Chapter 16
Adaptability of the Lean-Sigma Methodology for Operations in a Multicultural Workplace

Noé Gaudencio Alba-Baena and Aldo Salcido-Delgado

Abstract Overseas operations, as beneficial as there are, present challenges such as the adoption of the organizational culture, working methodologies, and practices. Different strategies have been exercised to successfully reach the expected benefits of these operations and take advantage of the local resources. Managers have faced local resistance and miscommunication barriers, moreover, the cultural differences have impacted the operations reducing in general, the efficiency of these operations. The need for integration in the cultural component has been addressed by different researchers; however, there is limited information on methodologies used for such integration. The present work proposes a methodology for the integration of the national cultural characteristics for creating a local workplace culture. The described methodology is accompanied by an example of implementation in a multicultural scenario. The case study shows successful implementation of the Lean-Sigma methodology in response to a problematic situation in the operation site of Juarez (Mexico). A study of the local culture helps in the selection of the tools used during this implementation and to exceed the customer expectative and compete for larger projects with this and other customers.

Keywords Lean-Sigma · Workplace culture · Overseas operations

16.1 Introduction

In searching to maintain a competitive business in the growing globalized market through growth in a globalized market, companies find several benefits in expanding to international customers and outsourcing parts or their complete production systems.

Such strategies include partnerships, the merging with other players, or the acquisition of companies in different regions around the world. The potential for increasing

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the assets because of these movements have been limited in part due to communication issues and cultural differences between the different actors. The benefits, economic value, and competitive advantages expected from these movements have overseen the challenges occurring due to the cultural aspects given in each region. Experience has shown that it is common to find resistance and confrontation in adapting policies and working methods when local employees and foreign management test them during the day-to-day operations. Managers in charge of foreign origin face administrative challenges, especially for those managers who are not familiar with local culture and common customs (Omar and Urteaga 2010).

In their report, Berson et al. (2005) argue that organizational culture is one of the fundamental characteristics of strong organizations and that organizations can be influenced by the values of their leaders permeated through the organizational practices. In consequence, long-lasting companies develop their own cultures and tend to hire and attract employees with similar culture and behavior characteristics, including their moral values (Johns 2006). Moreover, in developing a culture, the organizations have included systemic influences from their immediate environment (Findler et al. 2007). At the time of taking the organizational culture to overseas operations, their practices, and cultural values can influence the national or regional culture in the recipient environment. House et al. 2004 remarks that if the organizational culture is strong, their values permeate and transfer from the organization to the overseas culture. However, Berson et al. (2005) and De Hilal (2006), observed that in overseas operations the interaction will be as reactive as the differences in values are with the overseas values and the resistance will count for each to the challenged cultural points. At the same time, Inglehart (2004) considers that the work culture of an organization can be influenced by the values, sociopolitical environment, and geographical location of the region where it is located in foreign operations.

The organization itself can absorb characteristic features of external environments such as the culture of the workers. Generally, this phenomenon is given by the contribution of the adopted values towards efficiency, value-added, and guided by the increase of operational profits. This adoption not only reflects flexibility and value of the elements in a business, moreover, this phenomenon also influences the response of employees to management strategies adaptation regardless of whether they come from abroad or are local practices.

The success in taking overseas advantages has been studied for the last decades with contrasting results. Aycan et al. (2000) reported the variations in the distance to power after the implementation of different strategies used by human resources managers (ARH) in ten countries. The authors conclude that a common resistance and reactivity of the employees toward the power (directives) is resultant of the lack of enrichment or empowerment toward downstream the organization. For a specific case, Kim et al. (2004) show how the organizational culture had impacted the overall performance at several operations in Singapore. Concluding that there is a strong correlation between the cultural values with the performance metrics affecting the outcomes, productivity counts for the manufacturing, annual premiums growth, and the sum insured by insurance companies. Moreover, the influence of cultural values affects directly personnel retention, as shown by Kerr and Slocum (2005).

To weight this effect, the authors compared an organizational culture and their values with its national staff (both from the USA), measuring the assimilation of the organization values, how the culture influences the "loyalty" of the staff and how impacts the employee turnover cycle. When moving operations abroad, the challenges are more complex than the mere adaptability of the organizational goals and values. The challenges include the cultural strives but also the methodological contrasts, the analysis, and understanding of the context will help in the decision criteria used for defining the methods and management tools used for running overseas operations (Williams et al. 1984).

A successful cultural exchange depends also on the staff's fast integration into the organizational culture and the synergy between the local culture and the organizational values. To have more possibilities in succeeding, managers can influence the staff selection and search for the more suitable to the organizational culture and values. Managers need to have a clear understanding of the local culture and be able to make this link (Naor et al. 2014). The efficiency of this understanding is reflected directly in the enthusiasm, commitment, and loyalty of employees (Marc and Farbrother 2003). Then, the clear measurement of the local culture and the later comparison to the organizational culture will provide the tools for maximizing the human factors in operations abroad. Other factors must be considered if an organization is looking for keeping its operations competitive in the XXI century. Productivity, quality, costs, and deliverability among others are critical factors to address in their strategic considerations. For facing these challenges, managers have several world-class manufacturing strategies (WCMS), such as Lean Manufacturing, Six-Sigma, Lean- Sigma, and other more specialized approaches. Modern competitive challenges require organizations to have lean, efficient, cost-effective, and flexible manufacturing practices. However, in general, the implementation of these methodologies has been reported low rates of success (See Fig. 16.1).

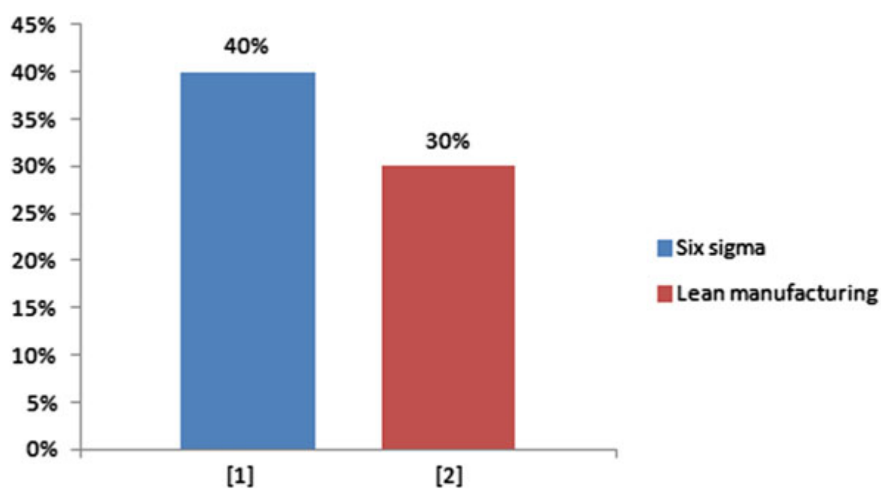

Fig. 16.1 Failure rates after implementing WCMS [1] Six-Sigma and [2] Lean Manufacturing (Roser, 2017)

The success rates have been reported in unexpected levels of 40% for Six-Sigma projects and 30% for Lean Manufacturing projects (Where Lean Went Wrong—A Historical Perspective 2017). One of the main reasons can be attributed to the influence of the cultural factors mentioned above. Under the described conditions, different studies and strategies have been tested for increasing the world-class methodologies' success rates; Estrada-Orantes et al. (2019) proposed the use of the E-strategy as guidance for solving problems in organizations using a Lean-Sigma approach in overseas operations.

