Edukacja
dla inżynierii przyszłości

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Internships as a form of cooperation between science and business – a case study

Staże jako forma współpracy nauki i biznesu – studium przypadku

Key words: knowledge transfer, cooperation, internships.

Słowa kluczowe: transfer wiedzy, kooperacja, staże.

Streszczenie
Staż jest jedną z form współpracy nauki i biznesu, a jednocześnie dobrym sposobem na rozwijanie wiedzy i umiejętności stażystów. W artykule przestawiono korzyści ze współpracy przedsiębiorstw z uczelniami poprzez realizację staży pracowników przedsiębiorstw na uczelni. Artykuł został opracowany na podstawie stażu zrealizowanego przez pracownika firmy na Politechnice Rzeszowskiej. Przedstawiono plan stażu, zrealizowane działania oraz poczynione na podstawie wiedzy i umiejętności zdobytych przez stażystę praktyczne wdrożenia. Przedstawiony jest widoczny przykład transferu wiedzy z uczelni do przemysłu oraz obustronne korzyści. Artykuł mówi o korzyściach, jakie uzyskał stażysta oraz o firmie, w której jest on zatrudniony. Przedstawiono także korzyści dla uczelni z realizacji tego stażu. Praca prezentuje wytyczne do planowania i realizacji praktycznych zagadnień, na co należy zwrócić uwagę, aby uzyskać maksymalne obustronne korzyści.

Introduction

The cooperation between science and business is indispensable for ensuring the development of both industry and science. Due to such cooperation, the industry receives the latest knowledge and technologies, and universities obtain information on industry problems and needs. The role of universities consists in conducting scientific research in order to ensure the development of science and to prepare the future company employees for performing good quality work. These employees will possess up-to-date knowledge available to use and necessary in companies operating in today reality. For this purpose, universities have to recognize the market needs and adapt the education programs and contents of courses to them. In order to achieve this, it is indispensable to make close and continuous cooperation with industry. This cooperation can be pursued in various ways [3, 9, 13]. These forms of cooperation are presented in table 1.

Each of the presented forms of cooperation needs engagement. It is also vital to ensure a certain amount of time for the performance of common tasks. That is why, the tasks realized within a framework of cooperation must be given appropriate priority.

This work offers an example of the internship undertaken by a production company employee at a university. This internship was spurred by the company needs concerning the acquisition of knowledge for solving current problems as well as the company's development. The company management, aware of the need for the latest technical and organizational solutions implementation and the need to sustain the company's competitiveness, quality and production flexibility, as well as for the company's development, implements various forms of cooperation with the university.

Among others, the company decided to send an employee for an internship to the university because of the possibility for developing the employee's competences. The employee's task was to use the knowledge acquired during the internship and to disseminate it in the company among other employees. In order to ensure the greatest benefits for the company, it was indispensable to meet the following requirements:

– ensuring the employee's engagement,
– arranging enough time for an employee to accomplish the tasks scheduled in the internship,
– ensuring visible support for the employee's actions by supervisors,
– other employees' openness to changes.

Tab. 1. Forms of cooperation between science and industry

No	Form of cooperation	Goal	Advantages
1	Conducting common R&D and implementation tasks	Solving company's problems, development and implementation of innovative solutions	For company: a company receives new solutions For university: a university receives knowledge about practical problems
2	Conducting trainings and dedicated courses	Transfer of knowledge from university to industry	For company: Company employees receive the latest knowledge For university: University employees receive practical knowledge through the feedback from the company employees
3	Preparing expertise for industry	Evaluation of the implemented or proposed to implement solutions	For company: The knowledge about the solution level For university: The knowledge about the implemented or proposed to implement solutions
4	Conducting research in industry	Receiving the knowledge about current problems, trends, systems, technologies, etc. used in industry	For company: Diagnosis of functioning and the comparison to other companies For university: Information about the areas and directions of the future scientific research
5	Conducting research and implementation projects by students in companies	Validation of students' knowledge in practice	For company: Realization of projects by people who possess the latest knowledge and who are under substantial supervision of a university employee For university: Possibility of acquiring the knowledge about practical problems
6	Students' internships in companies	Validation of theoretical knowledge and development of practical knowledge	For company: Acquisition of trainees with the latest knowledge and a fresh view on the company's problems For university: Better preparation of university graduates for work in industry
7	Researchers' internships in companies	Acquiring the knowledge about the company's practical problems by university employees	For company: A possibility of using the knowledge of university's researchers for solving company's problems and improvements For university: Development of practical knowledge of university's employees, what can let to better preparation of university's to work in industry graduates and better adjustment of scientific researches' directions to industry needs
8	Internships of the company employees at university	Acquiring the latest knowledge by a trainee	For company: Possibility of acquiring the necessary knowledge and using it for solving problems and for the company development For university: Acquiring the information about the current needs and problems of the company

Proper engagement of a trainee and the first signs of improvement may evoke the enthusiasm among other workers in the company, who eagerly accept the new knowledge that was acquired by the trainee and disseminated in the company.

