Optimisation Study of Discrete Manufacturing Simulation of new Energy Vehiclebattery Packs Abstracts

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Abstract—In recent years, the number of global new energy vehicles has soared, and production enterprises are facing problems such as increasing market demand and intensifying industry competition. The structural design and balance planning of the battery pack production line determine the output of new energy vehicles. This paper takes the battery pack assembly line of Q enterprise for new energy vehicles as the research object, calculates its capacity and station utilization rate through simulation software, and provides an effective design scheme for the formal production line construction.

Keywords: simulation modelling; discrete manufacturing; bottleneck processes; capacity optimisation;

1. INTRODUCTION

Manufacturing is the mainstay of the national economy. In general, according to its product manufacturing process characteristics of the manufacturing industry can be divided into continuous manufacturing and discrete manufacturing. Relative to Continuous Manufacturing System, Discrete.

Manufacturing System products are usually a large number of parts through a series of discontinuous processing and assembly, from the processing process, discrete manufacturing enterprise production process is a complex process composed of different parts processing sub-processes either in parallel or in series, which has more variability and uncertainty [1-3].

In this paper, we take the battery assembly line of new energy vehicle of enterprise Q (as shown in Figure 1) as the specific research object of the discrete manufacturing process, and aim to give the theoretical optimal solution through virtual study before the formal construction of the production line[4-6].

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Figure 1. New Energy Vehicle Battery Pack Production Line

2. COMPONENTS OF DISCRETE EVENT SIMULATION

Discrete Event Dynamic System (DEDS) is a system whose state is driven by some events and changes at some uncertain discrete points in time, and if the activities and state changes of a discrete event system are relatively frequent, it is called a discrete event dynamic system. [7-9].

Due to the inherent discrete nature of DEDS and the complexity of the internal mechanism, it is usually difficult to use conventional mathematical models such as difference equations, differential equations, etc. to describe and obtain an analytical expression of the system dynamic process, while discrete-event system simulation can be carried out with the help of the computer to build a model of the actual discrete system, which can better describe the performance of DEDS in various aspects through the operation of the simulation of visualisation and data[10]. At present, discrete event system simulation is also one of the most effective and reasonable methods to study DEDS, in which the three relations between simulation model, discrete system and computer are shown in Figure 2.

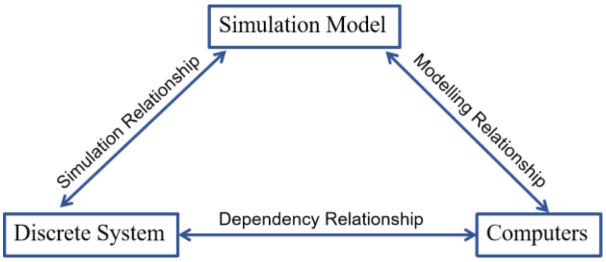

Figure 2. Component relationships for discrete system simulation

3. EXAMPLE OF MODELLING A BATTERY PACK ASSEMBLY LINE

The part of the battery pack assembly line that needs independent control of the equipment area is divided into the lowest level subsystems through class libraries, and then these third level subsystems are linked and embedded to form the various workstations as the second level subsystems, in which the AF50/AF80/AF150 multi-similar workstations are taken as an example, and can be constructed directly through the hierarchical construction of the duplication and the adjustment of the details of the internal parameters. Finally, we can build the conveyor belt, turntable and other line equipment in turn, and associate the equipment and workstations to finally build a simulation model of the whole battery pack assembly line at the highest level. The 2D simulation diagram of the battery pack assembly line is shown in Figure 3.

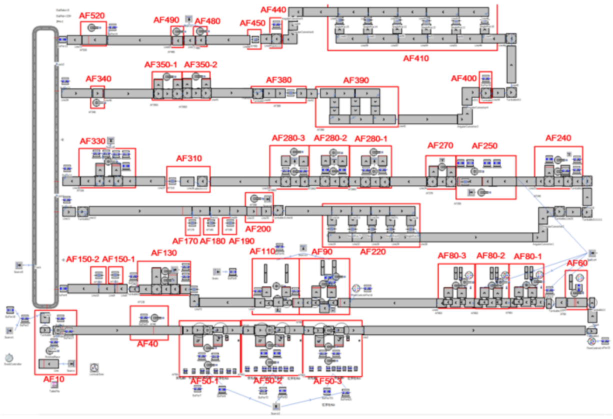

Figure 3. General view of the simulation model of the battery pack assembly line

After the process of modelling the production line, it is necessary to count the production capacity JPH of each U-shaped line and bus body, where the calculation of JPH can be implemented by means of SimTalk language programming, since the production per hour per unit is calculated as follows:

$$JPH = \frac{N \times 360}{t} \quad (1)$$

Where N is the number of moulded parts coming off the line and t is the load time in seconds. Assuming that the station in the production line where the moulded product goes down the line is X, and the station immediately adjacent to the previous process is Y, and outputting the production capacity by means of control programming, assuming that these two adjacent stations are triggered by the object entrance (Entrance) to the control, and if the control of the entrance of the Y station is programmed to be Yjph:= EventController.simtime, when the moulded part enters the entrance of X, the load time at this time is the current simulation time minus the value of Yjph, and the number of moulded products going down the line can be obtained by subtracting Yjph from the current simulation time. When the moulded part enters into the entrance of X, the load time at this time is the current simulation time minus the value of Yjph, and the number of moulded parts coming off the line can be recorded automatically by the built-in statistical data key word statnumin in the downline workstation, so the programming expression for the calculation of the final JPH is as follows:

$$JPH = \frac{root.X.statnu\min 3600}{EventController.simtimeYjph} \tag{2}$$

Thus, either the Display object or the Variable object can be used to achieve the real-time output of the production capacity JPH.

