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Impact of laser and other high technologies on manufacturing efficiency in Lithuanian and Finnish sheet metalworking industry

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1. Introduction

Growing market competition compels manufacturing enterprises to be on the hunt for new means of increasing production efficiency. Recently the pressure of the global competitive environment has forced manufacturers to concentrate their strategies at an increase in efficiency. To achieve it the requirements of reduced production cost and improved product quality are to be fulfilled. Modern production organizations are working in the global environment which requires continuous perfection [1]. New generation lasers and other high technologies, upgrading of knowledge and data bases and the production organization are the measures to be taken by each enterprise seeking to improve the effectiveness of productivity. General production efficiency includes not only the work of the personal directly engaged in manufacture, but also the work performed by the staff indirectly related to it, i.e. by managers, auxiliary, quality controllers, administration officials, etc. [2]. The work efficiency of the latter employees is increased with the implementation of information technologies [3].

In sheet metalworking industry a great role is played by flexibility and adaptability of an enterprise to the rapid varying production environment. Customers require high quality versatile products, shorter delivery terms, better service and lower prices. Simultaneously, life cycle of a product shortens and shortens [4]. This is a great challenge to metal sheet product manufacturers.

The objective of enterprise strategy is the improvement of all its indices. Quality is repeatedly identified with efficiency, both being somehow separate and inherently connected concepts [5]. The value of a developed product is its quality which can be achieved by high level specialists and technologies. With the intention of improving quality the enterprises emphasize the application of Enterprise Resources Planning (ERP), Just In Time (JIT), Total Quality Management (TQM), SIX Sigma and other strategies and philosophies as the panaceas for production problems solution [1]. Regrettably, in many cases some easily achievable things involved in the product quality are forgotten. Nowadays, elaborated maintenance of technologies and products, complicated equipment and exploitation affect production effectiveness and profitability [5].

The aim of this paper is to determine the impact of CNC laser cutting and other high technologies (CNC punching, CNC bending, robotic welding and riveting) on the general manufacture efficiency and effectiveness. Efficiency in this paper is considered as complex set that pertains from many parameters which affect the customer requirements definition term and make product or service delivery span. The definition methodology of company activity efficiency in the next chapter of the paper is presented. Analysis of activity efficiency will supposedly help manufacture enterprises avoid waste and errors and increase their profit.

2. Methodology of efficiency definition

Work efficiency E as mentioned above depends on a lot of parameters and can be expressed as the following abstraction function

$$E = f\left(z_1, z_2, z_3, z_4\right) \tag{1}$$

where z_1 is manufacturing productivity index, z_2 is machine tool workload coefficient, z_3 is product delivery time to the customer, z_4 is product quality cost and index. In this paper the impact of manufacturing productivity index and machine tool workload coefficient on work efficiency will be considered. Other parameters as a conditionally constants in this research are left and their influence on work efficiency by appropriate industry good practice and experimental coefficients are estimated.

Lithuanian and Finnish sheet metalworking manufactures applying the same above mentioned facility participated in the investigation. According to the headcount, the biggest manufacturing enterprise is Lithuanian comprising nearly 600 employees. Five enterprises are medium size with a hundred to two hundred people. Five small companies have bellow a hundred employees. Lithuanian enterprises are spread all over the country, while Finnish sheet metalworking companies are located in the southern and central parts of the country. As it is seen from Fig. 1 Finnish enterprises were established much earlier.

2.1. Impact of laser and other high technologies on productivity of sheet metalworking industry

From the viewpoint of manufacturing productivity and effectiveness increase, production technologies are of great importance as they are constantly improving while human labour is decreasing [6]. It is of great relevance to reduce the weight of structures and improve seeking their functions in sheet metalworking industry. On the other hand, the appearing modern technologies make it possible to produce effectively and economically the products of metal sheets. These technologies allow to cut the number of maintenance workers, to improve the product quality

and shorten the manufacturing time. In this case employees have to be highly motivated and qualified.