Subject and goal of the internship and work methodology – Case study

The main assumption of the internship was acquiring by a trainee the knowledge which will be may be practically used in the company. Therefore, the best solution was to determine the methods and tools which could be used later in the company as well as studying the methodology and various cases of their practical use and implementations in various enterprises, and, next, their implementation in the chosen areas of the company. As it is known, practice is the best way for acquiring knowledge.

The internship was undertaken within the program „SCIENCE – INTERNSHIP – ECONOMY – 2nd edition" („NAUKA – STAŻ – GOSPODARKA – edycja II"). For the internship, the following subject was chosen: *Improvement of work organization in the production line of wet filter*. The methods and tools learned by a trainee were then intended to use to improve the functioning of a chosen area of the company where the trainee is employed. By implementing changes in work organization, the production line is supposed to be more efficient and to provide the appropriate work quality. The main goal of the internship was the improvement of a value flow and the increase of production line capacity.

The detailed goals were as follows: defining a value for a customer in a chosen process, processes identification, wastes identification in the processes and improvement of work organization. In order to fulfill the goals, the trainee had to acquire certain knowledge and perform the settled practical tasks under the supervision of a tutor who evaluated the correctness of this knowledge implementation. Work methodology is presented in Fig. 1. The internship was thematically connected to the modern lean manufacturing concept, and it concerned the recognition and practical use of the lean manufacturing tools and methods.

Step 1.	Knowledge of lean manufacturing methods and tools
Step 2.	Studying previous implementations
Step 3.	Collecting and analyzing data
Step 4.	Searching for possibilities of the process improvement
Step 5.	Implementation and evaluation of the implemented solutions – results presentation

Fig. 1. Work methodology

Nowadays, lean manufacturing conception is the most willingly used conception helping companies to adapt flexibly themselves to the changing requirements of the market [1, 2, 5, 7, 10]. The conception uses a set of methods and tools which help in the process analysis and development [11, 12]. Unfortunately, some previous research shows [8] that many companies haven't implemented this concept yet.

Schedule of work realization

Tasks performed within the internship and the methods and tools recognized by a trainee are presented in table 2. Next, in the further part of the work, the results of the analyses are described. After the project was completed, it was presented by a trainee during a lecture to the students who study Management and Production Engineering.

Table 2. The tasks performed and the lean manufacturing methods and tools recognized and employed

No	Task	Methods and tools
1	Identification of the flow in a production process of wet filters. Review of processes performed within the chosen product family manufacturing. Identification of performed operations. Specifying a number of workers employed on the production line.	Technical documentation review Work observation Interviews with workers
2	Determining a sequence of activities performed within certain operations in a production process of wet filters.	Snapshots of work activities
3	Gathering data for the purpose of value stream mapping: data concerning a material flow, data concerning an information flow, places of inventory, quantity of inventory, cycle times of certain production operations	Time study Work observation Interviews with workers
4	Creating a graphic representation – a current state map of the processes. Presentation of a value flow on the production line with the use of defined graphical symbols: processes, data concerning processes, material flow, information flow, inventory. Calculation of lead time and processing time.	Value stream mapping – current state map
5	Identification of problems on the analyzed production line: inventory, down-times, brake-downs, nonconformities, nonconforming products, setups, unsufficient workers' skills, unsuitable tools and means.	Observation of a production process
6	Analysis of a current state map. Wastes identification. Calculation of tact time. Analysis of cycle times. Analysis of manual and automatic work.	Work study Tact time Work balancing
7	Construction of a graphic future state map of the processes. Developing proposals of improvements in the process. Presentation of proposals in the form of a graphical map of a value flow – future state.	Value stream mapping – future state map
8	Development of a schedule of the chosen lean manufacturing tools implementation on the analyzed production line, depending on the needs resulting from the analyses.	One piece flow, FIFO, Supermarket, Kanban system, Spaghetti diagram, SMED, Standardization
9	Evaluation of the implementation. Assessment of the achieved process improvement.	Assessment of lead time and processing time Assessment of efficiency

Analysis performed with the use of learned methods

Wet filters (Fig. 2) are produced on a production line where three employees work (Fig. 3). On the line, an automatic process (injection moulding) and a manual assembly are performed. A value stream map (current state) of the process is presented in Fig. 4. The production line didn't achieve the maximum capacity, which is determined by an injection moulding machine capacity.

