Transactions on the Built Environment vol 68, © 2003 WIT Press, www.witpress.com, ISSN 1743-3509

Decision matrix for the panel production line technological improvement policy definition

N. Fafandjel, D. Pavletić & M. Hadjina
Department of Naval Architecture and Ocean Engineering
Faculty of Engineering, University of Rijeka, Croatia

Abstract

Technological improvement in comparison to technological renewal, presents a greater project challenge, because it requires a more detailed approach in terms of defining input variables to meet user demands. In context of such improvement, denominated as refitting of the panel production line within, one of the major Croatian shipyards, the authors explored various methods to determine technological improvement policy. They used a functional breakdown concept for panel production line equipment components. Refitting includes the overall replacement of driving operations on the panel production line in general, that represents objects of technological improvement. To ensure a systematic approach to define improvement policy, and to consider all relevant parameters and user requirements, the decision matrix method is applied. Due to the application of such method, cause-effect relations were established and absolute and relative priorities of observed parameters were defined. Furthermore, all panel production line characteristic and driving operations have been systematically analysed with the objective to assure required capacities and high quality of finished panels. The authors emphasize that for a successful accomplishment of refitting goals, conventional treatment of panel production line capacity, based on average panel, is not appropriate, Fafandjel [1]. Such capacity definition cannot provide information of actual throughput of stations, or technical–functional characteristics of functional units. Therefore, the authors are suggesting the appliance of panel with characteristics that makes it a most complex one for fabrication on the particular panel production line, instead of an average panel, which is defined as a standard one.

Transactions on the Built Environment vol 68, © 2003 WIT Press, www.witpress.com, ISSN 1743-3509

1 Introduction

Investments, according to their extents, can be categorized as appertaining technological renewal or technological improvement. Within both approaches, when bidding for offers, one can either improve the existing facility (refitting) or buy a completely new one.

As a consequence, bonded financial resources for refitting are rather smaller than ones that should be used for the installation of new panel production line. However, refitting requires more detailed definitions of complex technical, technological and production requirements. In this paper, a solution for defining such requirements is suggested by using suitable configurations of various tools. Such solution is based on recognizing the functional systems over the panel production line stations that are objects of refitting.

Furthermore, in a sense of refitting, an approach to technological improvement of the existing panel production line, with systematic analysis of line parameters and characteristics, in sense of reaching demanded objectives, is given.

Refitting includes the overall replacement of driving operations on the panel production line in general, that represent objects of technological improvement.

The panel production line technological improvement is planed with the objective to achieve increase in line capacity, while obtaining minimal investment or modification costs, and minimal line down time.

Capacity can be viewed from two aspects. Firstly, as a total quantity of material that can pass through the panel production line in a single time unit (e.g. t/h or t/day), and secondly as a measure of capability to deposit welding material in a single time unit (e.g. kg/h). For analysing purposes, the first aspect was considered.

Costs represent all financial resources associated with line refitting.

Down time is defined as a time during which the panel production line is out of operation due to improvement actions.

Production time is considered as a time needed for single quantity unit manufacturing.

2 Panel production line description

At the beginning of any improvement process, it is necessary to define its purpose and objectives. As an example, a panel production line improvement located within one of larger Croatian shipyards has been analysed. Chosen panel production line is presented in figure 1.

Such production line consists of five successive stations, as follows:

Station I, where after transport of two plates from plate storage, positioning them on platform with magnets occurs, followed by mounting, lining up, adjusting of plates and tacking;

Transactions on the Built Environment vol 68, © 2003 WIT Press, www.witpress.com, ISSN 1743-3509

Station II, where after transport from Station I is completed, follows butt welding of the first side, plate rotation with crane for 180 degrees, and butt welding of the second side;

Station III, where rotation of plate for 90 degrees occurs. Than follows preparations for profile fillet welding, grinding, marking positions for openings and profiles. Afterwards, cutting of openings and checking quality of welded joints follows;

Station IV, where after transport from Station III, mounting of first line of profiles coming from profile storage and their fillet welding occurs and;

Station V, where after transport from Station IV, storage of completed panels for further disposition is organized.

