Optimization Method of High-Speed Train Composite Material Workshop Planning and Scheduling

Yanliang Jie, Lei Hao, Shujun Yan, and Xueli Zhang

College of Mechanical and Electrical Engineering, Xi’an Traffic Engineering Institute, Xi’an 710300, Shaanxi, China

Correspondence should be addressed to Shujun Yan; yanshujun@xjy.edu.cn

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1. Introduction

Manufacturing applications are everywhere in people’s lives, and it is a key industry of the national economy. What needs to be emphasized is that the country’s economic growth is also realized by the manufacturing industry, so the speed of the manufacturing industry will affect the economic strength of a country. The scheduling plan of production line or production equipment mainly solves the problems of production sequence, production quantity, production start and end time, production end time, and production cycle of each product in the actual production process. These problems are the parts that cannot be planned by the enterprise production planning and control and are the actual production operation level of the enterprise.

The birth of high-speed trains is precisely to satisfy people’s desire for efficient and environmentally friendly travel. As a new modern means of transportation, high-speed trains have unique advantages whether they are safe, efficient, environmentally and friendly, and convenient. Electricity is the power source of high-speed trains, so the stability and reliability of the power system play a vital role in the safe operation of high-speed trains. As we all know, trains must be stopped and started according to actual road...
conditions, time requirements, and other factors during operation, including continuous adjustment of vehicle speed, which has very high requirements for the power system.

With the continuous progress of computer technology, the use of advanced information management technology to manage the production process has become an unstoppable trend. White and Hahn believe that, in the production of composite parts, the relevant processing parameters are time, temperature, and pressure. They believe that one of the most important issues in composite material processing is residual stress. Due to the introduction of preload, the strength is adversely affected by residual stress. They developed a process model that can be used to predict the residual stress history of composite laminates during curing. At the same time, they applied curing kinetics and visible coelastic stress analysis to obtain the residual bending moment and curvature of the asymmetric cross-layer laminate. Although their research has certain reference value, the factors considered are not comprehensive [1].

Sfarra et al. examined three different types of laminates, each of which was implemented with thirteen layers of fabric in an epoxy matrix. In the first one, only aramid fibers are used, while the other two are hybrid laminates reinforced by mixed basalt and aramid fibers; the basalt and aramid fibers are arranged in an intercalated or sandwich-like structure. All laminates were subjected to an energy impact of 12.5 J. They used different nondestructive testing (NDT) methods to check the impacted laminate. Although their experiment clarified the material changes, the research content was not accurate [2]. Abdel-Hady et al. introduced the design, simulation, and manufacturing process of an integrated thermal photovoltaic enclosed parabolic collector (ITPV CPC) using composite materials. Their design includes two flanges for supporting photovoltaic panels. They performed simulations based on 3D modeling and structural finite element analysis (FEA). In the simulation, the upper limit of the wind pressure and temperature rises load that the ITPVCPC structure bears is similar to the actual working conditions. They performed an optical analysis of the sink to study the effect of structural deformation on the collection of sunlight. Although the cost of the materials that they developed is relatively low, they lack certain experimental data [3].

Chen et al. were unable to determine the fiber quality after conventional drying treatment for wood plastic composites (WPC) before use. They first studied the effect of pulsed cyclone drying (ICD) on the quality of poplar wood fibers by applying scanning electron microscope, Fourier transform infrared spectroscopy, and X-ray diffraction techniques. Subsequently, they considered the influence of ICD conditions (such as inlet temperature, inlet wind speed, and feed rate) on the mechanical properties and fiber dispersion of WPC. In addition, they compared the quality of the fiber and WPC with the quality of the fiber and WPC processed by the oven drying method. Although their research has certain feasibility, it still has certain flaws [4].