This approach defines a series of steps interactive for validating the decisions, increasing with different tools communication (in Horizontal Organizations), and reducing the impact of avoidances of the local staff answering to the management requirements in vertical organizations. The success in the adoption of these WCMS and methodologies is also critical from the customer side, as the implementation of world-class strategies, influences the perception and confidence of the intermediate and final customers. In the same approach, this strategy can help to keep a market advantage, besides the detailed management, planning, budgeting, training, and efficiency, it is necessary to respond to the customer needs and expectations. A case shown by Salcido-Delgado et. al (2019), presents a process behaving as expected but with the need to respond to a market competitive requirement and a customer expectative. behavioral challenges in organizations, keep hidden from most managers' scope, and are valued in large by experienced managers. For managers abroad, this behavioral component is a dark region that delays the expected results.

To increase the possibility for implementation of WCMS with success rates in overseas operations then, it is necessary to consider and measure the cultural factors of the region/nation. The cultural analysis can be key guidance for determining the chosen organizational structure at the given site, in the implementation of a world-class methodology for the selection of tools and activities or used for the selection between a horizontal and vertical local organization, will also help in meeting the expectations from the staff and workers at the site and the original organization. Helping also in determining the tool kit with the integration or distancing expected culturally, for example, a consensus tool is more efficient in a horizontal structure and a directive instruction more efficiently in a vertical organization. For measuring the cultural aspects, Hofstede (1980) proposed a method for measuring it for different nations divided as follows: distance to power, resistance to uncertainty, femininity, masculinity, individualism, and collectivism. The data coming from this study has been the guide for many studies addressing and comparing the cultural aspects of organizational integration. However, the social integration and globalization from the last decades have impacted people in different ways and some regions have developed unique multicultural regional cultures, like the one at the border region between Mexico and the USA. Alba-Baena et al (2019) described this region as highly competitive, with investments from North American countries (the USA and Canada), from Europe (France, Italy, and others) and Asia (Japan, South Korea, and others); divided into more than 3,700 factories, with more than 1,300,000 workers. After six decades of interaction, this border region has developed a unique culture and social behavior, which is different from the Mexican and USA working and social cultures. This scenario is suitable for testing a methodology for integrating the cultural aspects of projects based on world-class methodologies.

This chapter includes a methodology for integrating the cultural aspects to the tool selection during the adaption of a world-class methodology such as Lean-Sigma in a factory located in Juarez, Mexico, a city with more than 320 factories employing more than 275,00 workers. The steps include the measure of the cultural aspects of the site for implementation (following the Hofstede (1980) survey or the later version for example), the analysis of the adaptability of the organizational values to the local values, the selection among the possible tools to be adapted to the given scenario, and finally the measurement of the level of success in the adaptation of the tools and the adoption of the methodology by measuring the changes in the process outcomes. The following sections present the regional culture analysis, the list of tools integrated for solving the case, and presents the steps followed for implementing the Lean-Sigma methodology and solving a specific problem in this facility. For reference, this facility has management of French origin and vertical organization is observed as an operative structure. The problem to solve is a cosmetic defect in the stamp-printing process.

16.2 Project Preparation

Firstly, the work-culture analysis is based on the survey proposed by Wu et al. (2001) which considers the six dimensions of culture proposed by Hofstede (1980). The questionnaire was translated to Spanish and the 24 questions were divided into groups of four questions for evaluating the proposed dimensions. After gathering the data, coded results are compared to the scores obtained by Hofstede for the USA, Mexico, Italy, and France (management origin) for the surveyed groups. Surveys in two manufacturing operations were gathered (see Table 16.1 for the data characteristics). The instrument representativity was validated using a random sample of 30 and evaluated using the Cronbach’s alpha coefficient to estimate the reliability of this instrument under the given conditions according to Tavakol and Dennick (2011). The Cronbach coefficient shows a result of 0.837 in case 1 (of French management) and 0.712 in the second case of Italian management indicating that the reliability of the applied questionnaires. Data resultant is then compared to the indicators proposed by Hofstede as seen in Fig. 16.2.

As expected for a multicultural site, the large scores in several dimensions are the product of the influence of the international cultural values merging in this region (see Fig. 16.2). As shown in Fig. 16.2a, top values are registered for the cases in

