Scholar Publishing Group
Kinetic Mechanical Engineering
https://doi.org/10.38007/KME.2021.020301
ISSN 2790-2676 Vol. 2, Issue 3: 1-10

Workshop Motion Simulation Based on Power Mechanical Engineering

Essimbi Andrea*
Tech Univ Cluj Napoca, Comp Sci Dept, Memorandumului 28, Cluj Napoca 400114, Romania
**corresponding author*

Keywords: Power Machinery, Mechanical Engineering, Mechanical Manufacturing, Workshop Motion Simulation

Abstract: With the continuous growth of its high-tech and intelligent industries and the continuous improvement of its population quality, China has become the largest manufacturing country. However, while developing, we should also recognize that the changing situation is a challenge. In the current era of intelligent development, China's MME need to change flexibly according to their own enterprise development situation in order to maintain strong competitiveness, quickly adapt to market demand and accelerate their intelligent development. The main purpose of this paper is to study workshop motion simulation (WMS) based on power mechanical engineering. This paper analyzes the characteristics of mechanical manufacturing (MM) enterprises, analyzes the concept and construction steps of AHP, and studies the optimization strategy of equipment system. Experiments show that MME should focus on analyzing the use of equipment in the factory, improve the utilization rate of equipment within a reasonable range, control equipment failures and maintenance processes, reduce the corresponding failure maintenance time, and make full use of equipment and other resources to achieve the ultimate goal of improving production efficiency.

1. Introduction

With the continuous development of global machinery manufacturing enterprises (MME) towards intelligence and efficiency, the advantage of low-cost production and manufacturing relying on labor has obviously faded. Therefore, China's MME must be based on the current market situation and the global competitive environment, and start from their own actual production situation, reduce the waste of resources, improve the production efficiency of enterprises, improve the economic efficiency of enterprises, and greatly improve the production efficiency, Maintain its long-term business capability [1-2].

In relevant research, Asadi et al. mentioned that the motion simulation platform (MSP) is widely used to generate driving/flight motion sense for users [3]. Due to the dynamic and physical limitations of the active joints of the motion platform and the physical limitations of the passive joints, the working area of the MSP is limited. Therefore, an adaptive flushing filter (WF) was developed to take into account the human vestibular system and improve the efficiency of the method using time-varying filters. Kamalapurkar et al. mentioned that the goal of motion tomography is to restore the description of the vector flow field using the measured values along the trajectory of the sensor unit [4]. A predictor corrector algorithm is developed to recover the vector flow field from the trajectory data using the occupation kernel. The initial estimate is established, and then under mild assumptions, such as the trajectory of the relative straight line, the convergence is proved by using the contraction mapping theorem.

At present, the overall development of domestic MME in China shows a trend of horizontal expansion, while the depth of vertical development within the system is still insufficient, and the production efficiency of enterprises has not reached the standard even when the labor cost advantage is lost [5-6]. The purpose of this paper is to make a detailed analysis of the internal links of the production of domestic MME, study the key factors that affect the production efficiency of each link, and establish a simulation model of the production efficiency of domestic MME.

2. Design Research

2.1. Characteristics of MME

The characteristics of MME are generally as follows:

(1) Standardized management: standardization is the main feature of China's contemporary MME, which mainly includes the standardization of production operations, process operations and management models [7-8].

(2) Systematic management: MM enterprises promote systematic management in implementation, make full use of internal and external resources, find the best allocation of resources, carry out effective merger and reorganization, and achieve the strategic objectives of manufacturing enterprises [9-10].

(3) Process management: Focusing on a certain product of a MM enterprise, the whole resource is allocated and integrated from the source of production, weakening the previous functional management mode.

(4) Information management: MM enterprises must effectively use information, pay attention to information transmission and sharing.