Varadan et al. describe the first direct measurements of the material properties \( \varepsilon, \mu, \) and \( \beta \) of microwave chiral composites prepared in the laboratory in the frequency range of 8–40 GHz. Reflection and transmission measurements of normally incident linearly polarized plane waves were carried out in a specially designed free-space facility using a point-focusing antenna. It is shown that \( \varepsilon \) and \( \mu \) are comparable for all three samples at a given concentration, but \( \beta \) has equal but opposite values for left- and right-handed samples, while it is nearly zero for isochiral samples [5].

In order to make the workshop production process orderly, the time window constraint is applied to the hybrid flow shop load balancing scheduling process with reentrant process constraint, so that each workpiece to be processed starts processing at a fixed time node in each process, which is more conducive to evenly distributing processing tasks to related stations and balancing the load of parallel stations. This paper fully considers the most important index of scheduling problem and the important characteristics of multiobjective flexible job scheduling problem, which is different from the classic job shop problem and involves the reasonable utilization of enterprise resources.

The innovation of this paper is that it is developed using ASP.NET technology with a B/S-based architecture model to determine the order allocation for each production line and define the order processing order according to a predefined order scheduling plan. Then, according to the specifications of each order, the combination of production parameters for each process is predefined before production processing.

2. Optimization of Workshop Planning and Scheduling

2.1. High-Speed Train. The vibration of high-speed train will not only cause physical injury to drivers and passengers, but also damage the train and track line, endangering the safety of railway operation. The vibration of the train makes the mechanical equipment fatigue wear, stiffness, and strength broken, shortening the service life of the equipment; in the operation of the train, excessive vibration will affect the smoothness of the vehicle and endanger the operation safety of the train; when the train passes through bridges, tunnels, and other places, the vibration of the train will also pass through the track to the building, endangering the safety of bridges and other buildings [5]. Broadly speaking, high-speed trains refer to trains that can operate at a maximum speed of 200 km/h or more. It is generally considered that, for land transportation, a travel speed of 200 km/h and above can be considered high speed.

Generally, it is carried out under the working state of the mechanical system. By monitoring the running mechanical equipment and measuring the external vibration signal, or by exciting the equipment under nonworking conditions, the relevant signals are obtained through analysis, so as to judge the mechanical vibration situation and provide the basis for the vibration reduction work. Due to the variety of materials in the composite material workshop and the specificity of raw materials, perishable materials, and other materials, on the basis of developing the basic material inventory management function module, it is also necessary to develop a material management system suitable for the
composite material workshop according to their different characteristics, and it should have certain universality [6].

High-speed trains are not the same as high-speed railroads. High-speed trains are cars and high-speed railroads are roads, which are closely related but not the same concept. As long as the railroad system and the train system are compatible with each other, high-speed trains can run on the corresponding lines.

According to the requirements of manufacturing enterprises, important parts and materials should be effectively tracked in the whole life cycle of products. According to a specific batch and sort, the specific materials used in the product can be found intuitively and conveniently. The common feature of this kind of materials is that there are many tiny cavity structures or layered structures in the materials, so the materials have certain ventilation [7, 8]. High-speed trains belong to modern high-speed transportation, which is the centralized embodiment of the top science and technology of trains and can significantly increase the speed of train travel and thus improve the efficiency of train transportation. High-speed trains are fast and comfortable, smooth and safe, energy-saving, and environmentally friendly.

2.2. Composite Materials. Figure 1 shows the microstructure of aluminum-silicon composites of different sizes after extrusion heat treatment. The grain size in the composite material prepared by spray deposition is very small. At the micron level, the grain size provides indirect strengthening by affecting the grain size which is relatively weak and can be ignored; and the particle size has a dislocation in the matrix of the composite material. The impact is more significant [9].

If we can consider the influencing factors of the mold stacking process in the purification workshop and accurately predict the start time, processing time, and completion time of the mold in the purification workshop, then the layout scheduling plan based on this will be more consistent with the actual situation. This paper studies the modeling of the influencing factors of the mold in the cleaning workshop scheduling process and designs a reasonable adjustment strategy for the relevant factors, so the mold scheduling in the cleaning workshop is a dynamic scheduling problem [10, 11].