Table 16.1 Characteristic parameters of the personnel surveyed in two locations

	# of respondents	Average age (years)	% Female staff	% Male staff
Case 1	108	30	37	63
Case 2	140	31	44	56

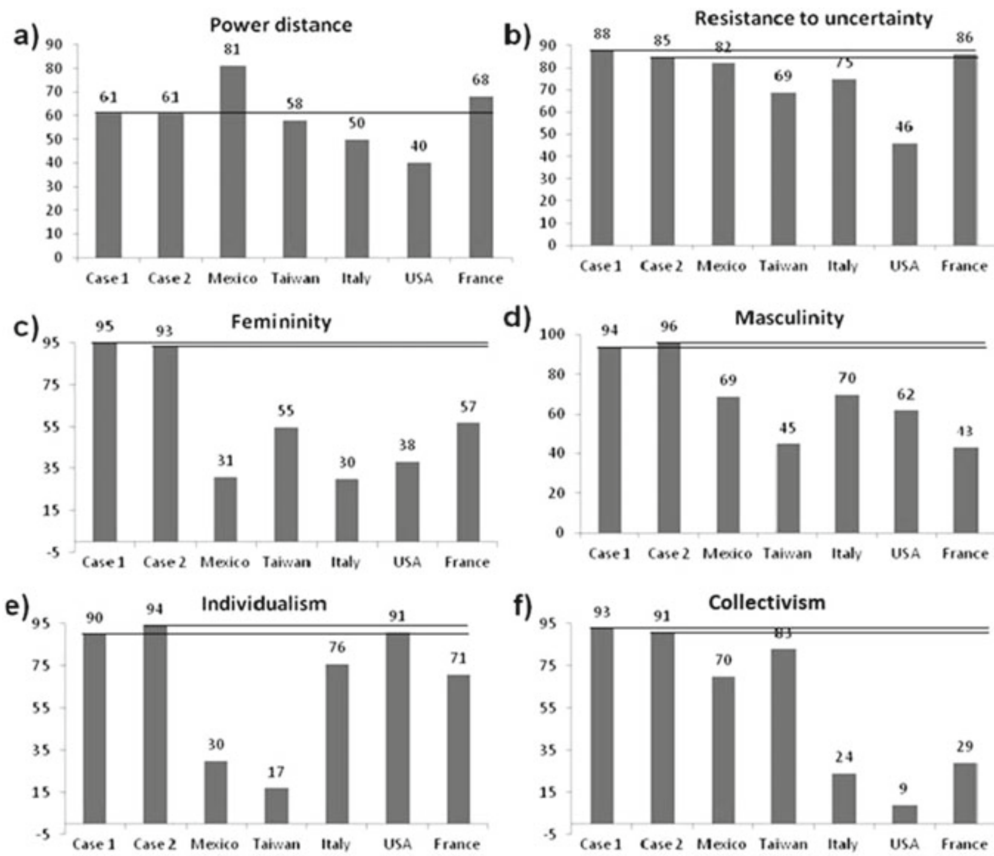

Fig. 16.2 Comparisons between the scores of Mexico, Italy, France, and the USA against the scores obtained in cases 1 and 2 for the dimensions **a** distance to power, **b** resistance to uncertainty, **c** femininity, **d** masculinity, **e** individualism, and **f** collectivism respectively

Juarez except for those values for the distance to power (or the extent to which the less powerful members of organizations and institutions accept unequally) in both cases of Juarez of 61. These scores compared to those for Mexico and France, are showing that the staff attitude is more equalitarian than those expected for the national character. Knowing this, managers will find more efficient the combination of quantitative and qualitative tools for communicating and make decisions in this environment. Two other values are also remarkable in Fig. 16.2e and f, is shown a combination of attitudes that promotes individualism and collectivism at the same time. Such a combination of scores is reflected in the worker's decision to satisfying his personal needs (individualism) and keep efforts towards the higher benefit (collectivism). Using this information, managers will know that the decisions on economic goals or to design strategies must show benefits to both the workers and the organization.

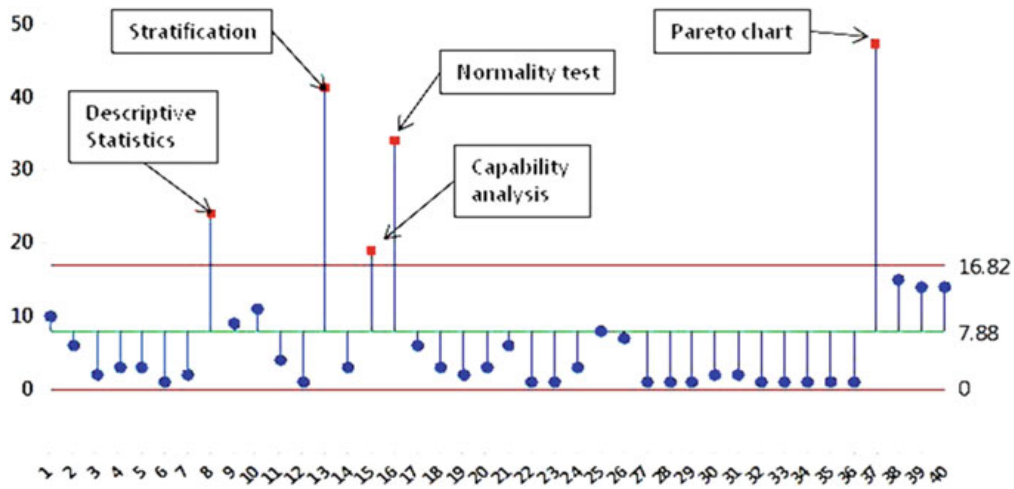

Fig. 16.3 Graph comparing means of data values from the tools used in the analyzed projects

16.2.1 Set of Tools for the Case Study

Considering that the use of a given tool reflects a cultural comfort, then, it is possible to measure and compare the use of a tool over others and determine the tendency to use a specific type of tool. In this case, reports in a repository at the autonomous university of Ciudad Juárez is used to identify industrial projects implementing world-class methodologies in their solutions.

A meta-analysis is used for filtering the projects following the four-phase information flow in the PRISMA statement (Moher et al. 2009). The filtered projects are used for identifying the tools used, data then is quantified and coded. With the list of tools a statistical evaluation is carried out using a Means Analysis, the results of this analysis are shown in Fig. 16.3. 40 of the top used tools are shown. From these five are the relevant: descriptive statistics, stratification, normality test, capability tests, and the Pareto charts. These results show that for the Juarez case, the preferred tools are related to statistics and quantitative values, an approach, favoring the distance to the power and decisions that require less communication among ranks, which is expected in the Mexican work culture.

16.2.2 Adapting a Methodology

The described list of tools can be organized in the scope of a WCSM, Six-Sigma for example. In Mexico, The National Council for Standardization and Certification of Working Competencies (CONOCER, www.conocer.gob.mx), certifies the expertise and use of Six-Sigma as a problem-solving methodology with the norm EC0264 (problem-solving through the Six-Sigma methodology level I). In the same context, the same council certifies the expertise in the use of the methodology. WoW-Vation

Table 16.2 List of tools suggested for use in each stage for solving problems (EC0264)

Stages Norm 0264	DMAIC available tools
D	Stratification, Pareto, quality function deployment (QFD)
M	Descriptive statistics, repeatability, and reproducibility studies (R & R), Pareto, stratification, point chart, bar chart, pie chart, data collection sheet
A	Brainstorm, stratification, 5 whys, Ishikawa diagram, descriptive statistics, histogram, normality test
I	Experiment design, main effects chart, Pareto, stratification, XR chart, XS chart, I-MR chart, Z-MR chart, means analysis, point chart, box chart, proportion chart, P chart, NP chart, a graph of points, bar graph, pie graph, two-sample t, one-sample t
C	Failure mode analysis (FMA), control plan, visual instructions

for solving problems with inventive (EC1074), the use of a method of root-cause for incidents analysis (EC0479). The use of the 5s methodology for continuous improvement is certified under the (EC0491 norm). The case of the EC0264 certification is based on the DMAIC methodology (see Table 16.2) which includes tools shown in Fig. 16.3, which are the base for the adaption of Lean-Sigma.