For this reason, it was necessary to identify problems which were present on the production line, and then, to find their causes and propose improvements to be implemented. Therefore, first of all, work was observed and the problems that appeared were registered. Examples of the activities that were registered in an assembly operation no 1 are presented in table 3.

Fig. 2. Photo of a wet filter

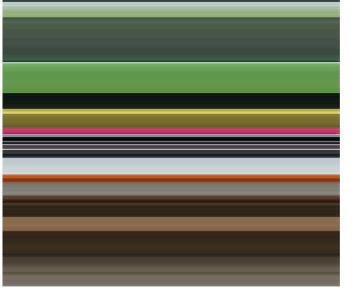

Fig. 3. Photo of a wet filter production line

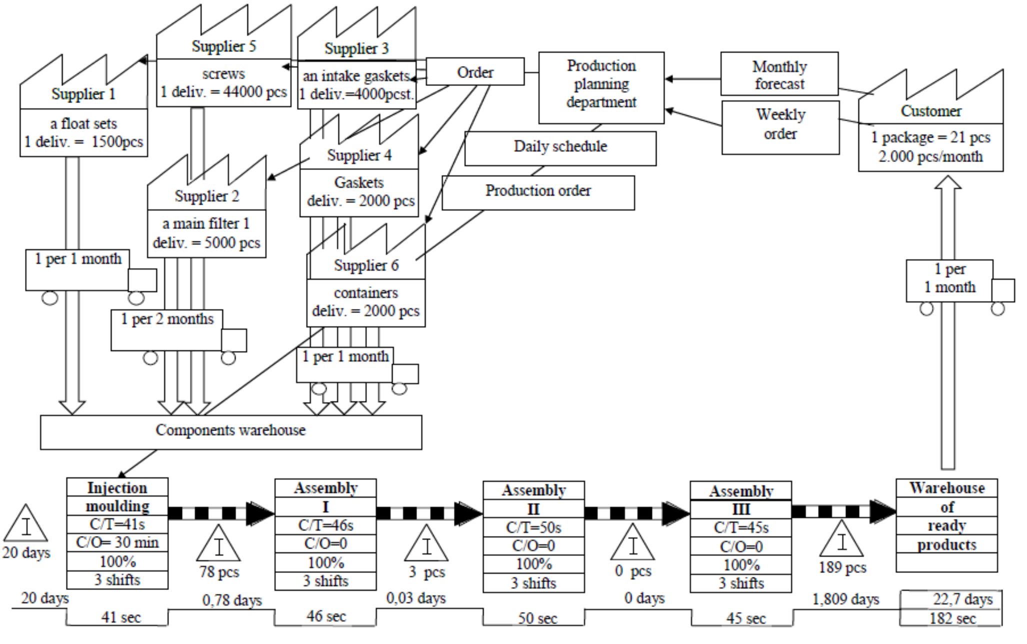

Fig. 4. Value stream map – current state

Table 3. Activities performed in an assembly operation number 1, the devices and tools used and the elements of the product assembled

Sequence of activities	Used devices, tools and materials	Assembled product components
1) Cutting of an ingot from a plate of the container	pliers	plate of the container
2) Placing a float set in a fixture	fixture	a float set
3) Placing a plate of the container in a fixture and screwing down a float set	fixture, screwdriver,	plate of the container, a float set, 3 screws
4) Placing a gasket of a filter net	fixture, grease	a gasket of a filter net
5) Placing a gasket of a plate of the container	fixture, grease	a gasket of a plate of the container
6) Placing a main filter	fixture	a main filter
7) Placing a filter cover	fixture	a filter cover

During the observation of work various problems were identified. Among the most important, the following were recognized:

– delay of start-up of the production line,
– a stoppage of the production line resulting from the lack of components,
– an operator performing an operation III had to wait for work,
– build-up of inventory before operation II and operation III,
– the fixtures inadequate for the assembly tasks.

The problems were analyzed with the use of Ishikawa diagrams. An exemplary analysis is presented in Fig. 5.

