FACTA UNIVERSITATIS
Series: **Mechanical Engineering** Vol. 4, N° 1, 2006, pp. 93 - 103

THE USE OF EVOLUTIONARY PRINCIPLES AND ALTSCHULLER MATRIXES IN DETERMINATION OF DIRECTION OF FURTHER LUMBER SCRAPS PELLETING SYSTEM DEVELOPMENT

UDC 674.817

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Abstract. *Much attention has been given to solving the lumber scraps problem in developed countries during the last few years. The result of this research is the invention and development of new technology for lumber scraps processing; the technology of pelleting Within the global strategy of integral development of products, one particular theory which has shown good results in use, especially in the field of inventions of high rank is TRIZ. By the use of evolutionary principles and Altschuller matrixes as partial methods, the previous principal solution for lumber scrap pressing will be analyzed, and there will be an attempt of further development determination, as well as of further generation of new principal solutions for lumber scrap pelleting system. If we take into consideration the fact that both the methods that will be used and the system that the methods will be used on are relatively new and unknown in this area, it will be interesting to see the results of the following analysis.*

Key Words*: Lumber Scrap, Pelleting, Innovative Technology*

1. INTRODUCTION

One of the biggest problems of lumber industry in this area (area of former SFRY) is the processing and use of lumber scraps. Keeping in mind the tendency to operate as economically as possible, people today are seeking ways of using all their available resources as best as possible and achieve as much financial gain. From an ecological point of view, this is the problem with society at large. Since 1997 the development of new technology for processing lumber scraps has begun: the technology of pelleting. This technology encompasses the pressing of lumber scraps into pieces of 6 – 10 mm in diameter and 15 – 30 mm in length, called wood pellets. The process of pelleting is based on the concept of pressing out the input raw material through the openings of the matrix. The shape and size

Received October 20, 2006

of the wood pellets are optimal from both the combustion and heat releasing viewpoints. In developed countries of West and North Europe as well as in the USA, the technology of pelleting has been widely spread and has also suppressed previously used technologies of lumber scrap processing. Unfortunately, the technology of pelleting is new and unknown in this area (the countries of former SFRY).

By the use of evolutionary principles and Altschuller matrixes as partial methods, the previous principal solution for lumber scrap pressing will be analyzed, and there will be an attempt of further development determination, as well as generation of new principal solutions for lumber scrap pelleting system. If we take into consideration the fact that both the methods that will be used and the system that the methods will be used on are relatively new and unknown in this area, it will be interesting to see the results of the following analysis.

Namely, the use of the TRIZ theory is important and it gives good results in the field of high ranked inventions. Particularly important methods from the aspect of lumber scrap pelleting system development are the principles of technical systems evolution and the selection of the principal solutions according to the Altschuller matrix. Their use should prevent straying just as it should direct the further lumber scrap pelleting system development toward the right stream; moreover, it can help us to reach faster the level of the competition set by the manufacturers from developed countries or even to make a step forward.

2. EVOLUTIONARY PRINCIPLES OF THE LUMBER SCRAP PRESSING SYSTEM

The principles of the technical systems evolution represent the partial TRIZ method. The use of the technical systems evolution principles begins with the introduction of examining the systems on the technological S- curve. Because of that, when we use the rules of technical systems evolution, we introduce the abstract goal of the examined system further development. This goal, i.e. the abstract stimulus is the base for further solution seeking through system, intuitive and associative methods. In the use of evolutionary principles, it is appropriate to know the following basic procedures.

At the start of the analysis, an attempt of spotting the adequate S-curves of the given system should be made, both for personal and competition's products. Further procedures depend on the results of this allocation.

System in the Phase I

The technical system development will be solved through basic research and discovery of a new physical effect. First, the bases for the complete system functioning are developed.

System in the Phase II

Parallel to the introduction of the system into the market, the further technology development is done in the sense of system optimization, which leads to a quality product.

System in the Phase III

The system has reached a high level; its further technical improvements are difficult and coupled with high expenses. Considerable improvement of the system quality is possible only through introduction of a brand-new technology (the technology leap).

As can be seen in the diagram (Fig. 1), the production of the pellet-presses began in 1995 in the developed countries. Until now, the optimization and improvement of the mentioned systems has been in progress, with the capacity and whole system efficiency increase. At the same time, the systems for drying, cooling, managing and transporting have been developing intentionally. Unfortunately, we are still in the group of countries where the pelleting system development is at the low level, more precisely at the level of prototype making and examining. Yet, it does not mean we are unable to make a quick progress and thus get closer to the developed countries.

The analysis of the lumber scrap pelleting system through the evolutionary curve, before the very beginning of the idea solution concept, points out that we have to take into consideration the fact that we are in the beginning of this system development and that we are only partially highlighting our problem. Technological system parameters, as well as the mathematical model of the process are still a big unknown to us. On the other hand, a limiting development factor of this system is the means needed for the development. When we take into consideration these facts, we come to the conclusion that we have to start from simple performances of this system, perform the function testing, optimize it, and only then move to the more complex performances of the lumber scrap pelleting system.