16.3 Integration into a Lean-Sigma Project

The resultant cultural scores for Juarez, Mexico, and the organizational culture from the company are now matched for selecting the tools for the implementation of Lean-Sigma. For the adoption of a Lean-Sigma methodology, the tools are now matched in the steps of the Lean-Sigma: (a) Identify and measure the problem, (b) conduct a root cause analysis, (c) develop a solution, (d) verify the solution, and have (e) a control plan, as described by Estrada-Orantes et al. (2014). However, the tools' selection requires a larger definition of the activities, then, the steps are divided into 21 activities as is shown in Fig. 16.4. Then, the tools are selected by the combination of local and organizational cultures under the activity requirement. The main goal of integrating the cultural data (in Fig. 16.2) into the selection process is to increase the potential for implementation success. Is expected to increase efficiency as the team members are "playing comfortably in common grounds." In this case study, the distance to power plays a distinctive role in the tools' selection, for example, the tools that promote the numeric evaluations and decisions, such as the Pareto charts, will be preferred over more interactive tools such as the Delphi method.

Following the sequence presented in Fig. 16.4, Table 16.3 shows in part the tools selected during this integration. In these tables, the column "Step" (of the implemented methodology) is related to one step from the methodology to adapt, the "Tool" column shows the selected tools, which are based on the described criteria, this according to the cultures' comparison, finally, the column "Workplace culture adaptation" gives a brief description of the reasons to select a specific tool at that stage were selected at a given stage.

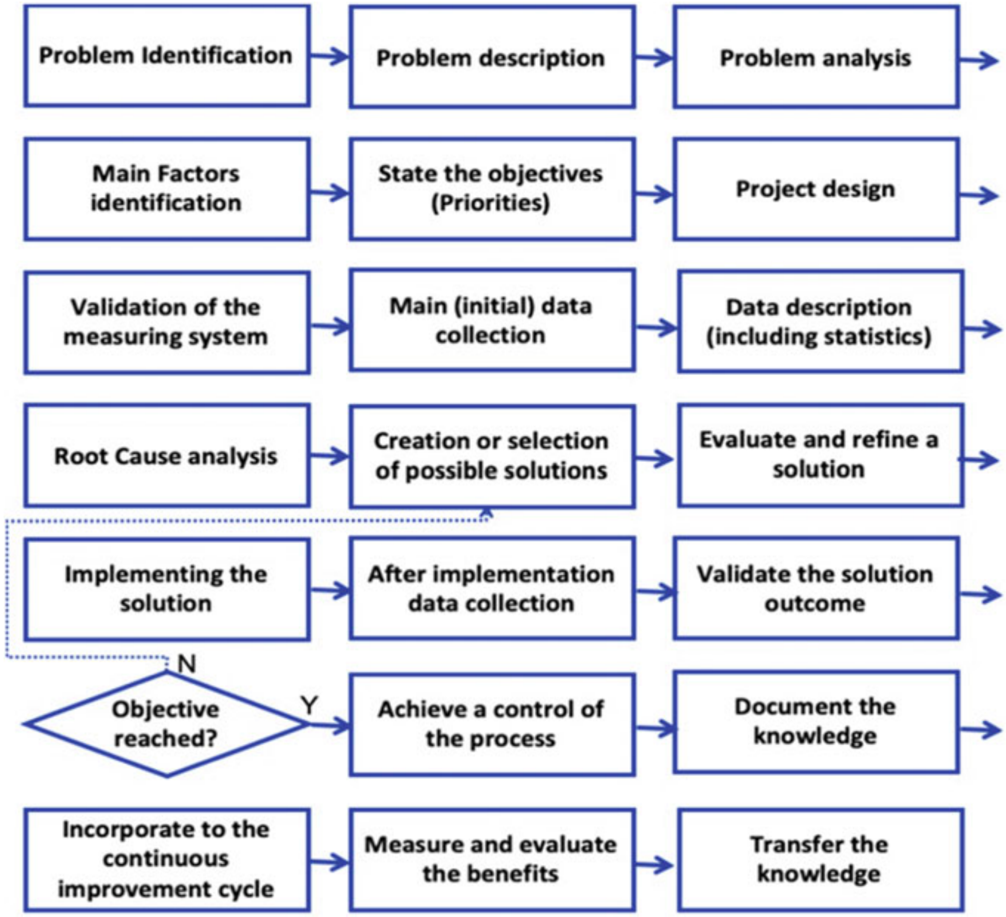

Fig. 16.4 Twenty-one activities chosen for adapting Lean-Sigma tools to the workplace culture (Alba-Baena unpublished data 2020)

Table 16.3 and its continuations highlight different reasons for using some tools, giving the reader an idea of the selection process. For example, a Pareto chart can be used in the different steps of the adaptation process, however, the use of this tool in the present case helps in giving a visual and a numerical comparison instead of promoting interaction, a Pareto chart is an efficient tool when the team has a vertical structure and members of different ranks may conflict in a decision talking process (for example in the first row in Table 16.3). By using this tool, the discussion is mainly focused on the quantitative values and their effects on the outcomes. The same occurs when the implementation includes a root cause analysis in a step (row 8 in Table 16.3). These tools help in reducing the subjectivity of the decisions and qualitative evaluation. The brainstorming tool is used in the "Develop a solution" step (row 7 in Table 16.3). Finally, other statistical tools are used under the same logic for integrating the Lean-Sigma methodology and its adaptation to this cultural environment.

Table 16.3 Relationship between problem-solving tools and dimensions of work-culture

Step	Tool	Workplace culture adaptation
Identify and measure the problem	Pareto chart	In this step, the Pareto chart helps in visualizing the information concisely, allowing a short time for interaction between the workers at different levels. Avoiding discussions-interactions between participants involved in a project. This complies with the marks gathered during the "distance to power" dimension values
	Stratification technique	The use of the stratification technique helps in categorizing a series of data, these of objective, or subjective values, and separates them to identify patterns. This tool requires a level of socialization among the participating individuals involved in the project and can be linked to the measured "collectivism dimension" level
Conduct a root cause analysis	Pareto chart	A Pareto chart in this step can be used for comparing the effect of each of the primary causes in the outcome values and determine the expected impact of the activities proposed for solving the problem and as mentioned can be related to the "distance to power" dimension
	Stratification technique	Combined with the Pareto chart, the stratification technique helps in the evaluation of the causes including the quantitative and qualitative considerations for reaching a robust solution, while the team have limited interaction, making the decision process to be based on numeric considerations

(continued)

Table 16.3 (continued)

Step	Tool	Workplace culture adaptation
	Normality test	Normality tests and further descriptive statistics help in the characterization of the collected data in the measuring step. This is a critical evaluation that determines the statistical treatment of the initial and outcome values. The calculations and interpretation required training and the ability to describe the outcomes to the team. Then, this tool can be associated with the "resistance to uncertainty" dimension and even to the "distance to power" values obtained in this example
Develop a solution	Pareto chart	The Pareto chart allows, for example, to track the effects and impact of the changes occurring during the implementations. The concise presentation and monitoring help the team to keep the levels of "distance to power" as expected
	The brainstorming technique	The brainstorming technique promotes team interaction, ideas about a specific issue, or problem which are proposed. This technique is associated with the "collectivism" dimension (especially in the same level team) as it requires the open participation of the members involved in the project
	The Ishikawa diagram	The Ishikawa diagram visually assists the identification of the root cause by the interaction of the team. More efficient is as combined with the brainstorming technique. This combination is suitable to the high levels graded for the "Collectivism" dimension in this example

