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Virtual Computer-Based Design of Ship Manufacturing Simulation System

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Abstract: The construction process of ship manufacturing simulation system is based on the virtual model construction by the computer, in which the virtual data analysis is done in order to accurately calculate the production capacity efficiency of the process workers and the effective mining of the factor affecting the productivity of production plant workers. This paper takes the corresponding reconfiguration based on the data analysis results of simulation model based. In this paper, during conducting the research process, we take the pipe production plant as an example for the effective establishment of its simulation models. During this process, we recorded corresponding data for the analysis of the simulation results of production planning and summed up the impact factors to provide a solid foundation for the theory and data in this article.

Keywords: Virtual computer, Ship manufacturing, Simulation system, Model construction.

1. INTRODUCTION

This paper made corresponding discussion for the simulation system of pipe production plant construction process during the ship manufacturing process, in which it combined the construction process of simulation model to conduct effective study on the calculation process of the machining time and capability efficiency of each workpiece and solved problems generated during the establishment of model. Secondly, it carried out appropriate introduction of the flexible resource scheduling method of pipe processing plant, in which the corresponding formula computer matrix is listed to discuss the relationship between the fixed resources and flexible resource, and the internal links and mutual influence between the two are combined to make an effective schedule, which can make the design process of ship manufacturing simulation system strongly rational [1].

From the development perspective, the design of ship manufacturing simulation system by virtual computer can have a positive role in promoting production efficiency and production quality. Through the effective application of simulation models, perfecting the process of system building is achieved to ensure that the simulation system design is more reasonable and targeted.

2. ESTABLISHMENT OF THE PRODUCTION PLANNING SIMULATION MODEL OF PIPE PROCESSING PLANT

This paper takes the pipe processing plant as an example to establish the production simulation model during the manufacturing process of ships. In this process, because the manufacturing of each segment of the tube is performed independently, the different type of tubes obtained during this process have been a constraint during the process because of the varied task size. Thus it resulted in a corresponding change in the manufacturing plans, so that the proportion of resources load used during the various processes changed. If the load resources remain constant, then the process at different manufacturing stages will produce different bottlenecks. In this paper, through simulation methods discussed, only an appropriate process can make the forecast for the short-term bottlenecks in the system, which are combined to obtain the reconfiguration.

During the course of the study of this paper, the pipe processing plant lacks processing time data for each stage of processing. The real production plan will be difficult to achieve due to the lack of data, but this problem can be divided into two aspects for an effective solution. First is the effective collection and collation of basic data, and a full range of integrated analysis. Upload the production planning which has been identified as well as information about product parameters to the database and use the simulation models for the effective integration of related information, which can make the simulation model compute efficiently its processing time, then transfer the calculated data to database for further analysis, and finally each segment processing time can be efficiently calculated [2]. The second is the simulation of the process scheme based on the calculation result of the above data, and the calculation of the prediction date of the completing time and resource efficiency at each step, which can make the effective analysis of the problems in supply and demand and provide reference for effective scheduling.

The first step in solving the problem is to calculate the specific processing time, but since it is not a time distribu-

