COMBINATION OF INDUTRIAL ENGINEERING PRINCIPLES INTO THE ART INDUSTRY: OPTIMIZATION MOVIE PRODUCTION PLANNING BY GENETIC ALGORITHM

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ABSTRACT

In this article, we present a case study of optimizing the production process for a short film in Italy, conducted by AM Production during pre-production. By applying principles of industrial engineering, we aimed to enhance production efficiency. Using simulation with genetic algorithms, we identified optimal production points, resulting in a significant cost reduction from approximately $60,000 to nearly $40,000. Importantly, our approach preserves the artistic integrity of the project, offering a more efficient planning framework. A key novelty of this work is the implementation of industrial engineering principles without disrupting the artistic vision. This study demonstrates the potential for industrial engineering to reduce costs and improve planning in artistic projects.

KEYWORDS

Industrial Engineering; Production Planning; Supply Chain; Optimization; Genetic Algorithm; Art Industry; Production Management; Industrialization.

1. INTRODUCTION

In an era characterized by rapid technological advancements and dynamic market landscapes, industries across the spectrum are embracing innovative methodologies to streamline operations, enhance efficiency, and optimize resource utilization. One such unconventional yet promising intersection lies in the integration of industrial engineering principles within the intricate realm of the movie industry. The art of filmmaking, often perceived as a creative endeavor, is underpinned by an extensive network of production processes, resource management, and logistical challenges. The convergence of industrial engineering with the movie industry presents an exciting opportunity to not only revolutionize traditional production paradigms but also to elevate the overall cinematic experience for audiences worldwide.

Historically, the movie industry has been defined by its artistic and storytelling dimensions. Filmmakers, cinematographers, and designers collaborate to craft compelling narratives that come alive on the silver screen.However, the intricacies involved in the production, distribution, and exhibition of movies are formidable, often leading to budget overruns, schedule delays, and

David C. Wyld et al. (Eds): SEC, NLPML, CYBI, SIGL, CRIS, AIAPP, CoSIT- 2024
pp. 127-136, 2024. CS & IT - CSCP 2024 DOI: 10.5121/csit.2024.140710

resource wastage. These challenges have sparked an industry-wide quest for operational improvements that maintain creative integrity while fostering economic sustainability.

Conversely, industrial engineering has thrived as a field dedicated to refining intricate systems by leveraging engineering principles, data analysis, and process enhancement techniques. Behind every single process in any industry is a system that could be run better by an industrial engineer. By transplanting the core tenets of industrial engineering into the movie industry, it becomes possible to mitigate bottlenecks, optimize resource allocation, and expedite project timelines.

This paper explores the synergistic potential of integrating industrial engineering practices into the film industry. Various categories within the movie industry can benefit from the integration of industrial engineering methods.This paper focused on the production planning in movie production and in this major it's been tried to reduced unnecessary costs that incurred project by wrong methods in production planning and enhance productivity by applying industrial management methods.

The integration of industrial engineering principles with filmmaking, offers a novel approach to reconcile artistic vision with operational efficiency. This paper lays out a structured framework for integrating these disciplines, paving the way for a thorough examination of how the fusion of creativity and engineering can redefine the entertainment industry's future. Industrial engineering principles have found success in diverse sectors like transportation, ports, automobile manufacturing, and even blood transfusion. Research indicates their significant positive impact on enhancing system productivity across these industries. [1,2,3,4,5]. And the integration of industrial engineering principles in production planning in different industries has al-ready been investigated [6,7]. This paper is about production planning problem in the movie, and tried to show the all-artistic groups or other occupation in all industries that with industrial engineers the procedure of any kind of industry could run better, and with system knowledge which is core of industrial engineering all process goes to achieved better productivity. There are some papers that was tried to enhance the procedure of movie production by using different method or tools. Cheng et al. (1999), Proposed is a solution to the scheduling problem in filmmaking using a branch-and-bound algorithm to minimize the cost due to talent hold days in the production of a feature film, without considering the actor availability[8]. Since efficient distribution is crucial for maximizing revenue, Rodrigues et al. (2006) addressed a significant gap in Operations Area studies, particularly in the realm of creative industries, and represents a pioneering quantitative analysis comparing vertical integration and performance within the film industry [9]. In a study conducted by Wang (2015), research focused on the movie talent scheduling problem by developing a model aimed at minimizing total talent costs. This model took into account variations in actors' fees and employed a genetic algorithm with an elitist strategy for smaller-sized problems and a discrete particle swarm optimization algorithm for larger-scale problems. However, a limitation of the study was the assumption of identical actor fees, which is unrealistic given that actors rarely receive equal compensation in real-world scenarios [10]. Aramuthakannan, et al. (2022) discussed the rapid growth of the Indian media and entertainment industry, specifically in Bollywood. It introduces a systematic scientific approach to a movie pre-production, utilizing network scheduling techniques like Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT), with findings indicating a marginal reduction in production time. [11]. Yu, et al., investigate the challenges affecting the revenue of domestic films, particularly focusing on the complexities involved in devising and executing effective ticket marketing strategies. Through an examination of the marketing environment [12]. Yanbing, et al. (2017) aimed to address the challenges in cinema scheduling by proposing a rational scheme that employs an intelligent optimization algorithm based on projection data. The objective is to enhance efficiency for theater managers, reducing scheduling time, and ultimately maximizing theater revenue. [13]. Forecasting the financial future is a crucial step in initiating