2.2. System Dynamics Simulation (SDS)

SD makes use of qualitative and quantitative research and simulation methods to simplify complex and changeable problems. It is the application of system based simulation and reasoning simulation [11-12]. The system model is established according to the theory of SD and the steps of model establishment. The simulation is carried out with the aid of software simulation system, and the system problems are solved by combining qualitative and quantitative analysis.

The SD analysis of the studied problem is based on the correlation between the system and the internal mechanism, through establishing the corresponding simulation model, determining the parameters and their initial values, and then conducting simulation. The causal relationship among the factors found in the whole process of establishing the model is called structure [13-14] in SD. The model simulation constructed by SD is a simulation that integrates structure and function, and is widely used to analyze and solve complex system problems. The main functions of SDS are as follows:

(1) The process of SDS is not only a simulation experiment, but also a real and systematic process of collecting and accumulating useful information. The SDS is mostly applicable to some complex problems. The system simulation technology can be used to simulate the system according to the required information [15-16].

(2) For some target systems that are difficult to build models, we can complete some problems such as prediction and evaluation by building simulation models to control the real situation of the system.

(3) Through SDS, the complex target system is decomposed into different subsystems, which facilitates the subsequent research and analysis.

(4) Through SDS, some problems in the system can be revealed, and new strategies can be found in time to improve and optimize the system [17-18].

3. Experimental Study

3.1. Concept and Construction Steps of AHP

Analytic Hierarchy Process (AHP) is often used to analyze problems with many criteria and objectives, and the method has greater flexibility. The basic construction steps of AHP are as follows:

(1) Establish hierarchical structure model

When applying AHP method to solve problems, it is necessary to build a clear hierarchical analysis model. It is divided into three levels, among which, the explanations of each level are as follows:,

Top level (target level): indicates the target to be analyzed and solved;

Intermediate layer (criterion layer): all intermediate layers involved in solving the overall goal;

Bottom layer (scheme layer): measures, indicators, procedures, etc. established to solve the overall goal.

(2) Construct the judgment matrix of each level

Under the same criteria, compare the indicators of the same layer in pairs, and define the judgment matrix A=(aij)n*n according to the 9-scale method.

Table 1. AHP nine scale method

Scale	One factor is more important than another
1	Equally important
3	Slightly important
5	Obviously important
7	Strongly important
9	Extremely important
2,4,6,8	The median value between the above two judgments
reciprocal	The ratio of importance of index xi to xj is aij, so the ratio of importance of xj to xi is aij=1/aij

(3) Single Ranking and Consistency Test of Hierarchy

Calculate the judgment matrix A corresponding to the criterion level for the indicators of this level. For each judgment matrix A, it corresponds to the following characteristic equation:

$$AW = \lambda W \tag{1}$$

Where, λ Represent the eigenvalue of the judgment matrix; W stands for and λ The corresponding eigenvector. Maximum eigenvector λ Max corresponds. Finally, check whether matrix A is consistent according to formula (2).

$$CR = \frac{\frac{\lambda_{\max} - n}{n-1}}{RI} \tag{2}$$

Where, CR is the consistency ratio coefficient of A. λ Max is the maximum characteristic root of A. RI is the random consistency index, as shown in Table 2-3. If CR ⩽ 0.1, A passes the consistency check. If CR>0.1, A needs to be adjusted accordingly until it meets the consistency check.

Table 2. Average random consistency index R.I

Order	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

(4) Hierarchical Total Ranking and Consistency Test

Calculate the importance of all elements in each layer relative to the highest level:

$$\alpha^k = \beta^k \alpha^{k-1} \tag{3}$$

Where, α K is the ranking weight vector of k-level elements relative to the highest level; β K is the weight vector of layer k relative to layer k-1; α K-1 is the weight vector of layer k-1 relative to the highest layer.

The sorting weight formula is:

$$\alpha^k = \beta^k \beta^{k-1} \Lambda\ \beta^3 \alpha^2, 3 \le k \le h \tag{4}$$

Where, α 2 is the weight vector of the second layer elements; H is the number of layers.

