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Optimal Control in Manufacturing Areas Increase the Productivity in the Aerospace Industry of Mexicali, Baja California, México

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ABSTRACT

Some specialized devices are designed with sufficient functionality for effective control in production, which is crucial for increasing productivity. These devices are MEMS, or Micro Electromechanical Systems. They are small, low-power microdevices that are extensively used in the aerospace industry's manufacturing processes. Their job is to control the operation of industrial systems by analyzing how they handle their tasks, comparing standardized values with real data, and activating and deactivating high-power actuator mechanisms like electric pumps, fans, and motors. Operating in accordance with the operating system reference values of industrial systems and producing a safe process, these microdevices have particular features that allow them to achieve the best operational performance of machines and equipment in the industrial sector at a low cost. Manufacturing components for airplanes subject to stringent rules owing to the high level of security required for air transport necessitates specific knowledge in the industrial processes of the Mexicali aerospace sector. Research was carried out to assess the use of MEMS in a city-based company that had no intention of using them. However, after seeing an increase in productive performance at one stage of their industrial processes, they decided to apply them across all of their manufacturing areas, a result of the widespread use of MEMS in the past decade and their ease of coupling with industrial systems. From 2018 until 2019, the investigation was underway.

INTRODUCTION

The utilization of microlevel electromechanical systems in conjunction with industrial processes to regulate highly powered industrial gear and equipment has brought about a technological revolution in the aerospace sector. The assessed industry's autopilot relies on these microsystems, which installed and glued electronic components into electronic boards. In addition to these features, MEMS can validate reference values and compare them to actual data to ensure that manufactured products are running efficiently. It can also elaborate on shutdown activities to halt equipment and industrial machinery when necessary to verify any situation beyond the functional characteristics of the manufactured articles. Similarly, MEMS can keep an eye on production by performing the igniting function. In Figure 1A, we can see a microconnection, and in Figure 1B, we can see multiple electronic micro-racks that house MEMS. Figure 1 is a 10 micron view of the microconnection and electronic microdrives of a MEMS utilized in an aerospace industry production line.

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Figure 1A shows two sections of the electrical connection that are in good shape, suggesting that the micro system is functioning at its best. Figure 1B shows multiple electronic boards, divided into sections by squares, with the connection point for two MEMS in the middle of each box. In order to swiftly make any necessary adjustments to the micro-connections of the MEMS or the microtableros, as well as to get a good understanding of the microsystems' operability and productivity, this microanalysis was created. It should be mentioned that a business specializing in electronic microcircuits for specialized microscopes3 invented the tuning procedure involving microsystems.