and establishing a production system, and determining the optimal approach to this process is paramount. And of course, one of the duties of the industrial engineer is to inform the investors and stakeholders of each project about the possible profit and loss of that project. Sahu et al. (2022) conducted predictive analysis during the initial phases of movie production. They offered detailed insights into forthcoming movies by introducing a CNN deep learning (DL) model aimed at constructing a multiclass movie popularity prediction system. This system aims to forecast the popularity of upcoming movies across diverse audience demographics[14]. On the other hand, S. R. S. Reddy et al. (2019), tried to suggested approach involves rating movies based on their set of features. The content-based movie recommendation system takes into account various movie characteristics, such as genre, actors' names, directors' names, and other attributes, to construct a recommender system. Specifically, the recommender system is developed by analyzing users' preferences for movie genres [15]. And in Y. Deldjoo et al. (2019) article a new movie recommendation system has been proposed and addresses the cold start problem for the new item [16].

As it can be seen, there are few researches in the field of integration of industrial engineering thinking in the film industry, and most of the existing researches are related to recent years. Contrary to the trend of industrialization of cinema and entertainment industry, there is still a tendency towards the traditional process and old planning model in the production stage of this industry. In this article, by implement-ing the principles of industrial engineering in the real world of the production of the entertainment industry, it has been proven that the full implementation of these principles will increase the profit and productivity of this industry. And this is one of the prominent points of this research, which takes into account all the factors of building the project in the real world, and the proposed model is completely consistent with the real production environment in the entertainment industry.

The main difference between this article and the articles that tried to improve filmmaking conditions by reducing costs is that in this article, all issues related to art and the artistic sector are considered without the involvement of industrial engineers. In this article, the production planning has been tried according to the director's in-tended time for filming each sequence. As a consequence, the production optimization discussed in this article respects the artistic vision of the director and preserves the artistic integrity of the film, ensuring no compromise on its artistic aspect. According to this important point, the filming days and the duration of each sequence are fixed according to the director's opinion, and also the director as art manager of project and other project agents do not feel any interference from the industrial engineer. Hence, the implementation of the findings in this article into real-world filmmaking becomes more feasible, facilitating the adoption of the suggested changes in filmmaking planning. Only according to the wishes of the artistic management of the project, the production planning is arranged taking into account the sci-ence of industrial engineering in such a way that the costs are reduced as much as possible.

This article emphasizes the role of industrial engineering in assisting film producers, leveraging the authors' extensive experience in film production. However, it acknowledges the challenge of integrating industrial engineering principles while respecting the artistic direction of the film director. Despite this, the article strives to present suggestions that can be realistically implemented in the film industry, considering all relevant factors to ensure practical application in real-world settings.

2. MATERIAL AND METHODS

2.1. Case Study:

This paper relies on information obtained from a film currently in the pre-production stage at AM Film Production company in Italy. The planning details incorporated in this paper are derived from the project planner's strategic plan formulated to guide the execution of this project. The budget that was determined by the project producer is based on this plan and all cost and expenses that producer admit-ted to incur either is solid based on this plan. This paper strives to enhance project profitability by implementing industrial engineering methods and insights. It aims to reduce project expenses while redesigning the production plan through industrial engineering principles, without compromising the artistic aspects of the project.

