Improvement Model to Increase production plan using forecasting tools and capabilities in an Industrial Paints

Ariana Balbin-Reymundo, Alberto Flores-Pérez, Juan Quiroz-Flores, Martin Collao-Diaz
Facultad de Ingeniería y Arquitectura, Universidad de Lima, Lima, Perú
20170140@aloe.ulima.edu.pe, jcquiroz@ulima.pe, alflores@ulima.pe, mcollao@ulima.pe

Abstract

The global paint industry has a reach valued at $209.4 billion for this year. At the national level in Peru, this sector represents 1.27% of GDP, so this industry is of utmost relevance since the national per capita consumption is low, therefore, there is a great margin for improvement of this. This article describes the implementation of an improvement model that uses forecasting tools and capabilities coupled with a simulation to increase compliance with paint production, therefore; the central problem is analyzed using the VSM tool, in which the root causes, percentage of value-added and non-added time of the process are identified. After implementation, the model increased compliance with production orders by 26.86%, increased availability of resin input by 27.92, % and decreased cycle times by at least 2.5%.

Keywords
Production orders, forecast models, paint industry, standard data, capabilities.

1. Introduction
Statista (2018) points out that for years globally the construction industry and the automotive and industrial coatings markets, in general, have been driving the growth in demand for the paint sector. For example, Asia and the Pacific constitute the highest demand in the sector, accounting for 45%. On the other hand, Liao et al. (2021) argue that the sector revolves in a changing and dynamic environment in which it depends a lot on its raw materials and laws that regulate the purchase of them, which to some extent requires excellent planning. Therefore, it is vital to optimize processes and reduce the times of activities that do not add value. In Peru, the current paint market has a current value of US$ 350 million and a volume of 40 million gallons, giving a per capita consumption of 1.3 gallons, understanding that there is potential to grow (Gestión 2016). Likewise, it has been identified that the low compliance of production in the sector is due to various factors such as lack of maintenance of the machines (Omoregbe 2017), lack of compliance with specifications (Patyal et al. 2021), lack of planning, skills/errors of operators in the tasks performed (Badeeb et al. 2017). Therefore, in this context, it is necessary for companies belonging to the paint sector to be more efficient in meeting demand, which ends up being measured in terms of being more productive and competitive at the same time. Therefore, a case study has been chosen that reflects the problems of the sector on the deficient fulfillment of production orders, in which the lack of availability of Resin, delays in quality control and reprocesses due to poor grinding were identified as the most frequent causes. Consequently, an improvement model has been developed to increase compliance using tools such as forecasting, instructions, and capacity management. In the same way, it is worth mentioning that the motivation lies in generating knowledge about forecasting tools, capacity management, and work methodologies in the paint sector which has been very little studied in recent decades demonstrating its effectiveness quantitatively. Finally, this scientific article is divided into five parts which are Introduction, State of the Art, Methodology, Validation, Results, Conclusions, and References.

1.1 Objectives
The general objective of this research is to increase compliance with production orders (COP) by at least 15%, which is oriented to the central problem identified. Consequently, it was proposed as specific objectives to achieve the forecast of the demand for Alkyres Asc resin - 70% for the optimization of the supply and increase of availability by more than 11% and, finally, to achieve the identification of the bottleneck operation using capacities. Among other aspects, the key contribution of the research by the researcher is to propose a forecast model for the company under study to improve its compliance indicator, considering the loss of income that this has generated, and at the same time, share knowledge with the research community about the industrial paints sector in small or medium-sized companies from a plant point of view.

2. Literature review

2.1 Importance of compliance with production orders

After having read various researchers and engineers, many of them agree that the manufacturing process starts from the production order, which is intensely related to the behavior of demand, which means having enough raw materials to meet the requirements and being more competitive in the market (Rodríguez et al. (2019). In the same way, it is vital to identify which factors determine the fulfillment of production and/or demand which favor the autonomy of operations, and operator performance and therefore result in greater productivity (Navarro et al.2019). There are studies related to production compliance for the sector under study, which has been carried out under the focus of measurement and management of performance of internal operations to achieve greater productivity, however, they end up proposing automation improvements and technological innovation, leaving aside the reality of small and medium-sized companies to acquire what is proposed (Rodríguez et al. 2017).

2.2 Work Instructions

According to the review, the instruction is a document that illustrates the activities to be followed within a production process, disseminating information and knowledge, providing information to operators, in which text and images are usually combined for a better visual understanding (Li et al. 2018). Its effectiveness can be seen applied in a case study in which the use of this instruction as a tool to standardize processes helped eradicate idle process time and NVA additionally reduced the requirement for labor. Approximately, 31.6 s of time per product cycle were saved, which increased production to 58 pieces compared to the existing production of 45-50 pieces in a 7-hour work shift (Rahul et al. 2019)

2.3 Forecast models

The quantitative estimation of future events is what the forecasting tool provides and why it is widely used (Perdigón et al. 2020). However, as there is no universal forecast model for the demand presented by each sector and/or company, it is a challenge to investigate more accurate and/or appropriate models for each situation. For example, after implementing a forecast model due to the problem of poor supply of its best-selling main products for a case study, a forecast accuracy of 92.11% and a performance of 94.41% were obtained (Cajigas et al. 2019).

2.4 Production capacity

The determination of production capacity is an important factor because it allows for establishing standards, functionality, quality, quantity, and more importantly the forecast of the fulfillment of deliveries demanded by customers (Hussein 2019). In addition to the above, in an international case study, it was possible to balance production capacity and demand in 2018 by integrating a model of capacity planning per operation and the fue moving average method considering what should be the maximum rate of output of its manufacturing process reaching that one of the products of the production lines under study represented a 97.01 % deficiency in production (Altendorfer 2018).

3. Methods

During the review of the literature, different models were found to evidence which was determined as the most appropriate tools to solve the central problem of the company study which can be seen in Table 1.