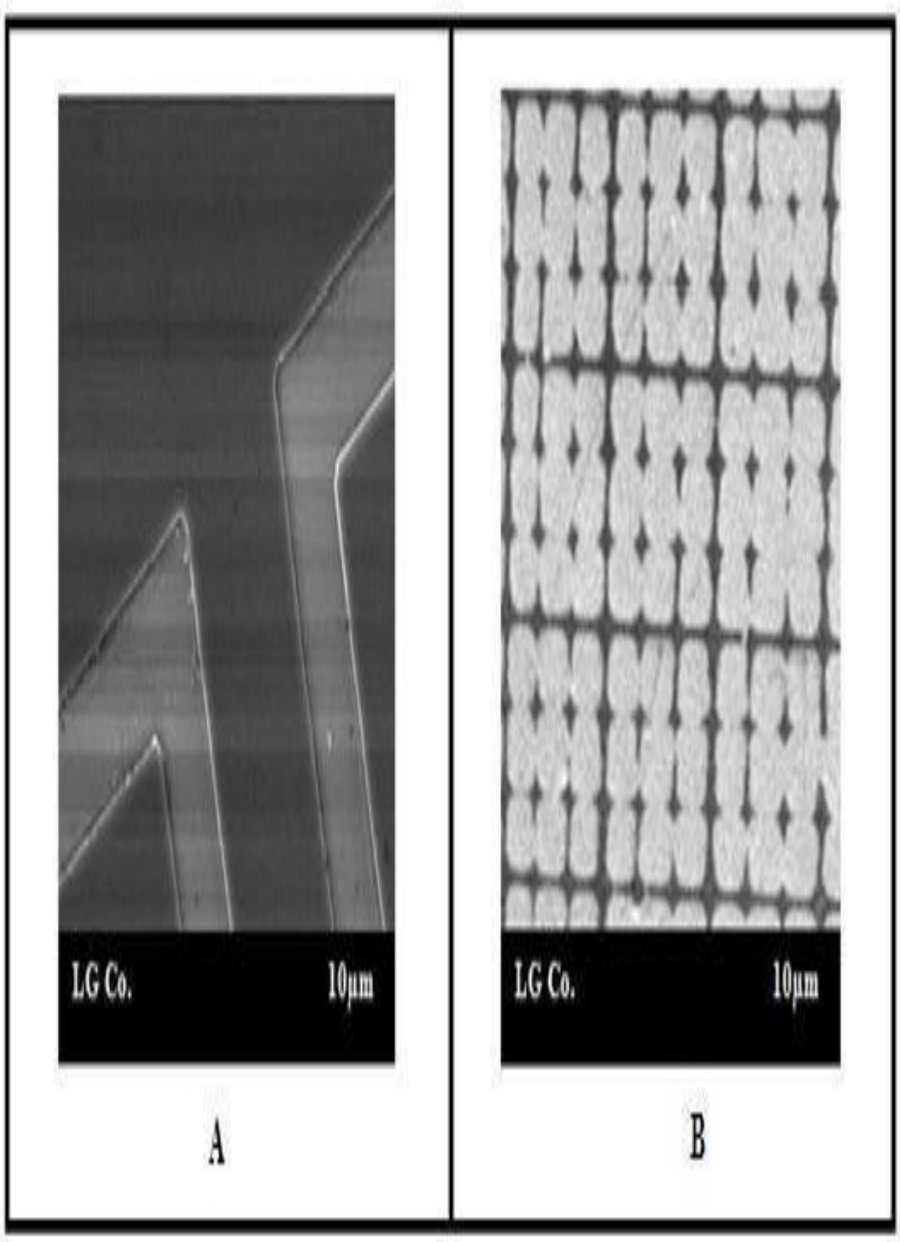

Fig. 1. Microscopic view of MEMS: (A) Microconexions and (B) Electronic microboards to MEMS (10X)

Importance of using MEMS

Every day, industries strive to improve the efficiency of manufactured products and industrial processes. Having these micro systems in small spaces and reducing the sizes of equipment and machinery4 have made MEMS technology a hot topic since the beginning of the 21st century, optimizing activities in the manufacturing areas. There are a lot of different systems that make use of MEMS, and the aircraft industry is no exception. Research in the aerospace sector examined the potential of micro systems for enhancing the usability of industrial machinery and equipment and for conducting rapid and accurate assessments of the primary functional attributes of manufactured goods using optical, electrical, and electromechanical sensors as well as electronic transmission-reception sensors. Because it enhances the manufacturer-consumer connection, which guarantees the trustworthiness of produced goods and generates benefits for both parties, the study's findings are pertinent to modern society. Electromechanical microsystems: where they came from

The primary goal of micro, small, and medium-Due to the constrained area, the electronic microcomponents' microconnections were extremely near and connected during manufacturing, which initially made connecting them a challenge due to the risk of short circuits and interference when functioning. Efficient operation of MEMS

The development of these microsystems has truly transformed electronics technology. However, there are still some limitations when it comes to their practical application. One of these is the apparent lack of understanding and enthusiasm among management and supervisory personnel in different types of industries. Another issue is the high cost associated with requesting MEMS with specific specifications8 due to a lack of manufacturing and testing capabilities. Manufacturing facilities and specialized personnel for test preparation and support when used in industrial processes are available to certain industries around the world. These innovative companies have experienced rapid growth in a

scale manufacturing (MEMS) was to develop technologies that could miniaturize both simple and complex industrial systems, allowing them to function in smaller spaces and hence reducing operating costs. This would allow industries to avoid having to build or rent large buildings, which would have been costly. MEMS are microelectronic devices that incorporate several functions. Originally coined in the US around the turn of the millennium, the term micro technical systems (MST) in Europe has since grown in use to describe what is now commonly recognized as micro electromechanical systems (MEMS) around the globe. According to the experts in this field, MEMS originated in the development of semiconductors, which were built upon the 1947 invention of the transistor by scientists Shockley, Bardeen, and Brattain at Bell laboratories. This sped up technological growth in the 21st century7, particularly in the field of electronics, by allowing for the creation of gadgets with more capacity, speed, and operational functionality, while also being smaller and cheaper.