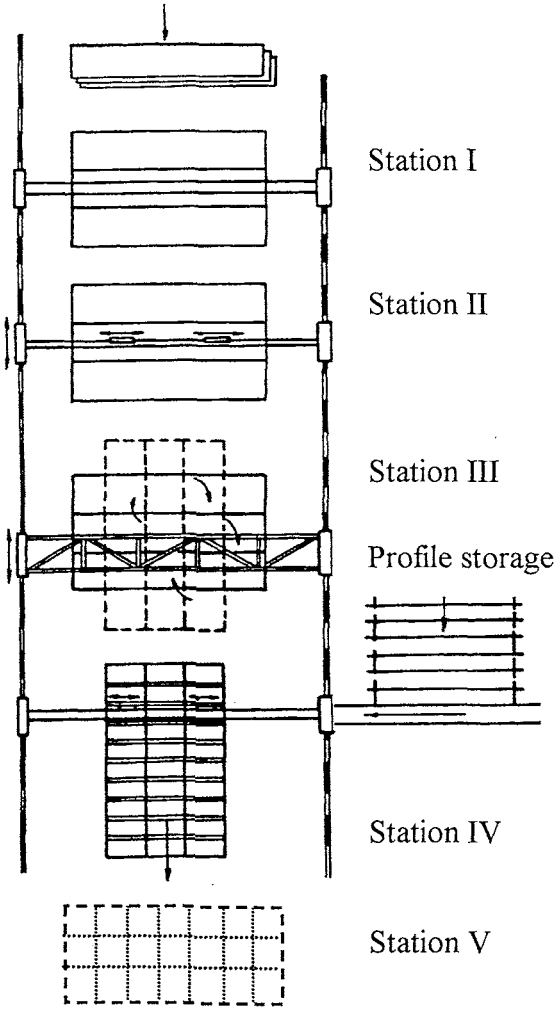


Figure 1: Panel production line.

Within panel production line refitting process following requirements have to be included:

- substitution of manual with automatic work,
- appliance of technologically improved equipment,
- higher level of production process integration,
- achieving of system with wider regulation range possibilities of parameters,
- improved dimensions and performance quality control,
- maintaining of required minimum of groove clearance.

3 Panel production line process map

In general, a process map is a graphical representation of a process flow identifying the steps of the process, input and output variables of the process, and opportunities for improvement. There can be several levels of detailed map. The well-defined panel production line process map is essential for panel production line inputs and outputs analysis.

After listing of all inputs for each process step, they were classified as critical, noise, SOP or standard operation procedure and controllable one.

Critical inputs (X) are input variables for that have been statistically shown, or is assumed, to have major impact on the variability of the result. Noise inputs (N) are input variables that affect the output results, but are difficult, impossible, or we choose not to control. Standard operation procedures (SOP) are input variables that are defined and controlled by existing standard procedure for running the process. Controllable inputs (C) are input variables that can be changed to see the effect on the result, Pavletić [2].

The complete panel production line process map is shown in figure 2. The map is presenting major input variables and outputs for each process step.