This movie is contained fifteen scenes that each scene contains a couple of shot that should be taken during the time that was determined for it. There are seven indoor scene, seven outdoor scene and one scene that should be taken inside a car, that was shown in table 1. In accordance with the director's decision, each scene is allotted a full day for filming, even if it could be completed in half a day. This paper adheres to this directive, ensuring consistency with the director's guidelines. The number of actors that are participated in this project are ten. There are ten actors A, B, C, D, E, F, G, H, I, J with different salary was chosen to work in this pro-ject by director. The salaries of these actors would be paid daily respectively 3500, 3000, 2000, 2000, 1800, 1500, 1500, 1000, 800, 500 dollars as can be seen at table 2.

Table 1. Divided scene based on their locations.

Location of scene	Indoor	Outdoor	In the car	Total
No of Scene	7	7	1	15

Table 2.Actors salary per day

Actor	A	B	C	D	E	F	G	H	I	J
Salary per day	3500$	3000$	2000$	2000$	1800$	1500$	1500$	1000$	800$	500$

According to the script of the project, all the actors are not present in all the scene, it means that an actor may be present in one scene but not be involved in the next one. But according to the law of Cinematic Contract, the contract of a film with actors must be concluded based on the day of the start of the collaboration and the end of the collaboration. In this scenario, the actor's availability is dictated by the contract, which specifies the duration of their commitment to the project. Once the contract expires, the actor has the freedom to sign with another project and is not obligated to remain available to the previous one. Figure 1 illustrate the movie production process operation, al-most all films follow a process similar to the one shown in Figure 1 in relation to their actors.

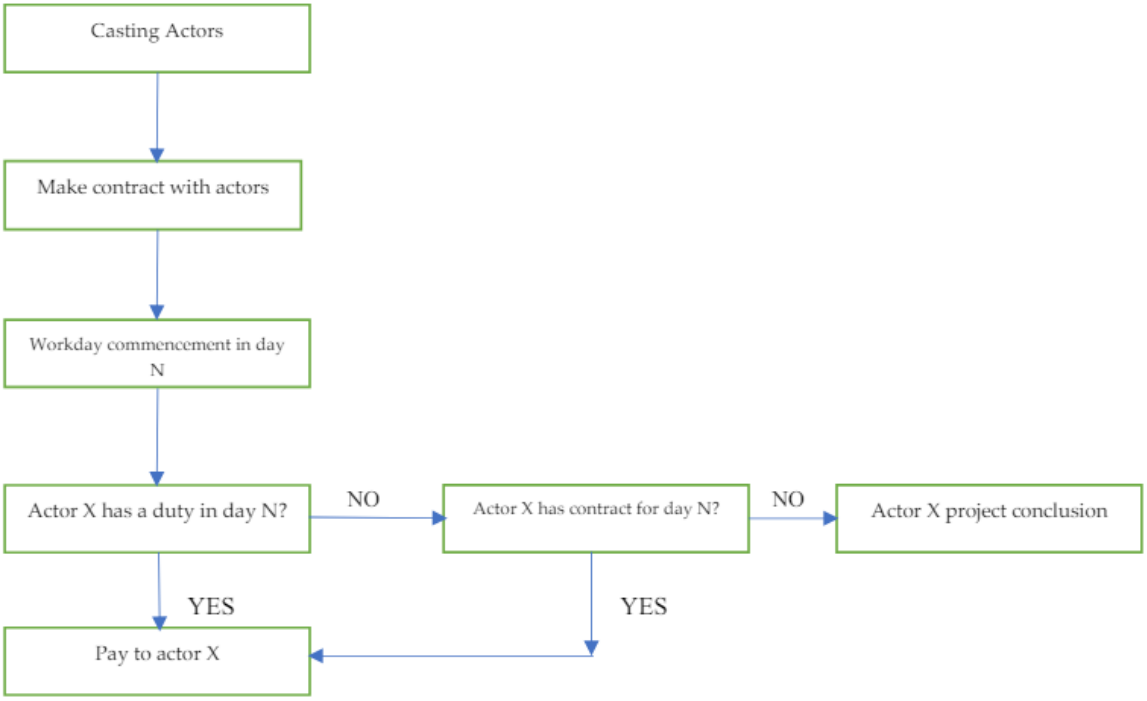

Figure 1. Every movie production process in the entire world.