short period of time thanks to the use of MEMS as control microdevices 9. The first microsensors were built with electromechanical microsystems, which led to the groundbreaking discovery of piezoelectricity activity. This activity was derived from the combination of silicon and germanium in pressure sensors, which were novel at the time of their manufacture and now serve a wide range of purposes in industries and other fields. The researchers behind MEMS initially experimented with silicon, but soon expanded their focus to include other materials with potential uses in aerospace, agriculture, food and beverage, automotive, biomedical, ceramics, metalworking, and other industries.

Evolution of MEMS

The development of additional microdevices, such as solid-state microtransducers and micro-actuators, for strategic purposes in different industries12, was expedited after the creation of MEMS in the early 1950s, with experiments conducted primarily with silicon material, the

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invention of the piezoresistive micro sensor in 1953, and the introduction of semiconductor strain gauges in 1957. The pressure sensor, which is still in widespread use today, was manufactured in the 1960s after the operation of the piezoresistive sensor was understood. Following this, microtransducers were manufactured in the 1970s, micro-actuators in the 1980s, micro-mechanisms and micromotors from 1987 to 1989, and microsystems have been created ever since, culminating in the development of MEMS and the manufacture of micro-robot micromachines13,14. After three conferences in 1987—one in Hyannis, Massachusetts, another in Princeton, New Jersey—academics and experts on the topic dubbed it MEMS because they were pioneers in this type of technology; all technology developed after 1970 was based on microtransducers and micro-actuators. Presently, MEMS are utilized as an interdisciplinary component of information in many scientific and engineering domains to address challenging problems, mainly associated with control engineering15.

Production Characteristics

The three critical steps in manufacturing MEMS, each of which is presented in detail right away, are essential for ensuring that the final product is fully functional.

1) Downsizing. The objective is to fabricate tiny devices with incredibly rapid response times.

b) Multiplication. In a short amount of time, it produces highly efficient operations that can make a big quantity of items.

c) Optoelectronics. The key is to link specialized electrical parts in the best possible way so that manufacturing processes run smoothly.

Being of tremendous relevance in the manufacturing regions of the aerospace industry, these features define the way the MEMS are operated based on the essential needs. An essential consideration is that, owing to their operational requirements, not all electronic components, even when reduced in size, can be connected. System controls

Things like these can be found in factories and are used to control various processes. Its many parts work together to carry out specific tasks in manufacturing processes, ultimately leading to the end goal. There are three types: open, isolated, and closed, all of which include feedback. By collecting numerical data of the assessed variables and producing the required control using a comparison process of standardized values, the control systems function according to specific regulations. For the most efficient operation of machinery and equipment in industrial settings, these systems regulate actuators, creating activation and deactivation functions at predetermined intervals. Electronic device control systems can range from very simple to very complicated, depending on the desired manipulation. These systems are created and built using basic components like coils, capacitors, relays, resistors, and low-power transistors, and are evaluated based on their functionality that regulate powerful actuators that cause the examined assembly line's high-effort tasks to occur. The manufacturing areas receive significant support from this activity, which results in 1.8 Advancements in MEMS

In the past decade, MEMS have emerged as the most important devices, and as a result, numerous sectors have begun incorporating them into their processes. Also, schools have started to cover electromechanical microsystems as a way to get students ready to do experiments that will be useful in many other branches of engineering. This is done to ensure that features or actions that equipment cannot regulate are constantly inspected.numbers

A. Procedures

To better manage particular processes in the manufacturing regions, an investigation was conducted in the aerospace sector in Mexicali with four steps. Here are the steps that were developed: First, in the aerospace industry's automated and manual insertion area in Mexicali, where the autopilot systems of commercial aircraft rely on electronic micro-drums, there is a correlation study of operational efficacy and operability involving workers, e yielding of industrial equipment and machinery, and line 1.

