ACTA SIMULATIO

International Scientific Journal about Simulation

electronic journal
ISSN 1339-9640

2017 Volume 3 Issue 1

CONTENTS

(MARCH 2017)

Acta Simulatio - International Scientific Journal about Simulation
Volume: 3 2017 Issue: 1 Pages: 1-4 ISSN 1339-9640

Received: 23 Jan. 2017
Accepted: 11 Feb. 2017

APPLICATION OF CLUSTER ANALYSIS IN THE STORAGE SYSTEM

Jana Kronová
Technical University of Košice, Faculty of Mechanical Engineering, Institute of management, Industrial and digital engineering, Park Komenského 9, 042 00 Košice, Slovakia, jana.kronova@tuke.sk
Peter Trebuňa
Technical University of Košice, Faculty of Mechanical Engineering, Institute of management, Industrial and digital engineering, Park Komenského 9, 042 00 Košice, Slovakia, peter.trebuna@tuke.sk
Peter Čižnár
Technical University of Košice, Faculty of Mechanical Engineering, Institute of management, industrial and digital engineering, Park Komenského 9, 042 00 Košice, Slovakia, peter.ciznar@tuke.sk

Keywords: cluster analysis, storage system, dendrogram
Abstract: The paper will deal with the application of cluster analysis in the storage system of a selected manufacturing company from the automotive industry. The cluster analysis will be based on monthly business expedition data. The result will be dendrogram representation of clusters, from which we select the optimal number of clusters. These clusters will present a proposal for storage products. Cluster analysis belongs to multivariate matematical-statistical methods. The aim of cluster analysis is to create clusters based on the similarity in compliance the conditions that the similarity of objects within the cluster is the largest, and similarity clusters as small as possible. Similarity is a fundamental idea in the formation of clusters of stocks.

1 Cluster analysis in storage system

1.1 Current warehouse system

Cluster analysis belongs to multivariate matematical-statistical methods. The aim of cluster analysis is to create clusters based on the similarity in compliance the conditions that the similarity of objects within the cluster is the largest, and similarity clusters as small as possible [1]. Similarity is a fundamental idea in the formation of clusters of stocks [2].

The paper will deal with the application of cluster analysis in the storage system of a selected manufacturing company from the automotive industry. We have data on expedition of products for customer per calendar year. Monthly development of the dispatch of products per year for individual customers the company is graphically illustrated in Figure 1.

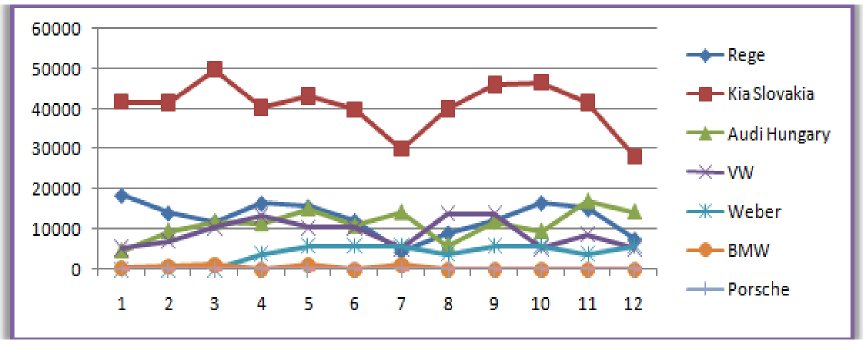


Figure 1 Development of product expedition

Percentage share on expedition of products to customers is shown graphically in Figure 2.

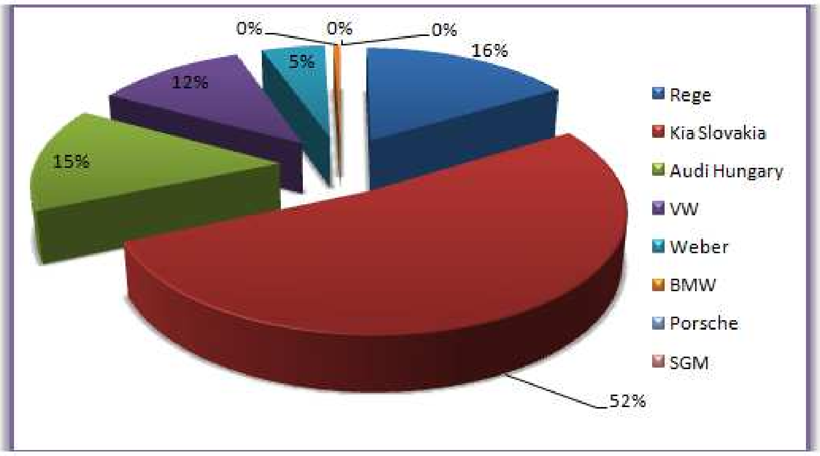


Figure 2 The share on expedition

The graphic representation on Figure 1, Figure 2 shows that the largest share of customers have Kia Slovakia (52%), Rege (16%), Audi Hungary (15%), VW (12%) of the total expedition.

The production company for storage of products in the warehouse of finished products using ABC analysis, based on which products are divided and arranged as shown in Figure 3.

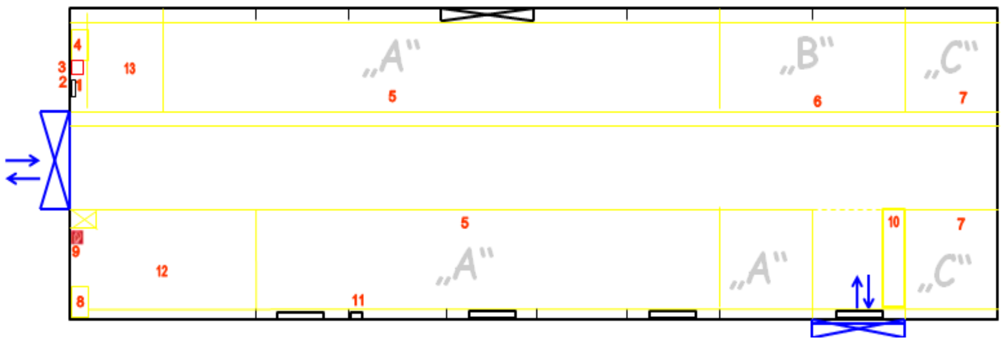


Figure 3 Partition in the warehouse by ABC analysis

The following figure shows graphically the percentage of expeditions of each product group by ABC analysis (Figure 4).