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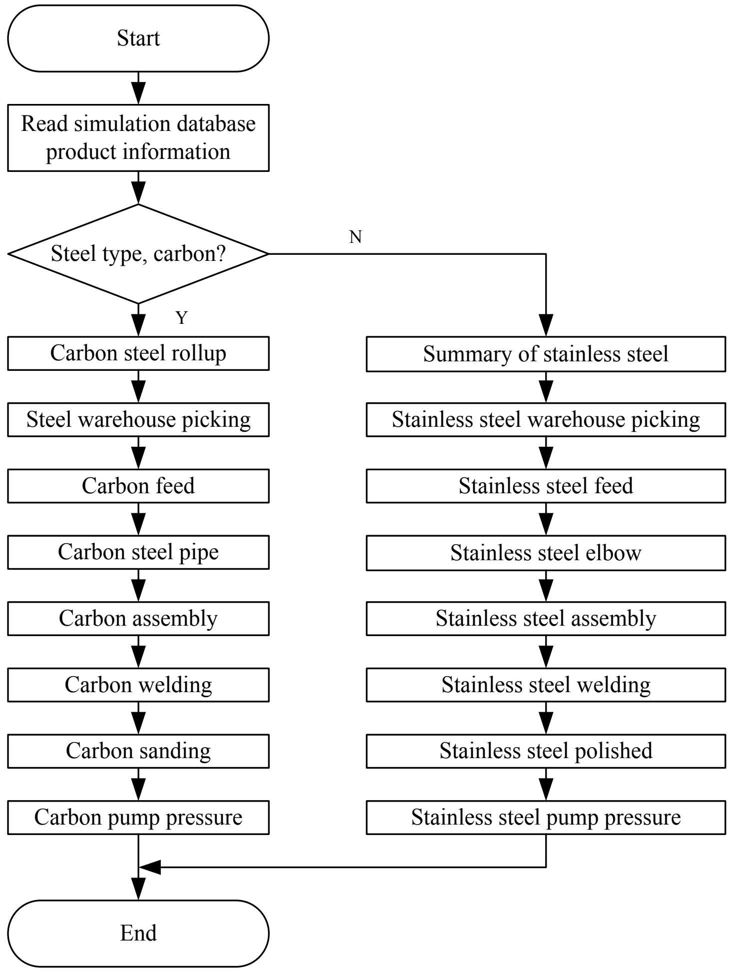

Fig. (1). Simulation flow chart of pipe processing plant.

tion process, the aim is to simplify the preparation of its calculation process. In this process, simulation experiments can be repeated to effectively eliminate this uncertainty factor. The second part of the process is to suck simulation time into the simulation model, but a large number of analysis data may lead to establishing a model more slowly, so that the later part of the results will generate a corresponding impact. The separate simulation process for the second part resolved in this article can ensure that the model running speed can be effectively protected.

In the design process of the pipe plant processing flow chart (Fig. **1**), the first step is the machining program in which the initialized simulation model can read the attribute information for each product from the simulation database. Then simulation entities enter into the carbon steel and stainless steel production line in accordance with the type of steel that they belong to respectively, through the material aggregate module and warehouse picking module to get fully prepared for the formal process. Each simulation entity enters the final process, turning from the cutting, bending, assembly, welding, grinding, pump pressure module, into the final processing. The simulation flow chart of pipe processing plant is shown as Fig. (**1**).

Results of simulation model of tube production plant planning process has two main aspects, one is the processing time of each process as shown in Figs. (**2**) and (**3**); the other is the number of specific programs, which through simulation get resources utilization information for various processes (Fig. **4**) and the processing cycle of different production lines (Fig. **5**).

3. FLEXIBLE RESOURCE SCHEDULING METHOD FOR PIPE PROCESSING PLANT

During the manufacturing process in a shipbuilding industry, pipe production plant is mainly constituted by a single technician and multi-ability workers, while the later process can correspond to grasp work for multiple processes, where technicians with single capacity were called fixed resources, whereas other craftsmen were called flexible resources [3]. However, during the production process, a reasonable allocation of flexible resources between the various processes is the key to improve the productivity; the paper takes this issue as a key research clue. The purpose is the continuous optimization of balance of flexible resource configuration between various processes, which can maximize the value of limited resource flexibility, and then the tg_processtime

分段名	管段名	下料	装配	焊接	打磨
MBAB01	MBAB01-AT24-1	327	838	6454	15321
MBAB01	MBAB01-BW03-2	583	2341	1380	3448
MBAB01	MBAB01-BW03-3	108	587	555	1562
MBAB01	MBAB01-BW03-4	1081	507	345	844
MBAB01	MBAB01-BW04-1	282	486	355	854
MBAB01	MBAB01-BW04-2	543	1698	1442	3448
MBAB01	MBAB01-BW04-3	164	312	617	1688
MBAB01	MBAB01-BW04-4	468	185	457	864
MBAB01	MBAB01-BW07-1	533	1538	495	1719
MBAB01	MBAB01-BW07-2	1124	203	358	991
MBAB01	MBAB01-BW07-3	881	299	358	1083
MBAB01	MBAB01-BW07-4	299	484	173	400
MBAB01	MBAB01-BW08-1	427	1919	587	1507
MBAB01	MBAB01-BW08-2	244	190	352	850
MBAB01	MBAB01-BW08-3	1045	1111	400	1023
MBAB01	MBAB01-BW08-4	254	171	226	460
MBAB01	MBAB01-BW25-1	248	967	317	1020
MBAB01	MBAB01-BW25-2	640	1021	415	1028
MBAB01	MBAB01-FV05-1	1089	1659	2375	5523
MBAB01	MBAB01-FV05-2	1146	441	1184	3456
MBAB01	MBAB01-FV05-3	108	617	1150	3138
MBAB01	MBAB01-FV05-4	976	318	1324	3375
MBAB01	MBAB01-FV05-5	147	1341	2670	5881