Composite materials are new materials made by optimizing the combination of material components with different properties using advanced material preparation techniques. Generally, defined composite materials need to meet the following conditions: (1) composite materials must be man-made; materials should be designed and manufactured by people according to their needs; (2) composite materials must be made of two or more material components with different chemical and physical properties, combined in the designed form, proportion, and distribution, with obvious interfaces between the components.

Because the dynamic scheduling is based on the actual production, the corresponding adjustment strategy is put forward, so the dynamic scheduling model is more suitable for the actual production process, so the operation plan based on the dynamic scheduling model is more practical. In the hybrid flow shop scheduling optimization simulation model, the event model maps to the production process, and the trigger execution constraints of the event are the process path and the processing time of the corresponding process [12]. In the production process, when a product is processed in a certain station of the production line, the next specified process will be selected according to the requirements of the processing technology. This process corresponds to multiple stations. The process of station selection is the process of dynamic production scheduling. From the perspective of simulation scheduling, the main purpose of the event mechanism in the production process is to simulate the real-time production process. Each stage of the production process requires a certain amount of time. With the passage of time, when it reaches a specific point in time, the state of the system will change; that is, the event is triggered to execute [13, 14]. The molding methods of composite materials vary according to the matrix materials. There are many molding methods for resin-based composites, such as hand-paste molding, injection molding, fiber winding molding, and molding.

2.3. Planning and Scheduling Optimization. Suppose that $\sigma$ is an effective schedule and $\alpha, \beta, \lambda$ is a nonnegative constant; then the optimized objective function is $f(\sigma)$; then,

$$f(\sigma) = \sum_{i} [\alpha E_i + \beta T_i] + \lambda R_S. \quad (1)$$

In the evaluation of the fitness function, a moderate selection method is also adopted to make excellent individuals survive as much as possible. At the same time, in order to avoid the appearance of "premature" phenomenon, the exchange form is used for mutation, and the elite is used in the mutation process. Selection and mutation algorithms also add heuristic methods. Most of the products do not take the disassembly process into consideration in the design. Due to the difference in the connection method and matching size of the parts, the disassembly time and process methods of the waste products will be affected. There are differences in the disassembly rate and disassembly time of
waste products with different usage conditions and degree of
damage, which makes the calculation of working hours
quota and the setting of lead time extremely difficult [15, 16].
Let $\xi$ be a triangular fuzzy random variable, and its
density function is

$$\varphi(x) = \begin{cases} 
1/2\alpha, & \text{if } \rho - \alpha \leq x \leq \rho, \\
1/2\alpha, & \text{if } \rho \leq x \leq \rho + \beta, \\
0, & \text{other.} 
\end{cases} \quad (2)$$

Among them, $\alpha > 0$ is called the left span, and $\beta > 0$ is
called the right span. For a nonnegative fuzzy random
variable $X$ and any real number $s$, the moment generating
function can be expressed as

$$M^F_X(s) = E[e^{sx}] = \int_{-\infty}^{\infty} e^{sx} \varphi(x) \, dx. \quad (3)$$

For the triangular fuzzy random variable $\xi = (\rho - x, \rho, \rho + \beta)$, the moment generating function is

$$M^F_\xi(s) = \int_{\rho-\alpha}^{\rho+\beta} e^{sx} (1/2\alpha) \, dx$$

$$+ \int_{\rho+\beta}^{\infty} e^{sx} (1/2\beta) \, dx = e^{sp} \frac{(1-e^{-\alpha s}) + e^{\beta s} - 1}{\alpha \beta} \quad (4)$$

The directly reused part passes through node 1-node 2-
node 11. Its equivalent transfer function is

$$W^F_{E,11}(s) = w_{12}(s)w_{11}(s) = p_{12}p_{11}e^{s(\lambda_{11} - \lambda_{111} - s)} \quad (5)$$