Table 1. Comparative matrix

Author and ref.	Quality control delay	Raw material availability	Identification of limiting critical operations
Li et al. (2018)	Instructions for work by station	-	-
Navarro et al (2019)	-	Adjustable forecast models	-
Altendorfer (2018)	-	-	Analytical module for limited capacity.
Proposal	Work instructions for CC.	Forecasting models	Capacity management by station

3.1 Proposed model

The proposed model handles a methodology that behaves like a process with expected inputs and outputs using tools for the solution of the central problem as shown in Figure 1.

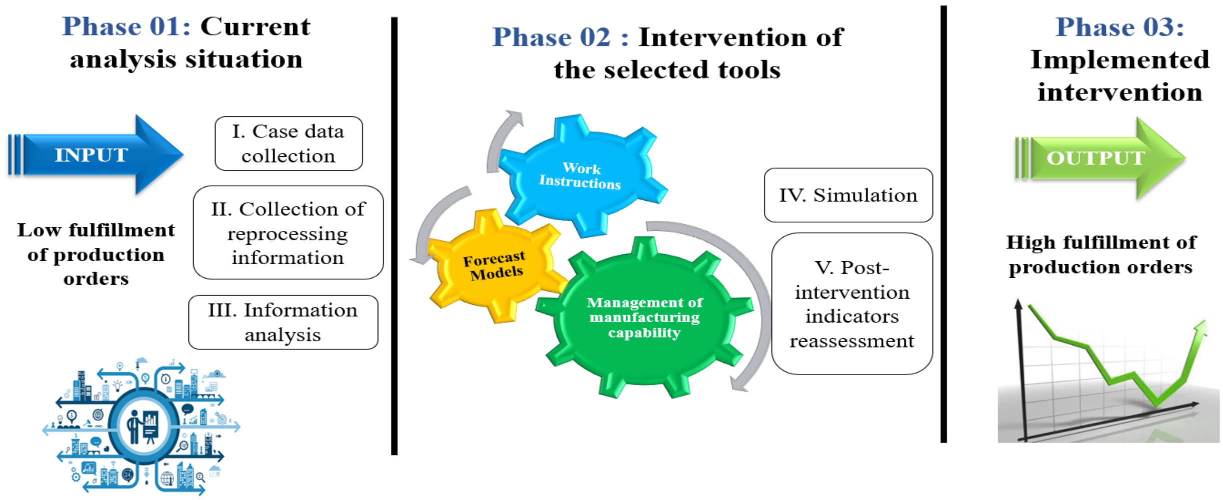


Figure 1. Contribution of tools in the proposed improvement

The proposed improvement consists of a methodological model of 3 phases, the first is the phase of the analysis situation, the next is the intervention phase where the tools and methods to be used are involved, and finally, it is the phase of improved interpretation in which the results are monitored through the established indicators.

3.1. 1. Phase 01 – Analysis of the current situation: This phase consists of diagnosing the central problem which was identified as the low compliance with the production orders, knowing what causes generate this problem. It is worth mentioning that in this phase information is collected to weigh the weights of the causes and in this way process the information to finally make the diagnosis of the initial situation and to be able to establish through the comparison of the previously shown matrix which relates the problems and the tools that were used by other researchers for the solution of similar problems in other manufacturing sectors. In the same way, the employees of the case study were part of the explanation of the problems that existed in the paint production plant. It can be argued that key diagnostic tools for the present study were the Ishikawa diagram, the Pareto chart, and the value stream map (VSM).

3.1.2. Phase 02 – Intervention of the selected tools: For this phase, the tools illustrated in Figure 1 were used, which were instructive work, which helped to standardize how the same operators could perform certain quality tests, without the need to be present the same quality manager to release a certain workload, given that this personnel, when in charge of the control of the three plants present in the company, are saturated and generate a bottleneck due to lack of human resources. However, as the instruction alone does not solve the delay in quality control, a support tool was used such as the learning curve in which it was possible to identify in which cycle or time the operator in charge of the grinding and nuancing process will be able to reach the operating time of quality control 01 and 02 under normal conditions, i.e.; the speed of work of the quality manager only supervising the paint plant. On the other hand, 03 forecast models were proposed for the optimization of the main input alkynes Asc resin - 70%, the models were forecast by patterns, by regressions, and by moving average considering "n" equal to the values 2,3,4,5 and 6 months, in all models statistical parameters were considered. Finally, about the identification of bottlenecks, a methodology for calculating capacities per station was proposed, considering the present or available capacity, the required capacity, and the maximum capacity. Within this phase, the use of the Arena software was considered in addition to the future value stream map to demonstrate the results obtained.

3.1.3 Phase 03 - Intervention implemented: In this last phase, it is vital to demonstrate through performance indicators to what extent or form has impacted what is proposed concerning the objectives set. The indicators, formulas, and objectives are shown below:

Cycle time in quality control: With this indicator, it is possible to calculate how long it takes to complete a specific task from the beginning to the end of it, in this case in quality control.
Objective: Reduce the indicator by 21% by bringing it closer to the current tack time value.

$$Tiempo\ de\ ciclo\ de\ CC: \frac{Tiempo\ disponible(Por\ jornada)}{Demanda\ (En\ lotes)}$$

Raw material availability rate "Alkyres Asc resin - 70%": With this indicator, it is possible to calculate the percentage of disposal of the input, based on its supply and prior planning.
Objective: To increase the availability of the main input by at least 11%.

$$Tasa\ de\ DMP: (\frac{Cantidad\ producida\ total\ de\ Resinas - Cantidad\ vendida\ total\ de\ resinas}{Cantidad\ producida\ total\ de\ Resinas})\ x\ 100$$

Production order fulfillment rate: With this indicator, it is possible to calculate the compliance trend in the plant.
Objective: To increase by 15% the fulfillment of the production plan in the industrial line of paints.

$$Tasa\ de\ COP\ (\%): \frac{N°\ de\ OP´s\ programadas}{N°\ de\ OP´s\ completadas}\ x\ 100$$

4. Data collection

Figure 2 shows each input collected before making the proposed improvement, in which the areas involved are observed, as well as symbols of reports, downloads, databases, and indicators elaborated that were useful for the collection and analysis of the same. . Considering that it intervened directly and indirectly in each reception and transformation of data into information.

