Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 29 (2012) 1521 – 1527

Procedia Engineering

www.elsevier.com/locate/procedia

2012 International Workshop on Information and Electronics Engineering (IWIEE)

Research on the Digital Workshop Layout Based on Steel Material Processing Workshop

Yang Liu[a]*, Mei Meng[a], Da-peng Wang[b]

[a]*College of Shipbuilding Engineering, Harbin Engineering University，Harbin 150001 ,China*

[b]*Bohai Shipbuilding Heavy Industry limited liability company，Huludao 125000 ,China*

Abstract

Aiming at the layout optimization of the steel structure machining workshop in modern ship manufacturing industry, a digital optimum solution is proposed. First optimize the production flow and enterprise resources and build the 3D visual parametric model. Second using optimization algorithm build the optimum layout model. Third apply estimation method on the optimum model. As for the initial layout plan, build the layout optimum model using the Improved Genetic Algorithm, and find out the minimization solution of the optimum. This paper is helpful for the digital manufacture workshop's layout optimization research.

Keyworks: shipbuilding steel structure machining workshop,parametric workshop model,optimum layout model,the Improved Genetic Algorithm, CATIA;

1. Introduction

The main issue of workshop's layout is the manufacturing process or logistics requirements. Meanwhile layout problem performs multiplicity for different optimization objective, practical problems and layout design stages. By now, there are few fruits in workshop layout research field. Traditional design mainly introduce foreign production line, but cannot combine it with the workshop's production capacity and scheduling management, especially do not reserve "manufacture flexible" for update products [1], so when the production plan changes, the production efficiency is heavily affected, and can't

* Corresponding author. Tel.: +1-333-951-0821; fax: +0451-82518443.
E-mail address: qingtianriji@yahoo.com.cn.

1877-7058 © 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.proeng.2012.01.166

exert its full capability. The development of 3D visualize modeling is slow, and rarely research results of visual layout studies on steel structure machining workshop [2][3].

Considering the layout issue of steel structure machining workshop, and taking a certain shipbuilding corporation as example, this paper works on the optimum layout model using a ameliorate Genetic Algorithm based on software CATIA. Furthermore, assessments of these optimum models are also made after secondary development of software. This paper provided a reference way for the layout and optimization of the digital production workshop.

2. Determine the layout plan

Clarify the manufacturing flow is the first step of making this optimum issue. A standard manufacturing flow should be made under some reasonable and suppleness consideration. After the standard flow and the production capacity of this workshop settled, next step is to select the appropriate equipment or to evaluate and optimize the existing resources (ERP) on occasion of reconstruction. The digital workshop can be constructed based on these preparations, and mainly the parameter model consists of resource bank, dividing manufacturing unit and the technics& process model. The optimum model can be gained using the optimization algorithm and considering the boundary limit. And the evaluation can be made using secondary development of the CATIA software or other software, looping circle of amending the boundary condition and new optimized model. Figure 1(a) is the chart of the digital workshop layout optimization solution.

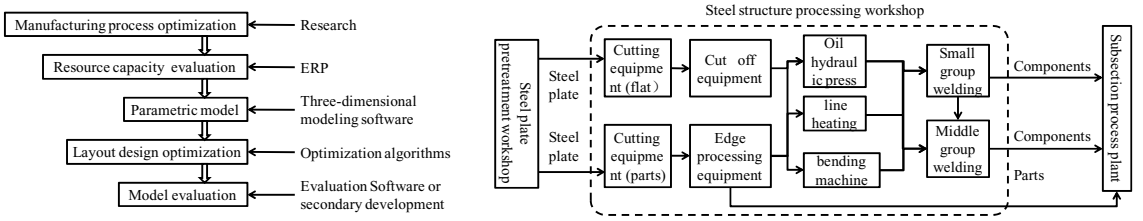

Fig.1.(a) Optimization solutions of digital workshop layout design;(b)Steel processing flow

2.1.Optimization of production flow and manufacturing resources

The steel processing operations of marine products is complex and connecting variable equipment fitting. Taking a corporation as example, its process planning was shown in figure 1(b), in the first 11 items of Table 1 are the original manufacturing resources (equipment), and item 12-14 are new.