The material recovery part passes through node 1-node 2-
node 10. Its equivalent transfer function is

$$W^F_{E,10}(s) = w_{12}(s)w_{10}(s) = p_{12}p_{10}e^{s(\lambda_{10} - \lambda_{110} - s)} \quad (6)$$

For any $i \in \{1, 2, ..., r\}$, define the fuzzy variable
$\zeta_{m,i} = g_{m,i}(\xi)$, $m = 1, 2, ...$; the function $g_{m,i}$ can be expressed as the following form:

$$g_{m,i}(u) = \begin{cases} 
a_i, & u_i \in [a_i, a_i + \frac{1}{m}] \\
\sup \left\{ \frac{k_i}{m} | k_i \in Z, \frac{k_i}{m} \leq u_i \right\}, & u_i \in [a_i + \frac{1}{m}, b_i]. 
\end{cases} \quad (7)$$

where $Z$ is the set of integers.

Assuming that the number of optimized feature points in
the $k$-th frame is $N_t$, $N_t > 0$ and the number of feature lines
is $N_i$, $N_i < 0$, the calculation formula for the number of iterations is as follows:

$$T_{\text{temp}} = \left[ \frac{w_p N_p + w_i N_i}{D_i} \times T_{\text{max}} \right] \quad (8)$$

$$T = \begin{cases} 
1, & T_{\text{temp}} < 1, \\
T_{\text{temp}} \leq T_{\text{temp}} \leq T_{\text{max}}, \\
T_{\text{max}} > T_{\text{max}}. 
\end{cases} \quad (9)$$

Among them, $w_p$ and $w_i$ are the weights of feature points
and feature lines, respectively, and $T_{\text{max}}$ is the maximum
number of iterations in all frames.

After the hybrid feature construction is completed, the
method based on key frames can be used to perform hybrid
feature matching and calculate camera motion related pa-
rameters [17]. Specifically, the degree of dispersion of each
stable feature line is determined by the number of optimized
feature points, the number of stable feature lines, and the
length of the feature line:

$$N_{\text{temp}} = \left[ \frac{N_t}{\lambda_p N_p + \lambda_i N_i} \times \frac{N_1 \times L_i \times N_{\text{max}}}{\sum_{m=1}^{N_{\text{max}}} I_m} \right] \quad (10)$$

$$N_i = \begin{cases} 
2, & N_{\text{temp}} < 2, \\
N_{\text{temp}} \geq N_{\text{max}}, \\
N_{\text{max}} > N_{\text{max}}. 
\end{cases} \quad (11)$$

Among them, $N_i$ is the number of points after the $i$-th
stable characteristic line is discrete.

When performing image forward matching, assuming
that the search window of the image feature $I_{k-1}(x_{k-1}, y_{k-1})$
of the previous frame is $I_k(x_k, y_k)$, the expression for
calculating the sum of squares of the feature pixel difference
of the two frames of image using $T_{k-1}(u, v)$ as the matching
template is as follows:

$$S_k(u, v) = \sum_{u,v} T_{k-1}(u, v) \left[ I_k(x_k + u, y_k + v) - I_{k-1}(x_{k-1} + u, y_{k-1} + v) \right]^2. \quad (12)$$

After traversing the image features in the current frame
of image matching search window, the smallest $S_k(u, v)$ is
obtained. When the value is less than a certain threshold, the
image feature corresponding to this value is used as the
candidate matching feature. At the same time, calculate the
sum of squared pixel differences $S_{k-1}(u, v)$ with $T_k(u, v)$ as
the matching template:

$$S_{k-1}(u, v) = \sum_{u,v} T_k(u, v) \left[ I_{k-1}(x_{k-1} + u, y_{k-1} + v) - I_k(x_k + u, y_k + v) \right]^2. \quad (13)$$
Through the conversion of the multimodal data acquired by the mobile device, the scene change rate of the current $k$-th frame and the $k$-th frame image is set to $v_k$. At the same time, the upper and lower thresholds of the search window $w_k$ are set to $w_{\text{min}}$ and $w_{\text{max}}$, and the relationship between the search window width $w_k$ and the scene change rate $v_k$ is

$$\frac{w_k - w_{\text{min}}}{w_{\text{max}} - w_{\text{min}}} = \frac{v_k - v_{\text{min}}}{v_{\text{max}} - v_{\text{min}}}. \quad (14)$$

