DISCRETE EVENTS SIMULATION TO IMPROVE MANUFACTURING PROCESS OF JACKETS OFFSHORE STRUCTURES

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ABSTRACT

Certain measures for optimization of jacket offshore structures manufacturing are presented in this paper. By using Discrete Events Simulation, various simulation models will be developed in order to reduce flowtime per jacket, identify bottlenecks, adjust manufacturing time to due dates and minimize probability of breaking them. This simulation model will be referred to a company with limited resources involving space and work-stations.

Keywords: Offshore energy, jacket, scheduling, Discrete Events Simulation, optimization, Assembly job shop scheduling, Lean Manufacturing.

1. INTRODUCTION

Wind power has a promising future but, nowadays it is really difficult to find places with high wind speed rates without being exploited. As a solution to this problem, offshore energy causes important advantages. In an offshore wind farm, energy production is 20% larger than in land, and this is because wind speed at sea is 1 m/s bigger and surface rugosity is considerably lower.

According to EWEA (2015), a growing tendency is clearly observed when it comes to offshore energy installed in the last years, 3,019 MW of net installed, grid-connected capacity was added in 2015, 108% more than in 2014. A net addition of 754 new offshore wind turbines in 15 wind farms were grid-connected from 1 January to 31 December 2015. It is also remarkable that 3,230 turbines are now installed and grid-connected, making a cumulative total of 11,027 MW.

From every kind of offshore structures, jackets are expected to be the most used ones. According to EWEA (2015), jackets structures could have a 40-50% of market share by 2020.

It is important to mention that costs derived from this kind of structures represent a 28% of the cost of the whole wind turbine. As reported by Sun, Huang, & Wu (2012), a substantial cost reduction can be expected over the long-term through economies of scale, learning effects and R&D efforts. The experience curve concept has been widely applied to predict the future trend of offshore wind energy costs, which expresses cost reduction as a function of increased cumulative installed capacity.

As reported by Blanco (2009), when total installed offshore wind power doubles, it is estimated that the costs per kWh can decrease by between 9 and 17%. In addition, a reduction of about 40% in the manufacturing of monopiles structures is forecasted.

Levelized cost of energy of larger turbines (6 MW) supported by jackets is around 11.1 cent/kwh while 3 MW turbines with monopile structures represents a LCoE of 13.4 cent/kwh; and a LCoE of 9 cent/kwh is the offshore target by 2020.

This could only be accomplished by using new technology, specifications optimization, standardization and big volumes in supply chain as well as maintain supplier cost-out.

When it comes to jackets manufacturing, traditional construction methods are based on point-to-point strategies and big painting cabins have to be replaced with new construction strategies based on optimized installations and mass production with assembly-based fabrication (prefabricated joints, optimized weldings…).

Apart from that, innovation plays also a big role involving Lean Manufacturing which derives to the optimization of the assembly process.

As stated by Kolberg & Zühlke (2015), Industry 4.0 aims for optimization of value chains by implementing controlled and dynamic production. What´s more, main processes in Lean Production are standardized, transparent and reduced to essential work. As a result, they are less complex and support the installation of Industry 4.0 solutions.

A simulation model will be developed in order to represent and optimize the construction strategy. The study case will be referred to the construction of these structures in a company with limited space, in which the fact of storing the parts of the jacket (Transition Piece TP, Jacket Upper Block JUB and Jacket Lower Block JLB) in different workshops makes it vital to analyze and schedule production activities involved. Minimizing flowtime per jacket, identify bottlenecks, adjusting manufacturing time to due dates and reducing probabilities of breaking them are the main goals of this study. Discrete Events Simulation will be used in order to achieve this.

As a result, an important reduction will be obtained in terms of resources (workstations) and time, and, as a consequence, manufacturing costs.

2. MANUFACTURING PROCESS OF A JACKET

Manufacturing process of a jacket can be performed by means of traditional construction methods which are based on point-to-point strategies or by means of innovative methods such as fabrication by joints, which will be the one studied in this model.

This construction strategy is suitable to mass production since it consists of prefabricated joints assembled with pipes. In addition to this, manufacturing process will be modelled as a pull-system since milestones will cause fabrication to start. Moreover, main solutions of Lean Manufacturing have also been performed in the model.

2.1. Parts of a jacket

Next figures show main parts of a jacket:

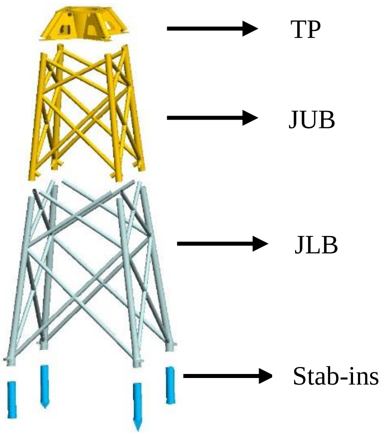

Figure 1: Parts of a jacket

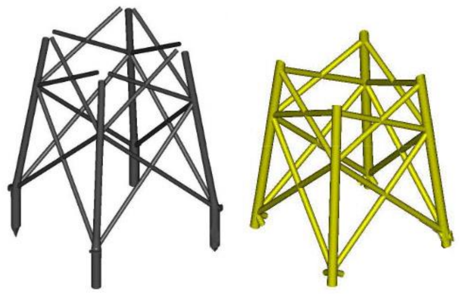

Figure 2: JLB & JUB

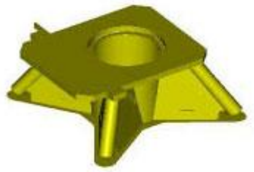

Figure 3: TP

2.1.1. Sub-parts of a jacket.

Next figures show main sub-parts of a jacket:

Figure 4: Bracing JUB & JLB

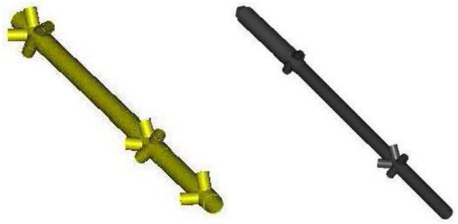

Figure 5: Leg JUB & JLB

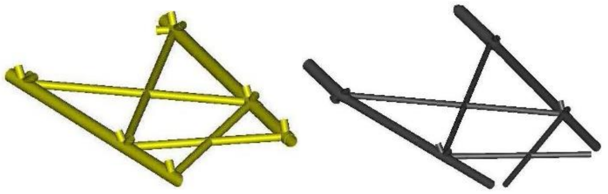

Figure 6: Row JUB & JLB

2.2. Construction strategy.

Main tasks involved in the manufacturing process of the jacket consist of assemblies of the sub-parts and painting of TP and JUB.

3. METHODOLOGY

3.1. Simulation Model.

This figure shows the flow chart of the simulation model. It basically consists of two inputs (drawings and material) which are necessary to start fabrication. Then, jackets are produced according to the construction strategy explained before and load-out of jackets is made according to different milestones for each cluster.

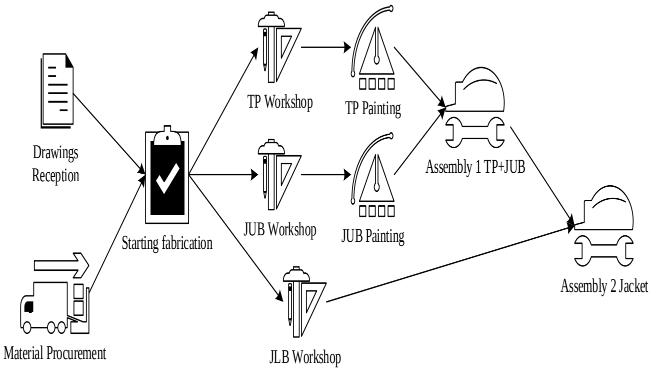

Figure 5: Flow chart of the simulation model

TPs, JUBs and JLBs are processed simultaneously assembling their sub-parts. Then TPs and JUBs are painted and after that, they are assembled (Assembly 1). Once Assembly 1 is carried out, the jacket is finally obtained after making Assembly 2, which consists of adding JLB to TP+JUB as shown in next figure:

Figure 7: Assembly 1 (TP+JUB) and Assembly 2 ((TP+JUB) + JLB).

Apart from representing the construction strategy, this simulation model is used to measure flowtime per jacket, identify bottlenecks by analyzing utilization of the main processes, quantify available space to buffer items as well as studying cost in terms of working hours for each part of the jacket. These will be the main indicators used to take into account when implementing measures to optimize the manufacturing process. Next figure illustrates main measures and goals taken into account:

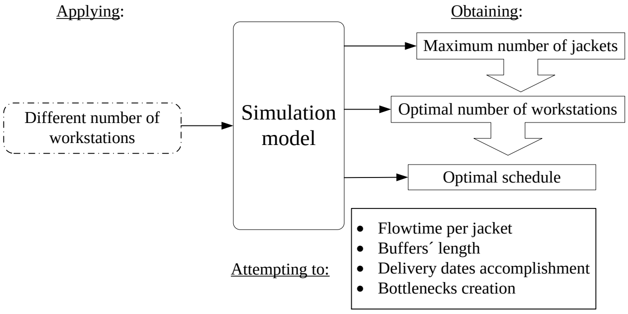

Figure 8: Measures, goals and indicators

3.2. Scheduling.

Scheduling of the project was made by means of a generic schedule consisting of clusters of jackets which are associated to the main payment milestones.

3.3. Discrete Events Simulation.

Due to the required detailed level in this work, Discrete Events Simulation has been chosen. This kind of Simulation has the following characteristics:

- Discrete (items flow, which are the parts and sub-parts of the jacket).
- Dynamic.
- Stochastic.

We used ExtendSIM Simulation software due to its versatility to represent any process, to its usefulness presented in terms of results and implementation and its easy use which avoids to using specific language coding. Next figure shows a screenshot of the simulation model developed:

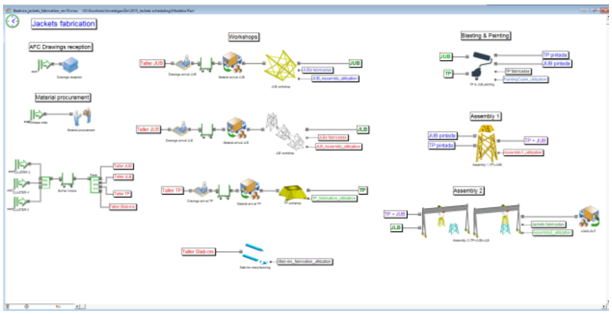

Figure 9: Screenshot of the simulation model.