Moreover, the presence of actors in the film based on the Scenes is shown at Table 3 and actors should be on set based on this following order:

Table 3. Information about the presence of actors in each scene.

Actor	Scene 1 (indoor)	Scene 2 (indoor)	Scene 3 (outdoor)	Scene 4 (outdoor)	Scene 5 (indoor)	Scene 6 (indoor)	Scene 7 (indoor)	Scene 8 (outdoor)	Scene 9 (outdoor)	Scene 10 (Car)
A	X	X	X	X		X		X		X
B	X		X		X	X		X		X
C	X			X	X		X			
D	X			X	X		X			
E			X	X			X		X	X

For the indoor scenes, an apartment was rented for a six-day period, comprising five days for shooting the indoor scenes and an additional day to ensure the completion of work. The decision to rent the apartment for six days was strategically made by the project planner to optimize costs, as the daily rent for the apartment amounted to $200. Consequently, the production plan was devised to align with this rental period, emphasizing the sequential recording of indoor scenes to minimize expenses. Following the project planner's directive, a common practice in movie production, filming commenced with the indoor scenes, adhering to a cost-effective approach. Subsequently, outdoor scenes were filmed accordingly, and the last day was allocated for the car scene. It is noteworthy that the project planner orchestrated this plan with the overarching goal of completing the filming production within a 12-day timeframe. This duration encompasses 10 days dedicated to shooting 10 scenes, in line with the director's preference for one scene per day, and an additional 2 days reserved as a Work Completion Guarantee (WCG).

Based on the decision that was made by project planner and production manager the order of the scene for filming will be as information that is provided in table 4:

Table 4. scene order plan for shooting based on the project planner decision. (WCG: work completion guarantee)

Days of Shooting	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
Scene's order	S 1	S 2	S 5	S 6	S 7	WCG	S 3	S 4	S 8	S 9	S 10	WCG

Based on this plane that is mentioned that it's like a common plan for film productions, the producer signed a contract with all actors for 12 days. The filming schedule allocates 10 days for principal photography according to the plan, with an additional two days allotted for quality assurance to ensure the project is executed satisfactorily. Moreover, there are other costs like apartment rent for six days and car rent for one day. Since this paper just focused on actors' availability planning, the expanse that films incur from this part of production is counted. It's evident that producers face numerous expenses during production; however, this paper does not account for all of these expenses. Specifically, the focus is not on all production costs but rather on a specific subset. Therefore, certain expenses are not included in the analysis presented here
Referring back to the previously mentioned data, the total costs associated with this section encompass actor salaries and apartment rental expenses. These costs, along with the project planner's proposed plan, will be outlined in Table 5.

Table 5. cost of project based on Project planner idea.

Type of costs	Actor A	Actor B	Actor C	Actor D	Actor E	Apt Rent	Car Rent	Total cost
Cost/Dollars	24000	18000	6000	6000	3000	12000	300	60900

As depicted in Table 5, the total project cost, based on the plan conducted by the project planner and project management, amounts to $60,900. This includes expenses for the apartment rental spanning six days, car rental for one day, and compensation for all actors throughout the entire project duration of twelve days. As previously noted, the project completion time is set at twelve days, with ten days allocated for shooting ten scenes, in accordance with the director's preference of one scene per day, and an additional two days reserved as a Work Completion Guarantee.

3. RESULT

Genetic algorithm is one of the best tools to find the optimum point in industrial engineering research. Genetic algorithm has even been used in research to find the optimal point in complex systems such as ports [17,18]. As mentioned earlier, this article primarily focuses on enhancing productivity through the production planning system, specifically centered around the project actors. Other factors have not been explored in this study. To achieve this objective, the project was simulated using a genetic algorithm with available data, and heuristic procedures were employed to develop an optimal production plan for the film.To achieve this objective, MATLAB coding was utilized to simulate the number of days each actor must be present and work on the project. A genetic algorithm was then employed to optimize the sequence of tasks, prioritizing actors based on their salary. Specifically, the sequencing order aimed to prioritize

tasks according to the actors' income levels, with an emphasis on completing the work of higher-paid actors earlier in the production process. Importantly, this optimization did not involve altering the assignment of actors to specific sequences but solely focused on rearranging the filming order for each sequence. As a result, the artistic direction of the project remained under the control of the director, ensuring minimal disruption to the artistic aspect of the film. The primary focus of this optimization was on production planning. After the applied the all information into GA, it shows the best solution or opti-mum solution for this project. The GA information is as following:

Population Size: 20; %Size of the population
Num Generation: 80; %Number of generation
Mutation Rate: 0.5; %Probability of mutation
Crossover Rate: 0.5; %Probability of crossover

The optimum solution based on the Genetic algorithm (GA) could reduce project total cost from 60900 to 43300.

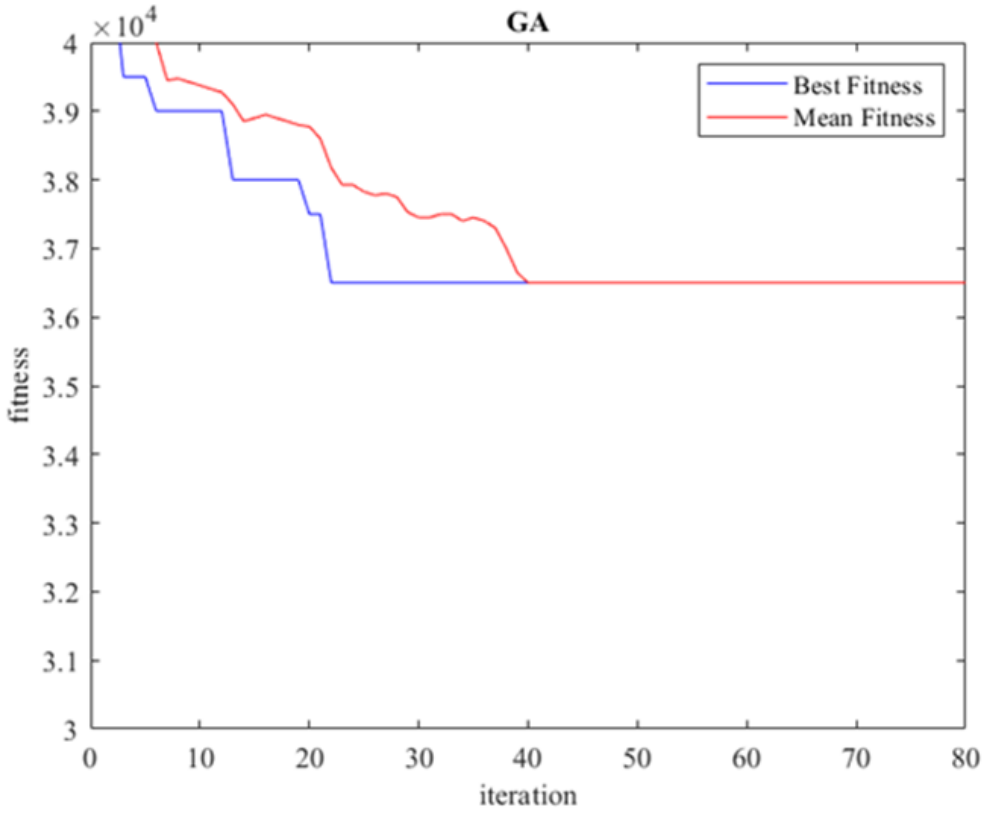

Figure 2: Genetic algorithm performance

The algorithm output resulted in a reduction of the project duration to ten days, accompanied by a significant decrease in project costs.Based on the proposed method of genetic algorithm is not necessary to make an appointment with all the actors of the project for the entire duration of the project. Rather, by changing the arrangement of the scene based on the earlier completion of the work of expensive actors instead of arranging the scene based on the location, the cost of the project can be reduced.

As a result, instead of having fixed contracts with actors for the entire project and short-term contracts for locations. According to the proposed model of the genetic algorithm, it should prioritize renting the location for the entire duration of the project. The sequence of scenes should then be adjusted based on the completion of work by the more expensive actors, ensuring that the tasks of higher-paid actors are completed earlier, thereby allowing for shorter-term contracts with them to be concluded. Moreover, after applying this procedure it's not necessarily to considered any more day as work completion guarantee on actor's contract.