(continued)

Table 16.3 (continued)

Step	Tool	Workplace culture adaptation
	The 5 whys analysis	The 5 whys analysis tool is based on the integration of consecutive questions for the searching of the causes and effects of the different aspects in the process conditions. Here, the team must interact and, however, is more efficient in the same hierarchy rank members. Then, this tool can be linked to the "collectivism" dimension levels
Verify the solution	Pareto chart	The rearranged effects of the remaining causes can be visualized and compared (in this step) by using a Pareto chart
	Descriptive statistics	Descriptive statistics show the characteristics of the data obtained in a quantitative way and on this step can be used as the base for the statistical comparison and evaluation of the changes and effects of the project or implementations in the production process
	Validation using a two-sample test	As for the descriptive statistics, the statistical evaluation provided by this test is based on quantitative grounds. However, the interpretation of the results is of a qualitative understanding. These tools are more than useful for teams working within a vertical organization but value a collectivist approach, which is the case of the present study

16.3.1 Using the Adopted Methodology in the Case Study

After, in the case study, the decision is to use the adapted Lean-Sigma methodology tested previously as a reliable methodology for short-term projects and simple problems, but also a powerful methodology for long-term projects and/or complex problems.

Thanks to its adaptability, fast solving time, Lean-Sigma can include statistical analysis that provides long-term reliability of the solutions (Estrada-Orantes and Alba-Baena 2014). Each step of this methodology is flexible, and it is open to use the required the tool from the engineering, management, or statistical areas (Estrada-Orantes et al. 2019). The five basic steps of the Lean-Sigma methodology were originally proposed by George et al. (2005) and for this case, the tools for each step are selected following the criteria of the workplace culture for facilities located in Juarez, Mexico, similarly to the mentioned and partially described in Table 16.3). During the implementation the adaptation follows the five Lean-Sigma steps previously mentioned (see Estrada-Orantes et al. 2014) and enlisted with their goals:

- *Identify* and measure the problem. How big is it?
- *Root cause analysis*: What is the root cause of the problem?
- *Develop a solution*: Identify the alternative solution that best solves the problem
- *Verify the solution*: Make sure that the problem is eliminated by the proposed solution
- *Control Plan*: Make a quick and effective plan, so that the previous situation does not come back

16.3.2 Case Description

This project is implemented in a facility dedicated to the automotive industry. The focus is on a stamping process of a label that identifies rubber hoses (final product). A pad printing technology (tampography process as shown in Fig. 16.5) is used for transferring the designs as painted patterns to the product. The hoses must be stamped according to the customer specifications, tampography is a common method for printing images on non-planar or other non-flatten surfaces such as spherical, conical, cylindrical, and other curved objects and uses a deformable pad that receives images from a flat cliché plate and transfers the images to the curved surface which is to be printed as seen in Fig. 16.5. Typically, an inverted cup containing a quantity of printing ink is used to apply the ink to the plate. Also to apply a new coating of ink to the plate, and the ink cup and a plate are moved relative to each other following each ink transfer operation (Dietz et al. 2001). However, such a process has several disadvantages such as the use of lots of consumables, many maintenance time, several cleaning periods, and set up in between, due to changes in the ink viscosity. The stamping process starts when the operator takes a precut hose from a container serving as a supermarket using an average of 1 min/pc. The plate setup (of 3 min/lot) is finished by placing a plate engraved, the paint container is filled talking an average of 3 min/pc. The first imprinting is made on a hose, and the distance to

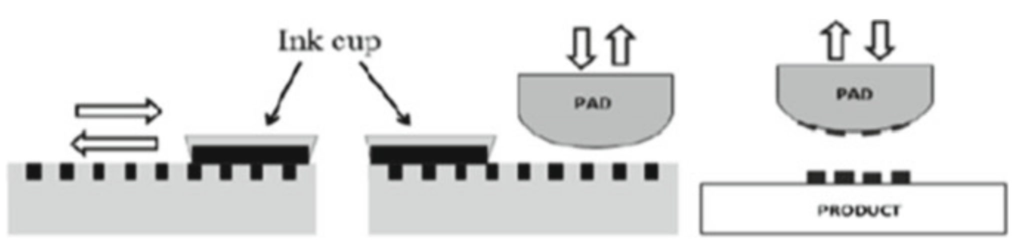

Fig. 16.5 Schematic of a tampography process

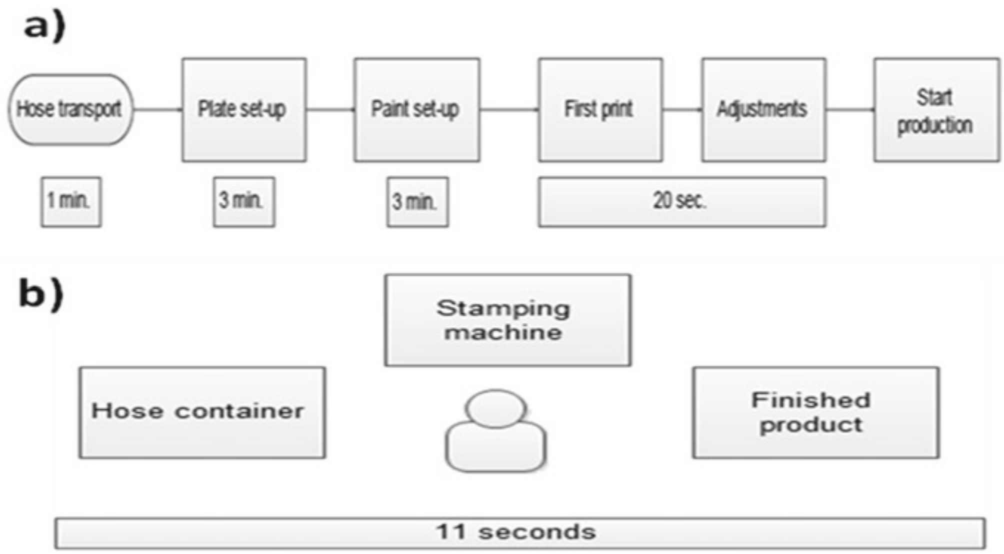

Fig. 16.6 **a** Initial setup of the tampography process, **b** Processing method used for stamping the product

the edge of the hose is measured, after making the proper adjustments (3 min/lot), the production time begins (see Fig. 16.6a). During the production process, the steps are as follow: the operator takes a hose and place this on a fixture with a specific orientation, then activates the stamping machine thru a pedal, after, removes the stamped hose and finally allocates the hose in a container. The layout and time for this process are shown in Fig. 16.6b showing a measured average of 11s/pc.