3.4. Problem description.

According to the construction strategy, this problem applies to an assembly job shop scheduling, since the assembly of the final product (jacket) can only be conducted after all sub-components are finished. The components of the final product are processed by different machines according to a predetermined process plan.

Assembly job shop scheduling is different from job shop scheduling. The main difference is that assembly job shop scheduling not only involves the string type scheduling decision but also coordination of the assembly operations.

As it is a space-limited company, buffers capacity will be a constraint, especially those located before the painting cabins and assembly 1 and 2 areas. It will be particularly important to quantify queue´s length in the painting cabin as TPs and JUBs concur at this point so as flowtime will be minimum.

In addition to this, bottlenecks will also play a big role in the fabrication process so they will have to be identified and avoided by increasing workshops´ resources.

4. STATE OF THE ART.

The problem of an assembly job shop scheduling can be treated by means of different methods. In the next paragraphs, there is a brief summary of the most relevant studies related to the problem considered:

Thiagarajan & Rajendran (2005) used dispatching rules as a way to minimize the sum of weighted earliness, weighted tardiness and weighted flowtime of jobs by incorporating the costs related to earliness, tardiness and holding of jobs in form of scalar weights.

Natarajan et al. (2006) modified some existing dispatching rules to take into account different weights for holding and tardiness of jobs. However, it can be said that this study is limited when it comes to processing time (it is assumed as a constant value), queue length (it does not represent a constraint in the model) and assembly operations duration (the same for all levels).

Lui & Ponnambalam (2012) applied a Differential Evolution-based algorithm in solving a flexible assembly line scheduling problem. They proved the superiority of Differential Evolution variants in comparison with the current work.

Cheng, Mukherjee, & Sarin (2013) studied the so-called "lot-streaming" technique, which consists of accelerating the flow of a product through a production system by splitting its production lot into sublots that are simultaneously processed and, as a result, work-in-process and cycle-time is reduced. They applied this method to an assembly environment. By implementing a polynomial-type algorithm to obtain optimal sublot sizes to minimize makespan. Later, Mortezaei & Zulkifli (2013) developed a mixed-integer lineal mode for multiple products lot sizing and lot streaming problems. This formulation enabled to find optimal production quantities, optimal inventory levels, optimal sublot sizes and optimal sequence.

Dai, Hu, & Chen (2014) developed a Genetic Algorithm based on a heuristic approach in order to obtain the optimal block sequence in shipyards. This study paid much attention to the minimization of uncertainty of processing times, as well as the minimization of makespan. They found that there is a negative effect between makespan and spread of processing uncertainty, with a non-linear relation.

Wan & Yan (2014) analyzed the problem of an integrated assembly job shop (AJS) in which scheduling and self-reconfiguration was very important to minimize the weighted sum of completion cost of products, the earliness penalty of operations and the training cost of workers. They simultaneously optimized the assembly of components and the capacity of workstations. A heuristic algorithm was proposed to reconfigure the manufacturing system to meet the changed demand at the minimum production and reconfiguration of cost. Their results were analyzed by numerical experiments and they show that the proposed algorithm promises lower total cost and desirable simultaneous self-reconfiguration costs in accordance with scheduling.

Jia, Bard, Chacon, & Stuber (2015) combined the used of Discrete Events Simulation with heuristics approaches to evaluate dispatching rules for assembly operations. Their main goals were minimizing makespan, the number of machines used and the weighted sum of key devices shortages.

Komaki & Kayvanfar (2015) studied the optimal sequence of jobs so as makespan is minimized in a two-stage assembly flow shop in which not all jobs are available at time zero. Several heuristic techniques and also a meta-heuristic algorithm called Grey Wolf Optimizer are applied.

5. EXPERIMENTAL RESULTS.

5.1. Generic schedule.

Once construction strategy is modelled according to a generic schedule, first results can be obtained:

According to delivery dates associated with main cluster milestones, next table points out finishing fabrication dates for each cluster of jackets and its corresponding milestone date with the gap measured in days between each date:

Table 1: Differences between delivery and finishing fabrication dates (generic schedule).

Cluster	Cluster milestone date	Finishing fabrication date	Gap
1	24/04/2017	22/04/2017	2 days
2	22/06/2017	18/06/2017	4 days
3	02/11/2017	18/10/2017	15 days
4	28/01/2018	01/01/2018	27 days

As shown, the generic schedule implemented in this model accomplish main cluster milestone dates but gaps related to last clusters are too high so a reduction in terms of resources could be carried out.

Once differences between delivery and finishing fabrication dates were analyzed, throughput of main parts of the jacket was measured:

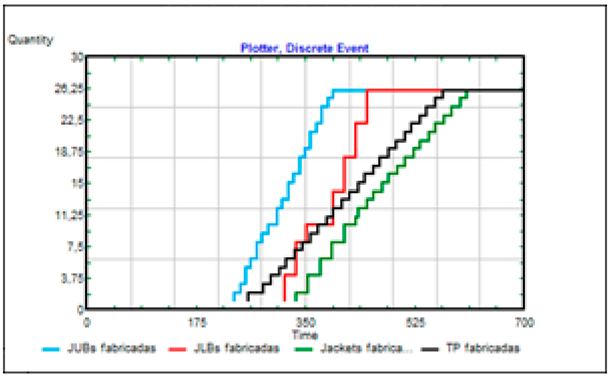

Figure 10: Throughput of main parts of the jacket (generic schedule).

