



## **Analysis of Costs of Use Industry 4.0 Tools, Industrial Design, Psychologic, Social and Law Regulations to Increase the Operative Yielding of Industrial Machines in an Automotive Industry of Tijuana, Mexico**

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**Abstract** – In this scientific study was made an evaluation of the use of industry 4.0 specialized tools to improve the operative yielding of the industrial processes of an automotive industry located in the Tijuana city, as is considered an industrial zone of the northwest of the Mexican Republic. This zone is a border city and is next to the California State of the United States of the America (USA), which have some important relations by the Free Trade Agreement between Canada, Mexico and USA. All products manufactured in this automotive industry of Tijuana, pass to a relevant automotive industry of the California State, to complete the car vehicles fabricated as commercial business of cars. The use of industry 4.0 tools, as the Internet of the Things (IoT), to evaluate five sensors utilized in diverse type of industrial processes to detect electrical failures in the products fabricated in this automotive industry, where investigation was made. With this specialized analysis was improved the operative yielding of five industrial equipment's and five industrial machinery improving the productivity and quality levels, and increased around 25% of the initial indices evaluated. The use of the IoT supported to connect industrial sensors to the industrial equipment and machinery analyzed, and sending information to the managers interested in the information of the sensors that were evaluated the operations of the industrial equipment and machinery, which were evaluated to improve it operative yielding, and with this the increase of the productivity and quality indices, and the economic gains. This scientific study was made in 2025. Also was evaluate the psychologic and social actions of workers of this automotive industry and too was analyzed the industrial design of the products manufactured, and the law regulations to supports to workers in their human rights and works with security. This automotive company fabricates computer modules for car vehicles.

**Keywords:** IoT, Automotive industry, industrial processes, industrial sensors, industrial equipment and machinery, psychologic, social, law regulations, industrial design.

### **1. INTRODUCTION**

The IoT of the industry 4.0 is an important tool that is utilized in the industrial activities, which are supported to connect industrial sensors to evaluate diverse type of industrial operations in any type of industrial company, to detect any type of anomalies in the industrial equipment and machinery. In this industrial company, the use of IoT was used to know very fast, some electrical failures, and were supported fast the solutions to fix the

industrial equipment and machinery, and avoid the generation of great quantity of defective products<sup>1</sup>. This increased the productivity and quality factors and was obtained economic gains. Also, this investigation was made an analysis of the psychologic and social relation between workers, where is very relevant in the actions of the elaboration of activities of industrial processes in the manufacturing, considering the law regulations, to maintain a cordial situation and reach the goals of the productivity and quality<sup>2</sup>. These important aspects, have great interest in the labor relation between managers, supervisors, workers and specialized people, and also administrative personnel that supports some anomalies of workers as, when workers as seek and occurs accidents in the industries. Another relevant factor evaluated, was the industrial design where was an important aspect in the fabrication process to the manufactured products of this industrial company, which was very important in the functionality of the computer modules fabricated in this automotive industry that permits elaborates this scientific study<sup>3</sup>.

## 2. INDUSTRY 4.0 TOOLS

Industry 4.0 is referred to as the digitalization action of the industrial process of the industrial companies, to automatize and robotize the industrial operations<sup>5</sup>. These actions involve diverse type of tools that elaborates specialized functions, with intelligence technologies to interconnect the mayorly of the areas of each industry, to have advanced automatization and can take decisions in real time<sup>6</sup>. This type of industry is considered as the four industrial revolutions, where is contemplated in all industries of the world, to are in competitive action, representing an important change in the manufacturing areas. To reach the competitiveness of an intelligent industrial and autonomy company, is necessarily to know about cybernetic systems, Internet of things (IoT) and advanced analysis<sup>7</sup>. The term of Industry 4.0 was used at the first time in a relevant event in Hannover, Germany in 2011, as an strategic action to have high technology, which are utilized to obtain information as numerical or text, of the industrial equipment, machinery, systems and electronic devices, which to collect, analyze and generate actions as automatized operations can optimize the industrial processes. The main industry 4.0 tools are explained in the next table <sup>18</sup>.