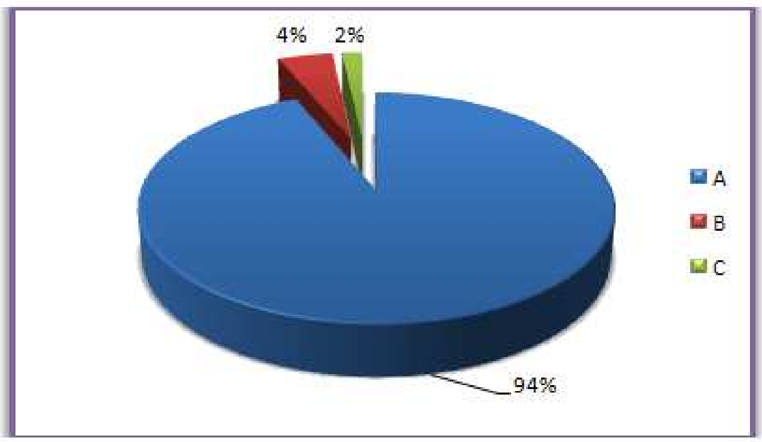


Figure 4 The share on expedition by ABC analysis

Volume: 3 2017 Issue: 1 Pages: 1-4 ISSN 1339-9640

We see that Group A products have the largest share of the expedition with a 94% share, so storage in the warehouse is closer to the expedition.

1.2 Cluster analysis in the storage system

When cluster analysis of the products we have not taken into account the current method of distribution of products according to ABC analysis [3]. This division will be compared at the end of the article with the results of the cluster analysis and subsequent storage suggestions [4].

The first step in the clustering process of finished products is the creation of clusters based on input data of the expedition in the given year. The output of the cluster analysis is dendrogram shown in Figure 5.

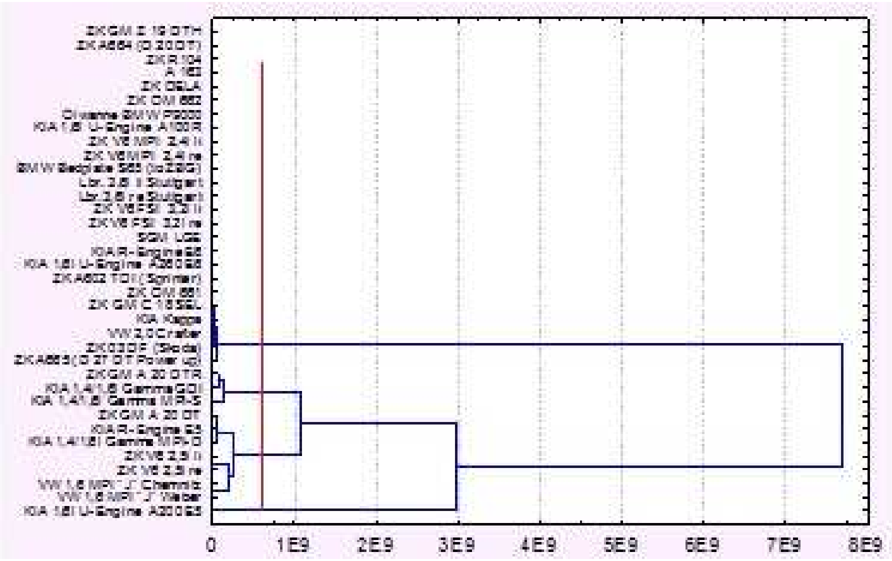


Figure 5 Dendrogram

Based on a heuristic approach to selection of clusters, there are optimal 4 clusters of products. Percentage of individual clusters of products is graphically illustrated in Figure 6.

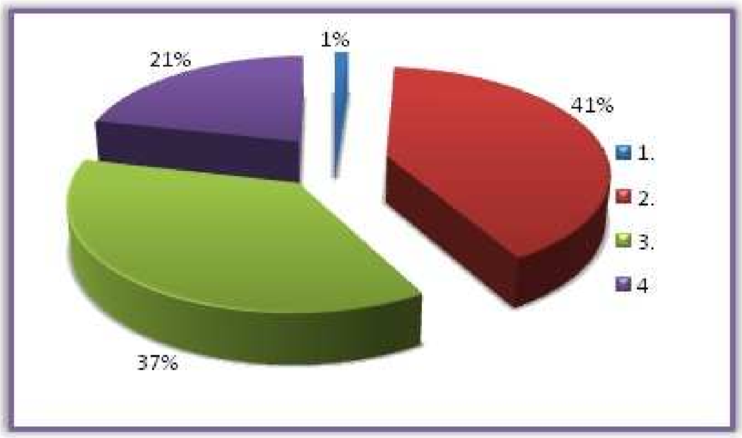


Figure 6 The share on expedition by cluster analysis

The most significant clusters by expeditions for custormers are 2.cluster (768 497 pcs, 41% share) and 3.cluster (693 420 pcs, 37%). 4. cluster consists of the product to the customer Kia, United Kingdom, which is the biggest consumer of company, the percentage share those cluster is 21%, which is 405,830 units of products. The 1. and 2. cluster contain most types of products for different customers, but their expedition is low. Requirements of customer for production are one-off, so their percentage of expedition is low. Requirements of customer for production are one-off, so their percentage of expedition is low.

1.3 Layout of warehouse by clusters

At the conclusion of the cluster analysis of the product stocks, it can be noted that the division of the products into groups (clusters) by cluster analysis is different from the original division of products by the ABC analysis.

Acta Simulatio - International Scientific Journal about Simulation
Volume: 3 2017 Issue: 1 Pages: 1-4 ISSN 1339-9640

The result of cluster analysis of stock items in the form of clusters of finished products is taken into account in the proposal of layout of the warehouse shows in Figure 7 in 2D and in Figure 8 is 3D forms.