As it can be seen, jackets manufacturing is strongly dependent on TPs manufacturing especially for the last ones.

Apart from that, JUBs seem to be constructed faster than JLBs so a line balance is needed.

Flowtime per jacket was measured as the difference between starting and ending fabrication dates for each jacket.

Next figure illustrates its evolution:

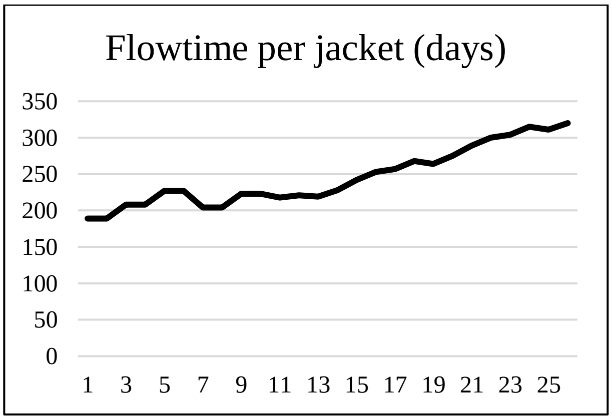

Figure 11: Flowtime per jacket evolution (generic schedule).

Flowtime per jacket increases according to project progress, what implies that jackets manufacturing lasts more when the project is ending than at the beginning. This can be produced because of the over-occupation of some workstations in certain stages of the project so as a consequence, fabrication has to be adjusted to due dates by means of a better assignment of resources.

Bottlenecks will be identified by analyzing % utilization of different workstations. Once detected, it will be important to optimize resources so as fabrication will not be blocked. The table below indicates average value of flowtime per jacket:

Table 2: Average flowtime per jacket (generic schedule).

Average flowtime per jacket	245,62 days

As it can be perceived, it will be particularly important to reduce flowtime per jacket.

Next figure shows utilization coefficients of the most important workstations:

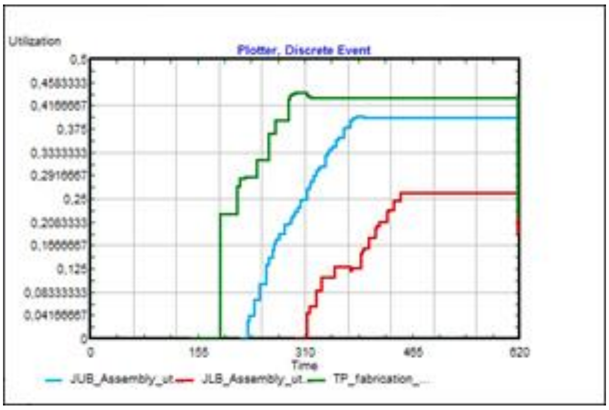

Figure 12: Utilization JLB, JUB and TP workshop (generic schedule).

As it can be seen, workshops seem to be not fully-exploited since coefficient of utilization is quite low, what implies that number of workstations is oversized.

On the other hand, it is important to avoid too high utilization since fabrication could be blocked if a certain machine gets damaged. Next figure shows evolution of utilization of painting cabins and assembling workshops:

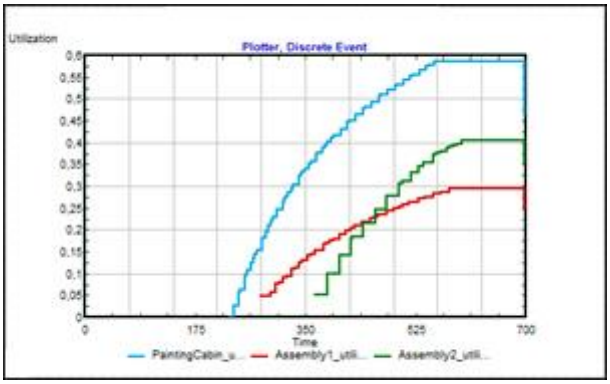

Figure 13: Painting cabin and assembling utilization (generic schedule).

As space is a limited resource in the company, it is vital to analyze the evolution of the buffers´ capacity in order to determine whether or not queues´ length are suitable for space available. Apart from that, if space required is reduced, another project could be carried out so profitability would increase. Most critical buffers in the process are the ones located before assembly operations due to the size of the parts of the jackets and painting cabins, in which JUB´s and TP´s wait to be painted.

When it comes to buffers located before assembly operations, next figure illustrates its evolution:

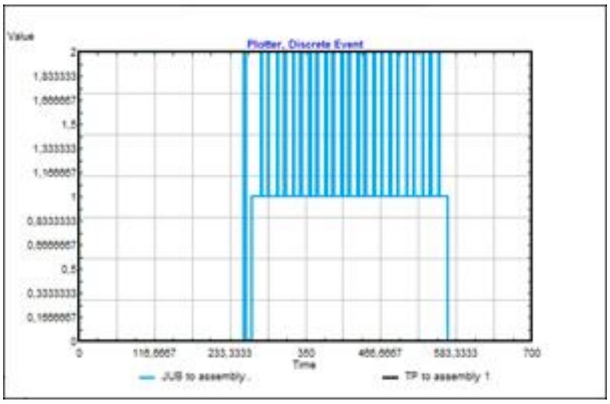

Figure 14: Buffer assembly 1 (generic schedule).