However, this time is not including the daily adjustments (55 times per shift) to keep the product under the specifications, causing the reduction of the productivity to an average rate of 75 pcs/hr. The customer has documented a complaint because of these productivity levels and delivery failures. At the same time, this customer is launching a new product, and biddings are called for the new project. At the moment, the facilities located in Juarez are the main vendor of this product, and the complaint risks not only the continuation of this business but the opportunity for growing sales to this customer. In consequence, regaining the confidence of the customer is critical not only for keeping the business with this customer but for competing with better chances in the new product bidding. The manager has assembled a multifunctional team for having an improvement and respond strongly to the customer's complaint, and prepare for the bidding process.

16.3.3 Implementation Plan

For using the adapted methodology, the description is divided into three sections: diagnosis, solution, and improvement. For using the Lean-Sigma approach in this case, the "develop a solution" step includes both, the solution and improvement sections of the project.

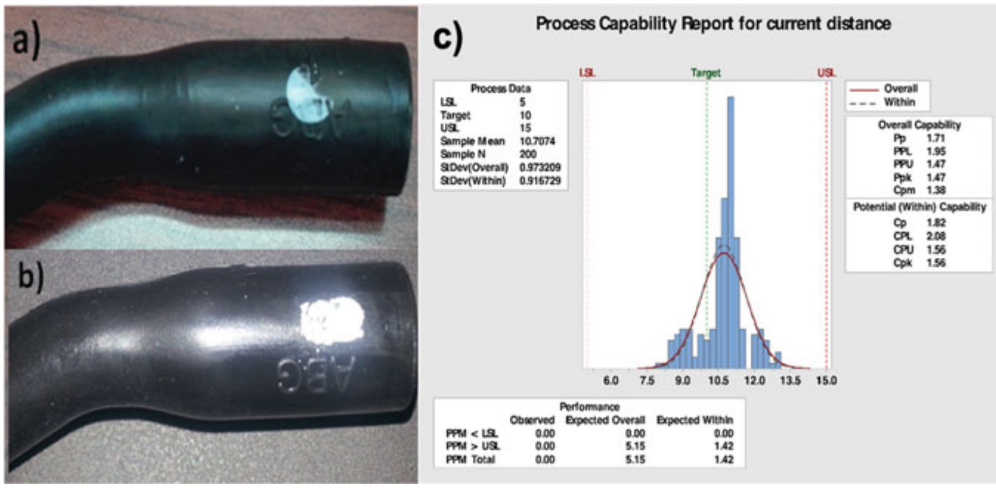

Fig. 16.7 Examples of cosmetic defects due to **a** lack of paint, and **b** excess of paint. **c** Cpk and data of the edge to the printed stamp

16.3.4 Identify and Measure the Problem Step

To identify the problem, the customer requirement (or complaint) is translated to a quantitative value. An initial diagnosis is used to identify the main variables (such as Productivity, Cost, and Quality), data then are arranged in tables and control charts for visualization and initial analysis. The statistical description of the obtained data then is used for making statistical comparisons to the product specifications or standardized values of the process which is used to determine the size of the problem.

In this case, the processing times are distributed as follow: 3% for the initial set-up, 75% in adjustments related to the operation, and 22% in production time, resulting in the mentioned average rate of 75 pcs/hr, which are below the required 400 pcs/hr. Also, quality defectives are about 4%, cosmetic defects are detected as the main causes as seen in the examples in Fig. 16.7a and b. From a quantitative point of view, the design specification requires a distance to the edge of the hose to be around 10 mm with a tolerance of 5 mm. To eliminate recurrent causes, initial actions include the implementation of programmed maintenance activities, after, statistical data is gathered and compared to the expected limits as seen in Fig. 16.7c), here is possible to see that the process Cpk is 1.56 (4 ppm), increasing the productivity to 78 pcs/hr and the cost to 5.33 IEU (internal economic units)/pc.

16.3.5 Root Cause Analysis Step

According to Estrada-Orantes et al. (2019) in finding the root cause, variations from the measuring system (a recurrent cause) and the process need to be analyzed before moving into deeper causes. In this case, The measuring system is based on a metallic

Gage R&R Study - XBar/R Method

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0000106	0.10
Repeatability	0.0000105	0.10
Reproducibility	0.0000002	0.00
Part-To-Part	0.0109468	99.90
Total Variation	0.0109575	100.00

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.003262	0.019575	3.12
Repeatability	0.003233	0.019399	3.09
Reproducibility	0.000436	0.002615	0.42
Part-To-Part	0.104627	0.627763	99.95
Total Variation	0.104678	0.628068	100.00

Number of Distinct Categories = 5

Fig. 16.8 Results for the gage R&R test on the edge distance for the stamping process

ruler and the worker's visual readings. A Gage Repeatability & Reproducibility (G R&R) study shows that the first is not contributing to the causes of variation as the variation caused by the process (see the part to part values in Fig. 16.8). A combination of tools such as brainstorming, stratification, and cause and effect analysis helps the team moving deeper from the symptoms to conditions, and causes of variation in the process. The analysis is shown in the partially filled cause and effect (Ishikawa) diagram (see Fig. 16.9). Actual equipment conditions and the analysis results in three possible solutions for increasing the productivity and competitiveness as seen in Table 16.4) to upgrade to newer technology, replace the equipment with the same technology, and replace the required components.

16.3.6 Develop a Solution Step

Up to this point, the majority of the tools used are of quantitative nature, were selected as described previously, and used as exemplified in Table 16.3. Before the implementation of the solution and the change of technology, a containment plan is implemented to increase the productivity to 16,000 pcs/wk. With these actions is expected to reach rates to comply with the customer requirements. This containment plan requires extra efforts from the production staff testing their commitment by increasing to three regular shifts and two weekend overtime shifts causing also an immediate increase in costs. With these actions, the production time moves to 176