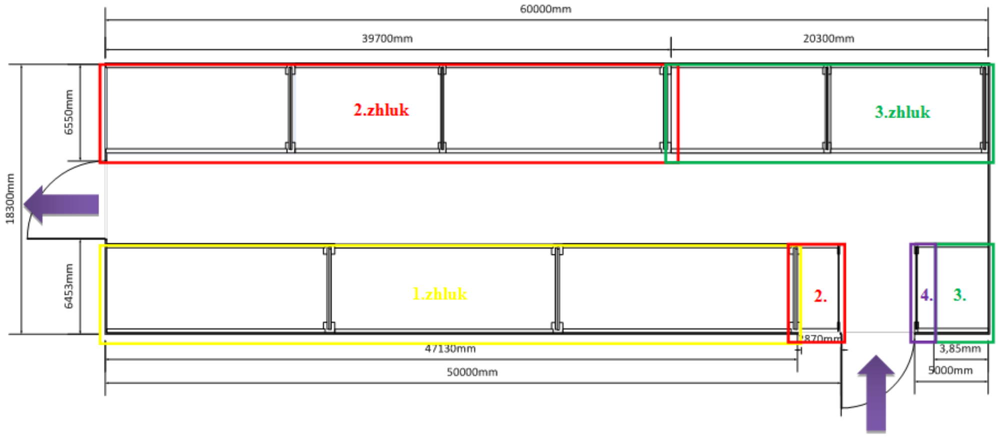


Figure 7 2D proposal of layout of warehouse

Figure 8 3D proposal of layout of warehouse

Acknowledgement
This article was created by implementation of the grant project VEGA 1/0708/16 "Development of a new research methods for simulation, assessment, evaluation and quantification of advanced methods of production".

References

[1] EVERITT, B.S., LANDAU, S., LEESE, M., STAHL,D.: Cluster Analysis. London: Wiley, 2011. 348 p. ISBN978-0-470-74991-3.
[2] KAUFMANN, L.: Finding groups in data: an introduction in cluster analysis. Hoboken: Wiley. 2005. 342 p. ISBN0-471-73578-7.
[3] TREBUŇA, P., HALČINOVÁ, J.: Experimental modelling of the cluster analysis processes. In: Procedia Engineering. Vol.48. 2012. p. 673-678. ISSN 1877-7058.
[4] TREBUŇA, P., FIĽO, M., PEKARČÍKOVÁ, M.: Supply and distribution logistics. Ostrava. Amos, 2013. 133 p. ISBN 978-80-87691-02-1.

Review process
Single-blind peer reviewed process by two reviewers.

Received: 21 Feb. 2017
Accepted: 05 Mar. 2017

APPLICATION OF SIMULATION TOOL FOR SCHEDULING IN ENGINEERING

Darina Dupláková
Technical University of Kosice, Faculty of Manufacturing Technologies with a seat in Presov, 080 01 Presov, Slovakia, darina.duplakova@tuke.sk
Svetlana Radchenko
Technical University of Kosice, Faculty of Manufacturing Technologies with a seat in Presov, 080 01 Presov, Slovakia, svetlana.radchenko@tuke.sk
Lucia Knapčíková
Technical University of Kosice, Faculty of Manufacturing Technologies with a seat in Presov, 080 01 Presov, Slovakia, lucia.knapcikova@tuke.sk
Michal Hatala
Technical University of Kosice, Faculty of Manufacturing Technologies with a seat in Presov, 080 01 Presov, Slovakia, michal.hatala@tuke.sk
Ján Duplák
Technical University of Kosice, Faculty of Manufacturing Technologies with a seat in Presov, 080 01 Presov, Slovakia, jan.duplak@tuke.sk

Keywords: simulation software, scheduling, engineering

Abstract: This article is focused on the possibility of application of simulation tool for scheduling in manufacturing plants. Introduction of this article describes the function of attributes of the jobs or machines – dispatching rules. After that it is created the general overview of the most common used scheduling software in the manufacturing plants. The last part of this article is dedicated to practical example of application the scheduling software in the manufacturing plant.

1 Introduction

Planning establishes what, how, where and in what order work will be performed, while scheduling sets forth who and when. Construction planning is the development of a feasible operational design for completing the work [3]. The process involves the selection of work sequence and methods, and provides information for the scheduling process [1]. Scheduling determines the timing and specific sequence of tasks necessary to carry out the plan [2]. The schedule is a result of the planning process and reflects the selected plan. Scheduling is an important planning activity in manufacturing systems to help optimise the usage of scarce resources and improve the customer satisfaction (Figure 1). In the engineering there is applied the scheduling software that use the simulation scheduling software with dispatching rules (Table 1). Dispatching rule is a function of attributes of the jobs or the machines [4]:

- Job attributes: weight, processing time, due date, etc.
- Machine attributes: speed, number of jobs waiting for processing, total amount of processing waiting in queue, etc.

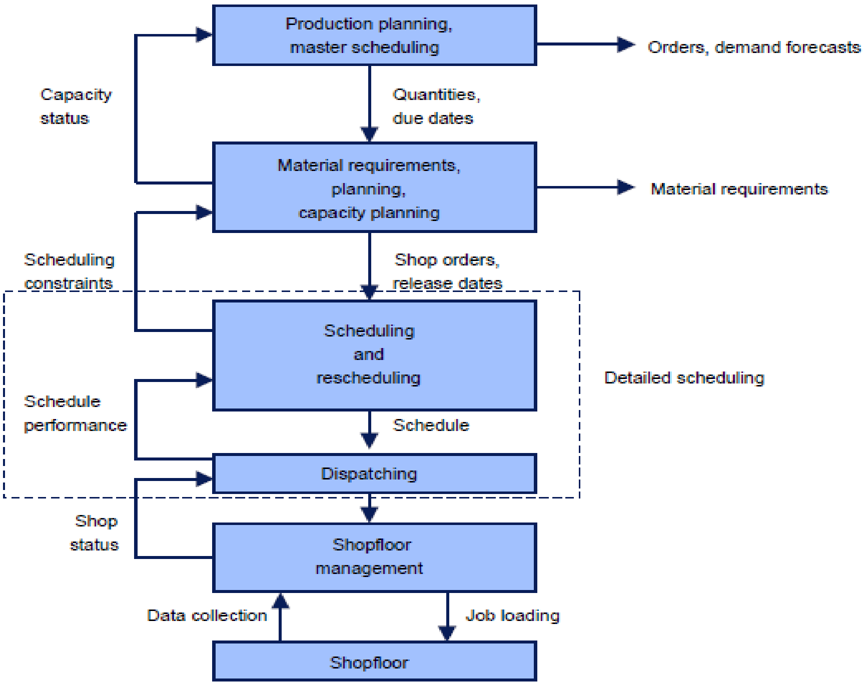
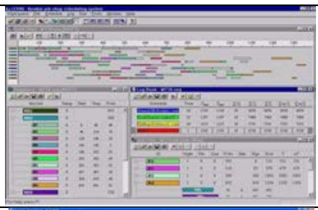


