.) in your business? Please specify if any.

Often.........Never						Important .Unimportant				
5	4	3	2	1	**2.10**.How often does the business receive feedback from customers?	5	4	3	2	1
5	4	3	2	1	**2.11**.How often is customer feedback used in product development processes?	5	4	3	2	1

2.12 Evaluate the suitability of your organizational structure for fast or flexible production methodologies.

Often.........Never						Important .Unimportant				
5	4	3	2	1	**2.13**.To what extent can you fulfill/find solutions to your customers' demands/ problems by using certain technologies and methods?	5	4	3	2	1
5	4	3	2	1	**2.14**.What is the level of competence to adapt to changing market conditions?	5	4	3	2	1

2.15. Flexible hours, taking initiative, etc.) If yes, please specify.

2.16.Are there incentive motivation systems in the business to increase the self-confidence of your employees? Please specify if any.

2.17.Do you plan to make improvements in light of the questions in this section? If your answer is yes, give an example.

3. RESOURCES

3.1. Financial Infrastructure

3.1.1.Do you have financing/credit opportunities that you can allocate to invest in new technologies?

3.1.2.Would you consider investing in sectors outside of your field of work? If your answer is yes, give an example.

3.2.Do you have machines compatible with Industry 4.0? (Can he work without a human being?)

Often.........Never						Important .Unimportant				
5	4	3	2	1	3.2.1.What is the level of horizontal formal communication channels between your employees?	5	4	3	2	1
5	4	3	2	1	3.2.2.What is the level of vertical formal communication channels between your employees?	5	4	3	2	1

3.3. Physical Infrastructure

3.3.1.Can you extract data from your operations through communication ports? If your answer is yes, give an example.

3.3.2.Do you have machines compatible with Industry 4.0? (Can he work without a human being?)

Often.........Never						Important .Unimportant				
5	4	3	2	1	**3.3.3**.What is your level of using the communication ports of your devices?	5	4	3	2	1
5	4	3	2	1	**3.3.4**.What is your level of knowledge on data collection with your machines in their current state or with integrated sensors?	5	4	3	2	1
5	4	3	2	1	**3.3.5**. Is fault detection and calibration performed independently and automatically by the machines in pre-production and production processes?	5	4	3	2	1

3.3.6.Do you use sensors in your operational processes related to production? If your answer is yes, give an example.

High. . . . . Low						Important .Unimportant				
5	4	3	2	1	**3.3.7**.Can your employees use the data produced by digital tools (sensors, etc.) for strategic decision making?	5	4	3	2	1
5	4	3	2	1	**3.3.8**.Is the production processes monitored with smart sensors/RFID and the data collected is automatically transformed to feed the decision support systems?	5	4	3	2	1
3.3.9. Are there intermediate elements/systems (hardware, wireless connection systems, etc.) that will provide information transfer between employees and machines?										
3.3.10.Do you plan to make improvements in light of the questions in this section? If your answer is yes, give an example.										
					4. INFORMATION SYSTEMS					
4.1.Data Integration										
4.1.1. Does your company have a database management system? Please specify if any.										
4.1.2.Does your company use software such as ERP? If your answer is yes, give an example.										
Often. . . . . Never						Important .Unimportant				
5	4	3	2	1	**4.1.3**.What is the level of effective use of information systems?	5	4	3	2	1
5	4	3	2	1	**4.1.4**.What is the level of integration of data produced in different units?	5	4	3	2	1
5	4	3	2	1	**4.1.5**.What is the standardization level of data produced from information sources?	5	4	3	2	1
5	4	3	2	1	**4.1.6**.What is the level of precaution taken for cyber security in your institution?	5	4	3	2	1
Often. . . . . Never						Important .Unimportant				
5	4	3	2	1	**4.1.7**.What is the level of user identification, administrative user separation and data flow (IEC62443 standard etc.) in the processes where information technologies are used?	5	4	3	2	1
5	4	3	2	1	**4.1.8**.What level of automatic information is provided to those responsible (manager, operator, etc.) of operations (logistics, production, marketing, etc.) carried out within the scope of company activities, about the operation and critical processes of the operation, through software applications?	5	4	3	2	1
4.2 Data Use in Decision Making Processes										
High. . . . . Low						Important .Unimportant				
5	4	3	2	1	**4.2.1**.What is the level of instant data capture from operations from business functions (production, logistics, service, R&D and marketing)?	5	4	3	2	1
5	4	3	2	1	**4.2.2.**If instant data can be drawn from business functions, what is the level of real-time monitoring of the captured data?	5	4	3	2	1
5	4	3	2	1	**4.2.3**.What is the level of making the produced data meaningful and using it in planning?	5	4	3	2	1
5	4	3	2	1	**4.2.4**What is the level of task-based use of the produced data?	5	4	3	2	1
Often. . . . . Never						Important .Unimportant				
5	4	3	2	1	**4.2.5**.How often do your employees use personalized methods (signs, voice commands, etc.) for data entry?	5	4	3	2	1
4.2.6. Do you have information technology infrastructure such as physical server, cloud-based server, system backup information (NAS etc.)?										

High............Low						Important .Unimportant				
5	4	3	2	1	**4.2.7.** What is your remote access activity level to business data?	5	4	3	2	1
4.2.8 Do you plan to make improvements in light of the questions in this section? If yes, give an example.										
					5. CULTURE					
High............Low										
5	4	3	2	1	**5.1**. What is the intra-firm diffusion level of mechanisms for compensating employee errors in the operation of company functions?	5	4	3	2	1
5	4	3	2	1	**5.2**. What is the level of your employees adapting to a new practice/method?	5	4	3	2	1
5	4	3	2	1	**5.3**. What is the level of competence of your employees in information technologies (technology developed for data recording, transfer, manipulation, use and interpretation)?	5	4	3	2	1
5	4	3	2	1	**5.4**. At what level do the causes of the problems experienced in the company operations spread within the company?	5	4	3	2	1
5	4	3	2	1	**5.5** What is the level of trust of your employees in the decisions made by the information systems?	5	4	3	2	1
Often.........Never						Important .Unimportant				
5	4	3	2	1	**5.6**. How often do your employees submit training requests to management to critique new competencies?	5	4	3	2	1
5	4	3	2	1	**5.7** How often do your employees receive proposals to change the business structure/actions on global innovations related to the business's industry?	5	4	3	2	1
					5.8. How often are urgent/rapid decisions taken for company strategy and operation based on the feedback of your employees?					
5.9. Do you plan toimake improvements in light of the questions in this section? If your answer is yes, give an example.										

<u>Annex-2</u>:
Additional Survey Questions:

1. How many employees does the company have?
2. Which departments does the company get external help from?
3. Could you share the process diagram and describe the process flow?
4. What is the daily capacity of the company?
5. Does the company have machines working in shifts in the production flow?
6. What are the additional machines for working full capacity? How many workers does the company need in the case of full capacity?
7. What are your criteria for choosing the suppliers? Who pays the delivery costs?