The adaptive search window is

$$w_k = \frac{v_k - v_{\text{min}}}{v_{\text{max}} - v_{\text{min}}} \times (w_{\text{max}} - w_{\text{min}}) + w_{\text{min}}, \quad (15)$$

Through the scene change rate of the image, an adaptive image feature matching search window can be obtained, so that a more accurate matching search can be performed during the matching initialization and projection point matching process [18].

3. Planning and Scheduling Optimization Experiments

3.1. Experimental Environment. This experiment uses ASP.NET technology for development, adopts B/S-based architecture mode, uses Microsoft’s integrated development platform Visual Studio 2013 to develop the prototype system, and uses Microsoft’s SQL Server 2008 as the backend database management system. The interaction between application and database adopts ADO.NET technology. In this system, operators can conveniently access and operate various functional modules of the server system through a browser. No need to install the client, the operation is simple and convenient, being easy to maintain and upgrade [19, 20].

3.2. Unit Test. After each unit module is completed, the unit test is carried out. The tested modules mainly include information input module, information query module, production scheduling calculation module, and result query module. The white box test method is mainly used. The test content mainly includes module interface test, module partial data structure test, and module boundary test. The interface parameters of each module are checked, and the boundary values of some functions are also analyzed and tested. Each independent branch program can be executed effectively and can effectively handle errors. Basically, the modules are operating normally. The test index reaches the performance index of the simulation system [21, 22].

3.3. Production Scheduling. According to the planned number of days affected by equipment failure, find the affected mold key parts plan, suspend the mold key parts plan in production, release the equipment resources that have confirmed the plan, conduct rescheduling, and redistribute the tasks originally scheduled on the faulty equipment to other equipment. And the system provides alarm prompt for the influence of the extended die [23].

3.4. Workshop Integrated Optimization Model. The batch size of the parent product should be determined according to the corresponding subproducts, the batch size should be obtained from the information in the BOM, and the delivery date should be calculated by the start time and transportation time of the corresponding subproducts. Processing time and preparation time, preparation cost, inventory cost, and shortage cost are determined by production quantity and product data. Finally, the batch order of each machine has been determined, and the start time and completion time of batch processing are determined according to the preparation time, transportation time, and batch scale of each batch [24]. When the batch of the same product is processed continuously without time interval, only the first batch of the product needs preparation time. This paper adopts a layered coding strategy. [25].

3.5. Workshop Capacity Optimization. According to the preestablished order scheduling plan, the order allocation of each production line is determined, and the order processing sequence is defined. Then, according to the specification of each order, the production parameter combination of each process is set in advance before production and processing [26].

4. Optimization Effect of Scheduling

4.1. Sensitivity Analysis. The comparison of the effectiveness of the three production planning operations is shown in Table 1. From the comparison of the three scheduling results, the delivery guarantee rate, production cycle, and load utilization rate are significantly improved, but the improvement of the delivery guarantee rate is not very prominent. After analysis, the reason is that the delivery time of emergency orders is usually short, even unreasonable. Even, in the case of overtime, it cannot be guaranteed. In order to ensure that their orders can be processed first, the sales personnel should pay more attention to the quality of their orders; the purpose of artificially shortening the delivery time is to seize the on-site processing resources, while the delivery time is set far away for nonurgent orders. If the production load is not managed, the phenomenon of “grinding labor” will occur, and the processing will not start until the delivery time is approaching. Through the application of network planning technology and DBR system in TOC theory, the production cycle and capacity utilization rate are significantly improved, the capacity load is increased by 25%, and overtime work is effectively controlled. All overtime work must be based on the planned production demand. Overtime work cannot be done at will. The input-output ratio of overtime work is very high, and the production cycle is greatly shortened by 30%; therefore, the plan of production scheduling optimization is very effective.