**Table –1:** Main characteristics of the principal industry 4.0 tools

| Main Factors                                        | Relevant Information                                                                                                                                                                                   |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tools                                               |                                                                                                                                                                                                        |
| <b>Artificial Intelligence and Machine Learning</b> | Is used to elaborate predictive evaluations, optimize and preventive maintenance of industrial processes in industries.                                                                                |
| <b>Internet of Things (IoT).</b>                    | Are utilized to detect and control industrial operations with electronic sensors and electronic devices interconnected between its components, to collect numerical and text information in real time. |
| <b>Analytic and Advanced Big Data</b>               | This tool is used to collect and evaluates great quantity of numerical data, to improve to take adequate decisions, and to improve the industrial processes of manufacturing areas                     |
| <b>Robots and Cobots</b>                            | These relevant and automatized systems are utilized as collaborative components in the industrial processes, in repetitive and dangerous operations.                                                   |

|                                                        |                                                                                                                                                                                                                                                     |
|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                        |                                                                                                                                                                                                                                                     |
| <b>Cloud computer system and edge computer systems</b> | Are utilized to collect, store and analyze the textual and numerical information to improve the industrial processes to take decisions very fast and correctly.                                                                                     |
| <b>Digital twins</b>                                   | This relevant tool is applied to virtual replicas to industrial processes in industrial equipment, machinery, systems and electronic devices; to simulate some new changes in the industrial operations, before be applied in industrial processes. |
| <b>Augmented reality and virtual reality</b>           | Are used to elaborates simulations in real time to capitation, maintenance and technical assistant of the industrial processes of industrial companies.                                                                                             |
| <b>Cybersecurity.</b>                                  | This tool is very important in the information security (text and numerical), to ensure the information and not loss any type of information.                                                                                                       |

Table 1 shows the main industry 4.0 tools in its principal characteristics to understand about its application and be utilized in this scientific article. As is illustrated in this table, all industry 4.0 tools mentioned in this investigation, are very important to control the industrial processes to have a fluid industrial process and reach the goals of the productivity and quality indices in this industry that permits the realizing of this investigation, and any type of industry at the worldwide<sup>6</sup>.

### 3. ADVANTAGES AND DISADVANTAGES OF THE INDUSTRY 4.0 TOOLS

The use of industry 4.0 tools mentioned above, have great relevance in the evaluation and the application of the continuous improvement in the industrial operations in industrial companies. For this reason, is necessary analyze the advantages and disadvantages of its use that are expressed the principal aspects, which are expressed in table 2<sup>5</sup>.

**Table -2:** Advantages and disadvantages of the use of industry 4.0 tools

| Important Aspects                                                                                         | Use of Industry 4.0 Tools                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Main Process                                                                                              |                                                                                                                                                                                                                                                             |
| <b>Advantages.</b>                                                                                        |                                                                                                                                                                                                                                                             |
| <b>Can generates great supports to improve the industrial processes with the next actions.</b>            |                                                                                                                                                                                                                                                             |
| <b>Control Action</b>                                                                                     | Is very relevant to control operations of industrial process and have a fluid flow process to reach the goals of productivity and quality indices                                                                                                           |
| <b>Security of Information</b>                                                                            | Are utilized to obtain, analyze, store and ensure the information (text or numerical) to take decisions fast and correctly.                                                                                                                                 |
| <b>Automatized Operations</b>                                                                             | Have great interesting in the control of industrial operations in any type of industry, and have automatically the information evaluated.                                                                                                                   |
| <b>Major Efficacy</b>                                                                                     | With this type of tools, are obtained major production and less quantity of errors, by the automatization processes.                                                                                                                                        |
| <b>Flexibility and Control</b>                                                                            | Can be more flexible and control the flow process, using the best flow production in the manufacturing areas of industries.                                                                                                                                 |
| <b>Low Costs</b>                                                                                          | With the industry tools, can reduce the costs of the production process of manufacturing areas of any type of industry                                                                                                                                      |
| <b>Disadvantages</b>                                                                                      |                                                                                                                                                                                                                                                             |
| <b>As is mention in the last paragraphs, are more advantages than disadvantages, but will mention now</b> |                                                                                                                                                                                                                                                             |
| <b>Unqualified personnel</b>                                                                              | To the use of the internet tools, is necessarily know about it relevant tools, because are require specialized knowledge to obtain the maximum efficiency of the operative yielding of the industrial equipment, machinery, systems and electronic devices. |
| <b>Specialized knowledge.</b>                                                                             | Is necessary that the workers of each company and at each level of knowledge and functions keep updating themselves constantly.                                                                                                                             |