4. DISCUSSION

While the genetic algorithm proposed numerous arrangements to enhance the project, this article focuses on presenting the best and most optimal arrangement among them, representing the pinnacle of optimization.According this this idea proposed by the genetic algorithm the order of the scenes for filming should be in the order shown in the figure. By following this sequence, the cost of the project will be optimized and the investment in this project will be more economical and its profit will be higher.

Table 5: Proposed scene order plan for shooting based on Genetic algorithm.

Days of Shooting	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Scene's order	S 5	S 3	S 1	S 10	S 6	S 8	S 2	S 4	S 7	S 9

As can be seen in Table 5 based on the proposed plan that generated by genetic algorithm the scene plans ordered shows that actor A job will be done at day eight and Actor B job will be done day sixth and Actors C, D and E jobs will be done at day ninth, ninth and ten respectively. Based on this, the contracts signed with the actors would be based on the last day of their work and their salaries would also be based on this basis. That mean the salary paid to actor B would be based on six days of work, and the salary of worker A will be based on 8 days of work, and the rest of the actors subsequently would be paid based on their last day of work.

With this method, unlike the usual procedure, it's not necessarily to sign the con-tract of all the actors until the end of the production period. And in this sense, the project will be more optimized. And of course, because the indoors scene are not recorded one after the other, it is necessary to have a rental contract with the apartment where the indoors scene are recorded for the entire duration of the project. This implies that the cost of renting an apartment for internal scenes will increase, but the overall project cost will decrease. Because based on this production planning method, contrary to the usual procedure in the film industry, instead of the sequence of recording the scenes based on the location, according to the sequence of the sequences is based on the earlier end of the working days of the expensive actors. Of course, all this proposed method is taken into consideration by the director without interfering with the artistic planning. Based on this procedure the optimized cost of this project is as follow chart in table 6:

Table 6: Cost of project based on Genetic Algorithm ideas.

Type of costs	Actor A	Actor B	Actor C	Actor D	Actor E	Apt Rent	Car Rent	Total cost
Cost / Dollars	16000	13500	4500	4500	2500	2000	300	43300

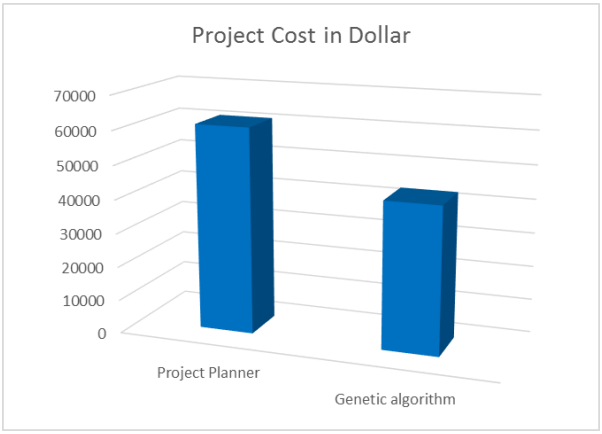

Figure 3: Production cost based on two different production plans.

As can be seen based on figure 3 information the production cost based on the plan that was proposed by genetic algorithm would be more beneficial rather than plan that was proposed by the project planner for this movie production managers and producers.

5. CONCLUSIONS

As previously highlighted, the integration of industrial engineering and its principles across revenue-generating production and service systems leads to enhanced profitability and cost reduction, thereby boosting operational efficiency. In this article, we explore the application of industrial engineering principles within the global film production industry, aiming to optimize production efficiency and achieve cost-effectiveness. Through the implementation of production planning grounded in industrial engineering methodologies, substantial cost savings of nearly twenty thousand dollars were achieved, resulting in heightened project efficiency and profitability. For the film examined in this study, production costs were initially estimated at close to sixty-one thousand dollars without the integration of industrial engineering principles. However, post-implementation, these costs were reduced to approximately forty-three thousand dollars, underscoring the profitability and efficacy of employing industrial engineers across all production sectors.This project demonstrates that by implementing industrial engineering principles in the film industry, productivity can be increased and production costs reduced by up to 30%.

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