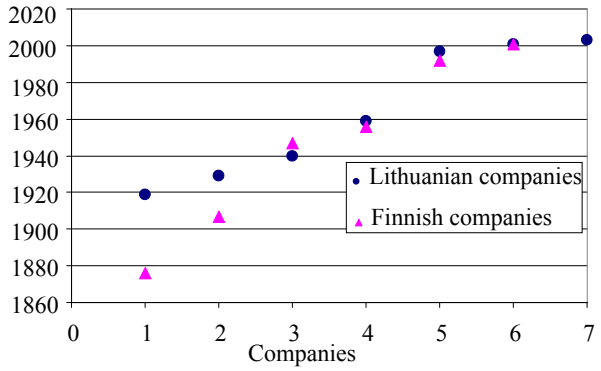

Fig. 1 Establishment date of Finnish and Lithuanian sheet metalworking companies

2.2. Estimation of productivity index

The enterprises estimate productivity index according to their own or borrowed methods. It is not wrong, it is worse when the productivity index is considered to be excellent and no changes are needed. Such consideration may sharply affect productivity as it may be done in case an enterprise cannot evaluate its productivity. In order to increase productivity, the organization has to know an accurate knowledge of it. Manufacturing productivity P is the ratio of manufactured product value to the cost to produce it [7]

$$P = \sum_{i=1}^{n} O_i \Big/ \sum_{j=1}^{m} I_j \tag{2}$$

where O is the value of manufactured products, I is manufacturing cost. It is obvious that the term of productivity comprises two notions important to production engineering and competitive engineering. The first notion is closely connected to production technologies and their possibilities; the second is also closely connected to the development and estimation of the product value.

A common mistake is when manufacturing improvement is considered as stimulating an increase in productivity index. It may happen, whereas in fact it depends on a number of indices and activity results. An effective labour is thought to bring an increase in productivity. Unfortunately, a greater quantity of products manufactured per time unit does not indicate productivity which includes the value, quality of the product manufactured and cost used to achieve it.

The productivity indices are strongly affected by downtime or under produced products. Then the cost increases and without the created value the enterprise loses its customers which may cause lasting negative impact. Product demand in the market is one of the indices which the enterprise has to observe and analyze because it has no power to monitor it. Nevertheless, the product demand has to be taken into consideration in launching a new product. Product versatility enhances its successful marketing and value; therefore product designers have to take it to their minds at an early stage of the product development. Product value is increased by qualitative product maintenance during its all life cycle. The indices related to cost depend on the enterprise directly. The estimation of productivity can help the enterprise to determine a primary datum point from which various situations can be studied and analyzed.

One of the most popular methods of productivity estimation and evaluation is the calculation of partial productivity indices [8]. In this way, general productivity is

$$P = P_H + P_M + P_C + P_E + P_O \tag{3}$$

where P is general productivity, P_H is productivity index of employees, P_M is productivity index of materials, P_C is productivity index of investments, P_E is productivity index of power, P_O is productivity index of cost used.

The partial productivity index is frequently calculated for the principal equipment, manufacture section or a highly qualified operator. In this paper the aspects of employee‘s productivity index will be analyzed in greater detail

$$P_H = \frac{O_h}{I_h} \tag{4}$$

where O_h is the value annually generated by employees, I_h is the number of employees.

Application of good experience and skills to production processes makes the major impact on partial productivity. Use can be made of it, depending on production system traditions, experience, tooling and machine tools. The greatest effectiveness may be reached when employees are capable of optimally applying their knowledge and experience [9]. Benchmarking is one of the popular methods to share and acquire good practice among different companies in the same industry area [10]. Own products development and production have advantages against those which are created away. Adaptive design in CAD systems [11] can increase new product development efficiency.