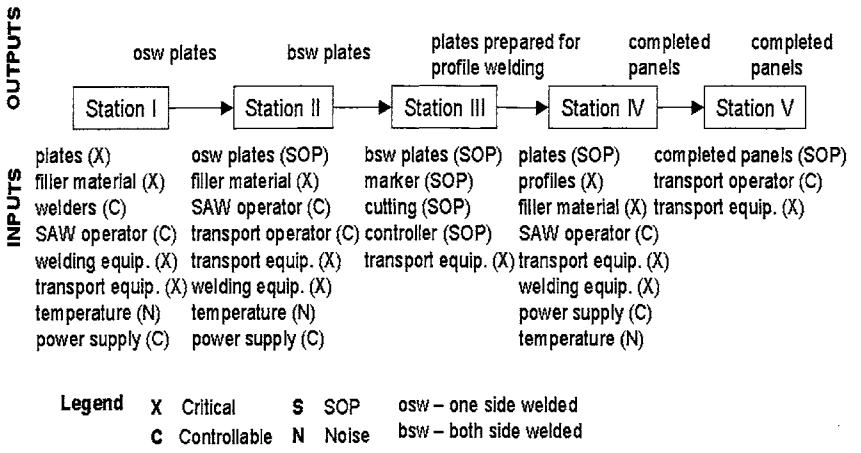


Figure 2: Panel production line process map

4 Cause-and-effect relationship tools

For determining cause-and-effect relationships two basic tools can be applied: cause-and-effect diagram and cause-and-effect matrix.

4.1. Cause-and-effect diagram

The first tool, a cause-and-effect diagram, is a graph that shows the relationships among a problem and its possible causes. Those diagrams are used during brainstorming sessions where possible solutions for a problem are being sought. In this context, they provide a model for the connections between the problem, and factors that affect it. The problem is called effect, and the factors that affect it are called the causes. Cause-and-effect diagrams are useful in understanding the effects that several factors have on a process. They are also known as fishbone or Ishikawa diagrams, Rao [3].

Here, an cause-and-effect diagram is used for evaluation of chosen panel production line parameters. In accordance with observation and monitoring of this line the cause-and-effect diagram shown in figure 3 is developed. As one of the objectives is to increase the capacity the of panel production line, the research team decided to examine influence and relationships of panel production line parameters on its capacity. The main category of influence parameters are material, welding equipment, transport equipment, personnel, panel production line layout and other.

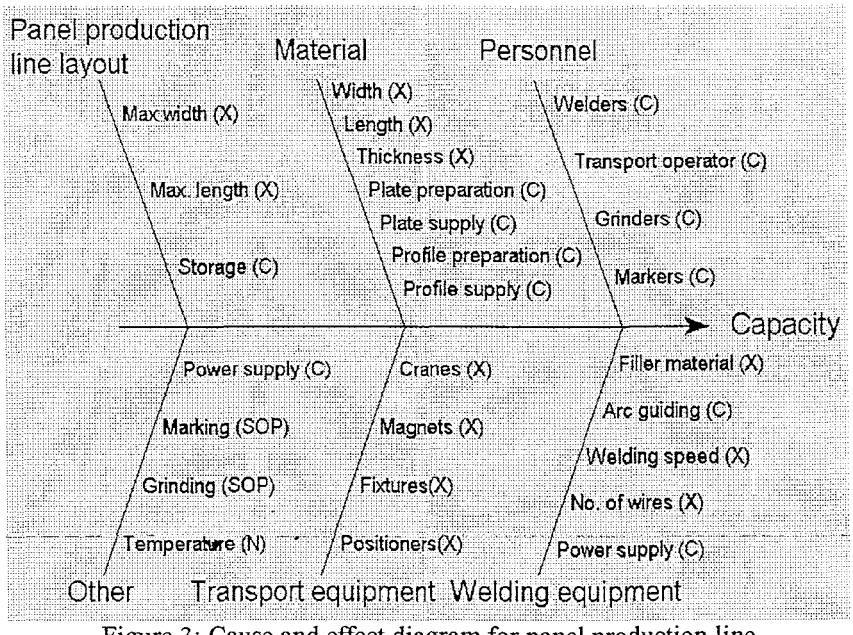


Figure 3: Cause and effect diagram for panel production line

4.2. Cause-and-effect matrix

The second tool, a cause-and-effect matrix or a decision matrix, is a simple quality function deployment matrix, used to ensure that the customer requirements are considered in determining the key characteristics of the product/process.

Cause-and-effect decision matrix is used to relate the key inputs to the key outputs using the process map and the cause-and-effect diagram as primary sources of input information. Key outputs are rated according to their importance, while key inputs are scored as to relationship to key outputs, Breyfogle III [4]. Importance of each output is rated on the scale from 1 to 10 where with 1 is rated output with no importance to customer, while with 10 is rated output with the highest importance to customer. The expert team appointed for panel production line improvement rated outputs as is shown in table 1 and table 2.