Figure 1 Flow diagram in manufacturing system

Table 1 The most used scheduling software in engineering

LEKIN		- heuristic methods - dispatching rules - 6 basic work environment - 60 standard benchmark problem - graphic presentation of results: Gantt charts - import and export of external algorithms
Preactor Scheduling Software		- minimization of production time - minimization of costs - maximization of operation efficiency - rules for planning - output: Gantt charts
SchedulePro		- final capacity planning - reducing cycle time - capacity analysis - maintenance planning - graphical interpretation: Gantt charts - analysis: sources (material, worker, etc.), using of machines
Seiki Software		- minimization of production time - creation sequence of production - ensure accuracy of supply - avoiding bottleneck - reduction semi-products
Delfoi Planner		- reduction lead time - reduction work in progress - increase accuracy of supply - monitoring all changes directly by software

2 Scheduling software LEKIN

LEKIN is a scheduling system developed at the Stern School of Business, NYU. Major parts of the system were designed and coded by Columbia University students. LEKIN was created as an educational tool with the main purpose of introducing the students to scheduling theory and its applications. Besides that, the system's extensibility allows (and encourages) to use it in algorithm development. The project has been directed by Professor Michael L. Pinedo, Professor Xiuli Chao and Professor Joseph Leung. This development has been partially supported by the National Science Foundation.

Short description of scheduling software Lekin:

- 6 basic workspace environments: single machine, parallel machines, flow shop, flexible flow shop, job shop, and flexible job shop.
- A set of sample problems.
- More than 60 standard benchmark problems from different sources.
- Smooth input of user problems.
- Various dispatching rules and heuristics.
- Gantt chart with drag-and-drop support.
- Graphic tool for comparative analysis of different schedules.
- Complete graphic printouts.
- Easy attachment, import and export of external algorithms.

In the scheduling software Lekin there are used the following dispatching rules [4]:

- *Earliest Due Date* – EDD - selects the next job from the queue based on their due date.
- *First in First Out* –FIFO - selects the next job from the queue based on their arrival time at the current machine.
- *First Come – First Served* – FCFS - the first job to arrive at a work center is processed first
- *Longest Processing Time* – LPT - the job with the longest processing time is processed first
- *Shortest Processing Time* – SPT - selects the next job from the queue based on their processing times at the current machine
- *Weighted Shortest Processing Time* – WSPT - sequences jobs in nonincreasing order of their weight-to-processing-time ratios
- *Critical Ratio* – CR - selects the next job from the queue based on their relatively available time divided by the total remaining process time of the job

The main menu of scheduling software Lekin provides the six frameworks: single machine, parallel machines, flow shop, flexible flow shop, job shop and flexible job shop. The overview of the above mentioned frameworks is presented in the following figure (Figure 2).

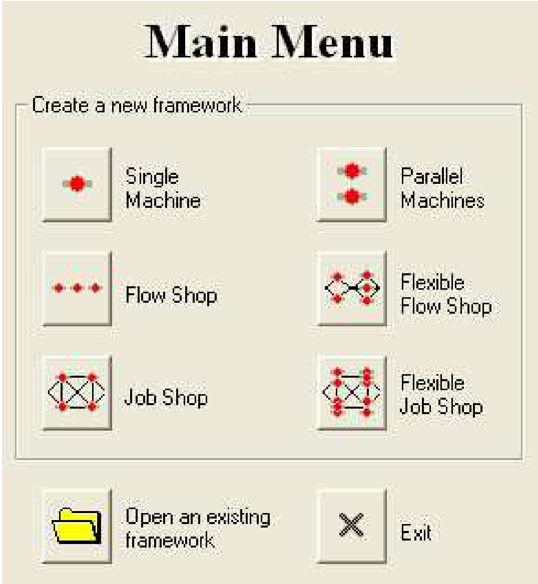


Figure 2 Main menu of scheduling software Lekin

The scheduling software Lekin uses for scheduling the Gantt charts. It is a type of bar chart which provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project. The horizontal axis of Gantt chart is a time and the vertical axis is a task. In the engineering there is quite often used for scheduling of production time. In the following part of this article is presented the example of application this software for determination of optimal production time.

3 Application of scheduling software in engineering

In this case, it was used the flow shop framework for the illustration of application the scheduling software Lekin in the manufacturing plant – production of bearings. In the following table there is presented the machine production time of manufactured parts - bearings. The total production time (Table 2) will be optimized by several dispatching rules which are described in the previous part of this article.

Table 2 Production time in seconds

Operation	Bearing 1	Bearing 2	Bearing 3	Bearing 4
No. 1	0	2.9	21	2.9
No.2	26	0	0	0
No.3	2.9	0	14	3.6
No.4	0	155	17	16
No. 5	3	0	0	0
No. 6	0	3.6	43	47
No. 7	0	0	37	38
No. 8	0	0	0	49
No. 9	30	44	41	55
No. 10	12	22	45	18
No. 11	60	60	60	60
No. 12	7	3	3	3
No. 13	60	60	60	60

Acta Simulatio - International Scientific Journal about Simulation
Volume: 3 2017 Issue: 1 Pages: 5-10 ISSN 1339-9640

Production process was optimised by three dispatching rules: EDD, LPT and CR (Figure 3, Figure 4, Figure 5). In the following figure there are presented the Gantt charts after the application of above mentioned rules.