The comparison of the sound insulation of different materials of the heavy roof is shown in Figures 2 and 3. It can be seen from the figures that the composite material designed for the heavy roof greatly improves the sound insulation performance of the overall structure and the
sound insulation effect of the standard point (120 cm from the ground) is more obvious than the near field point (10 cm from the top).

The comparison of sound insulation between different materials of light roof and real vehicle working conditions is shown in Figure 4. It can be seen from the figure that the sound insulation performance of the composite material designed for the light roof is more obvious than that of the real vehicle and the high-frequency sound insulation effect is increased compared with the standard point of the heavy roof. At the same time, it can be seen that when the composite material on all side roof is removed, the medium and high-frequency sound insulation performance can be significantly reduced. It can also be seen that when all the side roofs are made of composite materials, the sound insulation performance of medium and high frequency is significantly reduced, which is almost consistent with the sound insulation curve of the real vehicle. The high-frequency sound insulation effect of composite material designed for heavy roof is poor, while the low-frequency sound insulation effect of composite material designed for light roof is poor. The sound insulation performance of composite material designed for steel roof is the best in all frequency bands. Compared with condition 7, the sound insulation of the composite without rubber pad damping layer is decreased, but it is still improved compared with condition 3 which is close to the actual structure of the pantograph car; especially, at frequencies above 500 Hz, the weighted sound insulation is increased by 1.2 dB, and, compared with condition 5 of the nonpantograph car, the weighted sound insulation is increased by 3.2 dB. With the further increase of the running speed of high-speed trains in China, the noise of the no pantograph carriage also increases greatly. The composite material can improve the sound insulation effect without increasing the mass, so it is possible to be applied in the nonpantograph carriage of high-speed trains in China.

The average efficiency of each station is shown in Table 2. Through the comparison of schemes, it is found that, in the unit time of 5000 s, the efficiency of each station of scheme 1 is higher and the blocking of the buffer area is the best. Compared with the actual production using the third option, the data of the first option are better, so the first option should be used in the production.

### 4.2. Comparison of Scheduling Results

The comparison results of convergence speed are shown in Table 3. As the number of processes increases, the number of iterations for these three algorithms to converge to the optimal solution also increases. When the number of processes increases to 50, the ant colony algorithm converges to the optimal solution in the 2412 generation, and the simulated annealing algorithm converges to the optimal solution in the 68512 generation. The genetic algorithm is between the ant colony system and the simulated annealing algorithm, and it is in the 25000th generation. Generation converges to the optimal solution. It can be seen that the convergence speed of the other two algorithms and the ant colony algorithm is more than an order of magnitude difference.

Through simulation, each parameter is calculated with different values. The parameter selection and results are shown in Table 4. Considering the optimal solution and the relative stability of the solution process, the practice is to use the parameter scheduling results measured in this paper. The objective function value of the optimal solution is 30014.7, and the optimal convergence rate reaches 100%.

Table 5 shows the comparison before and after workshop optimization. After entering the production information of the order, the GA method based on simulation can be used to quickly obtain the order scheduling plan of the workshop. In solving the problem of shop order scheduling, compared with manual experience method and priority rule method, the order production cycle after genetic optimization has been reduced by 7.34% and 8.98%, respectively. After GA optimization, the order processing time was reduced by 10 hours.

Figure 5 shows the statistics of die completion rate after improvement. The on-time completion rate of the mold is 87%, which shows that the method of combining dynamic scheduling and simulation proposed in this article has a certain significance for the adjustment of the actual production plan. The method of dynamic scheduling simulation modeling is used to simulate the production process of the mold in the purification workshop. Taking into account the relevant production factors, the actual processing cycle of the various molds in the statistical simulation model is based on the latest completion time of the corresponding mold. Push up and down the start time of the mold, then the on-time completion rate of the mold will be greatly improved, and the scheduled operation plan will be more in line with the actual site operation.