Table 1: Cause-and-effect decision matrix for panel production line (inputs from process map)

Rating of Importance			10	7	3	5	
Process Step		Critical Process Inputs	Capacity	Costs	Down time	Production time	**Total**
1	Station I	Plates	10	1	0	5	**132**
2		Filler material	3	1	3	5	**71**
3		Welding equipment	3	3	3	3	**75**
4		Transport equipment	7	10	10	7	**205**
5		Welders	5	2	1	5	**92**
6		Power supply	1	7	7	1	**85**
7	Station II	Filler material	7	1	3	7	**121**
8		Welding equipment	10	10	7	10	**241**
9		Transport equipment	7	10	10	7	**205**
10		SAW operator	5	1	1	5	**85**
11		Transport operator	3	1	1	3	**55**
12		Power supply	3	7	7	3	**115**
13	Station III	Transport equipment	7	10	10	7	**205**
14	Station IV	Profiles	7	1	1	3	**95**
15		Filler material	7	1	3	7	**121**
16		Welding equipment	10	10	7	10	**241**
17		Transport equipment	5	10	10	7	**185**
18		SAW operator	5	1	1	5	**85**
19		Power supply	3	7	7	3	**115**
20	Station V	Transport equipment	5	10	10	5	**175**
21		Transport operator	3	1	1	3	**55**
Total			**116**	**105**	**103**	**111**	

There are two main approaches to the cause-and-effect matrix. The first approach is a general one, which is used for relatively simple processes. The second approach is a focused one, which is used for larger, more complex operations. Within the second approach there are two phases. In the first phase the inputs are correlated to outputs that provide basis for Pareto analysis. In the second phase, new cause-and-effect matrix is started with three or four critical inputs from the first phase matrix, Wadsworth [5].

Table 2: Cause-and-effect decision matrix for panel production line (inputs from cause - and – effect diagram)

Rating of Importance			10	7	3	5	
Process Step		Critical Process Inputs	Capacity	Costs	Down time	Production time	**Total**
1	Cause and effect diagram	Panel line width	5	10	10	5	**175**
2		Panel line length	3	10	10	5	**155**
3		Capacity of storage	3	5	5	1	**85**
4		Plate width	5	1	1	3	**75**
5		Plate length	7	1	1	3	**95**
6		Plate thickness	10	1	1	7	**145**
7		Plate preparation	1	3	5	1	**51**
8		Plate supply	3	3	3	1	**65**
9		Profile preparation	3	3	5	1	**71**
10		Profile supply	3	3	3	1	**65**
11		Cranes	7	10	10	5	**195**
12		Magnets	5	7	5	3	**129**
13		Fixtures	5	7	5	3	**129**
14		Positioners	7	7	5	3	**149**
15		Welders	5	1	1	1	**65**
16		Transport operator	5	1	1	1	**65**
17		Grinders	5	1	1	3	**75**
18		Markers	5	1	1	3	**75**
19		Filler material	7	1	3	5	**111**
20		Arc guiding	1	7	3	1	**73**
21		Welding speed	7	7	1	5	**147**
22		Number of wires	7	7	3	7	**163**
23		Power supply	3	7	7	3	**115**
Total			**950**	**532**	**222**	**440**	

In the matrix, factor of importance for each parameter is rank ordered and every listed input parameter is correlated to every output parameter. Finally, total value for each parameter is obtained by multiplying rating of importance with value given to parameters and adding across for each parameter. Total value of each input parameters, relatively to the other inputs, represents the level of parameter importance. The higher total is, the influence of input parameter on outputs is greater.

Based on the process map and cause-and-effect diagram a cause and effect decision matrix is developed.