Productivity index Pc is related to the investments, high-tech equipment. The investments are to satisfy the purchase of the most necessary machine tools. Analysis of Finnish and Lithuanian enterprises activities shows that the low index of high-tech equipment workload has a direct effect on the labour productivity. It is caused by insufficient skills of the operators working with the mentioned equipment and without a rational sequence of the parts being machined. Workload can be evaluated and increased by applying a concurrent engineering method [12]. It helps to achieve the optimal value of any machine tool workload coefficient η applying the following function

$$\eta_i = \frac{\sum_{j=1}^{v} (S_m)_j}{R_i} \rightarrow 1.0 \tag{5}$$

where S_m is total machining time of typical design features, j is the number of design features types, R is machine tool work time resource.

$$S_m = \sum_{k=1}^{r} \sum_{l=1}^{o} T_{kl} q_{kl} \tag{6}$$

where k is the number of products, q is the volume of products being manufactured, l is the number of design

features which can be manufactured by *i* type machine tool, *T* is machining time of a typical design feature.

Activity efficiency and effectiveness by benchmarking results of the mentioned seven sheet metalworking companies in Finland and Lithuania have been carried out.

3. Results

Seven Finnish and seven Lithuanian sheet metalworking enterprises using above mentioned laser and other high technologies participated in this investigation. As it is mentioned above, general productivity of an enterprise is the ratio of the value achieved to the cost input. Annual turnover of an enterprise may be taken as the achieved value, while its cost may be the number of employees who were working to achieve that annual turnover. By applying this method a partial productivity index of an employee is obtained. As it is seen from Figs. 2 and 3, the turnovers of both countries gradually increase. Fig. 3 indicates that the period of 2001-2003 years was difficult to Finnish manufacturers. This year the production scope was either constant or decreased as it is stipulated by a general slow down of economy. As it is seen from Figs. 2 and 3 the difference of production level between Lithuanian and Finish manufacturers is evident.

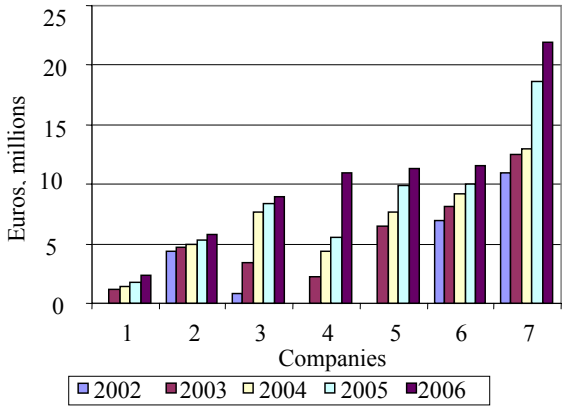

Fig. 2 Turnover of Lithuanian manufacturers

This leap in Lithuanian industry is due to the implementation of expedient investments and strategy plan. The Finnish manufacturers enjoy the stronger traditions in competitive products manufacture; therefore they could afford to allot all investments to improvement of the product quality and functioning. In this way, Finnish manufacturers improve their production technologies and reduce production cost. Lithuanian companies produce several unsophisticated products or fulfil some orders which require greater costs and the value achieved is smaller. Among the enterprises participating in this investigation each country has a company with exceptionally higher turnover. The rest of the companies do not show any greater differences in their turnover. Both countries have a company which has been recently established and its turnover is considerably smaller.

The variation of employees' number in Lithuanian and Finnish companies during the recent years in Figs. 4 and 5 is showed. No significant tendencies in the variation of employees' number are observed. The earlier

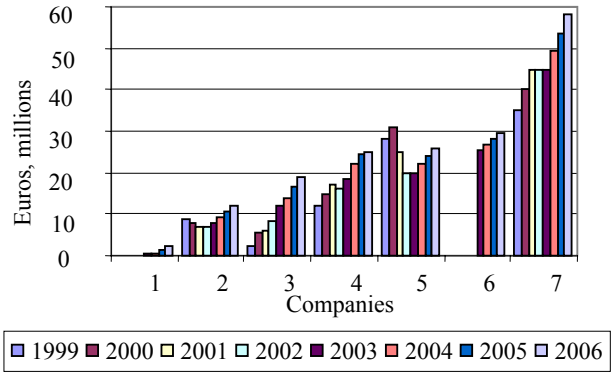

Fig. 3 Turnover of Finnish manufacturers

companies have a greater number of employees which is gradually reduced. Overall number of Lithuanian and Finnish employees differs greatly. The biggest Lithuanian company has about 600 employees while the Finnish – only 250. The other Finnish companies employ less than 250, in three of them the employees' number never reach 100. In Lithuania the smaller number of employees is in newly established companies. In earlier companies the number of employees is not easily cut even because the level of the available technologies is not so high that redundant employees could be fired.