bxg_processtime

分段名	管段名	下料	装配	焊接	打磨
NBAB01	NBAB01-PV01-1	927	3432	661	1618
NBAB01	NBAB01-PV01-2	2092	3438	470	1445
NBAB01	NBAB01-PV01-3	709	2215	398	1341
NBAB01	NBAB01-PV01-4	187	695	61	199
NBAB01	NBAB01-PV35-1	565	2203	474	805
NBAB01	NBAB01-PV35-2	1907	770	189	573
NBAB01	NBAB01-PV35-3	418	2092	222	623
NBAB01	NBAB01-PV35-4	1899	820	200	557
NBAB01	NBAB01-PV35-5	148	741	184	486
NBAB01	NBAB01-PV35-6	1289	1055	791	116
NBAG21	NBAG21-PV03-1	981	1837	1020	1366
NBAG21	NBAG21-PV06-1	79	4918	5030	1685
NBAG21	NBAG21-PV06-2	1839	3449	6083	775
NBAG21	NBAG21-PV06-3	178	992	992	256
NBAG21	NBAG21-PV24-1	622	1765	1086	213
NBAG21	NBAG21-PV37-1	543	2689	279	617
NBEG11P	NBEG11P-PW001-1	217	5256	4430	1946
NBEG11P	NBEG11P-PW001-2	204	1895	1023	273
NBEG11P	NBEG11P-PW001-3	39	5122	3999	1495

Fig. (2). Calculated results of pipe processing time of each segment by carbon steel and stainless steel (unit: seconds).

MBEG21P	14.80829	40.24416	51.12226	101.5289
MBEG21S	19.48956	46.87424	35.55191	83.49554
MBEG22C	5.730098	16.01781	26.31643	46.56042
MBEG22P	18.58525	60.26945	89.60407	188.3414
MBEG22S	43.00921	95.57935	83.85549	192.2039
MBEG23P	27.85948	71.41209	76.01602	178.7139
MBEG23S	25.84406	71.90031	111.3185	255.1649
MBFBU01	1.510442	1.12038	3.158965	8.245973
MBFG02	12.40402	29.21127	63.3131	145.0609
MBHD01	.147572	.3960021	.1095902	.2574136
MBPD01P	15.30205	29.76591	43.37283	105.0294
MBPD01S	10.5374	26.41236	31.44314	75.3292
MBPD02P	17.13478	39.23702	60.40799	130.7479
MBPD02S	22.15117	53.73598	54.30121	111.8313
MBPD03P	11.28621	22.64681	58.95549	133.8278
MBPD03S	6.873386	11.83503	36.34743	73.08959
MBPD10	14.19453	34.12048	101.0342	188.595
MBPD11	11.64179	27.76604	33.68641	69.98109
MBPD20	10.38483	18.26506	48.12011	100.9826

NBEG22S	5.20115	11.81611	8.584577	4.964904
NBEG23P	1.378974	8.117036	3.986041	2.694777
NBEG23S	3.202232	8.841812	4.279852	5.047864
NBHD01	4.40225	8.012298	6.91414	10.78454
NBHD02	4.087848	7.822727	5.652909	5.19407
NBHD03	.4501569	.5405548	2.794657	8.224097
NBHD04	11.4105	10.53629	9.380911	6.263426
NBHD05	.2916362	.4620789	3.119329	7.674036
NBHD06	3.972304	7.649377	4.820166	5.020765
NBHD07	4.204099	8.010626	7.361649	11.85414
NBHD08	.9738973	1.589621	4.592863	9.07156
NBPD01P	6.748888	12.88735	8.092156	3.386722
NBPD01S	11.31286	26.03432	20.51112	8.895305
NBPD02S	.3922969	.6493505	.745691	.1388165
NBPD10	1.880762	7.800812	6.185299	2.940017
NBPD11	7.183386	17.9444	12.45015	5.02891
NPD1A	4.553199	11.92108	31.16002	10.315
NPD1A1	38.8091	122.0226	311.5307	107.9571
NPD1B	57.20787	153.6538	358.533	121.8823

Fig. (3). Calculated results of pipe processing time of each segment by carbon steel and stainless steel (unit: hour).