Phase 2: To compare the circumstances before and after the implementation of MEMS, a correlation study was conducted to determine the relationship

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between productivity and quality.Step 3: A mathematical simulation was conducted using MatLab's Simulink to design MEMS. These devices will be used to control the operation of an industrial machine that installs and assembles electronic microcomponents on a surface. The goal is to decrease energy consumption and production expenses by controlling the activation and deactivation times of these components. Step 4: Two MEMS were manufactured once the optimal operating of the MEMS from Step 3 had been established. These were intended for a functional characteristics evaluation team that would compare the autopilot devices' current and voltage values to reference standards. Since MEMS has substantially contributed to raising production, quality, and productivity indices, incorporating them into industrial processes across all industries is crucial. This is used as a basis for statistical evaluations using the MatLab software18.

Once the electromechanical microsystems began to be used, both the industrial equipment and machinery and the workersincreased the operating levels, and with this the productivity indices that kept the management and supervisory personnelconcerned.

Correlation of operability and operational efficiency

An appropriate indication reflecting the manner in which the operations in the examined aerospace industry were carried out is the operability of the industrial equipment and machinery, as well as the workers' abilities. Unfinished goods would end up in certain parts of the manufacturing regions, leading to incomplete inventories and extra storage expenses, because there wasn't comprehensive control over all stages of the industrial processes before the use of electromechanical microsystems. An integral part of accomplishing the planned objectives throughout different time intervals—hourly, daily, weekly, monthly, seasonally, and annually—is the working efficiency of industrial equipment and machinery, as shown in Figures 2 and 3. In figure 2, which is from June 2018, we can see the number of workers needed to prepare manual operations for MEMS. There were 90 people in line 1, which was evaluated in this investigation. However, a lot of that staff didn't actually do anything because, according to management and supervision, they were there as backup in case some workers were too tired, sick, or otherwise unable to do their jobs well. Overall, there were ten pieces of machinery and equipment, and operational efficiency indices reached 60%, suggesting that the workers and industrial machinery on line 1 were not put to good use, leading to suboptimal productivity indices.

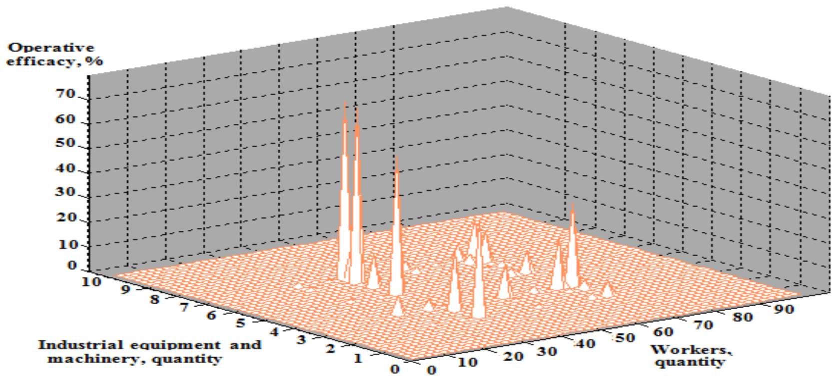

Fig. 2. Correlation of indices of operational efficiency and operational performance of industrial equipment and machinery and workers (June 2018)