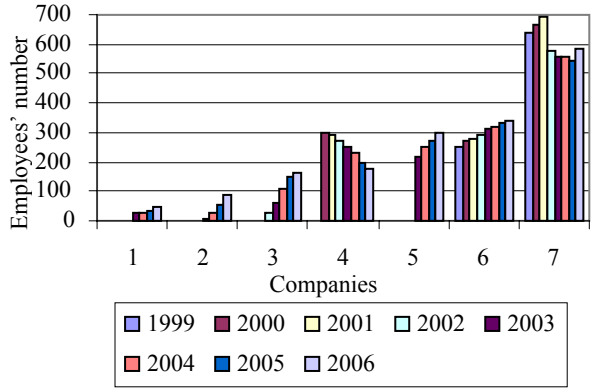

Fig. 4 Number of employees in Lithuanian sheet metalworking industry

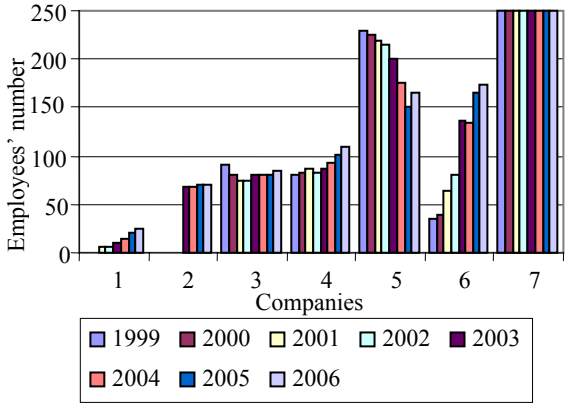

Fig. 5 Number of employees in Finnish sheet metalworking industry

In that case the enterprises should find it advantages to increase the manufacturing productivity by reducing the number of employees and renovating their tech-

nologies, at the same time training the rest of their working people. New manufactures are gradually increasing their number of employees, thus an increase in their production efficiency is to be based on the growth of turnover. Nevertheless, comparing the trends of Finnish and Lithuanian sheet metalworking manufactures, it is evident that the employees' number in Lithuania is about twice greater, while their turnover is nearly twice lower.

Figs. 6 and 7 show the variation of the output index in Lithuanian and Finnish sheet metalworking manufactures. In this case the datum point is the year 2003, when the output index was 1. As it is seen from Fig. 6, the greatest growth of this index is in the second and fifth enterprises which were established earlier and they both have proper traditions in sheet metalworking sphere. The output index starts increasing with a gradual increase in turnover by renovating technologies and simultaneously reducing the number of employees. There are two enterprises whose output index has decreased compared to that of 2003. Both of them have been established lately, but their activity is quite unlike. The third enterprise experiences an increase in the number of employees and inappropriate growth of turnover as well as incapability of implementing modern progressive technologies which could help either reduce or keep a constant number of employees. In the fifth enterprise a gradual, even increasing growth of turnover is noticed with a faster growth of the number of employees. The latter enterprise was established in 2003; therefore an increase in the staff is unavoidable.

When compared the indices of employees efficiency of Lithuanian and Finnish enterprises it is evident

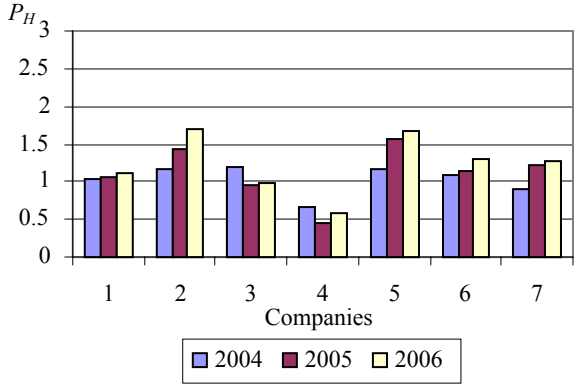

Fig. 6 Variation of the employees' productivity index of Lithuanian enterprises compared to the year 2003