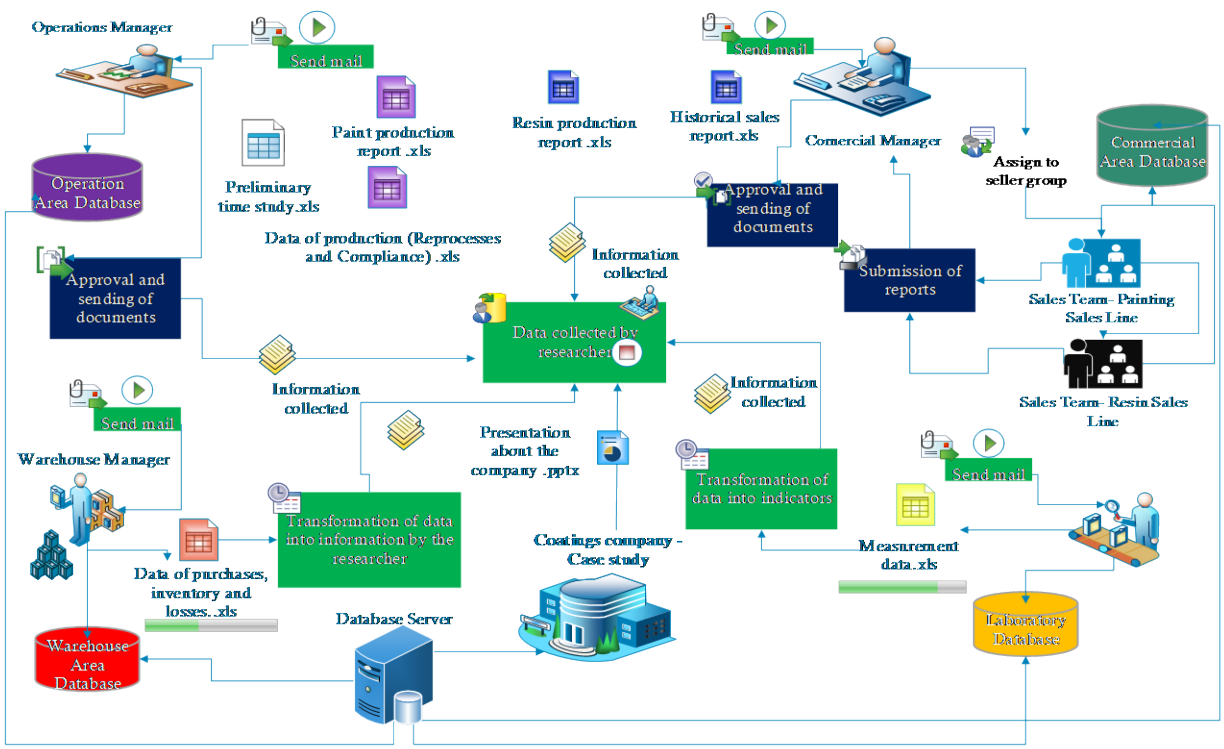


Figure 2. Relationship diagram of the processes performed in data collection

5. Results and discussion

5.1 Numerical results

This section shows the results obtained, for example; phase 01 which contemplates the phase of analysis of the current situation of the case study, after collection of the information and subsequent calculation of indicators, compliance with production orders were quantified, which had a current value of 53.64% on average in the present company understudy for a semi-annual period of work, which was well below the average value of the coatings sector which is 88.08%, observing a gap of 34.44%.44%. In the same way, as mentioned above, this low compliance was due in a certain way to the shortage of the product Resina Alkyres Asc - 70%, which is the main raw material that is used from the first process to start production, therefore; the resin availability indicator was built through a history of resin sales and total production of the same, calculated by the difference the available percentage of all the production of the main input that is sent to the industrial paints plant, obtaining a value of 30.23% availability and 69.77% availability to be marketed as a final product. On the other hand, in the same phase in the realization of the value map of the initial situation, it was obtained that the value of the effective time of the quality control operation exceeded the takt time, with values of 88.8 and 75.3 in units of seconds per gallon respectively. In this sense, the results obtained from phase 02 are presented, which contemplates the tools that would solve the present problems, about the tool of the w k instruction that was proposed so that to a certain extent the operators may also be able to perform the quality tests and previously corroborate if their batch is correctly produced considering the parameters of viscosity, fineness, and colorimetry and achieve the decrease of quality control time. Se established the use of the tool to support the learning curve obtaining that an average plant operator in the 1930-second cycle, attempt or repetition of the task will achieve a quality control cycle time of 39.69 minutes per lot, which is below the minimum and maximum values of the quality control operation 48 and 55 in minutes per batch respectively that was carried out in the tests carried out by the quality laboratory itself.

5.2 Graphical results

In the same way, the graphs and tables that are part of the solution and the support of the results found are shown. Considering the proposed improvement that covers various tools that have been used in cases of previous studies with similar problems in some cases and applied to sectors very close to the paints and coatings sector.

Figure 3 shows the difference concerning the COP (%) of both the sector and the company understudy in the period from March to August of 2021., it is worth mentioning that throughout that period information was collected and ordered for the generation of indicators (Figure 3).