Consistency check on the weight of total hierarchical sorting is consistent with that of single sorting. If the CR is less than 0.1, it is considered that the consistency inspection is finally passed; otherwise, it is not passed and needs to be adjusted.

3.2 SD Modeling Steps

The modeling of SD is mainly divided into the following five steps. The overall modeling steps are shown in Figure 1 below.

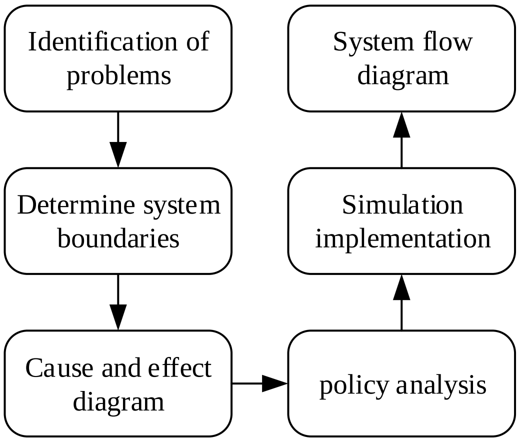

Figure 1. Modeling process diagram of SD

(1) System analysis

System analysis is the first step to deal with complex problems by using SD. Its main task is to analyze the problems of the target system and find out the main causes.

The main steps of system analysis: collect the current status of the system and make statistics on the data; Fully understand the user requirements, specify the purpose of system research and the problems to be solved; Clearly define the problems, variables and contradictions of the system and conduct systematic and comprehensive analysis; Define the boundary of the system, and distinguish the initial variables, external dependent variables and input variables; Identify the patterns of system behavior.

(2) System structure analysis

Its purpose is to simplify the information in the system and analyze and build the feedback mechanism existing in the system.

(3) Establishing a normative mathematical model

Establishment steps: establish L-horizontal variable, R-rate variable, A-auxiliary variable, C-constant, etc; Estimate the parameters; Assign values to all parameters.

(4) Model simulation and policy analysis

Analysis steps: conduct simulation and analysis of different strategies, and deeply analyze the system; Seek new strategies to solve system problems, and conduct simulation again to obtain optimized information and further discover new problems; Modify and improve the model, and improve the parameters and system structure.

(5) Model inspection and evaluation

The SD method is a process of gradually approaching to the real system simulation through system decomposition, comprehensive simulation and cycle iteration. The length and difficulty of the SDS process is related to the complexity of the studied system and also to the research goal. For the process of application and SD research, its system modeling is not a success. The establishment of the model requires model modification, parameter debugging, etc. based on the real feedback of the studied system, until the establishment of a model that meets the requirements of system research. The inspection and evaluation of the model are involved in the above steps. As shown in Figure 2 below, it is a cyclic process diagram of model modification after evaluation during the modeling process.