Table 2 represents the main relevant information about the advantages and disadvantages of the use of the industry 4.0 tools in the industrial processes that are very important in the control of the industrial operations, as were controlled in this industrial company, where was made this scientific study<sup>7</sup>.

### 3.1 Automotive industry

Is relevant type of industry, where are located around 50 industries in the Tijuana city, where was made this investigation<sup>9</sup>. This type of industry have great interesting at the worldwide, because, manufactures a lot pieces of car vehicles in the world, being mechanical, electronic, electromechanical and electropneumatic systems and devices. The main parts that are fabricated in the industrial company where was made this scientific study are expressed in table 3<sup>10</sup>.

**Table -3:** Parts manufactured in the automotive industry evaluated (2025)

| Operation factors                                  | Functionality                                                                                                                                                                                                                       |
|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Products Manufactured                              |                                                                                                                                                                                                                                     |
| <b>Mechanical Systems</b>                          |                                                                                                                                                                                                                                     |
| <b>Clutches</b>                                    | Is a special part of any car to begin and stop the vehicle, elaborating the function of the change the velocity of the car.                                                                                                         |
| <b>Drive shafts</b>                                | Relevant part of car to transfer power and movement of vehicles.                                                                                                                                                                    |
| <b>Gearboxes (manual and automatic)</b>            | Generates the function of transfer the power of motor of cars to tires to advance vehicles.                                                                                                                                         |
| <b>Electro-Electronic Systems</b>                  |                                                                                                                                                                                                                                     |
| <b>Lithium Batteries for Electric Car Vehicles</b> | Are very relevant actually, for the importance of the lithium to generates electrical energy in batteries. Generates the function to supports to turn on the cars, supplying to other electrical or electronic devices of vehicles. |
| <b>Control Module Engine</b>                       | Control the operation of the majorly of the electrical and electronic devices of cars.                                                                                                                                              |
| <b>ABS braking systems.</b>                        | Are very relevant to brake cars in the required moment and avoid accidents.                                                                                                                                                         |
| <b>Stability control</b>                           | Is very important in the stability of cars to maintain the right way.                                                                                                                                                               |

Table 3 illustrates the parts manufactured in the automotive industry installed in the Tijuana city, which permits the elaboration of this scientific study, being mechanical and electro-electronic parts.

### 3.2 Costs in industrial operations

Are very relevant in the prosperity of each industrial company, where includes costs of salaries, raw material, industrial processes (specialized strategies), industrial equipment and machinery, administrative costs, customer services, electricity service, gas service, water service and others not assigned, but can appear in any time of the production time<sup>11</sup>.

### 3.3 Industrial design

Is very important in the manufacturing products fabricated in the automotive industry to determines the correct operation of the products manufactured. This is very important to avoid the generation of actions as incompatibility of the parts fabricated with the other parts of the car vehicles, to obtain the maximum operative yielding of cars<sup>12</sup>.

### 3.4 Social, psychological and law regulations

Are relevant factors in the relation between workers of industrial processes, supervisors and managers to have a cordial relation and with this all people of this industrial company works very good and can obtain the maximum operative yielding and with this, reach the goals of productivity and quality indices<sup>3</sup>.