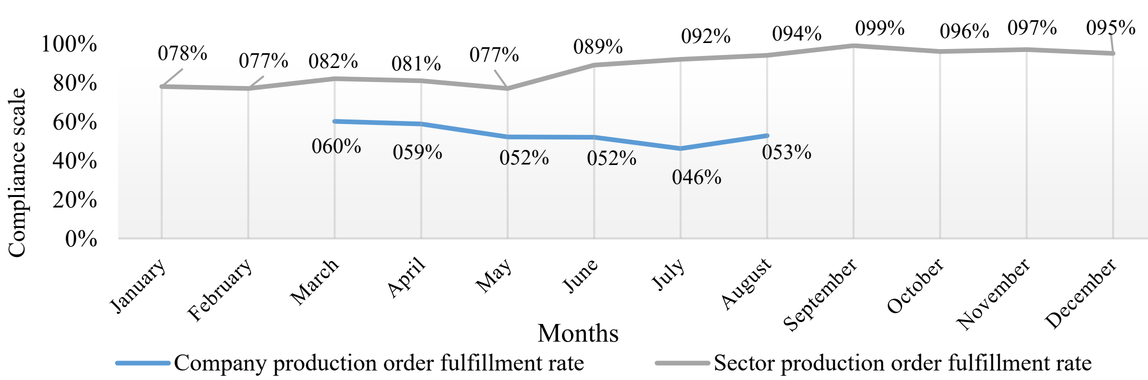


Figure 3. Comparison of production order fulfillment rate

In the same context, Figure 4 shows the dispersion of times in minutes of the batch numbers produced, observing that there were atypical data for certain batches, as well as that the production of many of them is between the range of 48 to 55 minutes per batch. In addition, it is observed that certain batches exceeded 100 minutes of inspection and laboratory tests (Figure 4).

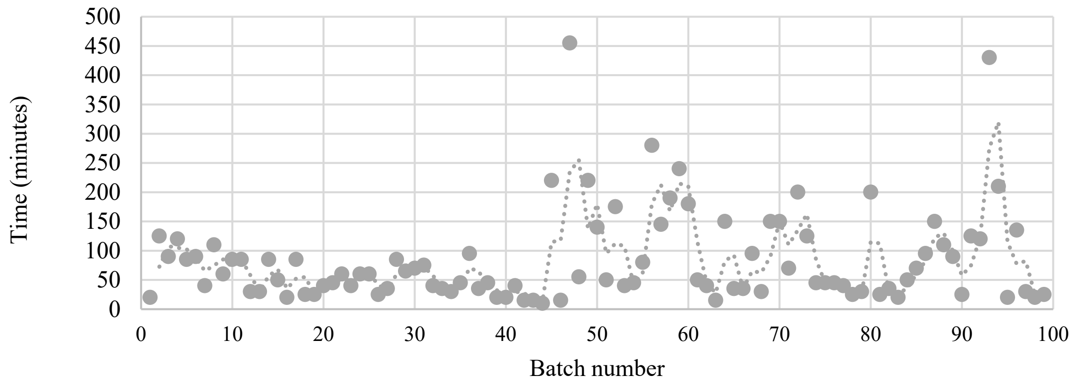
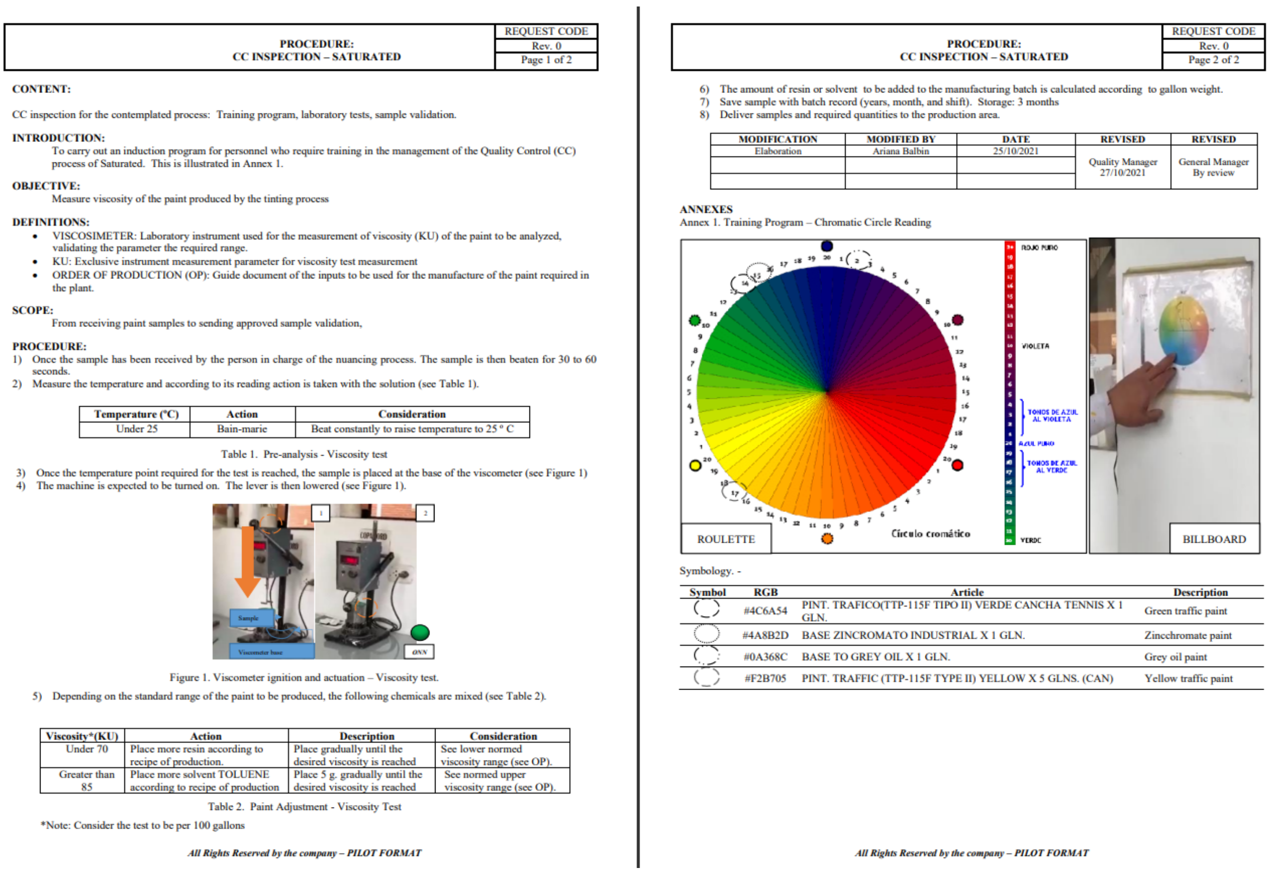


Figure 4. Dispersion of quality control time data

5.3 Proposed improvements

From the graphic results previously shown in the analysis phases of the current situation, the graphic and numerical results generated in phase 2 of the proposed intervention are deprecated, which are presented later.