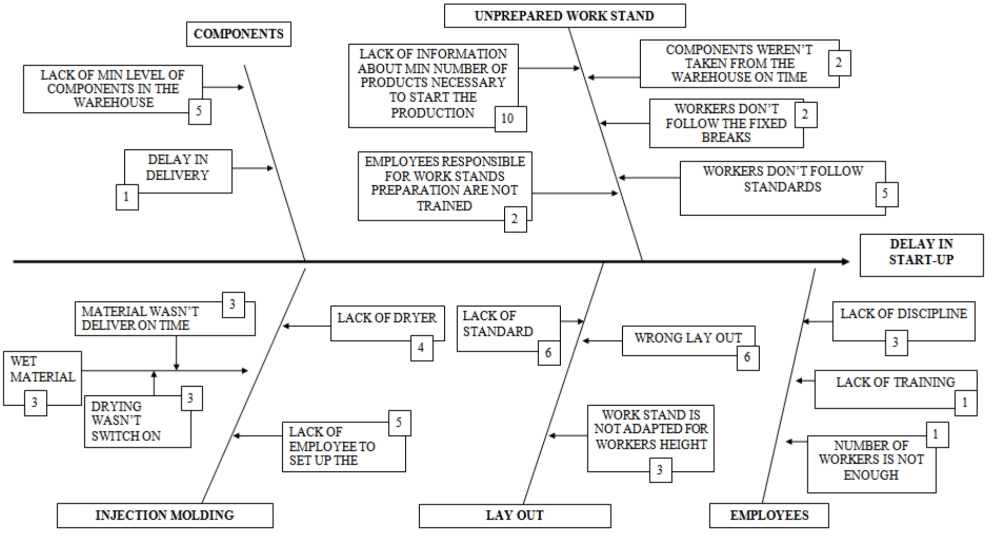

Fig. 5. Identification of the problem causes: delay of start-up of the production line

In order to achieve the required capacity of 700 pieces/shift, firstly, it was essential to eliminate the registered problems. It was necessary to implement such improvements to achieve cycle times in every operation in the production line similar to the injection moulding machine cycle time that is 41s. For this reason, a production cell with one piece flow was proposed to implement. A part of a future state value stream map is presented in Fig. 6. In order to implement the future state map, it was necessary to implement improvements which would eliminate problems and help to achieve better efficiency. The following improvements were implemented on the production line:

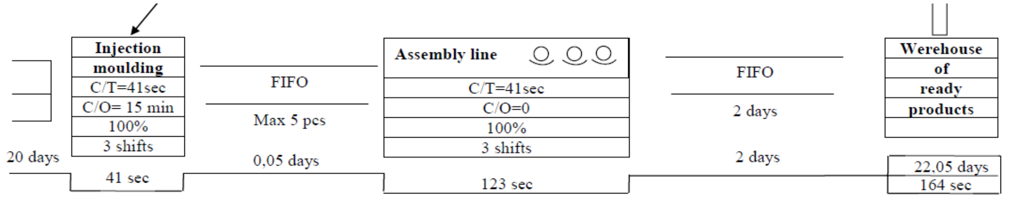

Fig. 6. Value stream map – future state – part

– change of fixture construction in order to facilitate a manual assembly process and reduce the cycle time – Poka Yoke solution (Fig. 7),
– change of tools – using a screwdriver with rotation speed of 800 rpm instead of a screwdriver with rotation speed of 500 rpm,
– establishing the best sequence of assembly activities performed and the preparation of work standards (Fig. 8),
– reorganization of a production line, implementation of a new lay-out of tools and components for assembly (Fig. 9),
– assigning a person responsible for supplying components to the work stands in order to enable the work to start on time and prevent from it stoppage resulting from the lack of components during work. A supply schedule was developed. It provides the information on the number of components and the frequency of deliveries of each component on the work stands (Table 4),
– preparation of suitable containers for the assembly components in order to have an adequate number of components needed to perform an assembly process without any problems,
– implementing a kanban system with the minimum and maximum number of components for an assembly process on the production line.