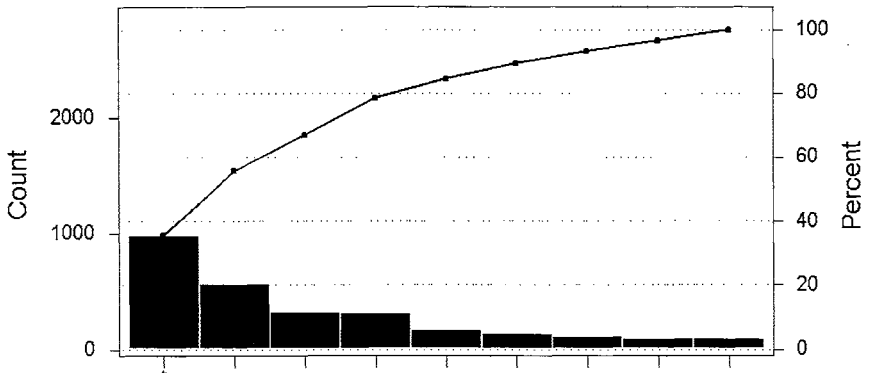
In table 1 are entered input variables shown on panel production line process map where they are listed in order of appearance in process. In table 2 are the same parameters appropriately categorised.

In further analysis of importance of panel production line inputs and their influence on panel line capacity and costs of necessary modifications only results from table 1 will be used.

5 Results analysis

To be very certain about level of parameters influence, further Pareto analysis will be applied.

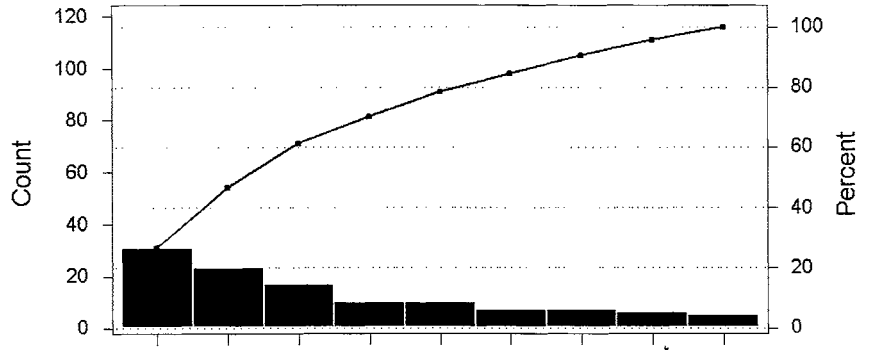
Pareto diagram clearly exhibit information about relative importance of factors of certain problem. This information helps to identify the most important factors, which will be firstly analysed. With help of Pareto diagram the fields of possible improvements are clearly identified. Information obtained by cause-and-effect matrix, provided in table 1, where additional calculations necessary for Pareto analysis are made. Drawn diagram shows cumulative percentage of points for each parameter. Using results obtained through cause-and-effect matrix the following Pareto analysis is conducted. As indicated in figure 4a) the most influential inputs on total sum of points are *Transport equipment*, *Welding equipment*, *Power supply* and *Filler material*. Analyzing impact of each input variable to panel production line capacity, shown in figure 4b), can be concluded that again *Transport equipment*, *Welding equipment*, and *Filler material* have major impact with almost 60%. In the same time, the major cost impacts have *Transport equipment*, *Welding equipment*, and *Power supply*, figure 4c).



Input	Transport equipment	Welding equipment	Power supply	Filler material	SAW operator	Plates	Transport operator	Profiles	Others
Count	975	557	315	313	170	132	110	95	92
Percent	35,3	20,2	11,4	11,3	6,2	4,8	4,0	3,4	3,3
Cum %	35,3	55,5	66,9	78,3	84,5	89,2	93,2	96,7	100,0