In Figure 5. the work instructions that were elaborated for the operators who need to follow the steps for the elaboration of fineness, colorimetry, and viscosity tests are observed.



PROCEDURE: CC INSPECTION – SATURATED	REQUEST CODE / Rev. 0 / Page 1 of 2

CONTENT:

CC inspection for the contemplated process: Training program, laboratory tests, sample validation.

INTRODUCTION:
To carry out an induction program for personnel who require training in the management of the Quality Control (CC) process of Saturated. This is illustrated in Annex 1.

OBJECTIVE:
Measure viscosity of the paint produced by the tinting process

DEFINITIONS:
- VISCOSIMETER: Laboratory instrument used for the measurement of viscosity (KU) of the paint to be analyzed, validating the parameter the required range.
- KU: Exclusive instrument measurement parameter for viscosity test measurement
- ORDER OF PRODUCTION (OP): Guide document of the inputs to be used for the manufacture of the paint required in the plant.

SCOPE:
From receiving paint samples to sending approved sample validation,

PROCEDURE:
1) Once the sample has been received by the person in charge of the nuancing process. The sample is then beaten for 30 to 60 seconds.
2) Measure the temperature and according to its reading action is taken with the solution (see Table 1).

Temperature (°C)	Action	Consideration
Under 25	Bain-marie	Beat constantly to raise temperature to 25 ° C

Table 1. Pre-analysis - Viscosity test

3) Once the temperature point required for the test is reached, the sample is placed at the base of the viscometer (see Figure 1)
4) The machine is expected to be turned on. The lever is then lowered (see Figure 1).

Figure 1. Viscometer ignition and actuation – Viscosity test.

5) Depending on the standard range of the paint to be produced, the following chemicals are mixed (see Table 2).

Viscosity*(KU)	Action	Description	Consideration
Under 70	Place more resin according to recipe of production.	Place gradually until the desired viscosity is reached	See lower normed viscosity range (see OP).
Greater than 85	Place more solvent TOLUENE according to recipe of production	Place 5 g. gradually until the desired viscosity is reached	See normed upper viscosity range (see OP).

Table 2. Paint Adjustment - Viscosity Test

*Note: Consider the test to be per 100 gallons

All Rights Reserved by the company – PILOT FORMAT

PROCEDURE: CC INSPECTION – SATURATED	REQUEST CODE / Rev. 0 / Page 2 of 2

6) The amount of resin or solvent to be added to the manufacturing batch is calculated according to gallon weight.
7) Save sample with batch record (years, month, and shift). Storage: 3 months
8) Deliver samples and required quantities to the production area.

MODIFICATION	MODIFIED BY	DATE	REVISED	REVISED
Elaboration	Ariana Balbin	25/10/2021	Quality Manager 27/10/2021	General Manager By review

ANNEXES
Annex 1. Training Program – Chromatic Circle Reading

Symbology. -

Symbol	RGB	Article	Description
	#4C6A54	PINT. TRAFICO(TTP-115F TIPO II) VERDE CANCHA TENNIS X 1 GLN.	Green traffic paint
	#4A8B2D	BASE ZINCROMATO INDUSTRIAL X 1 GLN.	Zincchromate paint
	#0A368C	BASE TO GREY OIL X 1 GLN.	Grey oil paint
	#F2B705	PINT. TRAFFIC (TTP-115F TYPE II) YELLOW X 5 GLNS. (CAN)	Yellow traffic paint

All Rights Reserved by the company – PILOT FORMAT

Figure 5. Quality control work instructions

Because it is necessary to present quantitatively the impact of the use of the work instruction and the significance it would have in the reduction of the quality control inspection process, the data obtained from the use of the learning curve tool is presented in Table 2, therefore, in that tabla it is observed that in the number of Cycle 1930 is expected to be a cycle time of 39.69 minutes per batch, considering the data observed and estimated from the values obtained by the equation of the learning curve Y = 485264*X ^(-0.0234) (table 2).

Table 2. Learning curve outcomes

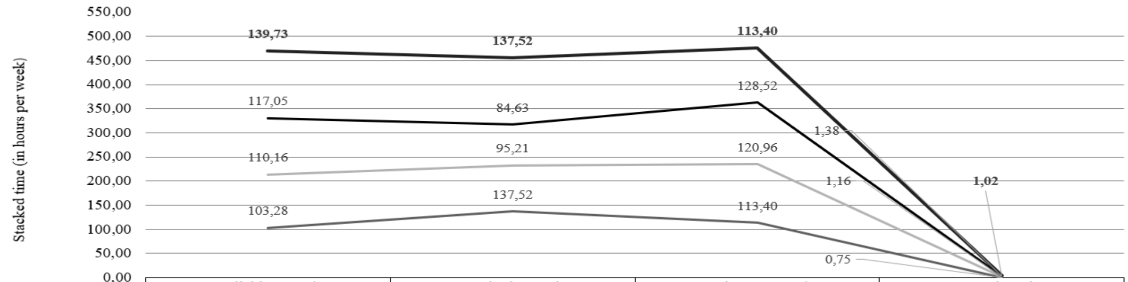
Log. X	Log. Y	Observed data		Estimated data		Calculated data	
		N° Batch	AAT	N° Batch	AAT	Cycle number	Cycle time
0,0000	1,6827	1	48,16	1	48,53	60	43,05
0,3010	1,6873	2	48,67	2	47,74	130	42,28
0,4771	1,6799	3	47,85	3	47,29	200	41,85
0,6021	1,6617	4	45,89	4	46,97	270	41,56
0,6990	1,6659	5	46,33	5	46,73	340	41,34
0,7782	1,6642	6	46,15	6	46,53	550	40,87
0,8451	1,6669	7	46,44	7	46,36	…	…
0,9031	1,6714	8	46,92	8	46,22	1930	39,69

Concerning the proposed models, it can be seen in Table 3. that among the three models the model that offers the lowest average percentage error is the forecast by behavior patterns, therefore, from it the supply of Alkyres Asc-70% resin was planned, taking into account the ratio of raw material and finished product with a value of 6.4 kilograms per gallon which was obtained from the historical recipe book for each production order, as well as parameters such as lead time, security inventory, gross requirement, scheduled receptions, available inventory, net requirement, order plan to increase the availability of resin. Therefore, it was identified that the resin production order must be launched a week in advance to have enough involved with the paint production order that would be the final product. Similarly, with the above mentioned it was possible to determine that the indicator of resin availability increased by 27.92%, considering that the percentage of effectiveness or success of the forecast obtained was 92.3%.