The cyclic stress response curve of the composite material is shown in Figure 6. It can be seen from the figure that the two composite materials of different sizes show similar cyclic stress behavior under the control of total strain, namely, cyclic hardening, and, with the increase of the amplitude of the total strain, the degree of cyclic hardening is also increased. When the number of processes increases to 50, the cyclic stress response curve of the composite material designed for light roof is more obvious than that of the standard point of the heavy roof. At the same time, it can be seen that when the composite material on all side roof is removed, the medium and high-frequency sound insulation performance can be significantly reduced. It can also be seen that when all the side roofs are made of composite materials, the sound insulation performance of medium and high frequency is significantly reduced. The relative stability of the solution process, the practice is to use the parameter scheduling results measured in this paper. The objective function value of the optimal solution is 30014.7, and the optimal convergence rate reaches 100%.

| Scheduling times          | Order delivery guarantee rate (%) | Total processing cycle | Bottleneck process load |
|---------------------------|----------------------------------|------------------------|-------------------------|
| Pushing production schedule | 44                               | 19 weeks               | 75                      |
| DBR scheduling            | 61                               | 16 weeks               | 82                      |
| Resource optimization scheduling | 67                             | 13 weeks               | 101                     |

Table 1: Comparison of the effectiveness of three production planning operations.
Working condition 3: aluminum profile + raw material + heavy roof
Working condition 7: aluminum profile + composite material + light roof
Working condition 8: aluminum profile + composite material (middle) + light top plate
Working condition 9: aluminum profile + composite material + steel roof
Working condition 10: aluminum profile + composite material (middle) + steel roof

Figure 2: Comparison of the sound insulation of different materials of the heavy roof (120 cm from the ground).

Figure 3: Comparison of the sound insulation of different materials of the heavy roof (10 cm from the roof).

Figure 4: Comparison of sound insulation between different materials of light roof and actual vehicle conditions.

Table 2: Average efficiency of each station.

| Scheme/average efficiency of each station | Average work rate (%) | Average idle rate (%) | Average blocking rate (%) |
|-----------------------------------------|-----------------------|-----------------------|--------------------------|
| Scheme 1                                | 61.78                 | 30.63                 | 7.60                     |
| Scheme 2                                | 60.68                 | 31.24                 | 8.09                     |
| Scheme 3                                | 59.55                 | 31.94                 | 8.61                     |
increases accordingly. For 4.5 μm, when the strain amplitude is 0.35%, 0.4%, and 0.5%, the relative error between the actual measured value and the calculated value is small, and the error is less than 8%; when the strain amplitude is 0.3%, the phase error is slightly too big, but less than 14%. For 20 μm composite materials, when the strain amplitude is 0.35%, 0.4%, and 0.5%, the relative error between the actual measured value and the calculated value is small, and the error is less than 9%. When the strain amplitude is 0.3%, the phase error is also slightly larger, but less than 11%.

4.3. Integrated Optimization Results. The influence of different content of mica powder on the mechanical properties of the composite is shown in Table 6. With the increase of mica powder content, the tensile strength, tear strength, and elongation at break of rubber composites increase first and then decrease, and the mica powder content reaches the maximum at 10 phr; the hardness and density show an increasing trend. The main reason may be that mica powder belongs to layered filler, which has small particle size, large specific surface area, and strong surface effect. When mica powder is added to rubber matrix, it can better match with the free volume of rubber matrix and hinder the crack propagation. When a certain amount of mica powder is added to rubber matrix, it can significantly improve the crosslinking density of rubber matrix and increase the mechanical strength of rubber composites; However, with the addition of mica powder, the free volume of rubber composites decreases and the distance between molecular chains increases, which leads to the decrease of intermolecular force. Moreover, the dispersion of mica powder in the rubber matrix may be uneven, resulting in the aggregation of mica powder, stress concentration, and the decrease of mechanical strength of rubber composites.