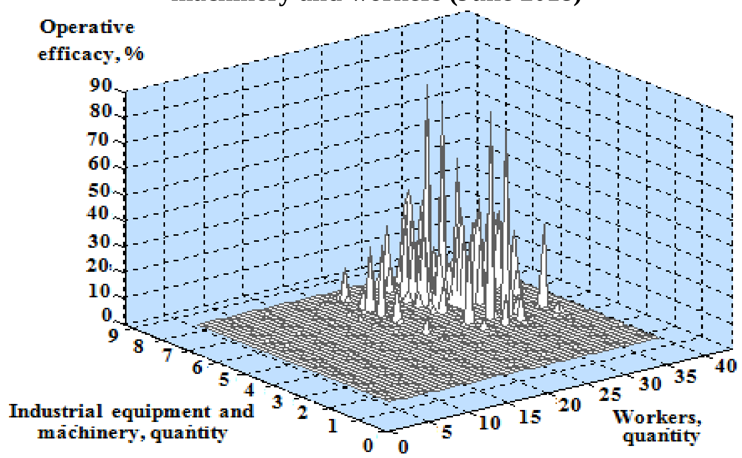

Figure 3 shows that the evaluation of the examined production area was done in June 2019, and that the decision to use electromechanical microsystems to increase productivity levels was made based on that. June was the month in which the assessments were conducted. When this aerospace sector's operational performance peaked, it was due to the combined efforts of its employees and state-of-the-art machinery. The chart clearly illustrates that the workforce was reduced to 40 people, which allowed for the relocation of the remaining 90s and resulted in cost reductions in production. This took place. The development of MEMS-based industrial operations control procedures led to a decrease in human labor and an increase in automated processes. In order to begin operations of a new product, the relocated workers had to establish functions in a new production line. This increased the evaluated industry's competitiveness. We cut down on equipment and machinery from ten to nine, which resulted in an eighty percent improvement in operational efficiency and atwenty percent decrease in power use. Correlation between quality and productivity In June 2018, output levels were close to 6,000 goods, and quality indices were close to 50%. Figures 4 and 5 show the productivity indices, which can reach up to around 75%. This is becauseoutput levels dropped due to the high number of mistakes made by hand during a variety of tasks. This necessitated a probe backed by professional investigators since there was a lack of optimalcontrol at each stage, which affected management and supervisory personnel.

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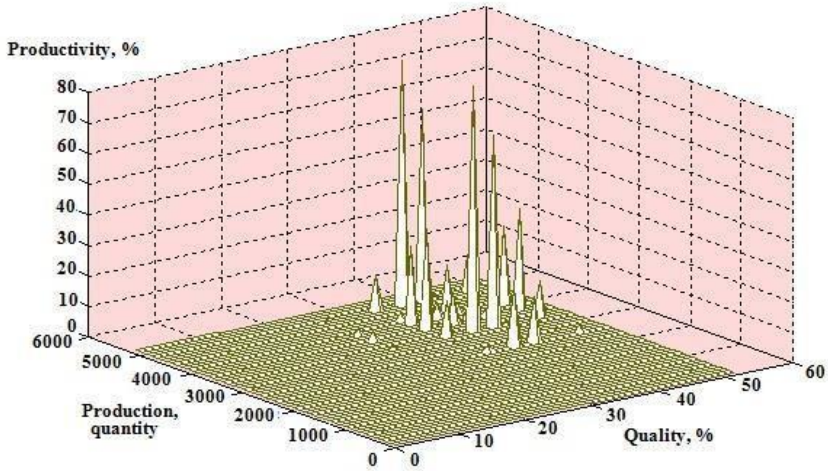

Fig. 4. Correlation of productivity and quality levels (June 2018).

In a large majority of industries of any type, managers and supervisors of industrial processes at each stage of manufacturing areas focus on the main production activities,and the concentration is so high that they do not generate improvements and continue to eject operations as a customary process, even observing that there were human and industrial equipment and machinery errors. In addition, they learned that unfinished products were stored due to the generation of errors, causing extra production costs. Figure 5 illustrates productivity levels close to 80%, increasing this factor by 5%, in addition to quantities of manufactured products close to 9000 and with quality indices of 85%.