Table 3. Results of forecast indicators

Indicators	Forecast by behavior patterns	Forecast by regressions	Forecast by moving average				
			n=2	n=3	n=4	n=5	n=6
Mean Error (ME)	-2.762	14.478	446	649	982	1.482	1.712
Mean Average Deviation (MAD)	2.762	14.478	1.433	1.589	1.887	1.849	1.933
Mean Aver Percent Error (MAPE)	6,20%	86,99%	8,64%	9,58%	11,27%	10,45%	10,79%

Concerning the capacity management tool, it was identified in the case study that the present company has a bottleneck in the grinding process, being able to observe that for a weekly load of 4140 gallons they have an available or present capacity of 103.28 hours/week, considering 8.5 hours/shift, 1 shift/day, 6 days/week, 3 machines/station, with utility factor of 0.8 and efficiency factor of 0.7. On the other hand, according to the management, the capacity required for the grinding process is 137.52 hours/week considering the historical demand, the percentage of defective, and the operating time of the same which were collected in the data collection phase. Therefore, in Figure 6 it can be seen that the value of the bottleneck is below the value 1 unlike the other two processes such as completed and nuanced. However, through the proposed improvement, given that the company under study does not have the infrastructure to expand its capabilities according to the previous analysis of the Autocad plan of the paint production plant, it was suggested in the first instance the use of 3 overtime hours for this process to increase the available capacity by 139.73 hours per week to obtain a value of not having bottlenecks. However, it is known that although the proposal incurs investing in more man-hours, it is suggested that the most appropriate in the long term is to reduce unplanned and operational downtime which directly contemplates the washing activity of the mill with the use of the pearls in a shorter time, therefore, the use of the Single Minute Exchange of Die (SMED) tool would be involved an er analyzing the activities involved in the grinding process for future research.



	Available capacity	Required capacity	Maximum capacity	Bottleneck
Improved Grinding process	139,73	137,52	113,40	1,02
Shading process	117,05	84,63	128,52	1,38
Completion process	110,16	95,21	120,96	1,16
Current Grinding process	103,28	137,52	113,40	0,75

Capacity Types

Figure 6. Capacity levels per workstation

5.4 Validation

To have much more reliable results, the Arena software will be used as a validation tool. The simulation was carried out involving all the processes that are required to produce paints. The simulation starts with the Input Analyzer software, which provides the distributions that best fit the sample data. The obtaining of the optimal sample was based on 192 observations made from the nuancing process which directly involves the use of the non-reusable resource, that is; consumable, Alkyres Asc Resin - 70%. From this initial sample, the number of observations required to have a reliable distribution was determined. Subsequently, the distributions belonging to the different activities of the process within the model generated in Arena were entered. In turn, for the comparison of the current model with the improved one, a confidence level of 95% and an error of 10% was used. The current model can be observed in Figure 7 and consists of 7 main activities, in which production orders can be observed stagnant in the grinding process due to the shortage of resin input. Similarly, Figure 8 shows the improved process which contemplates an additional branch that symbolizes a supply chain periodically for the greater fulfillment of production orders. Once the models have been carried out in Arena, the indicators have been exported through the Output Analyzer software and the paired test has been carried out, in the range of the paired differences it is concluded that the improved model according to the proposals for improvements significantly impacts the increase of the COP indicator, observe Table 4 for the analysis carried out.