Legend to the following Figure 3 - 5:
Grey colour – Bearing 1, Red colour – Bearing 2
Green colour – Bearing 3, Blue colour – Bearing 4

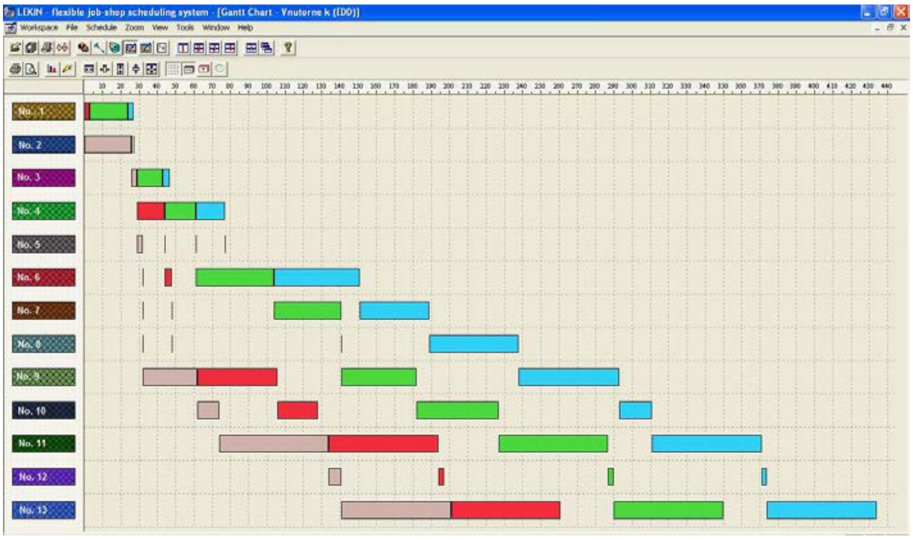


Figure 3 Optimization of production process – EDD dispatching rule

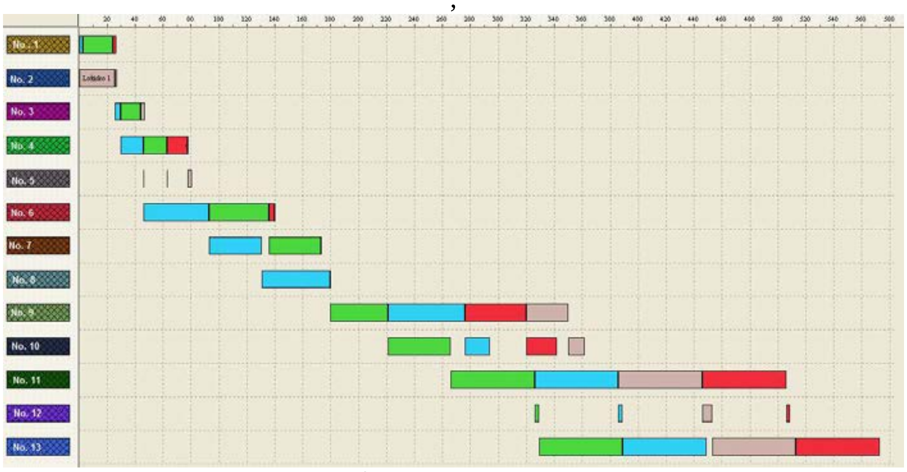


Figure 4 Optimization of production process – LPT dispatching rule

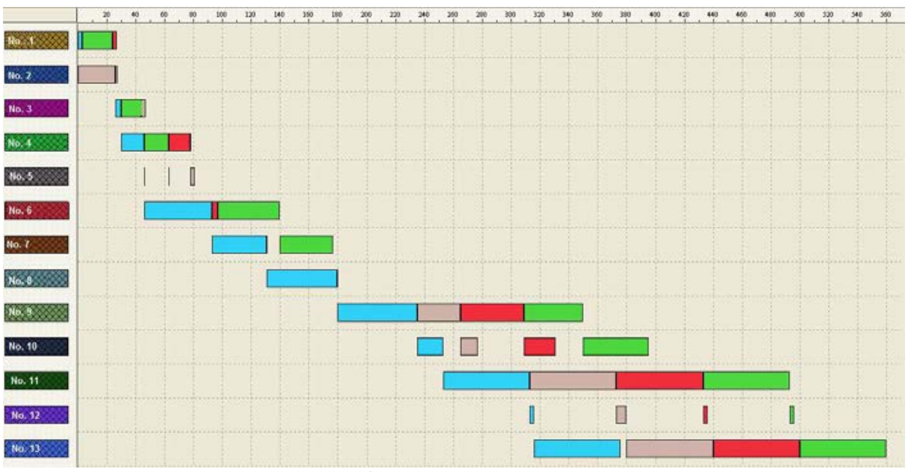


Figure 5 Optimization of production process – CR dispatching rule

In the following table (Table 3) there is presented the evaluation of previous production time and production time after the use of dispatching rules.

In the following figure (Figure 6) there is presented the final values of optimised production time after the application of dispatching rules. The red line above the bar, there is presentation of value of previous production time.

The above mentioned table and figure present that the biggest time saving is generated after the application of EDD dispatching rules. The time saving is about 32% from total value of previous production time. At least save by applying the LPT dispatching rule.

Table 3 Evaluation of production time

		Production time [s]	Difference between previous time and after the application of rules	Percentage value of saved production time
Previous production time		640	-	-
Production time after application of dispatching rules	EDD	435	205	32,03 %
	CR	560	80	12,5 %
	LPT	570	70	10,94 %