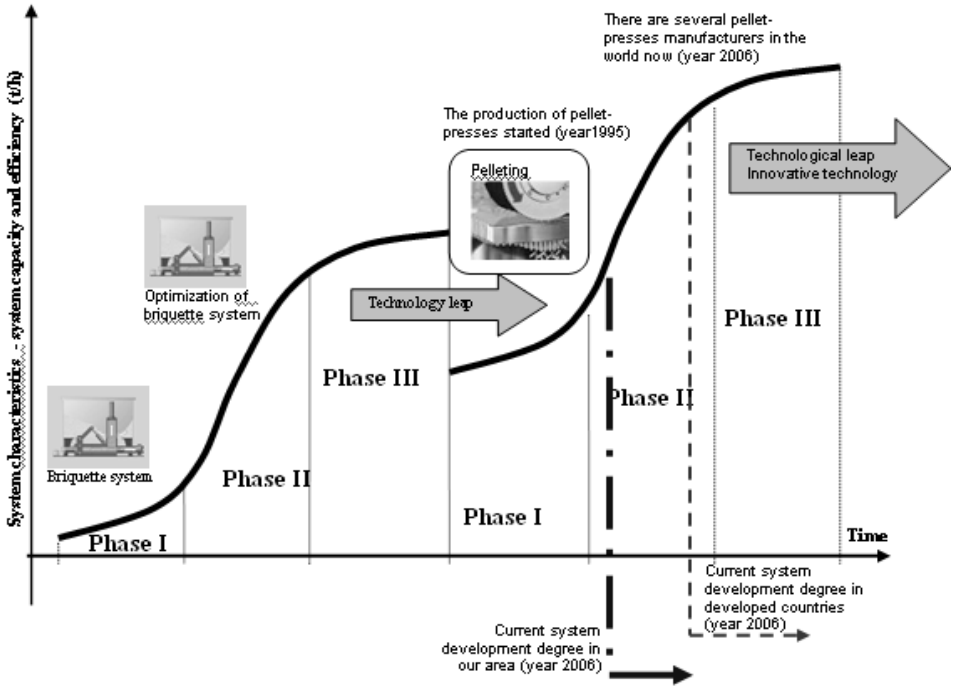

Fig. 1. The evolutionary curve of the lumber scrap processing system

By use of the evolutionary principles, it is determined that the lumber scrap pelleting system development is too backward in our area, comparing to the one in developed countries. Additionally, there has been an intense work on the mentioned system development in the developed countries. In order to reach their level of development, we have to make a fast and systematic approach to the task of development. In doing that, the most important thing is to keep moving in the right direction, because any kind of straying is just a waste of time.

Dealing with the analysis and development of pelleting technology, together with the use of the TRIZ method, that is, with models of functions forming, the decomposition of pelleting function can be achieved (Fig. 2). In order to gain the appropriate shape by using lumber scrap pelleting (DIN 51731), it is necessary to firstly grind (chop up) the lumber scraps, and then dry them in order to reduce the moisture to a regulated level (DIN 51731). Following the pressing, it is necessary to cool the completed products (wood pellets). In addition to all that has been mentioned above, it is necessary to provide transport of material from one system to another just as it is necessary to both manage and regulate the synchronized work of the system.

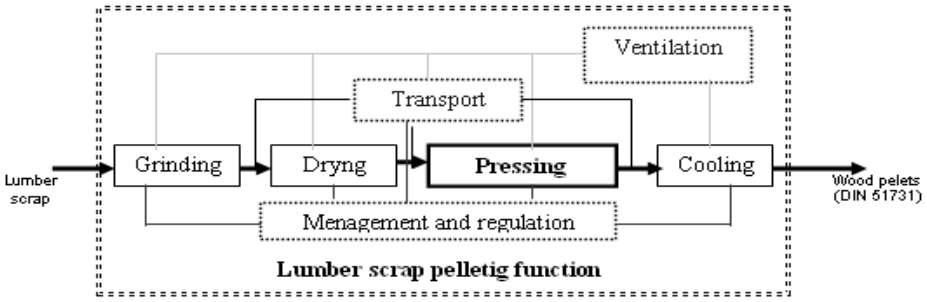

Fig 2. Decomposition of a Lumber Scrap Pelleting Function

3. THE SELECTION OF PRINCIPAL SOLUTIONS ACCORDING TO ALTSCHULLER MATRIX

By analyzing 200.000 descriptions of patents, Altschuller perceived the following:

- Abstracted states of the problems (tasks) and their solutions are repeated in different branches of science and industrial cases of use,
- The evolution of technical systems is always according to a same pattern, and,
- Real innovations can only be reached by connecting different fields of science.