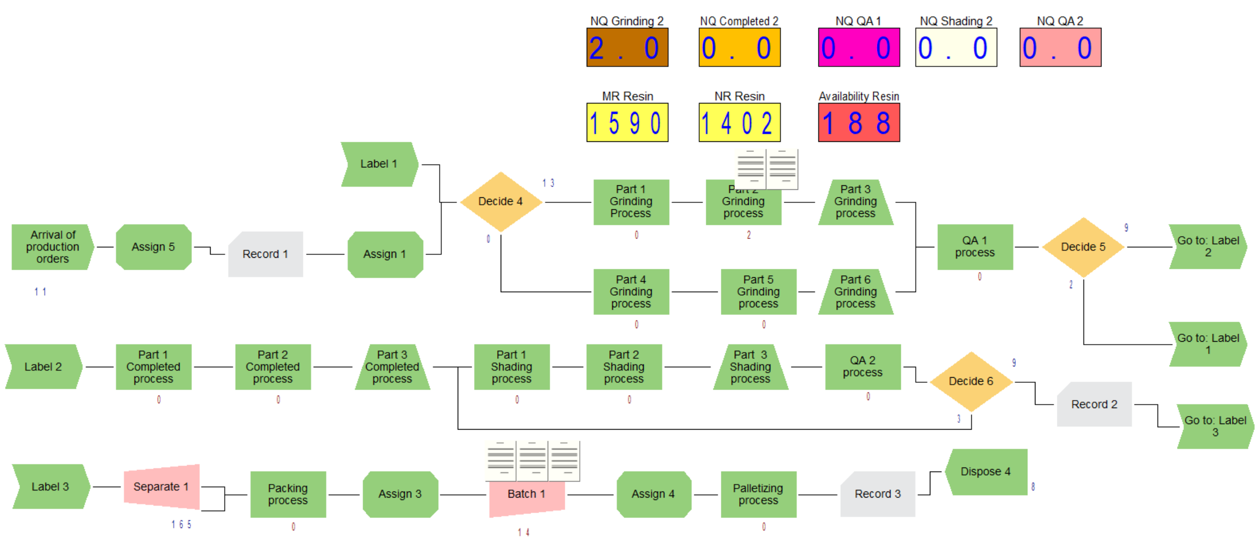


Figure 7. The proposed model simulated in the initial state

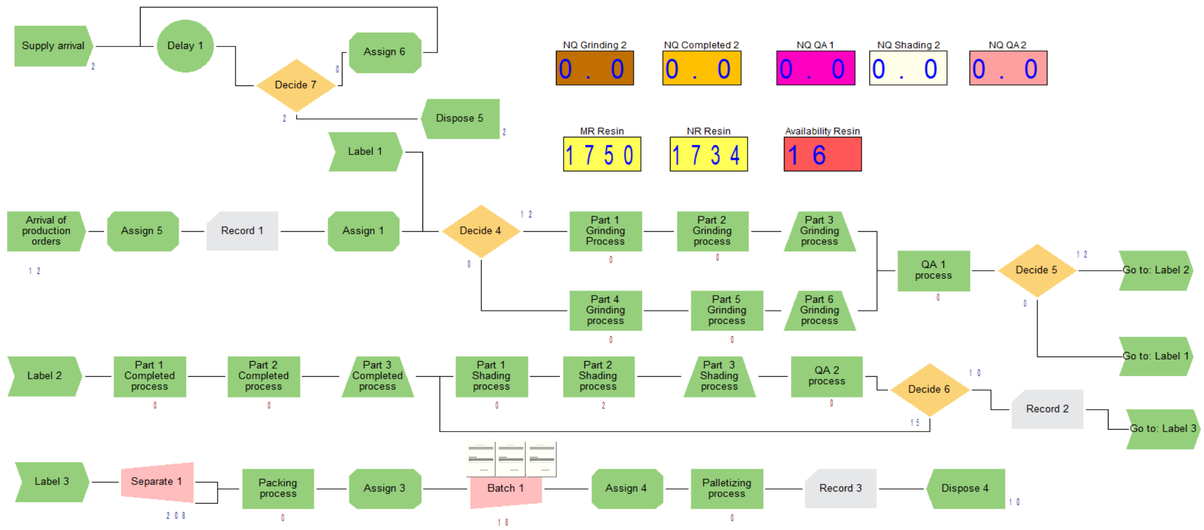


Figure 8. The proposed model simulated in the final state

Table 4. Results of indicators of the simulator

No	Indicator	IC Original			IC Improved		
		Average	Average Minimum	Average Maximum	Average	Average Minimum	Average Maximum
1	Batches in grinding glue	2,360	1,719	3,001	0,000	0,000	0,000
2	Queued lots CC 01	1,608	0,207	3,009	0,081	0,010	0,151
3	Queued lots CC 02	1,758	0,503	3,012	0,163	0,120	0,206
4	Average of use	1.140,84	700,880	1.580,80	1.118,63	623,760	1.463,160
5	Lead Time	286.24	218.03	386.99	276.39	178.32	332.04
6	Completed orders	7,009	5,010	12,003	10,500	8,960	14,640

In Table 4, it is observed that indicator 1 does not exist overlap so it does not require calculating the interval of paired differences, therefore, there are statistically significant differences, that is; the number of batches waiting for grinding was reduced to zero with the supply of the main input. Concerning the second and third indicators, as there is no interaction between the maximums and minimums, it is expressed that the lots waiting for inspections 1 and 2 have been reduced by 0.081 and 0.163 lots on average per day. On the other hand, as can be seen in the last three indicators, although the proposed model values show better results than the initial model, it can be observed that there is overlap between the maximum and minimum intervals, so it is necessary to make the comparison of means. Therefore, it is emphasized that the null hypothesis holds that the averages of the models are equal; H0: $\bar{x}1 = \bar{x}2$ While the alternative hypothesis holds that there is a significant difference between the means; H1: $\bar{x}1 \neq \bar{x}2$. In the report of the output Analyzer, it was obtained that for indicators 4, 5, and 6 the independent intervals. I.C. of the differences matched to 95% confidence show significant differences, so the null hypothesis is rejected in the 3 cases. For example, in indicator 4 the average resin used presented 95% CI (negative, negative) which would indicate that the highest value is presented by the improved model, that is, there is greater use of the input, materializing in 19.146%, about the lead time indicator, it is observed a reduction of at least 9.85 minutes on average compared to the initial scenario. Finally, about the main indicator COP, considering that the maximum number of scheduled production orders is 15 orders per day, knowing that in the initial scenario they met only 7,009 orders on average, and in the improved model implemented the proposed improvements are reached to meet 11.5 orders on average the level of compliance has increased by 26.86%.

6. Conclusion

This study corresponds to the implementation of an improvement proposal as an integrated system for the use of engineering tools in the manufacturing industry of industrial paints and coatings in Peru. In turn, the objectives of this work were the increase in compliance with production orders (COP) which is oriented to the central problem identified, consequently, the achievement of the increase in availability through the forecast model by patterns of behavior about the resin Alkyres Asc - 70%, finally, achieve the identification of the bottleneck operation through the use of capacity management in which it was possible to identify that the grinding process was the one that to some extent limited the pace of the production process, increasing waiting times and reducing productivity, which was reflected in the monetary loss due to non-compliance with production orders At the same time, a work instruction can be proposed regarding partial quality control inspections that to some extent generated work overload for the laboratory area. The results obtained in the study show significant improvements in the lead time of processing, the operating cycle times, the availability of the main resin input, and to some extent a standardization for partial inspections.

References

Altendorfer K., Effect of limited capacity on optimal planning parameters for a multi-item production system with setup times and advance demand information, *International Journal of Production Research*, vol. 57, no, 6,pp. 1892-1913,2018.

Beeb A., Abdulaal R., y Bafail A., An Application of Lean Manufacturing Techniques in Paint Manufacturing Company: A Case Study, *JKAU: Eng. Sci*., vol. 28, no. 2, pp: 51 – 73,2017.

Cajigas, M., Ramírez E., and Ramírez D., Production capacity and sustainability in new companies. *Revista Espacios*, vol. 40, no. 43, p. 15,2019.