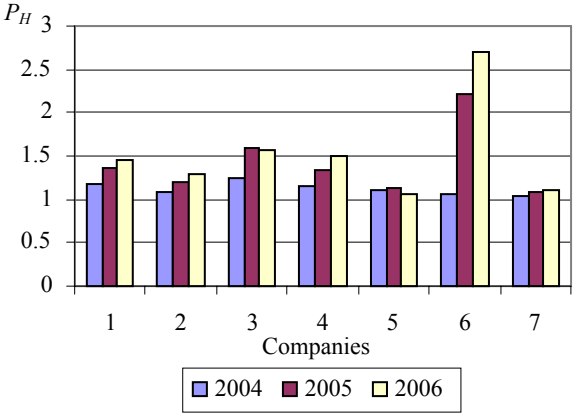

Fig. 7 Variation of the employees' productivity index in Finnish enterprises compared to 2003

that this index in Finland has not decreased compared to 2003. The sixth enterprise differs considerably. This company has been recently launched and is oriented to high-tech level products which are manufactured by means of elaborate technologies. The staff number is small and it is growing rather slowly. In Lithuania there are two companies whose employees productivity has fallen down compared to the year 2003. The fourth company has increased the number of its employees considerably.

On the right of the diagrams in Figs. 8 and 9 on axis *y* a monthly turnover produced by employees is represented. On the left we can see subjective evaluation of the enterprise according to the level of its technologies: 1 stands for very poor technologies, 5 – medium technologies, 9 – excellent high technologies. The company executive presents the evaluation.

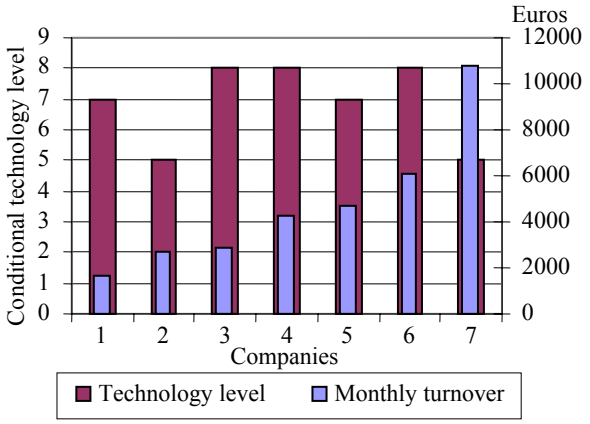

Fig. 8 Monthly turnover produced by employees in Lithuanian enterprises

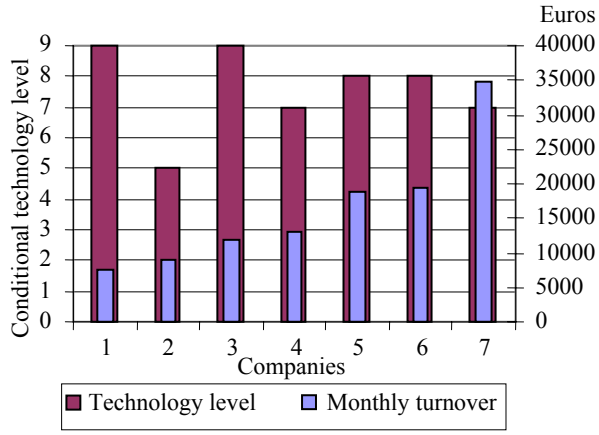

Fig. 9 Monthly turnover produced by employees in Finnish enterprises

The diagrams show that subjective evaluation is frequently not quite right as the other enterprises are not overviewed. Lithuanian and Finnish enterprises with the highest monthly turnover for an employee do not evaluate their technologies with the highest point. This fact indicates that they have a potential to grow and improve their results. Out of all participating enterprises only two Finnish manufactures evaluated their technologies with the highest point. Both these companies have a very definite already implemented strategy whose principal aims are investments to intellectual products and modern high tech-

nologies. The major difference between Lithuanian and Finnish companies is noticed in respect to the monthly turnover produced by an employee, which is a significant index of the general production efficiency. It is evident that in Finnish companies it noticeably exceeds Lithuanian indices. The index of the best Lithuanian company fractionally exceeds the indices of the worst Finnish company. In Fig. 10 and 11, on the right on axis *y* we see the turnover of Lithuanian and Finnish enterprises achieved in 2006.