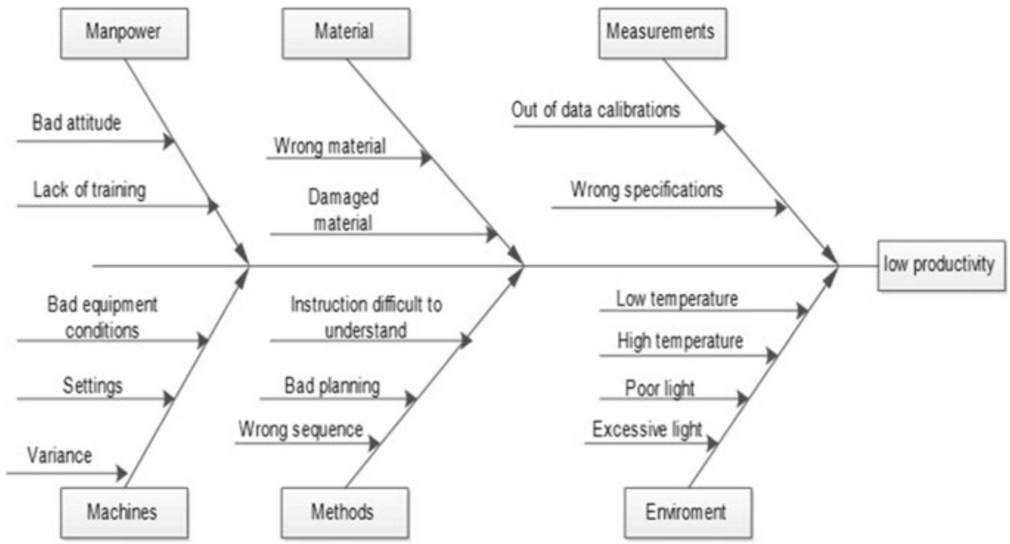

Fig. 16.9 Partially filled cause and effect (Ishikawa) diagram used in this case

Table 16.4 Options for solving the pad printing problem

Ideas	Advantage	Disadvantage	Classification
Upgrading to a newer technology	Reduction of ink consumption, reduction of preparation time, reduction of preparation time of stamping plate	Training on new technology, cost of technology	1
Replacing the equipment with the same technology	With new machinery print set, times are reduced	Cost of machinery, implications of getting rid of old machinery	3
Replacement of the required components	With the replacement of components, the reduction of production times is achieved	Components must be replaced periodically to maintain productivity	2

production hours/wk. From the problem analysis (see the previous section and Table 16.4), three options were suggested after exercising with the Nominal Group Technique (NGT). Table 16.4, shows the solutions (ideas), the decision factors (advantages and disadvantages columns), and the order for its viability (classification). During this decision-making process, the team considers the advantages and disadvantages of each possible solution, moreover, the evaluation includes the return over investment (ROI), productivity, reliability, quality, and adaptability of the solutions for this and other projects. The next step is to use the brainstorming technique for selecting among the available. The team decides for upgrading to a newer technology, which is cheaper and more reliable than the second of them, (to keep the same equipment but with new functional parts), or to acquire replacement equipment keeping the same technology. Options for the selected technology are offered by different

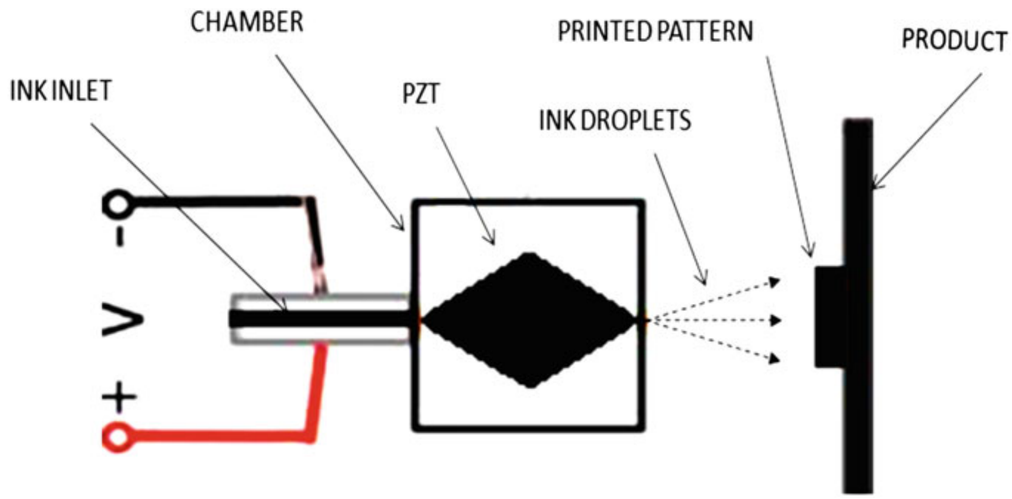

Fig. 16.10 Schematic of the selected inkjet stamping process proposed in the solution step

vendors weighing them for the mentioned and equipment characteristics. An inkjet technology is selected (see schematic in Fig. 16.10) because of its productivity, ROI, and quality characteristics. The advantages of using this technology include quicker changeovers, less and lower time for maintenance, cleaner stamping results (as compared to the actual process) and the more efficient use of the ink. In the same way, the price of the supplies and time for adapting this technology to the process are considered among the disadvantages. In the same way, the price of the supplies and time for adapting this technology to the process are considered among the disadvantages. After the proper implementations, adjustments, and training, initial data shows the potential of the updated process to speed up the production process and meeting the customer requirements. During the adaptation of the proposed technology, a vision system is included to synchronize the stamping distance with the paint jet drive and for comparing the stamp characteristics with the main patterns, helping in this way in measuring the quantitative values and feedback the operator during the visual (or qualitative) inspections. With the sensing arrangements including in the vision system, data is collected to a database in the intranet system, preparing in this way the process with Industry 4.0 characteristics. Also, this data is helping in monitoring the productivity data and the quality characteristics of the operations from the management position site and remotely from the headquarters. Results of the implementation show a viable production rate of 600 pcs/hr, a cycle time of 6 sec./pc is measured and a cost below 1.0 IEU/pc. Comparing data from the initial conditions to the adapted process, it can be seen that the process capability (Cpk) moves from 1.56 to 2.06 (see Fig. 16.7c and Fig. 16.11 respectively) an improvement that is reflected in an expected quality level or Six- Sigma level of 0.002 ppm. The return over the investment (ROI) is calculated using the latest unit cost of 0.9 IEU/pc. A value that is expected to adjust as the process is reaching its stabilization and the learning curve of the workers reaches its plateau. Considering the total investment the ROI then is calculated to reach its point of equilibrium at the production point of