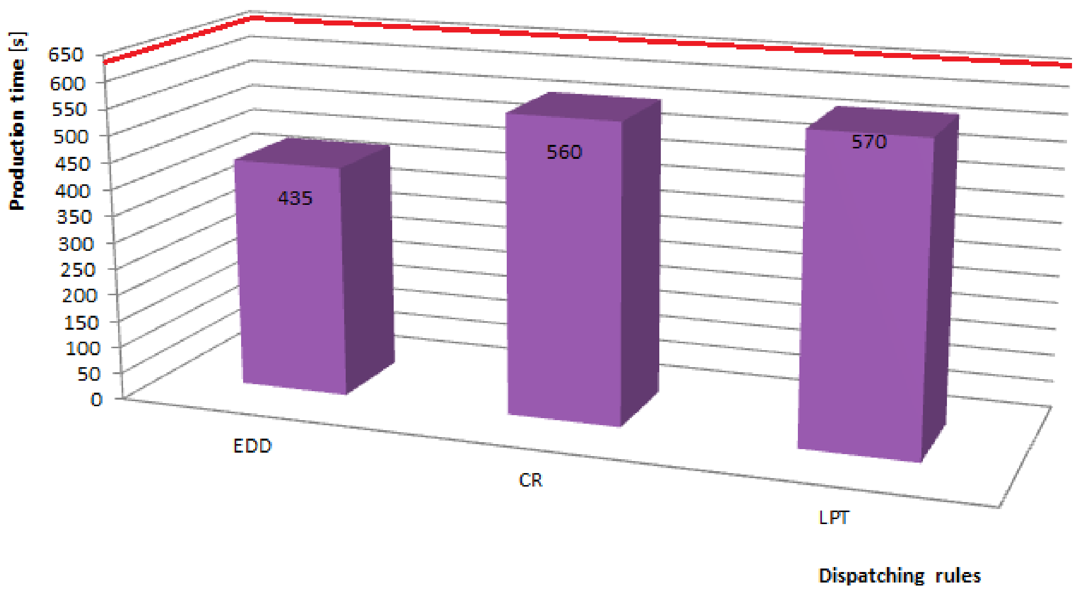


Figure 6 Production time after the application of dispatching rules

Conclusion

Scheduling plays an important role in most manufacturing and production systems. [8] It involves resources and time which must be addressed concurrently to satisfy constraints. [6][7] This article was focused on application of simulation tool for scheduling in engineering. The first part of article it was described the theoretical analysis of scheduling, dispatching rules and simulation tool for scheduling - Lekin. The next part of article described the application of scheduling software in manufacturing, namely in engineering. It was used three dispatching rules to the optimisation of production time. From the evaluation it was selected the EDD dispatching rule as the most optimal solution for this production. The time saving is about 32% from total value of previous production time. Simulation is a powerful tool that can be employed when designing and selecting scheduling strategies. [4] It is necessary to use this tool for evaluation, innovation and optimization of manufacturing processes, costs, scheduling, etc.

References

[1] BANKS, J.: *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*, USA: John Wiley & Sons, 1998.

[2] HUSÁR, J., KNAPČÍKOVÁ, L., MAČEJ, T., HLOCH, S.: *Some aspects of selection in production planning systems*, *Nové trendy v konštruovaní a v tvorbe technickej dokumentácie*, 2009. (Original in Slovak)

[3] FEDÁK, M., SEMANČO, P.: Assessment of Material Flow in Foundry Production by Applying Simulation Analysis, *Applied Mechanics and Materials 308*, 185-189, 2013.

[4] JANÁK, M., CMOREJ, T., VYSOCKÝ, T., KOČIŠKO, M., TELIŠKOVÁ, M.: Virtual reality as

an effective simulation tool for OSH education on robotized workplace, IMATEC web of conferences : ICIEA 2016. – Paris, *EDP Sciences*, 2016 Vol. 68, article no. 02002, p. 1-4, 2016.

[5] PINEDO, M. L.: *Scheduling, Theory, Algorithms, and Systems*, Springer-Verlag New York, 2012.

[6] STRAKA, M.: *Simulácia diskrétnych systémov a simulačné jazyky*, Košice: AMS, 2005. (Original in Slovak)

[7] STRAKA, M., ŽATKOVIČ, E.: *Modelovanie a simulácia - teória, výskum a vývoj*, Výskumné aktivity v doprave, staviteľstve a príbuzných odboroch: vedecko-odborný seminár: Herľany, Košice, Slovenská Spoločnosť Logistiky, p. 1-6, 2014. (Original in Slovak)

[8] ZAJAC, J., BERAXA, P., MICHALIK, P., BOTKO, F., POLLÁK, M.: Simulation of Weld Elbows Hot Forming Process, *International Journal of Modeling and Optimization*, Vol. 6, No. 2, p. 77-80, 2016.

Review process

Single-blind peer reviewed process by two reviewers.

Acta Simulatio - International Scientific Journal about Simulation
Volume: 3 2017 Issue: 1 Pages: 11-14 ISSN 1339-9640

Received: 25 Feb. 2017
Accepted: 19 Mar. 2017

POSSIBILITIES OF INFLUENCING THE POSTURE AND LOCOMOTION BY AFO ORTHOSIS WHILE SUFFERING FROM SPINA BIFIDA

Katarína Šromovská
Technical University of Košice, Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Letná 9, 042 00 Košice, Slovakia, katarina.sromovska@student.tuke.sk
Monika Michalíková
Technical University of Košice, Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Letná 9, 042 00 Košice, Slovakia, monika.michalikova@tuke.sk
Marianna Trebuňová
Technical University of Košice, Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Letná 9, 042 00 Košice, Slovakia, marianna.trebunova@tuke.sk
Jozef Živčák
Technical University of Košice, Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Letná 9, 042 00 Košice, Slovakia, jozef.zivcak@tuke.sk

Keywords: AFO orthosis, spina bifida, locomotion

Abstract: The work is focused on the possibility of influencing pathological standing and walking, using AFO orthoses while being disabled in the lower limbs with spina bifida, in other words, suffer from spine cleft. To influence the posture and locomotion of the patient with spina bifida - myelomeningocele, the application of AFO Carbon Ankle Seven was chosen [1]. The patient's muscle groups controlling the foot were significantly weakened, the knees were in a varus position. While standing, distinct hyperlordosis was visible and, at the same time, a slight bending of the torso as a result of balancing compensation was obvious. The main purpose of orthosis use is to improve the stability, balance, movement and walking dynamics of the patient.

1 Functional principles of selected AFO

The AFO orthosis (Figure 1) is an externally applied orthotic device in the area of the ankle joint and foot. It compensates the weakness and instability in the area of the ankle joint. It is designed to control the position and movement of the ankle, which means that it controls the ankle directly, but it can also be designed to control the joint indirectly. AFO can be used as a part of the footwear or as a full-contact, and it can be used either in static or dynamic design. AFO orthosis with a special carbon spring Carbon Ankle Seven is produced individually and is indicated for very active patients. Thanks to the special design, energy is accumulated in the carbon spring at heel strike and returned at toe-off. The orthosis allows the patient to walk naturally with lower energy usage [1,2].

The construction of the carbon spring takes into account the natural external rotation of the foot - 7°, while taking the dorsal arrangement into consideration. The proper manufacture of the plaster model and also precise construction of the actual orthosis usually means that the physiological posture of the patient's foot is preserved during walking. External rotation of the carbon springs in the area of the bend can help by a more favourable course of the foot (Figure 2). The compromise point is a point located in the ankle area that the orthopaedic technician chooses as an auxiliary point while making the orthosis [3].