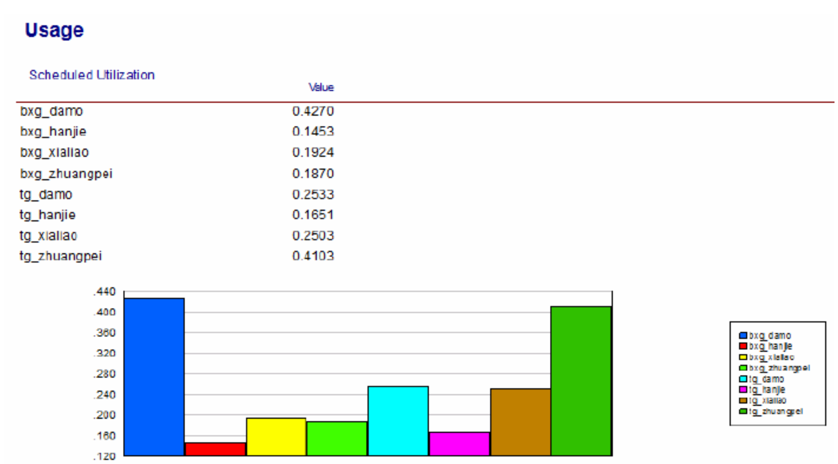

Fig. (4). Example figures of simulation results of each resource utilization.

efficiency of the tube production plant will continue to increase, making the hybrid deployment of flexible resources more scientific and reasonable.

In the process of research and discussion in this section, it mainly focused on the corresponding impact of rational allocation of flexible resources to enhance efficiency of every work piece during the tube production process. When the overall processing program produces change, rational management of resources can help meet the needs of flexible production plan, such that the flexible resource allocation process can achieve the objective of an effective balance. The first step of flexible resource scheduling process should be combined with the abstract question of tube production line in the production process, which is the allocation of flexible resources, and thus effective solution to its problems, methods and steps were enumerated.

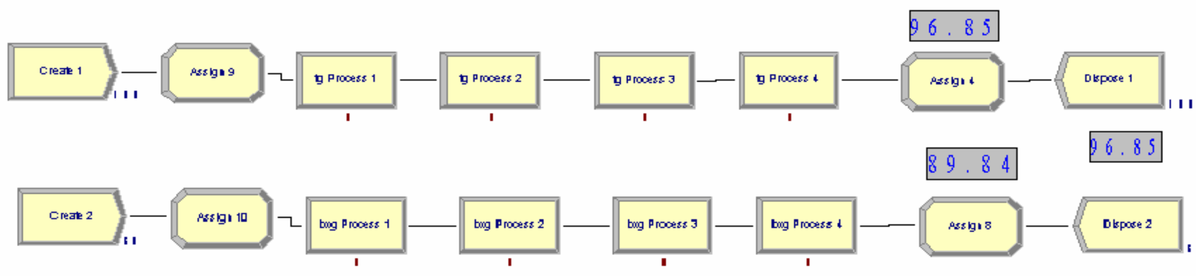

Fig. (5). Example figures of processing cycle simulation result by carbon steel and stainless steel production line.

Whether or not a worker has a comprehensive skills can decide multi-step operations of workers. If a worker was kept in a single step operation for a long time, the worker will be more harnessed for this process workflow, whereas unfamiliar degree will increase inefficiency for the other processes. In this process, because familiarity with the other workflow cannot guarantee supply and demand, the time required to complete the process will be significantly increased, thus leading to the result that the efficiency may be affected. Every process consists of a single skilled worker in the workshop. And in the number of options to ensure complete tool case, the efficiency of the workers can possibly be to obtain a fundamental guarantee. Then, the production quality of the jar can also be increased to a certain degree [4].