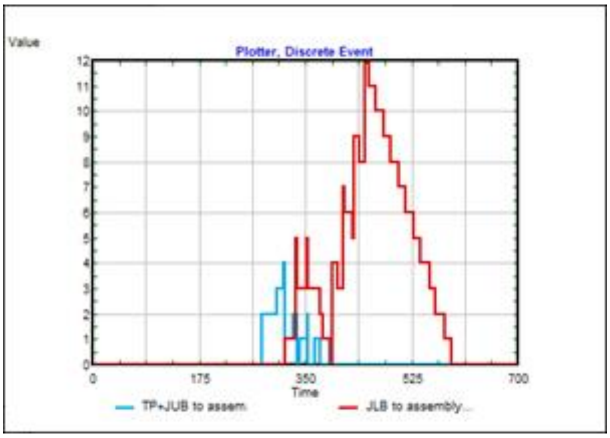

Figure 15: Buffer assembly 2 (generic schedule).

Concerning JUB´s and TP´s waiting to be painted, next figure shows their evolution during the project:

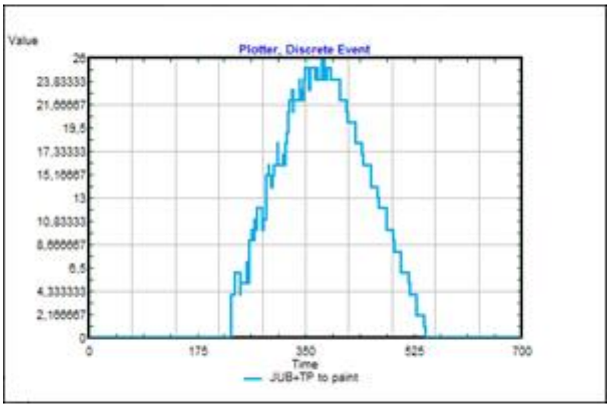

Figure 16: Buffer painting cabin (generic schedule).

According to results showed in previous figures, buffers located before assembly 2 and painting cabin have the highest queue lengths, so an especial attempt should be made to decrease them.

With reference to assembly 1 queue, it is interest to remark that there is not any single TP waiting to be processed so this also indicates that here it is an important bottleneck to consider.

5.2. Different number of workstations.

As throughput of main parts of the jacket was clearly unbalanced, number of workstations was modified to get the production process well-adjusted by creating multiple scenarios taking into account different number of workstations as variable factors and gaps to milestones and buffers´ length as response factors.

Next table shows best combination obtained in terms of reduction of workstations:

Table 3: Workshops modifications.

Decrease in:
-1 JUB Assembly
-2 JLB Assembly
-3 TP Manufacturing
-1 Assembly 1

As throughput rate was unbalanced, number of workshops of JUB, JLB and TP was modified in order to get the production line well-adjusted. Besides, as queue length of assembly 1 was not too long and assembly 1 utilization was also quite low, the number of workstations devoted to carry out assembling of TP and JUB was also reduced.

With reference to milestone dates accomplishment, next table shows results obtained with these new measures:

Table 4: Differences between delivery and finishing fabrication dates (different number of workstations).

Cluster	Cluster milestone date	Finishing fabrication date	Gap
1	24/04/2017	22/04/2017	2 days
2	22/06/2017	21/06/2017	1 days
3	02/11/2017	26/10/2017	7 days
4	28/01/2018	09/01/2018	19 days

As it can be seen, main milestones are accomplished even with the reduction in terms of resources made.

Throughput of main parts of the jacket obtained with new schedule is shown in the next figure:

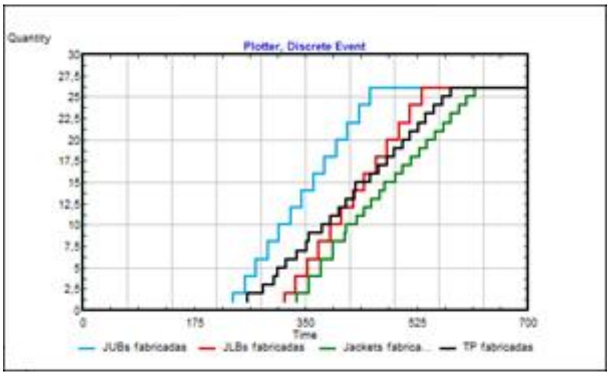

Figure 17: Throughput of main parts of the jacket (different number of workstations).

As shown, throughput rate is much more balanced in comparison with the one obtained by means of the previous schedule.

Regarding flowtime per jacket with the new schedule, an important reduction regarding average value is achieved. In addition, its evolution along project progress is much more regular than before:

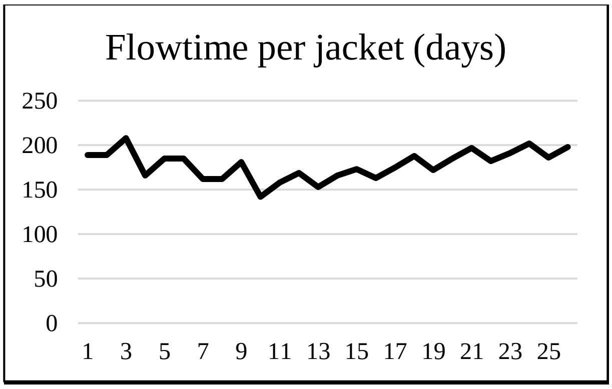

Figure 18: Flowtime per jacket evolution.