Battery assembly line in the process of actual production line operation must be considered in the workstation equipment failure, so in the simulation also need to simulate the faults caused by equipment downtime and equipment time-consuming repair, in the simulation There are three parameters describing the failure of the equipment, respectively, Availability, which is used to indicate the object's normal working time as a percentage of the total time;Repair time (MTTR) , used to indicate how long it takes on average to resume work after a fault arises; and finally, Mean Time Between Failure(MTBF) is used to describe the average time between two failures of the equipment object and conforms to the statistical distribution of negative indices. The functional relationship between these three parameters conforms to the following equation:

$$MTBF = \frac{MTTR \times Availability}{1 - Availability} \tag{3}$$

From equation (3-3), it can be seen that the complete failure parameters of the equipment can be obtained by obtaining any two of these three parameters. Among them, MTTR is generally determined by the enterprise according to the site survey and the difficulty of equipment repair, usually a certain value, and Availability Availability needs to be determined by the composition of equipment within the station, although the probability of failure of each piece of equipment within the station is independent and irrelevant, but due to the battery assembly line for a series-type process layout production line, so when any one of the equipment within the station fails, the whole station will be shut down until the station repair is completed. However, since the battery assembly line is a series-type process layout production line, when any of the equipment in a station fails, the whole station will be shut down until the repair of the station is completed, therefore, two methods can be used to set up the specific fault.

(1) If the workstation model is represented independently, the failure rate is set for the equipment respectively, and then the whole region is interlocked by the failsafe object, in the AF80 workstation, after any equipment failure, the failsafe will immediately stop the action of all the added equipment objects in the whole region until the object is repaired.

(2) If all the equipment content of the workstation is only concentrated with a workstation to represent, at this time, it is necessary to centralise all the equipment failure information in the workstation to establish statistics, at this time, the workstation's utilisability AS is:

$$As = \sum_{i=1}^{n} A_i \tag{4}$$

At this time the failure rate FS of the workstation is:

$$Fs = 1 - A_s \tag{5}$$

The failure-related data of the workstation can be calculated through equations (4) to (5).

Taking AF80 station as an example, the content of this station is to install the high-voltage copper rows on the battery pack module, mainly through the robot and fixtures to cooperate with the installation, through the statistics of the car company can be known as the MTTR is 5min, according to the offer library provided by the enterprise can determine the equipment availability is 98.314%, MTBF is 291.56min.

The utilisation, idling and blocking of each station can be visualised through the statistical analysis graphs. Taking one day of simulation as a cycle, the utilisation efficiency of each station in the battery pack assembly line is shown in Figure 4. The horizontal coordinate of the graph is the number of workstations, and the vertical coordinate is the percentage of a certain state in the simulation time. It can be seen that the equipment utilisation rate of each station is more consistent, and the overall balance of each station in the operation process is better, indicating that the process development and beat allocation in the early stage is more reasonable, in the AF10, AF90 and AF200 stations there are part of the blocking situation, which can be added by adding a buffer buffer in the front of the object to contain the workpiece of the workplace out of the carrying capacity to reduce the value of its blocking.

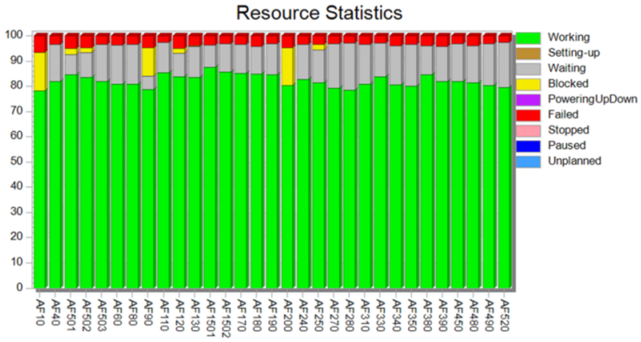

Figure 4. Analysis diagram of each work station

4. CONCLUSION

This paper takes the discrete manufacturing process of new energy vehicle battery packs as an example, and studies the balance improvement, capacity enhancement and management control of the beats of each station in the assembly line, so as to shorten the project cycle of automobile enterprises and achieve the intelligent optimisation of the assembly manufacturing process. On the idea of lean production, it has a certain reference value for enterprise operators and the field of new energy battery pack production.

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