On the left we can see the percentage of the company's turnover made by its products and the products as per order. It is also a significant index indicating the further perspectives.

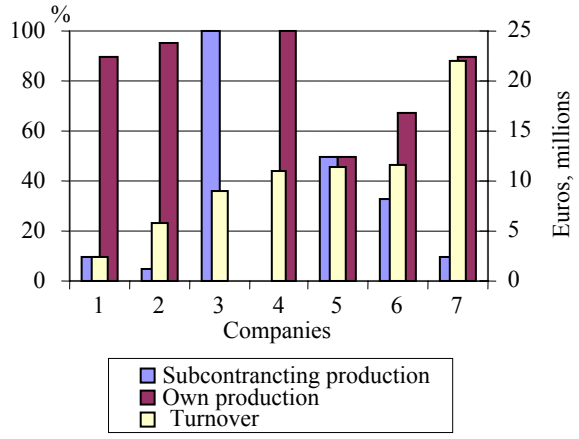

Fig. 10 Distribution of own products and production per order in Lithuanian enterprises

The diagrams show that Lithuanian enterprises produce about 30% of products as per order, and 70% their own products.

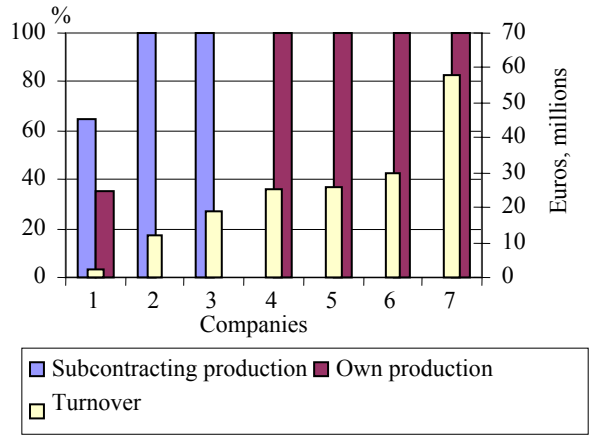

Fig. 11 Distribution of own products and production per order in Finnish enterprises

In Finnish enterprises these figures are similar, 37% of the turnover is obtained from the products as per order, and 63% of the turnover comes from their own products. Diagram 10 does not reveal any dependences while diagram 11 shows that enterprises with the largest turnover produce exclusively their own products without taking any special orders.

4. Discussions

All Finnish and Lithuanian sheet metalworking companies have friendly agreed to participate in the investigation. Summing up this research we can evaluate the position of each company in the labour market of its country and compare the obtained results with those achieved by the manufacturers of other countries. The diagrams indicate that Lithuanian indices are lower than Finnish. This fact shows the importance of evaluating the benefits and exploitation of available technologies. Overall number of employees working in Lithuanian enterprises is about twice higher than Finnish, whereas the value produced is twice lower. The sharp difference is seen when the monthly turnover of both countries is compared. Finnish producers surpass Lithuanian sheet metalworking companies even three times. The only reason lying in this backwardness is implementation and assimilation problems in high level technologies. In this investigation we have perceived not once that Lithuanian manufacturers do not lag behind, or lag a little according to the available equipment. Nevertheless, there is a lag in automation of auxiliary labour. Actually, to achieve the expedient results the companies have not only to possess modern technologies, they have to exploit them optimally. Optimal exploitation of all the equipment is one of the factors vital in improvement of productivity effectiveness and efficiency in Lithuanian enterprises. Another problem is dependence of the obtained turnover on the produced own products and products as order handled (see Fig. 11). The largest turnover of four Finnish companies producing their own products only has been achieved. As it is seen from Fig. 10, Lithuanian manufacturers do not produce their own proper products except the fourth company whose turnover is filled only with them.