We started from the current simply situation in the manufacturing process of tube workshop, and envisaged flexible resource allocation problem on multi-lines. Of course, the assumption of this problem has a certain thought. There are many production lines (with m to represent), such as the i production line $L=\left\{P_{i1}, P_{i2}, ..., P_{ij}, ...P_{ini}\right\}$ has n_i production processes,

$Pij=\left\{R_{ij1}, R_{ij2}, ..., R_{ijk}, ..., R_{ij}w_{ij}\right\}$ has W_{ij} flexible resources to allocate. However, in such a production line, the establishment process of capability efficiency of the process resource R_{ijk} matrix is shown below.

$$A_{ijk}=\begin{Bmatrix} \alpha_{ijk11} & \alpha_{ijk12} & \cdots & \alpha_{ijk1b} & \cdots & \alpha_{ijk1n_1} \\ \alpha_{ijk21} & \alpha_{ijk22} & \cdots & \alpha_{ijk2b} & \cdots & \alpha_{ijk2n_2} \\ \vdots & \vdots & & \vdots & & \vdots \\ \alpha_{ijka1} & \alpha_{ijka2} & \cdots & \alpha_{ijkab} & \cdots & \alpha_{ijkan_a} \\ \vdots & \vdots & & \vdots & & \vdots \\ \alpha_{ijkm1} & \alpha_{ijkm2} & \cdots & \alpha_{ijkmb} & \cdots & \alpha_{ijkmn_n} \end{Bmatrix}$$

Here, we use α_{ijkab} to refer to the k resource in *j* processes in the *i* production line, and R carried out the production line in which the production process capability b is efficiency factor. And to ensure that the difference between i and m is to be maintained less than or equal to 1, between a and m is less than or equal to 1, between b and n is less than or equal to 1, and between k and wij is less than or equal to 1, $\alpha_{ijkab}=0$ illustrates that the working efficiency in P_{ab} step does not exist, and also that workers cannot perform this process. However, $\alpha_{ijkab}=0$ indicates that the worker's P_{ab} ability in production line is 1, that is when α_{ijkab} is greater than 0 and less than 1, it indicates that the productivity of production line P_{ab} is low. However, if α_{ijkab} is more than 1; the productivity of a worker in P_{ab} process significantly exceeded the expected range of the working efficiency. However, the effective use of R_{ijk} resources in production process P_{ab} and maintaining α_{ijkab} greater than 1, will result in that the worker is fully capable of doing P_{ab} process work, its efficiency can be guaranteed, and is not influenced by other factors [5]. In such conditions, the establishment process of a matrix is as follows:

$$X_{ijk}=\begin{Bmatrix} X_{ijk11} & X_{ijk12} & L & X_{ijk1b} & L & X_{ijk1n_1} \\ X_{ijk21} & X_{ijk22} & L & X_{ijk2b} & L & X_{ijk2n_2} \\ M & M & & M & & M \\ X_{ijka1} & X_{ijka2} & L & X_{ijkab} & L & X_{ijkan_a} \\ M & M & & M & & M \\ X_{ijkm1} & X_{ijkm2} & L & X_{ijkmb} & L & X_{ijkmn_n} \end{Bmatrix}$$

Keeping the i and m less than or equal to 1, and a and m less than or equal to 1, and b and n are to be maintained less than or equal 1, then $\in\{0,1\}$. As can be seen from the formula, R_{iik} represents the assigned number of b step in a production line during pipe processing, which reflects the specific ratio of working hours and total resource load of workers. However, when it is 1, it is the R_{iik} distribution of the P_{ab} job step, if = 0, then it is not the R_{ijk} distribution of the P_{ab} job step.

In the P_{ab} process of workshop, processing resources include both flexible resources and fixed resources, the fixed resources equivalent to ability are usually represented by FC_{ab}, while flexible resources equivalent to capacity are normally represented by CC_{ab}. When the fixed resource efficiency capabilities are 1, then the fixed number of resources allocated FC_{ab} and processes P_{ab} are equal. When the productive capacity $C_{ab} = FC_{ab} + CC_{ab}$ of flexible resource allocation is equivalent to the workshop process P_{ab}, then the following formula can be deduced.

$$C_{ab} = FC_{ab} + \sum_{i=1}^{m} \sum_{j=1}^{ni} \sum_{k=1}^{wij} \left(X_{ijkab} * a_{ijkab} \right)$$