Table 1. Main technical parameters of equipment

No	Equipment name	The main technique parameters	Shape dimension*(m)*	Work area*(m)*
1	Plasma cutting machine Type Ⅰ	Cutting width 4.8m, cutting thickness 3-20mm, Velocity 4m/min	40*6	40*7
2	Photoelectric open machine	Cutting width 4m, cutting thickness 3-20mm, Velocity 4m/min	45*5	45*6
3	Flame cutting machine	Cutting width 6.8m, cutting thickness 3-20mm, Velocity 4m/min	50*6	50*9
4	CNC milling machine	The longest 15m, the shortest 1m, the	15*5	15*5

	5	Small plane edge machine	Cutting thickness 5-60mm, velocity 015-0.8m/min	0.5*0.5	1*1
	6	400Toil hydraulic	operating stroke velocity 100mm/s	6.4*1.8*5.56	10*4.8*5.56
7		600Toil hydraulic	operating stroke velocity 120mm/s	8*3.5 *8.2	12*6.5 *8.2
8		Samsung bending machine	16mm*6m	10.52*2.580*2.12	12.52*5.58*2.12
9		Samsung bending	25mm*8m	14.2*2.8*3	16.2*5.8*3
	10	20T driving 2	Velocity 20m/min	13*1.5*2.5	13*1.5*18
	11	30T driving 2	Velocity 20m/min	18*1*2.5	18*1*18
	12	Plasma cutting machine Type Ⅱ	Cutting width 4.8m, cutting thickness 3-20mm, velocity 4m/min	40*6	40*7
	13	Samsung bending	31mm*4.5m	8.95*3.015*2.3	10.95*6.015*2
	14	40T driving	velocity 20m/min	48*2*3	48*2*18

2.2. Workshop layout planning

Product layout, technics layout, group layout and fixed layout are four elements of facility layout. Fixed layout generally is used with hardly movable objects, isn't fitful here. The relationship between the processing speed and species of other three types of layout forms is shown in figure 2(a). According to the product character of few types and great amount, the idea of product layout is most appropriate.

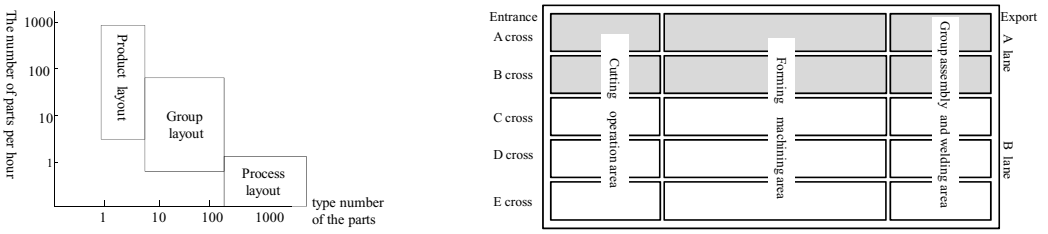

Fig.2.(a) Connection of layout and accessories;(b)Operation area subdivision

2.3. Workshop area planning

The area of workshop includes equipment & working area, the necessary yard, the buffer area and the the road. The road area includes pavements and the parts transportation alley, as formula (1).

$$A_t = A_e + A_y + A_b + A_r + A_o \quad (1)$$

A_t ——total area of workshop;
A_e ——equipment and working area;
A_y ——yard;
A_b ——buffer area;
A_r ——the size of the road;
A_o ——truss, auxiliary equipment, office area.

After calculation: $A_t \approx 30300 m^2$.

2.4. Operation area dividing

According to the work flow and the product layout type, 3 divisions are suggested. They are cutting operation division, forming machining division and group assembly division. On the base of table1, and figure 1(b), figure 2(a), the proportion is 27%, 50% and 23%, as figure 2(b) shown. From figure 2(b) we can see that there are 2 vertical avenue, 5 crosses and 2 lanes, B and C cross majored in complex curve plate parts, while the others are mainly for the plain plate and the small-curved parts. A lane consist of A and B cross, and B lane consist of C, D and E cross, and the production capacity of B lane is double of A lane.

3. Build visual parametric model of steel processing workshop

Software CATIA is used to construct the 3D visualized parametric model considering its advanced mixing modeling technique, variable driving and aft-parametric capability. Besides high efficiently build models like pipes, equipment and structures, CATIA can also produce auto-files.

3.1. Establishment of manufacturing resource model bank

The 3D visualized layout includes the workshop frame design, the production division layout and the equipment and facilities layout. Import the workshop blue print, and then build the base walls, and divide the operation area，and some of the equipment model when input the production equipment model information into bank. As shown in Figure 3(a).

3.2. Modeling of visual parametric workshop

Accomplish the road by setting the road width and position etc. when modelling. And then check the coincides after importing the proper equipment. The whole steel machining workshop parametric model is shown in figure 3(b).