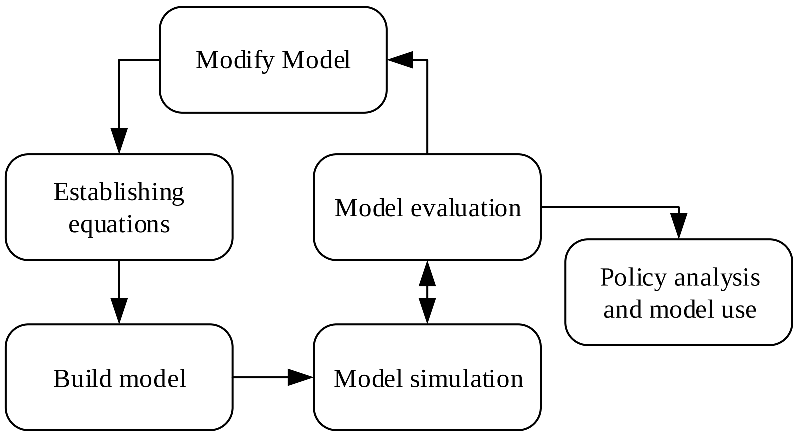

Figure 2. Assessment process diagram of SD

4. Experimental Analysis of Equipment System Optimization Strategy

Equipment is an important material basis in the production process. Scientific equipment management can effectively improve the production efficiency of enterprise equipment. The effective use of equipment in the production process and the increase of its actual use time have a significant role in promoting the enterprise's production efficiency. According to the equipment production data of the enterprise, a five-year forecast is made. According to the simulation results, different optimization strategies are formulated and the equipment system optimization strategy is simulated to compare the improvement of the enterprise's production efficiency before and after the change of the strategy, and further provide reference for the effective use of enterprise equipment.

Table 3. Index values of equipment optimization strategy

Strategy	Policy parameter value
Original strategy	Equipment utilization rate=0.80, equipment failure time=570 hours, equipment maintenance time=420 hours
Strategy 1	Equipment utilization rate=0.87, equipment failure time=570 hours, equipment maintenance time=420 hours
Strategy 2	Equipment utilization rate=0.87, equipment failure time=456 hours, equipment maintenance time=420 hours

It can be seen from Table 3 above that the original parameter values set by the enterprise correspond to the original strategy in the table above, the equipment utilization rate is the initial value of 0.80, and the equipment failure time and equipment maintenance time are 570 hours and 420 hours respectively. Strategy 1 only changes the equipment utilization rate from 0.76 to 0.87, and the other parameters remain unchanged. Strategy 2 reduces the failure time to 4/5 of the original 456 hours based on Strategy 1. Strategy 3 is to further reduce the equipment maintenance time to 4/5 of the original 336 hours on the basis of strategy 2.

According to the above different strategies, the simulation results of the actual operation time and production efficiency change value of the equipment are shown in Table 4 and Table 5.

Table 4. Variation of actual operation time of equipment

Time/Policy	1	2	3	4	5	6
Original strategy	66518.81	69432.36	71969.72	74405.79	76399.71	78321.85
Strategy 1	72413.33	75532.69	78416.92	80911.01	83223.33	85312.54
Strategy 2	72556.36	75561.70	78511.94	81107.22	83401.31	85445.51

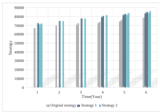

Figure 3. Statistics of actual operation time change of equipment

It can be seen from Figure 3 that the actual operation time of enterprise equipment in the past six years has changed to varying degrees due to different optimization strategies. It can be seen from the figure that since the device utilization is improved, the device time simulation results of Strategy 1 are significantly increased compared with the original strategy. Strategy 3 not only improves the utilization rate of equipment, but also reduces the failure time and maintenance time of equipment. In terms of actual operation time of equipment, Strategy 3 has greatly improved compared with Strategy 1. In the sixth year, the actual operation time of equipment has increased to nearly 85373 hours.

Table 5. Change value of equipment production efficiency

Time/Policy	1	2	3	4	5	6
Original strategy	0.788	0.789	0.789	0.789	0.790	0.790
Strategy 1	0.858	0.859	0.859	0.859	0.860	0.860
Strategy 2	0.860	0.860	0.860	0.861	0.861	0.861
Strategy 3	0.861	0.861	0.861	0.862	0.862	0.862