Figure 1 AFO orthosis, carbon spring and insertion into thermoplastic sleeve

Volume: 3 2017 Issue: 1 Pages: 11-14 ISSN 1339-9640

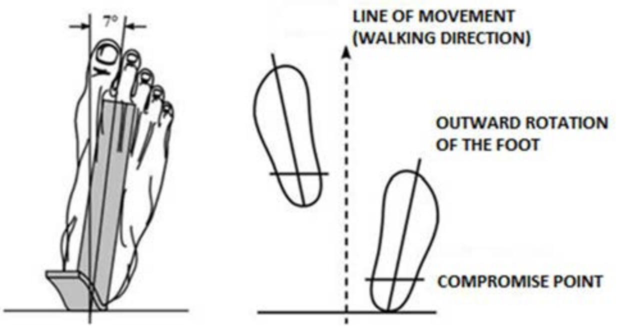


Figure 2 Effect of 7 ° outward rotation of the spring on the walk [2]

Choosing the right strength of the carbon spring is performed according to the body weight and the degree of user activity (normal or high level of activity). It is a prerequisite that the patients be able to walk. For active orthosis users, who use to walk or run more often, the demands and requirements on the spring strength increase. Application of Carbon Ankle Seven leads to a positive effect on the image of walking with support of the front foot, as shown in (Figure 3) and dynamic knee joint effect (Figure 4).

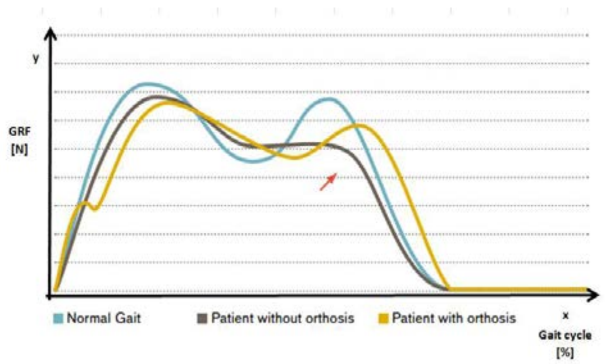


Figure 3 Comparison of the course of the ground reaction force from the pad under physiological conditions, in the pathology without the use of the orthosis and with the compensation achieved by the AFO [2]

By using AFO, the positive effect is evident. In the foot area, the results such as the energy return effect, support of the forefoot to the tip of the toe, harmonization with natural walking, and dynamic dorsal and plantar limitation of carbon fibers that support smooth walking, are achieved [3].

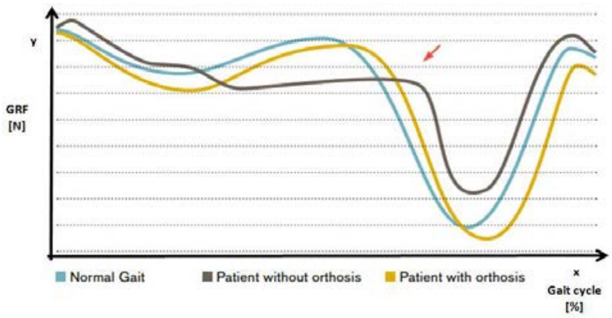


Figure 4 Illustration of increased knee dynamics when walking with AFO[2]

Also, by using AFO, an increase in knee joint dynamics is achieved. That leads to positive effect on the body's uplift with the extension of the hip and knee during the standing phase, more stability in the knee joint, and also the image of a walking resembles the physiological walking more [3].

2 Production of Carbon Ankle Seven

Physical examination consists of control, palpation, tapping - to find reflexes, and also includes a functional muscle test. The medical check-up of the patient consists of examination and observation of patient's reflexes and conditions. Palpation consists of examining sensitive bone structures, wrong leg postures, scars and wounds, which must be included in making the orthosis. After all the examinations, the measurements take place. All necessary measurements, such as length parameters, circumference of the limbs, as well as other important information and results, are written down into specific measurement forms. If necessary, also other details are marked down. On the lower limb, the measurements are taken on lower leg and foot.

To make a plaster negative, we need a container of water, plaster bandages, the carbon spring itself (or its template), nylon stocking for easier removal of the plaster negative from the patient's body, scissors, pencil, separation vaseline and a plastic tube. Also a pad under the foot with height adjustable heel, alternatively with a correctional heel and the front wedge to ensure the dorsiflexion positioning of the toes in the forefoot is very important. For better positioning of the carbon spring under the foot, it is necessary to slightly increase the heel by approx. 15-20 mm before making a plaster negative. On the limb, the compromise centre of rotation is marked in the ankle joint, as well as all protuberances, bone protrusions, pressure sores and painful places. It is also possible to mark the areas that need to be pressurized or relieved, as well as marginal lines.

First, a footprint is made. That means that a thorough footprint with a transversely and longitudinally shaped foot surface and its arches in the neutral position - sagittal plane – is created. The limb is separated by a nylon stocking and only then a print of shank is made. The footprint part is then attached with plaster bandage to the foot and shank plastering follows. Under the plaster bandage, there is a separating device, usually a tube, inserted, so that the print can be removed from the limb after hardening. The foot part should be kept in the correct position in the frontal and also in sagittal plane until hardening (Figure 5).

Figure 5 Plastering of foot and shank

After hardening, the guide lines are market transversely to the center axis, so that the precise reconnection of the cut plaster negative can be achieved. The print is cut and the bandage is removed. By this way, the plaster negative is made; however, it still needs to be checked for the correctness of the design. A suitable metal tube is inserted into the model. The outer end of the tube is used to attach the model itself into a gripper. Before molding, it is necessary to close holes using plaster bandages, so that the plaster cannot leak out. After checking the orthosis position in adjusting apparatus, the liquid plaster is poured onto the negative and is left to solidify. After hardening of plaster, the negative is removed from the stand, by pulling off the bandages and the positive model is selected, Fig.6. The model is then adjusted, so that to areas that need to be relieved, another coat of plaster is applied and from areas that need pressurization the amount of plaster is lowered. The deflections are evened and the model is smoothened at the end.

Figure 6 Positioning of the carbon spring on the plaster positive

The length of the calf is marked. The end of the carbon spring goes 20 mm under the cut in the heel area joint. The position of the carbon spring under the foot is marked. The length of it is from the heel to approximately 20 mm under the cut in the heel area joint. To mark the area of fixation and movement of the carbon spring, the model is divided into two parts. First, the length from the knee slot to the ground is measured and then the half of this measure is marked. To adjust the carbon spring to the actual shape of the shin, the lining from Pedilin needs to be applied and grinded onto particular areas, and if necessary, also the areas with possible cavities have to be filled. Due to external rotation, and when positioned correctly, the carbon spring flows in the area under the foot in the way of second metatarsal bone. Afterwards, the carbon spring is fixed to the model by a polyethylene duct tape across the foot arc and under the calf (Figure 7).