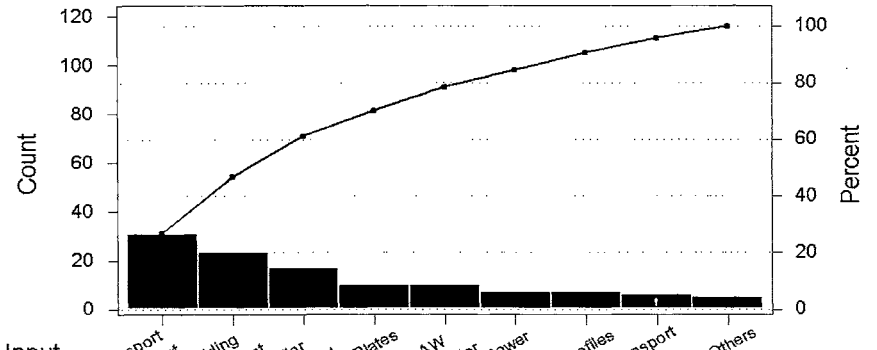
Figure 4 a): Pareto analysis of inputs influence on total (Tab. 1.)

From this analysis following conclusions can be drawn. It is obvious that modifications in line transport equipment will considerably increase capacity, but the costs of these modifications are also the highest. The *Welding equipment* has a bit smaller impact on line capacity increase while the costs of welding equipment modifications are almost half of transport equipment modifications costs. In authors opinion, the most significant is *Filler material*. The influence of filler material modification panel production line capacity in comparison with associated costs has greatest gain/give ratio that put filler material at the first place for further analysis and possible improvements.



Input	Transport equipment	Welding equipment	Filler material	Plates	SAW operator	Power supply	Profiles	Transport operator	Others
Count	31	23	17	10	10	7	7	6	5
Percent	26,7	19,8	14,7	8,6	8,6	6,0	6,0	5,2	4,3
Cum %	26,7	46,6	61,2	69,8	78,4	84,5	90,5	95,7	100,0

Figure 4 b): Pareto analysis of inputs influence on line capacity.



Input	Transport equipment	Welding equipment	Filler material	Plates	SAW operator	Power supply	Profiles	Transport operator	Others
Count	31	23	17	10	10	7	7	6	5
Percent	26,7	19,8	14,7	8,6	8,6	6,0	6,0	5,2	4,3
Cum %	26,7	46,6	61,2	69,8	78,4	84,5	90,5	95,7	100,0

Figure 4 c): Pareto analysis of inputs influence on costs of line modification.

Transactions on the Built Environment vol 68, © 2003 WIT Press, www.witpress.com, ISSN 1743-3509

6 Conclusion

This paper is analysing through systems approach methodology a panel production line technological improvement, in sense of refitting

The authors have proposed such methodology configuration as to enable processing of most relevant line input parameters in terms of reaching demanded requirements of its technological improvement. In such manner the hierarchy of produced results should lead towards the final objective i.e. towards an optimal distribution of financial resources allocated for planned improvement.

Such approach enables clear understanding and distinguishing of most influential parameters. Further steps should include costs analysis for every possible improvement strategy including design of experiment methods for determination of most appropriate parameter settings.

Furthermore, it is underlined that refitting of the existing line is more appropriate, than investing in a completely new line, due to requiring less financial resources and shorter line down time.

References

[1]. Fafandjel N., Simone V., Hadjina M., *Approach to the Panel Production Line Technological Improvement*, 15. Symposium SORTA 2002. - In memoriam prof. Leopold Sorta, Trogir, Croatia, 14. – 16. November, 2002.

[2] Pavletić, D., Mrakovčić, T., *An Approach to systematic selection of parameters for generator set optimization*, 13th International DAAAM Symposium, Proceedings, Vienna, str. 417 do 418., 2002

[3] Rao, A., et al., *Total Quality Management: A Cross Functional Perspective*, John Wiley & Sons, New York, 1996.

[4] Breyfogle III, F. W., *Implementing Six Sigma: Smarter Solutions Using Statistical Methods*, John Wiley & Sons, Inc., New York, 1999.

[5] Wadsworth, H. M., et al., *Modern Methods for Quality Control and Improvement*, John Wiley & Sons, New York, 1986.