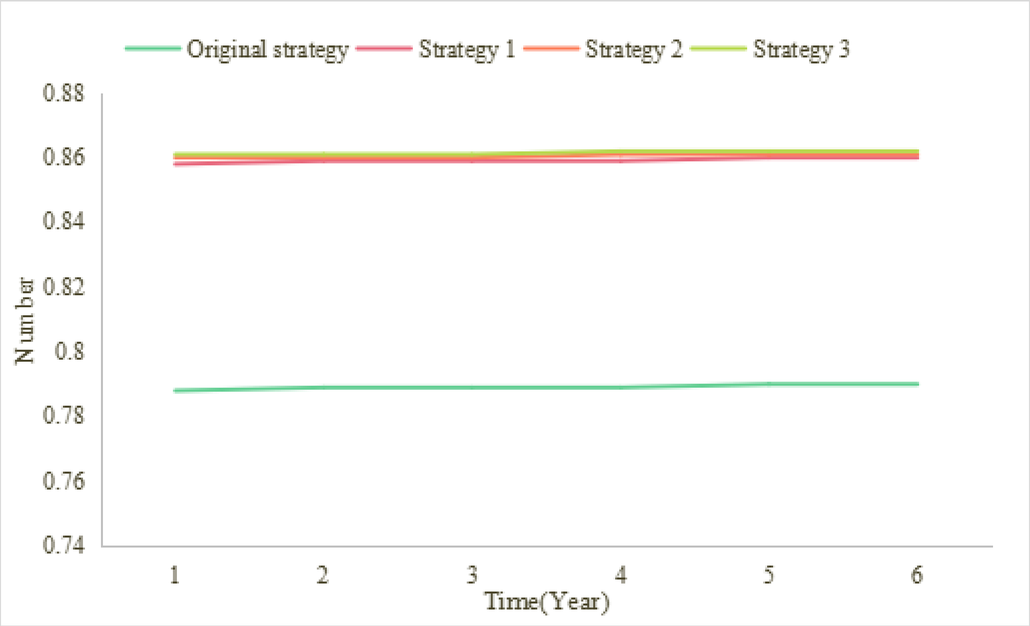

Figure 4. Analysis of change value of equipment production efficiency

It can be seen from Figure 4 that the changes of the original strategy and the three improvement strategies have an impact on the equipment productivity. Compared with the original strategy, strategy 1 has greatly improved the utilization of equipment. Without changing the number of original equipment, the actual operation time of all equipment has increased significantly, and the production efficiency has also improved significantly. Strategy 2 reduces the equipment failure time to 4/5 of the original. Compared with strategy 1, the equipment productivity has not changed significantly. Strategy 3 changes the equipment maintenance time on the basis of strategy 2 to further improve the equipment production efficiency. Compared with the original strategy, the production efficiency will be increased from 0.79 to 0.86 in the sixth year, with the most obvious optimization effect.

5. Conclusion

Low production efficiency is one of the main weaknesses in the development of China's MME. China's MME still have a lot of room for progress in the management and application of production technology, especially for the low labor productivity and low industrial value-added rate. Under the new situation, MME need to improve their production efficiency, control all kinds of costs required for production, and withstand the basic pressure of price competition to accelerate the transformation of enterprises and obtain more market space. The simulation results of equipment system optimization with different strategies show that the economic way for enterprises to improve equipment production efficiency is to optimize the existing internal equipment. More equipment procurement cannot fundamentally solve the problem of production efficiency. MME should focus on analyzing the use of equipment in the factory, improve the utilization rate of equipment within a reasonable range, control equipment failures and maintenance processes, reduce the corresponding failure maintenance time, and make full use of equipment and other resources to achieve the ultimate goal of improving production efficiency.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Sajjadi M, Pishkenari H N, Vossoughi G. Image acquisition for trolling-mode atomic force microscopy based on dynamical equations of motion. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 2021, 235(18):3654-3677. https://doi.org/10.1177/0954406220977554

[2] Mokhtari M, Taghizadeh M, Ghanbari P G. Fault tolerant control based on backstepping nonsingular terminal integral sliding mode and impedance control for a lower limb exoskeleton. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 2021, 236(6):2698-2713. https://doi.org/10.1177/09544062211035792

[3] Asadi H, Bellmann T, Mohamed S, et al. Adaptive Washout Filter Based on Fuzzy Logic for a MSP With Consideration of Joints Limitations. IEEE Transactions on Vehicular Technology, 2020, PP(99):1-1.