Table 5: Average flowtime per jacket.

Average flowtime per jacket	177,96 days

Next figure illustrates utilization coefficients of the main workstations involved in the manufacturing process:

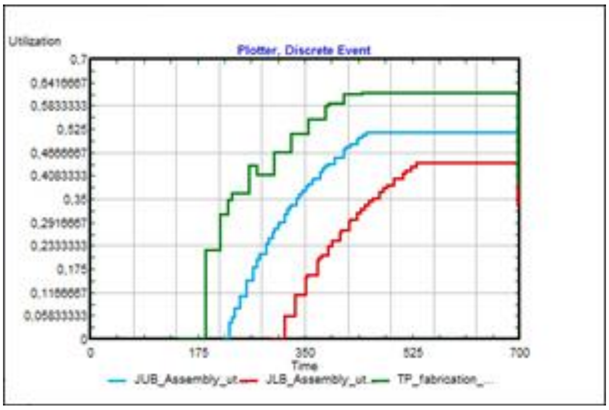

Figure 19: Utilization JLB, JUB and TP workshop (different number of workstations

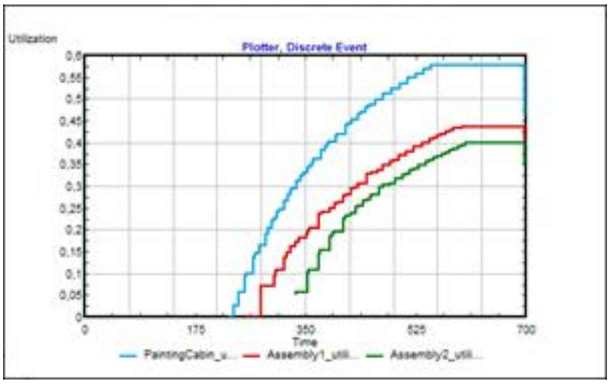

Figure 20: Painting cabin and assembling utilization (different number of workstations).

As a consequence of changes explained before, coefficients of utilization of main workshops have changed and now, workstations seem to be better-exploited.

Next figures show lengths of queues located before Assembly 1, Assembly 2 and painting cabin:

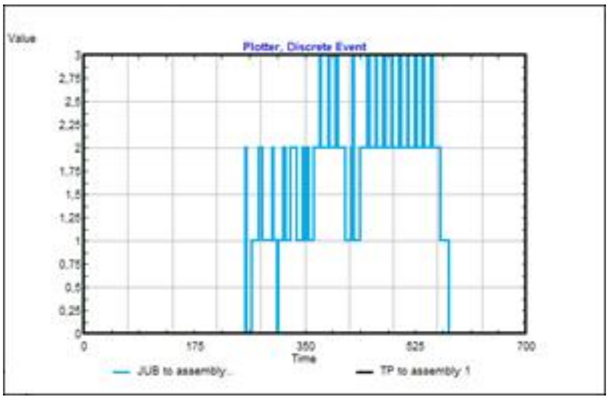

Figure 21: Buffer assembly 1.

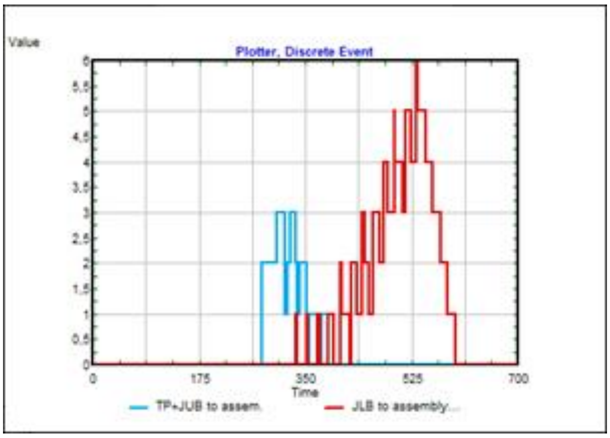

Figure 22: Buffer assembly 2.

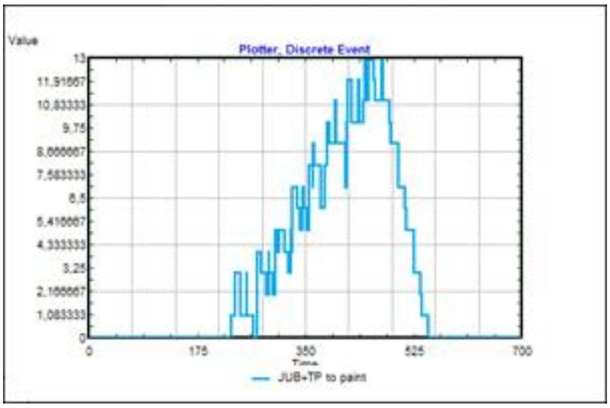

Figure 23: Buffer painting cabin.