The comparison of the algorithm operation results is shown in Figure 7. From the average running results obtained after 10 runs, the minimum objective function...
obtained by the MDPSO algorithm is better than GA and BMDPSO. This is because it has excellent evolutionary performance after improvement. The time is shorter than GA but slightly longer than BMDPSO. This is because the evolution of MDPSO is easy to implement, and only simple encoding and decoding operations are needed to obtain feasible sequences. The added algorithm complexity is small, and genetic algorithms need to be selected. Crossover, mutation, and infeasible solutions will be produced in the process of crossover and mutation, and the adjustment of the solution is very time-consuming, which will be more prominent in large-scale problems.

The influence of the improvement of production efficiency on the optimization results is shown in Figure 8. It can be seen from the results that the improvement of production efficiency has no effect on the total optimal mold change times but has an effect on the production balance. It can be seen that the number and batch of productions mainly depend on the downstream demand and the capacity of the material rack, and the production efficiency is not affected much. The improvement of production efficiency directly reduces the working time of each shift and can improve the balance of production time between shifts in a small range; but when the production efficiency is increased to a certain level, the overall optimization result becomes worse and worse. This is related

| Mica powder | Tensile strength | Tear strength | Elongation at break | Hardness | Density |
|-------------|-----------------|---------------|---------------------|----------|---------|
| 0           | 14.02           | 28.13         | 152.35              | 83       | 1.355   |
| 5           | 15.57           | 29.59         | 162.13              | 84       | 1.401   |
| 10          | 15.74           | 30.51         | 168.54              | 84       | 1.432   |
| 15          | 13.74           | 28.59         | 152.77              | 86       | 1.457   |
| 20          | 12.10           | 27.04         | 143.82              | 86       | 1.506   |

![Figure 6: Cyclic stress response curve of composite material.](image)

![Figure 7: Comparison of algorithm running results.](image)
to the interaction between the production time of the parts in production, the inventory, and the production volume of the parts.

5. Conclusions

In this paper, the acoustic performance of multilayer composite materials used in high-speed trains is studied. The main noise sources of high-speed trains and the measurement of vibration and noise of high-speed trains are described. Combined with the test of real train conditions, the sound field spectrum characteristics and noise transmission path of high-speed train carriage are analyzed, which provides data reference for the design of multilayer composite materials.

In this paper, through the computer simulation software to establish a simulation model for scheduling research, the simulation results can be directly displayed through the computer interface, more intuitive scheduling research. Through computer simulation, you can directly modify the simulation model to express your own ideas, so as to save more effective time to solve the scheduling results, improve the strategy faster and better, and avoid affecting the actual operation efficiency of the whole production system or even causing the system not to work normally due to the poor scheduling control strategy.

In order to realize the integrated modeling and optimization of production planning and scheduling of enterprise processing workshop, this paper starts from the scheduling layer, focuses on the description of the problem, and studies the establishment of model and solution algorithm, so as to gradually achieve the predetermined research goal. In this paper, a comprehensive objective model of integrated optimization of job shop production planning and scheduling is established, which overcomes the defects of traditional hierarchical decomposition method and meets the needs of solving the optimization problems with uncertain subobjectives and the optimization problems with different requirements of each subobjective in job shop scheduling. In this paper, according to the characteristics of small batch, multivariety, complex process, and reentrance of composite production, the production planning and scheduling mode of composite are established, the scheduling algorithm for the production of reentrant bottleneck equipment is studied, and the corresponding system is developed according to the mode; thus the application is verified. It is possible to combine other machine learning algorithms with multiobjective optimization algorithms and do some fine-tuning to perhaps get more satisfactory performance metrics.

Data Availability

This article does not cover data research. No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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