## 4. METHODOLOGY

In this investigation was made three activities to determine the actions that were more effect in the evaluation of the operative yielding of the industrial machines of this industry evaluated. The activities are expressed now:

- Analysis of social and psychological aspects to determines the relevance of these factors in the operative yielding of workers in the handling of industrial machines and in the productivity and quality indices.
- Evaluation of the operative yielding of industrial machines based in the industrial design and the deterioration of some metallic parts for oxidation actions.
- Analysis of the correlation of the costs and operative yielding to determines the relation of costs of salaries of workers of production lines, use adequate of raw material and industrial processes with specialized strategies to obtain an adequate production flow.
- Evaluation of the use of industry 4.0 tools as IoT and the relation with the productivity and quality levels.

## 5. RESULTS

The information obtained in this investigation, and which are expressed in the next sections, was relevant to determine the main factors that were the major effect in the operative yielding of industrial machines in this industrial company evaluated.

### 5.1 Evaluation of social, psychological factors and law regulations with operative yielding

These factors were very important in the evaluation of the operative yielding of the industrial equipment and machinery of this industrial company evaluated. Table 4 shows the information obtained, explaining that were very important in the operative yielding and productivity and quality levels.

**Table –4:** Analysis of social, psychological and law regulations in the automotive industry evaluated (2025)

| Relevant Factors              | Effect                                                                                                                                                                                  |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Production Aspects            |                                                                                                                                                                                         |
| <b>Social</b>                 |                                                                                                                                                                                         |
| <b>Operative Yielding</b>     | Was very important in increase of 35% of operative yielding of industrial equipment and machinery, for the adequate the relation between workers of industrial process and supervisors. |
| <b>Productive and Quality</b> | Was important in the increase of 40% and 35% of productivity and quality levels respectively,                                                                                           |
| <b>Physiological</b>          |                                                                                                                                                                                         |
| <b>Operative Yielding</b>     | Was very important in the increase of 30% of operative yielding of workers that were handling correctly the industrial equipment and machinery of this automotive industry.             |
| <b>Productive and Quality</b> | Was relevant in the increase of 30% of the productivity and quality levels.                                                                                                             |
| <b>Law Regulations</b>        |                                                                                                                                                                                         |
| <b>Operative Yielding</b>     | These were very controlled about the reach the adequate labor conditions of the workers of industrial processes, increasing the operative yielding in 40%.                              |
| <b>Productive and Quality</b> | Was supported to have an adequate relation of the workers of industrial processes and supervisors.                                                                                      |

Table 4 represents the textual and numerical information about the three interesting factors analyzed, where, which indicates in all evaluations that the operative yielding and productivity and quality levels, were increased in different percentages.

## 5.2 Analysis of relation of industrial design and operative yielding

This part of the investigation was relevant in the evaluation of the industrial design that was important in the functionality and coupling of the parts manufactured in this automotive industry and other parts of the car vehicles. This is illustrated in table

**Table –5:** Evaluation of industrial design and production factors in the automotive industry analyzed (2025)

| Important Aspects      | Relevant Information of industrial Design                                                                                                                                                                                                            |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Production Parameters  |                                                                                                                                                                                                                                                      |
| Advantages             |                                                                                                                                                                                                                                                      |
| Operative Yielding     | Was necessary elaborates a correct industrial design to determines the adequate operation of the parts manufactured. This increased the operative yielding in 45%.                                                                                   |
| Productive and Quality | Was relevant in the coupling of the parts manufactured in this automotive industry and other parts of cars, to have <u>and</u> increase of 35% of productivity and quality levels.                                                                   |
| Disadvantages          |                                                                                                                                                                                                                                                      |
| Operative Yielding     | Was necessary contract specialized people to develop the industrial operations in the manufacturing areas with correct actions, increasing in 30%. Without specialized people of the knowledge of industrial design, the operative yielding was low. |
| Productive and Quality | Were increased in 40% with the specialized people with industrial design knowledge, to increase these relevant factors, but without specialized person of this important topic, these interesting parameters were low with negative effects.         |

Table 5 presents the evaluation of the importance of the industrial design, in the manufactured products of this relevant industrial company, supporting to increase the operative yielding and productivity and quality levels.