[4] Kamalapurkar R, Chang D, Rosenfeld J A, et al. Motion tomography via occupation kernels. Journal of Computational Dynamics, 2021, 9(1):27-45. https://doi.org/10.3934/jcd.2021026

[5] Ahmadi B, Ahmadi B, Chegini S N, et al. Multi-objective reliability-based optimal synthesis of path generating four-bar mechanisms: A cooperative game theoretic approach. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 2021, 236(5):2298-2311. https://doi.org/10.1177/09544062211028902

[6] Netshimbupfe A F, Abdalla M, Erdem B D, et al. Solid Work simulation as a virtual laboratory concept for supporting student learning of mechanical engineering. New Trends and Issues Proceedings on Humanities and Social Sciences, 2020, 7(3):53-60. https://doi.org/10.18844/prosoc.v7i3.5233

[7] Georgiades F, Hedrih A, Atanasovska I, et al. Investigation on hardness testing of cemented carbide tool based on finite element method. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 2021, 235(20):5057-5069. https://doi.org/10.1177/0954406220976169

[8] Zaidi A, Taallah B, Izemmouren O, et al. Mechanical and durability properties of adobe blocks filled with date palm wastes. World Journal of Engineering, 2021, 19(4):532-545. https://doi.org/10.1108/WJE-02-2021-0094

[9] Ambade S, Tembhurkar C, Pantawane P, et al. Shielded metal arc welding of AISI 409M ferritic stainless steel: study on mechanical, intergranular corrosion properties and microstructure analysis. World Journal of Engineering, 2021, 19(3):266-273. https://doi.org/10.1108/WJE-03-2021-0146

[10] Sharma P, Singh R, Foropon C, et al. The role of big data and predictive analytics in the employee retention: a resource-based view. International Journal of Manpower, 2021, 43(2):411-447. https://doi.org/10.1108/IJM-03-2021-0197

[11] Ishizaka A, Prikshat V, Patel P, et al. A multi-stakeholder ethical framework for AI-augmented HRM. International Journal of Manpower, 2021, 43(1):226-250. https://doi.org/10.1108/IJM-03-2021-0118

[12] Dehghan M, Hooshyarfarzin B, Abbaszadeh M. Proper orthogonal decomposition Pascal polynomial-based method for solving Sobolev equation. International Journal of Numerical Methods for Heat & Fluid Flow, 2021, 32(7):2506-2542. https://doi.org/10.1108/HFF-09-2021-0598

[13] Buragohain M, Das N K D. A neoteric closed loop feedback controller based on correlative-elemental curvature algorithm. Circuit World, 2021, 48(3):341-353. https://doi.org/10.1108/CW-06-2020-0107

[14] Kunju F K F, Naveed N, Anwar M N, et al. Production and maintenance in industries: impact of industry 4.0. Industrial Robot: the international journal of robotics research and application, 2021, 49(3):461-475. https://doi.org/10.1108/IR-09-2021-0211

[15] Ghosh S K, Singh S. Pressure drop and heat transfer characteristics in 60 °Chevron plate heat exchanger using Al2O3, GNP and MWCNT nanofluids. International Journal of Numerical Methods for Heat & Fluid Flow, 2021, 32(8):2750-2777. https://doi.org/10.1108/HFF-08-2021-0580

[16] Ebrahimpour Z, Sheikholeslami M, Farshad S A. Heat transfer within linear Fresnel unit using parabolic reflector. International Journal of Numerical Methods for Heat & Fluid Flow, 2021, 32(8):2841-2863. https://doi.org/10.1108/HFF-05-2021-0338

[17] Johansson O, Rlestig H. Democratic governing ideals and the power of intervening spaces as prerequisite for student learning. Journal of Educational Administration, 2021, 60(3):340-353. https://doi.org/10.1108/JEA-04-2021-0079

[18] Chalakqazani M R, Asadi H, Nahavandi S. An Optimal Motion Cueing Algorithm Using the Inverse Kinematic solution of the Hexapod Simulation Platform. IEEE Transactions on Intelligent Vehicles, 2021, PP(99):1-1. https://doi.org/10.1109/TIV.2021.3068286