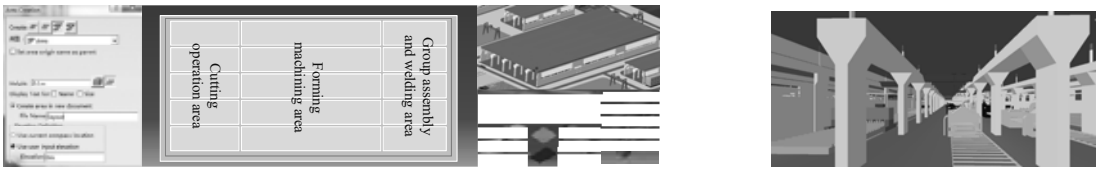

Fig.3(a) Production area plan and building ,and equipment;(b)Parametric model of steel machining workshop

4. Optimize and assess steel processing workshop's layouts

The main principle of optimization is to shorten the entire transport distance, to depress transportation cost and to benefit the logistic most [4]. Transportation cost is not considered in this paper. Meanwhile, the optimization principle also includes the minimizing the entire the area and using the facilities sufficiently. So when the equipment capacity filled the production demands, the human maneuvering and the flexibility for new equipment should also be considered as well as manufacturing resource layout.

4.1. Improved Genetic algorithm for minimum logistic

Genetic algorithms are stochastically search and optimization techniques which mimic the natural process of evolution. In this article a chromosome represents a component processing sequence, a gene

represents processing equipment or the field. We get initial population through the set of the probability of the chromosome in a population likely to occur.

4.2. Initialization

Equipment uses the natural number coding (Table 2) optional processing sequence chromo. Some parts (ruffled cubits board) is shown in figure 4. We get initial population by the judge of the probability of the chromosome in a population likely to occur, which depend on the labor distribution of the workshop (Table 3) and the type of the components to be processed.

Table 2. Equipment (work area) code

Equipment（work area）	Coding	Equipment（work area）	Coding
CNC plasma cutting machine Type Ⅰ	1	600T Oil hydraulic press	8
CNC plasma cutting machine Type Ⅱ	2	25mm*8mbending machine	9
Photoelectric open machine	3	16mm*6m bending machine	10
Flame cutting machine	4	31mm*4.5m bending machine	11
CNC milling machine	5	Line heating	12
Small plane edge machine	6	Small group welding	13
400T Oil hydraulic press	7	Middle group welding	14

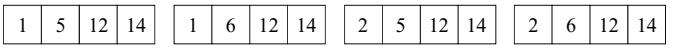

Fig.4. Chromosome encoding

Table 3. Percentage distribution of labour

Jobs/equipment	Motor boat		Non-motorized river boat	Average number of operations
	Marine	river		
incision	26	20	23	3
edge processing	6	5	6	3
bending machine bending	14	11	13	3
hydraulic press rolls	13	17	17	4
plate bending	9	18	13	3
group welding	32	29	28	5

4.3. Select operators

Commonly used selection strategies are: fitness proportional method, save the best individual method, the expected value method, ranking selection method, the league selection method[5]. We choose ranking selection method in this paper. The establishment of adaptive function, and get all the chromosomes population adaptation function value, either take some sequence, by comparing method through adaptive function value, whichever is the maximum value in the sequence corresponding will be added to a new population of chromosomes. Through this method, we filter out enough sequence to re-composite populations. Poor adaptability sequence of the original populations will be given up to improve the viability of excellence individual.

$$F(w) = \theta_1 f_1 + \theta_2 f_2 + \theta_3 f_3 \qquad (2)$$

f_1——Reverse function of the number of processes;
f_2——Transverse processes logarithmic function;
f_3——Discriminant functions of logistics feasibility.

Through the experiment for this case, the factors were selected as: θ_1=0.21, θ_2=0.46, θ_3=0.35.

4.4. Genetic operators

Operation of crossover and mutation operator is to change the order and location of the emissions of the equipment, resulting in different processing sequences (different solutions). Crossover operator is to randomly swap specify genes within gene segments from two chromosomes, resulting in new chromosome and improve individuals diversity of new population. Commonly used mutation operators are reversed, insertion, displacement and exchange, etc. In this paper we choose interchangeable operator, means exchange two genes from selected location, so as not to fall into local optimal solution, shown in Figure 5(a), (b).