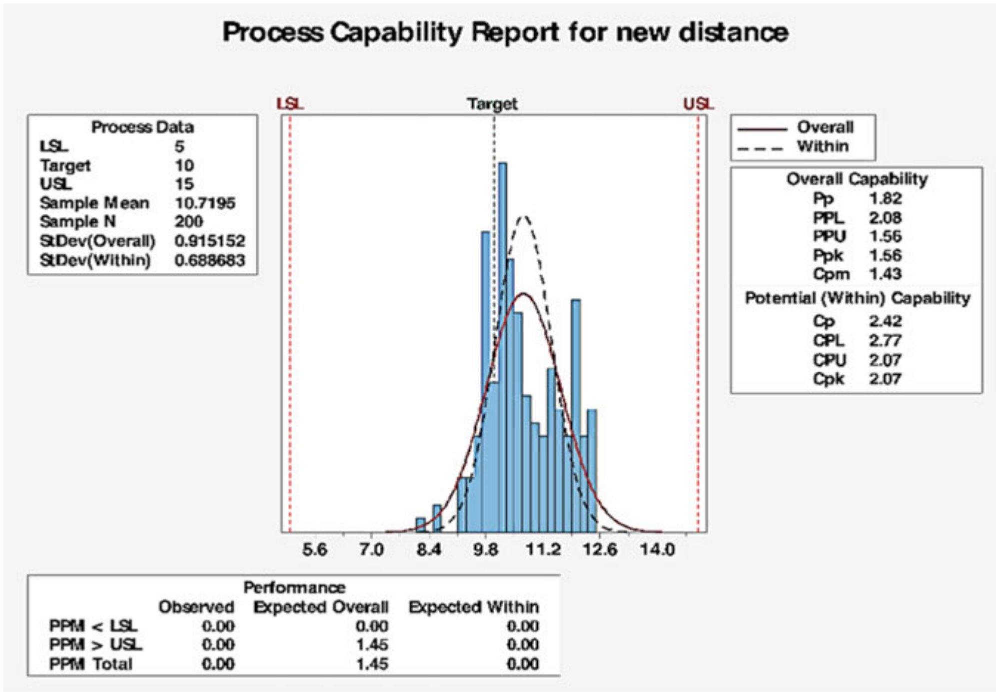

Fig. 16.11 Process capability study results after implementing the solution

615,000 pieces which, with the new production rate (600 pcs /hr) is manufactured in approximately two weeks.

16.3.7 Verify the Solution

For the organization and the local management is important to keep the success definition as quantitative as possible, then, during the validation step, statistical data is gathered to validate the efficiency of the implementation and the solution. Firstly, a cycle time comparison (Fig. 16.12) is used between the two processes. Forty random sample times are taken from the stamping process, using the pad printing (identified as Time process) and from the inkjet printing process (Time new process in Fig. 16.12). The statistical comparison shows a P-value of 0.0001 which is lower than the 0.05 for considering a statistically valid difference among the two samples, in this case, there is a change in the cycle times. In the same Fig. 16.12, it is observed that the mean values changed in 3 minutes, about 50% time reduction, despite the increase in variation measured by the standard deviation reduction that increases about ten times. However, the variation in the cycle time is expected to be reduced with the

Two-sample T for Time process vs Time new process				
	N	Mean	StDev	SE Mean
Time process	40	8.912	0.126	0.02
Time new process	40	5.98	1.15	0.18
Difference = μ (Time process) - μ (Time new process)				
Estimate for difference: 2.931				
95% lower bound for difference: 2.622				
T-Test of difference = 0 (vs >): T-Value = 15.98 P-Value = 0.0001 DF = 39				

Fig. 16.12 Two-sample t statistical comparison for cycle times using the pad printing and inkjet printing processes

learning curve. The Cpk shows that such variation is still between the specification limits and an improvement project can be used for reducing the inkjet printing process variation.

The statistical comparison for the quality characteristics uses the Two-Sample t tool data from both processes are gathered, observations of the cosmetic defects expected in the product do not appear (up to the writing of this report) when using the inkjet printing process. In the distance to the edge readings the printing distance data shows to be similar. The samples' comparison in Fig. 16.13 shows statistical data validation. Two hundred random samples are used from each stamping process. The pad printing (identified as current distance) and the inkjet (seen as new distances) stamped comparison shows a P-value larger than 0.05 indicating that the averages of the distances measured remain statistically the same.

From the results, it is possible to say that with the use of Lean-Sigma methodology in combination with the work culture analysis, the potential for succeeding and reaching the goals increases. More studies are required for confirming this approach,

Two-sample T for current distance vs new distance				
	N	Mean	StDev	SE Mean
current distance	200	10.707	0.973	0.069
new distance	200	10.72	0.915	0.065
Difference = μ (current distance) - μ (new distance)				
Estimate for difference: -0.0122				
95% CI for difference: (-0.1979, 0.1735)				
T-Test of difference = 0 (vs ≠): T-Value = -0.13 P-Value = 0.897 DF = 396				

Fig. 16.13 Statistical comparison study for printing variation before and after the solution

however, the improvements and reliability of the implemented changes in this production process are supported by the measured outcomes. In this case, the process is now able to compete in strong terms for this product and has now the flexibility for bringing more business. The increase in capability reduces the operation's time and frees one-third of the regular production capability and is possible to accept new projects at a lower cost (of 0.9 IEU/pc) with quality levels expected from a WCMS.

16.3.8 Control Plan

Finally, the Lean-Sigma methodology requires a control plan and the possibility to transfer the acquired knowledge to the organization in general. Two actions and tools are highlighted from this step, the use of a new Failure Mode & Effects Analysis (FMEA) and the adjustments to the improvement process plan. Changes include the documentation to identify potential failure modes in the system and their causes and effect due to the use of the newer equipment and failure modes by using this technology. Adjustments, documentation, changes, and additions of the functional elements of quality control are included, and the further institutionalization of the modifications will help in preventing or be prepared for future system failures.

16.4 Conclusions

The adaptation of the organizational culture to overseas operations will help in the creation of a workplace culture that connects to the organization and the people at the operations' location. This chapter presented a methodology for increasing the success potential when a world-class methodology, such as Lean-Sigma, is implemented. The case study shows an example of the use of this methodology, cultural differences and characteristics were evaluated during the adaptation of this methodology. After conducting a survey and using the classification and scores of the cultural aspects proposed by Hofstede the local scores for Juarez, Mexico were obtained. Of the cultural characteristics, the local staff shows low scores for the cultural characteristic of "distance to power" and high scores for the "collectivism" aspect as expected for a Mexican operation work culture. However, in the Juarez city case, other scores show that the local culture is different from the national (Mexico), the vicinity (USA), or the organizational (of French origin) culture showing characteristics of a multicultural environment. Under this scenario, with the cultural differences and organizational need for communicating among the different levels, the communication between the members of the organization may be difficult, the implementation of methodologies is also compromised. For example, a transversal approach for communication may confuse the local staff. Then, including the cultural component for implementing a methodology increase the possibilities for a successful implementation. The methodology presented show that the use of statistical tools allows members of both cultures to discuss and communicate on common grounds.

The case discusses the use of the steps of Lean-Sigma, dividing the activities into 21 to disaggregate the steps and identify the potential tools and methods to use in each activity then, choosing the ones that adapt better to the culture of both the organization and the local one. This report shows the results of selecting a different technology and improvements in the process, that increases the productivity rates from 178 to 600 pc/hr, the quality levels increased by 50% reaching a statistical Cpk value of 2.06, and the operational cost reduction from 5.33 to 0.9 IEU/pc. Aside from the ROI in two weeks, the adaptation is considered a success in the adaptation of the Lean-Sigma methodology. Finally, this case and methodology serve as a guide for organizations facing these challenges, while expanding operations around the world. Several implementations show that is possible to increase the success rates in adopting methodology, by adapting the tools and methods to the working site culture.

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