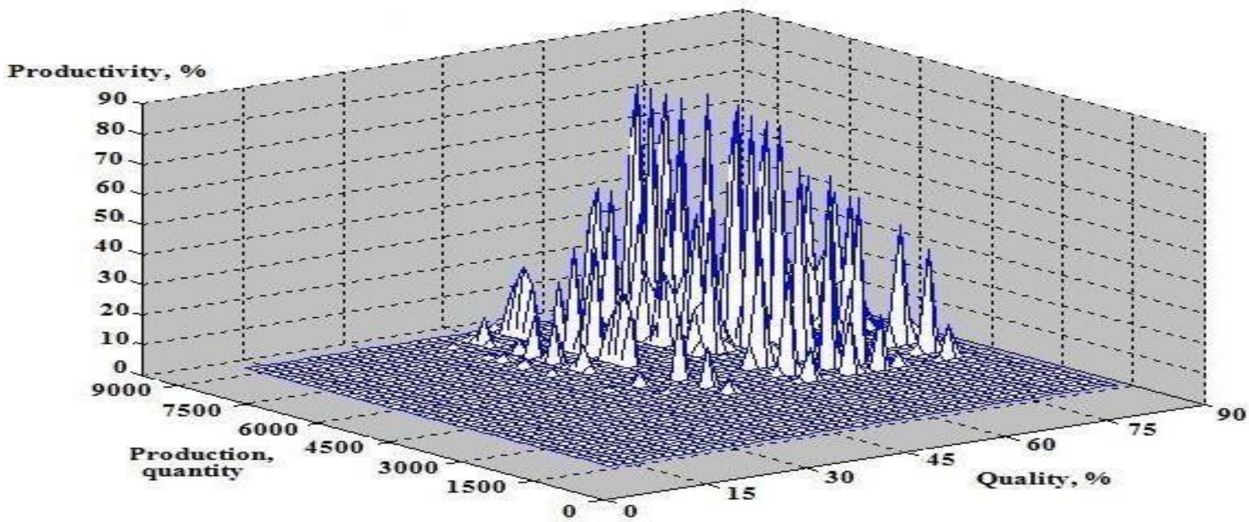

Fig. 5. Correlation of productivity and quality levels (June 2019).

Microanalysis of MEMS connections

One of the important aspects to achieve the optimal functionality of the MEMS was the microclimate control, with which these microsystems that developed the functions of control of industrial operations could be kept operating in good condition. In figure 6, a micro-micron analysis is shown, where small dust spots are observed, without being relevant to the functionality of MEMS. By other way, was necessary have micro-connections asclean as possible due in particular to the industry under review, free from agents that disrupt its operation. In addition to controlling the temperature and relative humidity, I use sophisticated filters to prevent the presence of contaminating agents, dust, and microbes. In an ideal world, MEMS would last for five years without failing, according to the lifetime estimate. This microanalysis was carried out over the course of a year.

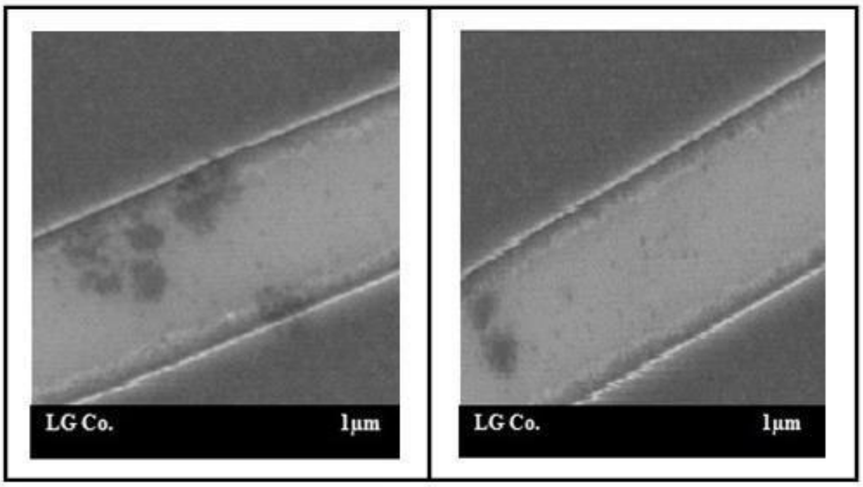

Fig. 6. MEMS microconnections dirty by dust from the interior of the evaluated industry

The final thoughts
Manufacturers and their employees alike have high hopes for the future of industrial technology and innovation because to the widespread adoption of MEMS, which promises to boost operational efficiency, quality, and productivity. The development of electronic microsystems regulated by MEMS for use in commercial aircraft automatic piloting has been one example of how these microsystems have helped solve problems in a variety of contexts, ultimately leading to better living conditions for populations and increased safety. Also, electromechanical microsystems that are either eaten to alleviate health symptoms or implanted into the body have helped save lives in the medical field. Opportunities in businesses have expanded because to MEMS technology, which provides a fresh viewpoint on old problems while also making things safer, more efficient, and cheaper. It has also led to the reduction of physical space requirements and the creation of novel industrial processes and products. The study's important findings—an increase in productivity, quality, operability, and safety indices in the industrial processes examined—mean that the aerospace industry in Mexicali should implement the same methodology company-wide.

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