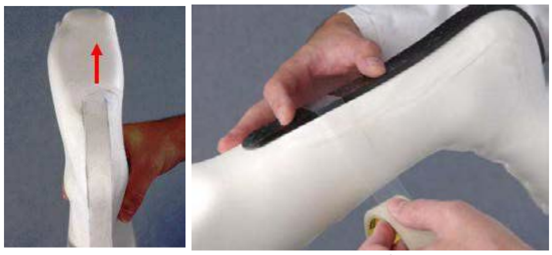


Figure 7 Check the correct positioning of the spring and its fixation to the positive

Then, one coat of perlon jersey is stretched onto the model. It is necessary to mould the high temperature thermoplastic on the model, using the negative air pressure. After the thermoplastic is shaped, the course of cutting edges is marked and the plastic is taken off the plaster positive model. In the foot area the cutting edge is above the ankle and in the calf are approximately to the middle of the calf. It is important that the cutting edges are not sharp; therefore they need to be grinded. At last, the calf area is separated from the foot area (Figure 8).

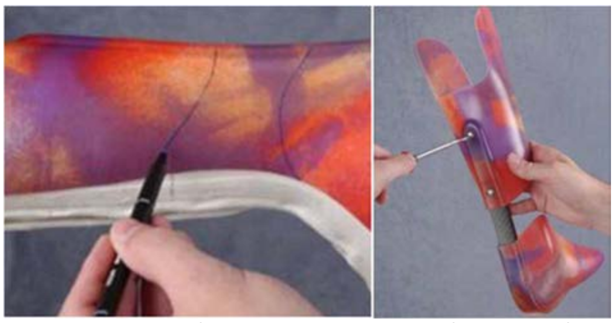


Figure 8 Marking of cut edges separating the foot and calf part and final assembly of the orthosis

Then the places for drilling holes in the calf area are marked. It is important to drill holes for carbon spring in the middle, because otherwise the premature wear out or carbon spring crack in the area of drilling can be inevitable. Also in the foot area the places for drilling holes are marked. The proximal hole is not at the highest heel point, because the carbon spring bends there.

3 AFO trial and application

To check the sagittal structure, the trial with the orthosis applied while using the laser vertical line, is

recommended. On the lower limb, the load line should flow 15 mm anterior from the compromise point of knee joint according to Nietert, who characterized the middle point of rotation. It is a posture in which the axis of orthosis knee joint rotation should be placed. It is the most neutral point in relation to natural polycentric knee joint and is determined empirically – in the anterio-posterior way: 60 % from the front and 40 % from the back, 2 centimetres above the medial slit of condyles.
The load line flows 2 mm posterior from large femur (trochanter), 15 mm anterior from the centre of the knee according to Nietert, 60 mm anterior from the outer ankle (Figure 9).

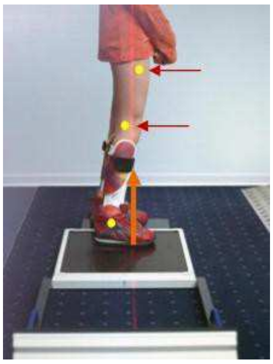


Figure 9 The correct course of the load line in the sagittal plane

Conclusions

At the examined diagnosis, the correct function of muscles controlling the foot was necessary to support. The muscle work was replaced by an "L" shaped flexible component made from composite material that was used as a basic material of the whole orthosis. The spring was embedded into the high temperature thermoplastic sleeves. The finished orthosis was completed by Velcro taping and the lower part of the foot area was evened as necessary.
By applying the AFO the stable upright stand of the patient was achieved. The stand corresponded with optimal load lines and it resulted in more stable as well as dynamic walking (Figure 10). Recently, the patient is able to walk along uneven terrain, stairs, as well as to ride a bike.

Figure 10 Stand before and after AFO application

Acknowledgement
This article was supported by the state grants KEGA 063TUKE-4/2016 (30%), KEGA 069TUKE-4/2017 (40%) and APVV 15-0356 (30%) of the Ministry of Education of the Slovak Republic.

References

[1] HONZÍKOVÁ, L., JANURA, M.: Využití různych typů ortéz AFO u pacientů s omezením v oblasti hlezenního kloubu a nohy – paréza nervus peroneus. Případová studie., Sofistikovaná biomechanická iagnostika lidského pohybu, reg.č.: CZ.1.07/2.3.00/09.0209, file:///C:/Users/LAB%C3%81K/Downloads/abstrakt_Honzikova_L.pdf , 2011
[2] OTTO BOCK: Carbon Ankle Seven. Information for Practitioners. Health Care GmbH, Duderstadt/Germany, http://media.ottobock.in/_web-site/orthotics/carbon-ankle-seven/files/carbon_ankle_seven_information_for_specialist_dealers.pdf
[3] [Online], Available: http://www.ottobock.sk/protetika/protetika-dolnych-koncatin/, 2017
[4] [Online], Available: http://www.ottobock.sk/ortotika/, 2017

Review process
Single-blind peer reviewed process by two reviewers.

JOURNAL STATEMENT

Journal name:	**Acta Simulatio**
Abbreviated key title:	Acta Simul
Journal title initials:	AS
Journal doi:	10.22306/asim
ISSN:	1339-9640
Start year:	2015
The first publishing:	March 2015
Issue publishing:	Quarterly
Publishing form:	On-line electronic publishing
Availability of articles:	Open Access Journal
Journal license:	CC BY-NC
Publication ethics:	COPE, ELSEVIER Publishing Ethics
Plagiarism check:	Worldwide originality control system
Peer review process:	Single-blind review at least two reviewers
Language:	English
Journal e-mail:	**info@actasimulatio.eu**

The journal focuses mainly on the original and new, interesting, high-quality, theoretical, practical and application-oriented contributions to the field of science and research as well as to pedagogy and education in the area of simulation.

Publisher:	**4S go, s.r.o.**
Address:	Semsa 24, 044 21 Semsa, Slovak Republic, EU
Phone:	+421 948 366 110
Publisher e-mail:	**info@4sgo.eu**

Responsibility for the content of a manuscript rests upon the authors and not upon the editors or the publisher.