Fig. 7. Fixture for operation II

Fig. 8. Work standard for operation I

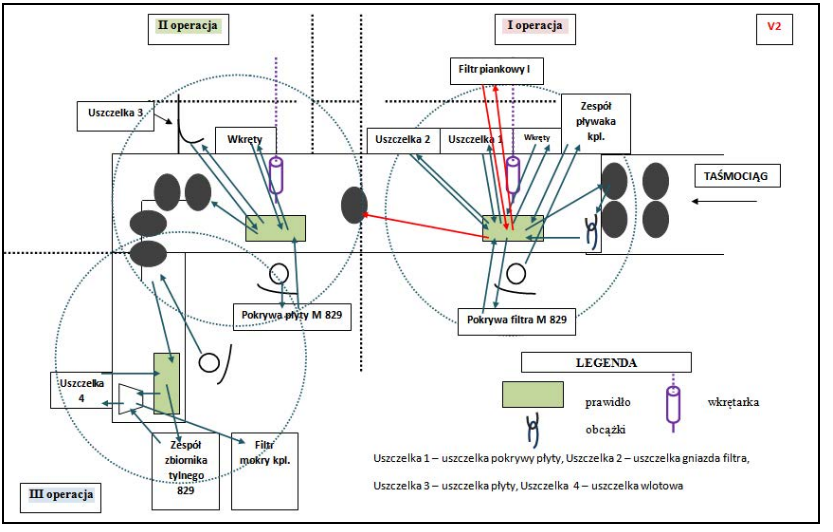

Fig. 9. Spaghetti diagram representing movements of operators working on the production line

Table 4. Number of assembly components, which should be delivered on the production line – fragment

Component	Number of pieces in a package	Number of packages	
		D1	D2
a float set	72	4	7
a gasket of a filter net	100	3	5
a gasket of a plate	60	5	8
a gasket of a cover	300	1	2
an intake gasket	450	1	1
a cover of a plate	40	7	11
a cover of a filter	50	6	9
a main filter	144	2	4
a set of back container	24	11	19
D1 – delivery 1, D2 – delivery 2			

Evaluation of the results of the improvements implementation on the production line

After the improvements were implemented on the production line, the efficiency of the line increased. However, the operation number III still needs to be improved (Fig. 10) because it was impossible to obtain the cycle time of 41 s. As a result, this can lead to inventory build-up among work stands or cause wastes in the form of waiting. The line efficiency before the implementation of improvements was 18.6% of the maximum capacity of the line. Whereas after the improvements implementation, the capacity of 75.7% of the maximum capacity of the line was achieved.

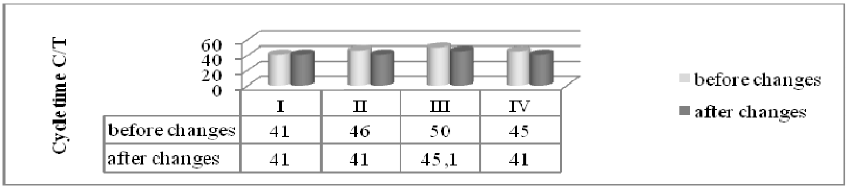

Fig. 10. Cycles times in production operations before and after changes

Additionally, the negotiations with a customer were carried out, and the customer agreed to introduce a structural modification in a product design. As a result, further reduction in a cycle time of the operation number III may be achieved.

Summary and recommendation

The presented analyses are only a part of the analyses performed by a trainee during the internship. They were conducted under the supervision of a tutor who monitored the accuracy of the analyses, helped with drawing conclusions and gave instructions to search for problem solutions. After the tasks were performed, the trainee worked out the results of the analyses and presented them during a lecture to the students of Management and Production Engineering. Due to this, not only knowledge was transferred from university to industry, but also practical knowledge was passed on to the university students. It increased their understanding of the lean manufacturing concept and the knowledge on the implementation of lean tools.

The most important benefits of the internship are considered as follows:

1. Transfer of knowledge concerning the modern lean manufacturing concept and the methods and tools related to it from the university to the enterprise.
2. Identification of the current problems of the company.
3. Practical use of the lean manufacturing tools in the company in order to improve the capacity, to reduce wastes and to improve production processes.
4. Identification of areas for further cooperation between the company and the university within the development of production organization in other areas of the company. During this internship, some of the analyses, e.g. delivery planning, have already covered other production lines in the company that were not initially planned.
5. Increasing the competences (knowledge/skills) not only of a trainee but also of other company employees who were involved in the improvements implementation on the production line.
6. Transfer of practical knowledge from the company to the university.

Most of all, the authors recommend that a strong connection between the subject matter of the internship and the business of the company where a trainee is employed should be ensured when planning any internship of a trainee at a university. The subject matter of the internship can't be unrelated to the trainee's every day work. It will enable better understanding of the gained knowledge as well as it will bring benefits for both a company and a trainee, due to the direct implementation of knowledge into solving current problems of the company.

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