Chamorro J., Díaz J., Fuentes O., y Lovo H., Maximum and minimum inventory policy in multi-echelon supply chains. Case study: a pharmaceutical distribution company, *Nexo Revista Cientifica*, vol. 31, no. 2, pp. 144 – 156, 2018.

Gestión, Paintings in Peru: A market that moves US$ 350 million of all colors, Available: https://gestion.pe/economia/mercados/pinturas-peru-mercado-mueve-us-350-millones-colores-121733-noticia/, May 25, 2016.

Hussein A., Balancing Production Capacity and Demand through Aggregate Production Planning (App): A Case Study at the Baghdad Soft Drink Company, Baghdad, Iraq. *Business Case Studies*, vol. 1, no, 1, p. 01,2019.

Li D., Mattsson S., Salunkhe, O., Berglund A., Skoog A., y Broberg J., Effects of Information Content in Work Instructions for Operator Performance. *Procedia Manufacturing*, vol.25, pp.628-635,2018.

Liao, M., y Wang, C., Using Enterprise Architecture to Integrate Lean Manufacturing, Digitalization, and Sustainability: A Lean Enterprise Case Study in the Chemical Industry. *Sustainability*, vol. 13, no.9, pp. 2 - 5,2021.

Navarro K., Meza J., Baldovino T., y Caruso N., Evaluation of the Supply Chain to Improve Competitiveness and Productivity in the Metalworking Industry in Barranquilla, Colombia, *Información tecnológica,* vol. 30, no. 2, pp. 25-32,2019.

Omoregbe O., Production facilities maintenance practices and sustainable competitive advantage in the paint manufacturing industry, Benin City, Nigeria, *Annals of the University of Petroşani, Economics*, vol. 17, no, 1, pp. 209-222,2017.

Patyal, V., Modgil S., y Koilakuntla M., Application of Six Sigma methodology in an Indian chemical company, *International Journal of Productivity and Performance Management*, vol. 70, no. 2, pp. 350-375,2021

Perdigón R., Viltres H., y Orellana A., Models for predicting perishable products demands in food trading companies, *Revista Cubana de Ciencias Informáticas* , vol. 14, no. 1, pp. 110-135,2020.

Rahul S., Bhardwaj A., Singh S., y Sachdeva A., Productivity gains through standardization-of-work in a manufacturing company", *Journal of Manufacturing Technology Management*, vol. 30, no. 6, pp. 899-919,2019.

Rodríguez F., Lima J., y Ribeiro L., Quantitative models for supply chain performance evaluation: A literature review, *Computers & Industrial Engineering*, vol. 113, pp. 333-346,2017.

Rodriguez O., Tost G., Redondo, J., Methodology for the Modeling of some Aspects Associated with Business Sustainability, and its Application in a Manufacturing Company. *Technological information,* vol. 30, no. 4, pp. 103-126,2019.

Statista Global Consumer, Paint and coatings industry worldwide- statistics & facts, Available: https://www.statista.com/topics/4755/paint-and-coatings-industry/#topicHeader__wrapper, November 12, 2019.

Biographies

Ariana Xiomara Balbin-Reymundo graduated from the University of Lima, where she studied industrial engineering from 2017 to 2022. She currently works in project logistics in a Cybersecurity company, previously she worked in a continuous improvement and consulting company for 1 year in the management area of projects, where he learned the importance of the synergy of the areas that involve having a company or organization. Additionally, knowledge in process diagnosis, planning of material requirements, master production plan, flow charts, DOP and DAP. Management of SAP ERP (Production and logistics modules), Power BI, and command of the English language.

Juan Carlos Quiroz-Flores is an MBA from Universidad ESAN. Industrial Engineer from Universidad de Lima. Ph.D. in Management and Business Administration at Universidad Nacional Mayor de San Marcos, Black Belt in Lean Six Sigma. Currently am an Undergraduate teacher at Universidad de Lima. Expert in Lean Supply Chain and Operations with over 20 years of professional experience in the direction and management of operations, process improvement, and productivity; specialist in the implementation of Continuing Improvement Projects, PDCA, TOC, and Lean Six Sigma. Leader of transformational projects, productivity, and change generator. Capable of forming high-performance teams, aligned to company strategies and programs for “Continuous Improvement”. He has published journal and conference papers. His research interests include supply chain management and logistics, lean manufacturing, lean six sigma, business process management, agribusiness, design work, facility layout design, systematic layout planning, quality management, and Lean TPM. He is a member of IEOM, IISE, ASQ, IEEE, and CIP (College of Engineers of Peru).

Martín Collao-Diaz at ESAN University and Industrial Engineer from the University of Lima specialized in supply chain management and operations. A leader with more than 25 years of a local and international experience in national and multinational companies in the industrial, hydrocarbon, and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution, and warehouse management), operations (planning and control of production and maintenance), and integrated system management (ISO 9001, ISO 14001, and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology among others focused to be a High - performance Organization (HPO). Development of a high-performance team. Member of IEEE and CIP (College of Engineers of Peru).

Alberto Flores-Pérez holds a doctorate degree in Education from Universidad de San Martin de Porres. Master’s degree in Supply Chain Management from Universidad ESAN. Engineer in Food Industries from Universidad Nacional Agraria La Molina. Currently working as an undergraduate professor at Universidad de Lima and postgraduate professor at Universidad Nacional Agraria. Professional, consultant, businessman, and professor with more than 27 years of experience in project implementation, quality management, safety, and agro-industrial plants management. Expert in Supply Chain (supplier management, storage systems, transport modeling, and distribution systems), Supply Chain, and Operations. Specialization in integrated management system audit and Shortsea Logistics at the Escola Europea Short Sea Shipping. Leader of transformational projects, productivity, and change generator. Specialist in the implementation of Continuing Improvement Projects, PDCA, HACCP, BPM in the agro-industrial sector, trainer of national government institutions and the United Nations (UNDP). Development of a high-performance team. Member of IEEE, SCEA Ohio, IOEM, and CIP (College of Engineers of Peru)