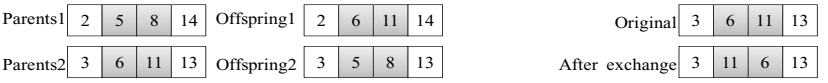

Fig.5.(a) The application of crossover operator;(b)The application of mutation operator

4.5. Algorithm selection and control

The control of choose-probability can be well solved by Boltzman changes technology. Set a higher initial temperature, to ensure that the global optimal solution can be preserved. And continue to reduce the temperature, control the Choose Probability in reasonable reduction range, computational speed can be in an accepted range by the complexity of the product. A initial temperature of 35 or more, the minimum temperature about 1, hybridization rate between 0.7-0.8, decreasing rate of 0.11-0.16,iterative to obtain the optimal equipment layout (work area) sequence of the workshop layout: 4-3-6-7-9-12-13, 1-2-5-8-10-11-14; 4-3-6-7-9-12-13, 2-1-5-8-10-11-14.

4.6. Evaluation and secondary optimization

The open data bank of CATIA has provided multi-language developing environment. Use several candidate solutions with the secondary developed program, and we can get the evaluation result as figure 6(a).

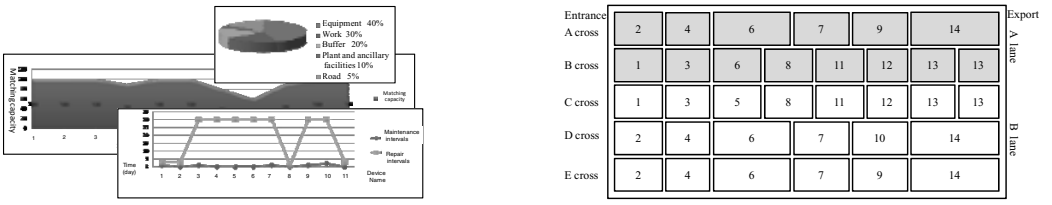

Fig.6.(a)Result of layout evaluation;(b)Steel machining workshop layout plan

4.7. Final solution

Final solution is selected by the evaluation. Each cross is 16 meters wide and 350 meters long, with 1 meter space between crosses. The workshop is 352 meters long and 86 meters wide, and the area is 30272 m^2.The workshop wall is 1 meter thick. The workshop can accommodate production of engine with water, electricity, stream and compressed air, also with the ventilation and air condition, as well as the base of lift equipment's installation. The area of cutting division is 7700 m^2, with the form division 14000 m^2, and the group assembly division 5600 m^2 (figure 6(b) and figure 7(a)).

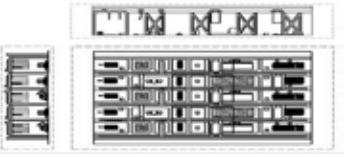

Fig.7.(a) Parametric model（optimized）;(b)Steel machining workshop engineering graph

This solution first classifies each cross function, satisfy the cutting technics and work flow, and build up the line ability. The vertical and horizontal connection is clear and tight, easy the material's transportations. The engineering graph can be drawn and dimensioned, also with equipment position. These graphs can be used for discuss or references. Examples are as figure 7(b).

5. Conclusion

1) Proposed a solution for digital workshop layout design, optimization and evaluation. Proposed a layout mode for shipbuilding steel process workshop, based on planned production flow and optimized manufacturing resource.

2) Proposed appropriate optimization method after the digital workshop model established. In this case we use an improved genetic algorithm to speed up the convergence rate.

3) Based on 3D visualization model, a logical and physical connection is build, so the analysis object update from the digital model to the parametric model, and make the attribute information database available.

4) According to the calls and research of the parameters of the digital workshop model information, we can evaluate the merits of workshop layout. And this can provide some reference value for the research on the workshop layout.

References

[1]Maotao Zhou, Zhiwen Wang, Chang Liu. Summarization on Design Method for Layout of Machining Workshop and Example Analysis. *Liuzhou Iron and Steel Technology*;2009,2:37-40.

[2]Li Xu, Weifeng Li, Zhihui Shi, etc.Application Study of 3D Simulation Technology in the Design of Manufacturing Shop Layout.*Machine Tool & Hydraulics*;2004,**8** :63-65.

[3]Jun Tie.The Theory and Algorithm of the Three-Dimensional Layout Optimization with Behavioral Constraints.*Dalian University of Technology*;2007.

[4] Li Xu, Jing-min Li, Xiulun Wang.Optimal design for equipment layout of workshop based on genetic algorithms. *Modular Machine Tool & Automatic Manufacturing Technique*;2004,**12**: 46-48.

[5]Quan Du, Shi-lun Ge, Qingmeng Gg. Research of Process Optimization in Shipbuilding Shop Based on Method of Shipbuilding Facilities' Collocation Optimization. *Science Technology and Engineering*;2009,**9**:3367-3370.

[6] Wu Zheng, Zhiming Wang.3D Industry Design. *Beijing Chemistry Industry Publishing Corp*;2005.