With reference to assembly 1, as number of assembling workstations was reduced, its length has increased but not considerably. However, assembly 2 operation queue length has decreased as a result of the new measures carried out. When it comes to painting cabin buffer, it has also been reduced.

Results achieved in terms of queue lengths are going to be considered as suitable for space limitations as they have been reduced considerably in comparison to the ones obtained by means of the generic schedule.

As it can be observed, clusters milestones dates are accomplished even with this important readjustment in terms of resources. Besides, length of the main buffers is not so high when it is compared with results obtained with the generic schedule and main workstations are better exploited so the modifications implemented in the generic schedule seem to be suitable to the manufacturing process.

5.3. Maximum number of jackets with generic schedule.

As gap between finishing fabrication dates and clusters milestones for the generic schedule was too high especially for last clusters (see table 1), maximum number of jackets than can be produced was calculated.

Results show that 2 more jackets can be fabricated (1 for cluster 3 and 1 for cluster 4). Gap days are shown in the table below:

Table 6: Differences between delivery and finishing fabrication dates (maximum number of jackets).

Cluster	Cluster milestone date	Finishing fabrication date	Gap
1	24/04/2017	22/04/2017	2 days
2	22/06/2017	18/06/2017	4 days
3	02/11/2017	01/11/2017	1 days
4	28/01/2018	26/01/2018	2 days

As it can be seen, fabrication dates are better-adjusted to milestones when more jackets are produced with the generic schedule.

5.4. Dynamic change in number of workstations.

Another measure that can be carried out consists of modifying the number of workstations during the project progress. As it has been explained before, milestones associated with cluster 3 and 4 are less restrictive so a reduction in the number of workstations from this date seems to be suitable.

Space needed will also decrease so the possibility of carrying out another project simultaneously will appear and as a result, profitability could be higher.

Next table illustrates changes made:

Table 7: Changes made in the number of workstations from fabrication of cluster 3.

From cluster 3, decrease in:
-1 JUB Assembly
-2 JLB Assembly
-4 TP Manufacturing
-1 Assembly 1

Results obtained in terms of differences between milestones and fabrication dates are shown in the table below. Gap days for clusters 1 and 2 will not be modified as changes are implemented for clusters 3 and 4:

Table 8: Differences between milestones and fabrication dates (dynamic change in number of workstations).

Cluster	Cluster milestone date	Finishing fabrication date	Gap
1	24/04/2017	22/04/2017	2 days
2	22/06/2017	18/06/2017	4 days
3	02/11/2017	26/10/2017	9 days
4	28/01/2018	09/01/2018	21 days

As it can be observed, gap days for clusters 3 and 4 have decreased in comparison to the generic schedule as a consequence of changes made in number of workstations.

5.5. Costs expressed in working hours.

Next figures show accumulated cost expressed in terms of working hours achieved with the 3 scenarios developed (generic schedule, different number of workstations and dynamic change in number of workstations) for JLB and JUB assembling operations. As working hours needed for each part are the same for each scenario since the same quantity of pieces are produced, final result will be equal but the evolution will be different for each situation.

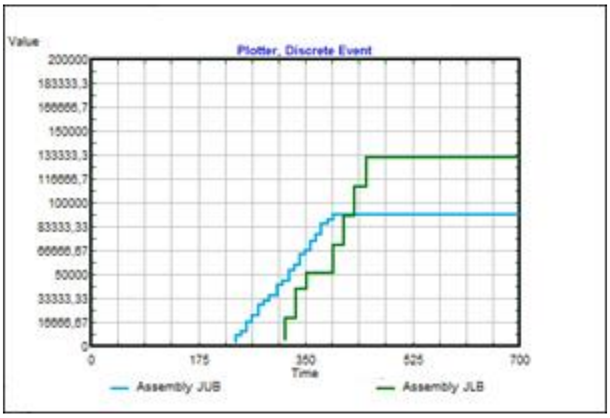

Figure 24: Evolution of cost expressed in working hours (generic schedule).

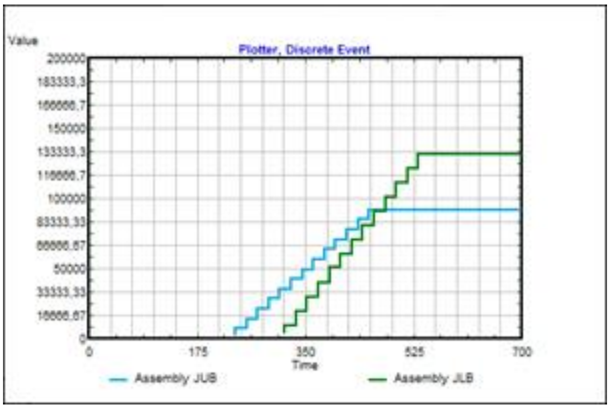

Figure 25: Evolution of cost expressed in working hours (different number of workstations).