For example: there are a number of much-needed pipe processing plans in the workshop, $Plan = \left\{ Plan_1, Plan_2, ..., Plan_i, ..., Plan_m \right\}$. However, it must be ensured that the $Plan_i$ leads to product in L_i production line, which can be obtained through $Plan_i = \left\{ WP_{i1}, WP_{i2}, ...WP_{iQ}, ...WP_{iQi} \right\}$ and the total number of artifacts are Q_i. However, the relationship formed between Q_i and q is gradually reduced which is less than 1. In this process, all parts of the processing line can be determined in the following order: $P_{i1}, P_{i2}, ..., P_{ii}, ... P_{ini}$. In this, the processing tools used in workshop can meet internal needs. Processing equipment is used to improve their number. So there is only one restricting factor for workshop workers' productivity, which is the flexible resources, which are multi-skilled workers. In the process of WP_{iq} workpieces, the need for workers to step on a particular application process to complete its operation, and its operating characteristics are both constraints to complete the work efficiently [6]. From the above discussion on processes, it can be concluded that if the processing capacity of its own worker is 1, the distribution function for each of the workpieces in different steps can be calculated through the statistic of historical data and its characteristics. The machining time of different workpieces in different processes is only related to their own characteristic parameters regardless of other factors. $Plan_i$ processing time matrix is as follows:

$$PT_i = \begin{Bmatrix} f_{i11} & f_{i12} & \cdots & f_{i1b} & \cdots & f_{i1n_i} \\ f_{i21} & f_{i22} & \cdots & f_{i2b} & \cdots & f_{i2n_i} \\ \vdots & \vdots & & \vdots & & \vdots \\ f_{iq1} & f_{iq2} & \cdots & f_{iqb} & \cdots & f_{iqn_i} \\ \vdots & \vdots & & \vdots & & \vdots \\ f_{iQ_i1} & f_{iQ_i2} & \cdots & f_{iQ_ib} & \cdots & f_{iQ_in_i} \end{Bmatrix}$$

Among this, f_{iab} represented the distribution function of the time for the q component of the b process in the L_i production line when the efficiency was 1.

Due to the special nature of processed products, with the change in plans, the amount of processing tasks in different production line and different processes will be changed, and the processing time cannot be accurately measured. This will result in the imbalance of different production lines or processes for different batch processing Plan, that is suitable for a number of program resources on the front lines of the various production processes configured. If not reconfigured, it may lead to the imbalance between next batch production line or process capacity, so that the total processing cycle becomes longer. Assume the processing cycle of Plan, $PC = \left\{ pc_1, pc_2, ..., pc_i, ..., p_{cm} \right\}$ represents the processing cycle of i production lines. The purpose of the study is how to allocate limited resources at different batches plan conditions, and make the total processing cycle T for Plan to be the shortest. Thus we established the following objective function:

$$Object: T = Min\ Max\left\{ PC_1, PC_2, ..., PC_i, ..., PC_m \right\}$$

Since it is difficult to establish the analytical expression of the main objective function of production system of a discrete event, we established the multi-line simulation models under the principle of discrete event modeling and simulation, use OptQuest simulation to take the optimization modules and find the best configuration for flexible resource [7]. The OptQuest applied package in Arena applied the tabu search, scatter search and other heuristic algorithms, moving skillfully control variables in the input space, to find the best combination of variables near the input control to achieve fast in an iterative way, to achieve the rapid and reliable proximity to the object. Of course OptQuest module has certain range of applications; we can integrate the preparation of a targeted optimization program into the Arena's VBA modules to achieve optimization purposes through the actual simulation.

CONCLUSION

This paper presents the design process of pipe production workshop planning simulation system combined with shipbuilding industry, along with discussion of the simulation system of pipe production plant construction process. We did the effective research for calculating the machining time and the efficiency of all parts of the workpieces combined with the establishment of simulation model, as well as solved any issues generated during the establishment of the model. Secondly, appropriate introduction to the scheduling method of flexible pipe processing plant resource is carried out by listing the corresponding formula into a computer matrix, thus providing an effective theory and data support for the follow-up research process. This paper analyzed the relationship between data related to all aspects of the process, hoping to have a positive role in continuing promoting shipbuilding productivity of industrial pipes.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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