The early design stage of new product development or early new order handled engineering stage must be more emphasized in Lithuanian companies. In particular, manufacturing cost forecasting [13]; the intended production cost early shows the future work efficiency and is available to make appropriate decisions in a time.

5. Conclusions

1. Investigation into the sheet metalworking Finnish and Lithuanian enterprises makes it possible to evaluate the work efficiency of separate and overall Lithuanian companies' production.
2. The partial productivity index of Finnish employees is about three times higher than that in Lithuanian sheet metalworking industry.
3. The number of employees in Finnish sheet metal design enterprises is smaller while the production value is greater than in Lithuanian analogous industry.
4. Low level of motivated workforce and automation of auxiliary labour and workload of machinery are the principal reason of backwardness of Lithuanian enterprises.

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LAZERINIŲ IR KITŲ AUKŠTŲJŲ TECHNOLOGIJŲ ĮTAKA DARBO EFEKTYVUMUI LIETUVOS IR SUOMIJOS METALO LAKŠTŲ APDIRBIMO PRAMONĖJE

R e z i u m ė

Šiame straipsnyje nagrinėjamas Lietuvos ir Suomijos metalo lakštų apdirbimo įmonių, naudojančių lazerines ir kitas aukštąsias technologijas, darbo našumas ir efektyvumas. Duomenys įmonėse buvo renkami apklausos metodu. Buvo nustatytas darbo efektyvumas ir našumo indeksas. Taip pat surinkta informacija apie abiejų šalių įmonių veiklos rodiklius: apyvartos kitimą, darbuotojų skaičių, naudojamas technologijas ir įrangą, gamybos pagal užsakymus ir savo gaminių gamybos įtaką darbo našumui. Nustatyta, kad daugiausia įtakos našumui turi gaminio tipas, įrenginių apkrovimas, darbuotojų įgūdžiai, naudojami procesai, įrankiai ir įrenginiai. Išanalizavus tyrimų rezultatus, padarytos išvados.

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IMPACT OF LASER AND OTHER HIGH TECHNOLOGIES ON MANUFACTURING EFFICIENCY IN LITHUANIAN AND FINNISH SHEET METALWORKING INDUSTRY

S u m m a r y

This investigation deals with efficiency consideration of Lithuanian and Finnish sheet metalworking enterprises which apply laser and other high-tech facilities. The benchmarking as a popular method has been used to achieve this aim. Work efficiency is indicated in the dimensions of productivity indices. The data on turnover, number of employees, applied technologies and tooling, influence of order handled and own products production in sheet metalworking industry of the above mentioned both countries have been acquired. Main factors for increasing productivity such as production type, the process to be applied, tooling and facilities, workload of machine tools and skills of employees have been emphasized in this research. The obtained results have been considered, discussed and appropriate conclusions have been made.

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Ю. Варис

ВЛИЯНИЕ ЛАЗЕРНЫХ И ДРУГИХ ВЫСОКИХ ТЕХНОЛОГИЙ НА ЭФФЕКТИВНОСТЬ ОБРАБОТКИ МЕТАЛЛИЧЕСКОГО ЛИСТА НА ЛИТОВСКОЙ И ФИНСКОЙ ПРОМЫШЛЕННОСТИ

Р е з ю м е

Рассмотрена эффективность литовских и финских предприятий обработки металлического листа, применяющих лазерные и другие высокие технологии. Для этой цели использовалось эталонное тестирование. Эффективность работы отражена в измерениями индексов производительности. Из предприятий обеих стран получена информация о показателях производства: изменение оборота, число сотрудников, применяемые технологии и оснастка, а также влияние работы по заказам и своих продуктов на производительность. Определено, что основное влияние на производительность имеет тип продукта, загрузка оборудования, квалификация рабочих, применяемые процессы, оснастка и оборудование. Полученные результаты проанализированы и сделаны выводы.

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