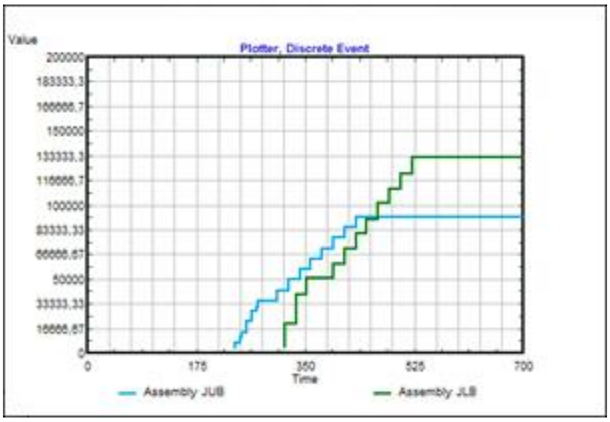

Figure 26: Evolution of cost expressed in working hours (dynamic change in number of workstations).

When it comes to manufacturing cost, it is preferable that its evolution was the less fast as possible in order to avoid big alterations in terms of cash-flow.

Consequently, the most suitable scenario according manufacturing costs is the one in which different number of workstations was considered as its slope is the lowest one. In addition, an important reduction will also be obtained as less workstations are used.

6. CONCLUSIONS.

The problem of an assembly job-shop scheduling is presented in this paper by means of a jacket manufacturing company with space and workstations as limited resources.

First results obtained by a generic schedule were analyzed and some limitations were detected. As a consequence, new measures were implemented to minimize flowtime per jacket, optimize workstations´ utilization and decrease buffers´ length as well as taking into account manufacturing costs expressed in terms of working hours.

Main improvements carried out involve solutions of Lean Manufacturing since the optimal number of workstations to accomplish main milestones was achieved and a balance in the line production was obtained by analyzing different scenarios. Regarding this study case, an important reduction in terms of workstations was achieved, what implies that space required to the manufacturing process has enormously been reduced so that more projects could take place simultaneously.

In addition, maximum number of jackets that can be produced with the generic schedule was determined.

Moreover, a dynamic change in the number of workstations was also performed as last clusters are less restrictive than the first ones.

Furthermore, this paper highlights how useful it is the tool of Simulation since certain simple measures taken into account and evaluated in these models allow companies to increase their profitability without involving too much investment.

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REFERENCES

Blanco, M. I. (2009). The economics of wind energy. *Renewable and Sustainable Energy Reviews*. http://doi.org/10.1016/j.rser.2008.09.004

Cheng, M., Mukherjee, N. J., & Sarin, S. C. (2013). A review of lot streaming. *International Journal of Production Research*, *51*(23-24), 7023–7046. http://doi.org/10.1080/00207543.2013.774506

Dai, L., Hu, H., & Chen, F. (2014). A GA-based heuristic approach for offshore structure construction spatial scheduling under uncertainty. *Ships and Offshore Structures*, *10*(6), 660–668. http://doi.org/10.1080/17445302.2014.944346

EWEA. (2015). The European offshore wind industry key 2015 trends and statistics. ... — *Documents/Publications/Reports/Statistics/* ..., (January), 31. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+European+offshore+wind+industry+-+key+trends+and+statistics+2012#1

Jia, S., Bard, J. F., Chacon, R., & Stuber, J. (2015). Improving performance of dispatch rules for daily scheduling of assembly and test operations. *Computers & Industrial Engineering*, *90*, 86–106. http://doi.org/10.1016/j.cie.2015.08.016

Kolberg, D., & Z??hlke, D. (2015). Lean Automation enabled by Industry 4.0 Technologies. In *IFAC Proceedings Volumes (IFAC-PapersOnline)* (Vol. 48, pp. 1870–1875). http://doi.org/10.1016/j.ifacol.2015.06.359

Komaki, G. M., & Kayvanfar, V. (2015). Grey Wolf Optimizer algorithm for the two-stage assembly flow shop scheduling problem with release time. *Journal of Computational Science*, *8*, 109–120. http://doi.org/10.1016/j.jocs.2015.03.011

Lui, W. H. V., & Ponnambalam, S. G. (2012). Scheduling Flexible Assembly Lines using variants of Differential Evolution. In *2012 IEEE International Conference on Automation Science and Engineering (CASE)* (pp. 594–599). IEEE. http://doi.org/10.1109/CoASE.2012.6386379

Mortezaei, N., & Zulkifli, N. (2013). Integration of lot sizing and flow shop scheduling with lot streaming. *Journal of Applied Mathematics*, *2013*. http://doi.org/10.1155/2013/216595

Natarajan, K., Mohanasundaram, K. M., Babu, B. S., Suresh, S., Raj, K. A. A. D., & Rajendran, C. (2006). Performance evaluation of priority dispatching rules in multi-level assembly job shops with jobs having weights for flowtime and tardiness. *The International Journal of Advanced Manufacturing Technology*, *31*(7-8), 751–761. http://doi.org/10.1007/s00170-005-0258-8

Sun, X., Huang, D., & Wu, G. (2012). The current state of offshore wind energy technology development. *Energy*. http://doi.org/10.1016/j.energy.2012.02.054

Thiagarajan, S., & Rajendran, C. (2005). Scheduling in dynamic assembly job-shops to minimize the sum of weighted earliness, weighted tardiness and weighted flowtime of jobs. *Computers & Industrial Engineering*, *49*(4), 463–503. http://doi.org/10.1016/j.cie.2005.06.005

Wan, X.-Q., & Yan, H.-S. (2014). Integrated scheduling and self-reconfiguration for assembly job shop in knowledgeable manufacturing. *International Journal of Production Research*, *53*(6), 1746–1760. http://doi.org/10.1080/00207543.2014.958595

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