## 5.3 Correlation analysis of costs and operative yielding

The analysis of the costs in this investigation was very important, because was evaluating the costs of raw material, salaries of basic and specialized perrons that handing industrial equipment and machinery and the costs of specialized strategies to industrial operations. The information mentioned above is illustrated in table 6, indicating the relation of the costs and operative yielding in base of the three factors mentioned above.

**Table –6:** Correlation analysis of costs and operative yielding in the automotive industry evaluated (2025)

| Relevant Parameters | Raw Materials, % |     |     | Salaries, % |     |     | Specialized Strategies, % |     |     |
|---------------------|------------------|-----|-----|-------------|-----|-----|---------------------------|-----|-----|
| Factors             | LCA              | MCA | HCA | LCA         | MCA | HCA | LCA                       | MCA | HCA |
| Operative Yielding  | 18               | 35  | 67  | 22          | 56  | 74  | 20                        | 49  | 70  |
| Productivity        | 21               | 39  | 70  | 25          | 61  | 78  | 23                        | 54  | 75  |
| Quality             | 17               | 33  | 68  | 21          | 59  | 75  | 21                        | 56  | 74  |

LCA. Low Correlation Analysis, Medium Correlation Analysis, HCA. High Correlation Analysis

Table 6 shows the correlation analysis of the factors involved with the different range of the correlation analysis in this part of the investigation. As is illustrated, the productivity level indicates the highest range in percentage, following by the quality indices and in the last section is the operative yielding. This means that the productivity level was the most parameter to reach the production goals in this industrial company.

## 5.4 Evaluation of use IoT and relation with production factors

This part of the scientific study was made to determines the positive effect of the use of the industry 4.0 tool as the Internet of the Things (IoT), and the supports in the productivity and quality indices of this automotive industry evaluated. In table 7 is expressed the evaluation of the factors mentioned above.

**Table -7:** Evaluation of use of IoT in the production factors in the automotive industry evaluated (2025)

| Production Factors   | Productivity, % |     |     | Quality, % |     |     | Operative Yielding, % |     |     |
|----------------------|-----------------|-----|-----|------------|-----|-----|-----------------------|-----|-----|
| Parameters Evaluated | LCA             | MCA | HCA | LCA        | MCA | HCA | LCA                   | MCA | HCA |
| Efficiency           | 59              | 83  | 94  | 65         | 86  | 96  | 56                    | 82  | 90  |
| Reliability          | 60              | 80  | 90  | 63         | 84  | 95  | 59                    | 80  | 89  |
| Fast Action          | 58              | 79  | 89  | 67         | 90  | 95  | 60                    | 88  | 94  |

LCA. Low Correlation Analysis, Medium Correlation Analysis, HCA. High Correlation Analysis

Table 7 is relevant for the analysis elaborated, which shows the characteristics of the use of the IoT as an industry 4.0 tool, where was utilized with some electronic sensors to obtain the information of the operation of industrial equipment and machinery in the automotive industry evaluated. This indicates that was very important, to increase the productivity and quality indices.

## 6. CONCLUSIONS

This investigation was made relevant to determine the aspects evaluated and the relation with the operative yielding of industrial equipment and machinery of the automotive industry that permitted the elaboration of this scientific study. All parameters analyzed were an effect in the operative yielding, where were participating as the skills of workers of the production lines, as the adequate situation of the industrial equipment and machinery with the maintenance actions corrective, preventive and predictive. Also, was elaborates an analysis of the costs of salaries of basic and specialized people of industrial processes. By other way, the use of IoT as industry 4.0 tool, was very relevant to increase the production factors, and with this the economic gains of this industry evaluated. This investigation can be applied to any type of industry in the world.



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