While looking for answers, he followed four basic principles:

1. The aim of a development is the ideal design,
2. **A problem can be overcome if the existing contradiction is solved,**
3. Only *innovations* represent progress, and,
4. A *process of innovation* can gradually be separated.

The art of innovative development is the ability of comprehending the contradictions (in the sense of conflicts), of their formulation and of our creative dealing with them. Removing an existing contradiction (or the conflict of the aim) is the most important characteristic of technical progress and it regularly leads to new solutions.

Altschuller defines contradictions the following way:

"Contradiction refers to mutually exclusive conditions that are directed to only one function, component, or the function in the whole system."

Technical or physical development contradictions represent the barriers toward an upper development of a system, whose aim is to increase total efficiency.

The characteristic of one technical contradiction contains simultaneous improving (A↑) and worsening (B↓) of system parameters considering the efficiency of the system. (C =*f*(A,B)).

Missing the basic contradiction during the problem processing can lead in a completely different direction.

What about practice? – In the firms usually one existing project is tested by TRIZ, in other words, it is tested if something better exists. In that case, the contradictions are extracted from the familiar principles unconsciously and they are closely formulated, so that only improved additions are visible. This does not solve the main problem; however the instructions that in some other relation can represent the improvement are often generated.

After Altschuller, researchers regularly meet similar *technical contradictions,* which are marked with 39 *characteristics of contradictions* (Fig. 3). The models of contradictions made in this way can usually be solved with the help of 40 *innovative basic principles.* They are connected into 1201 solution of contradiction through so called *matrix of contradiction (Figs. 5 and 6),* and many problems can be solved with their help.

Therefore, the basic problem with this method is how to define contradiction. By correct contradiction defining, we make hypotheses for an efficient problem solution, and with that we both acknowledge previous solutions and find new ones – **the innovative solutions.**

If we consider the function of lumber scraps pelleting system from the viewpoint of this method, we can easily conclude the following: in order to perform pelleting of various lumber scraps, it is necessary that chopped lumber scraps are transformed into solid state with the appropriate density (volume compactness); more exactly, it is necessary to compress and paste the particles of raw lumber scraps into little cylinders of 6 mm in diameter and 25…30 mm in length, which will have necessary shape stability and the other according to standard qualities.

1	Mass/weight of movable object	20	Energy use of unmovable objects
2	Mass/weight of unmovable object	21	Power, capacity
3	The length of movable object	22	Loss of energy
4	The length of unmovable object	23	Loss of material
5	Surface of movable object	24	Loss of information
6	Surface of unmovable object	25	Loss of time
7	Volume of movable object	26	Quantity of material
8	Volume of unmovable object	27	Reliability
9	Velocity	28	Measuring accuracy
10	Force	29	Production accuracy
11	Voltage or pressure	30	Exterior harmful factors
12	Shape	31	Interior factors that induces inside of an object
13	Stability of object structure	32	Technologicality
14	Firmness	33	Terrotechnologicality
15	Work duration of movable objects	34	Setting advances
16	Work duration of unmovable objects	35	The ability of adjusting to universality
17	Temperature	36	Structure complexity
18	Dimensional relations	37	Control and measuring complexity
19	Energy use of movable objects	38	Degree of automatization
		39	Productivity

Fig. 3. 39 Standard technical parameters (WSP) which characterize some contradictions

By a detailed analysis and examination of pelleting technology, we come to the following contradictions:

1. The specific mass of an object must be increased – increasing the mass with the simultaneous decreasing of volume.

Contradiction No 1: Increasing the mass with the decreasing the volume (Fig. 4)

2. The stability of an object must be increased – increasing the firmness with the decreasing of volume.

Contradiction No 2: Increasing the stability of the object structure with the decreasing the volume (Fig. 5)

The parameter of a system that aggravates (change is not allowed) / **What are requirements for the appropriate change of a system that need be improved**		1 Mass of movable object	…	8 Volume of unmovable objects	…	39 Productivity
1	Mass of movable object					35,3,24,37
2	Mass of unmovable object			**5,35,14,2**		
…						
…	…					
39	Productivity	35,26,24,37		1,35,10.28		

Fig. 4. The Matrix of contradictions – Contradiction 1

The parameter of a system that aggravates (change is not allowed) / **What are requirements for the appropriate change of a system that need be improved**		1 Mass of movable object	…	8 Volume of unmovable objects	…	39 Productivity
1	Mass of movable object					35,3,24,37
…						
13	Object structure stability			**34,28,35,40**		
…	…					
39	Productivity	35,26,24,37		1,35,10,28		

Fig. 5. The matrix of contradictions – Contradiction 2

The mutual principle for solving both contradictions is the principle 35:

35. The principle of changing state of aggregation-It is not about simple change here, for example change from solid to liquid state, but it is change into "pseudo" or "quasi state" ("quasi liquid") and into inter state, for example, the use of elastic solid bodies.

Thinking more according to principle 35 and its application, we come to the conclusion that during pelleting, in addition to pressing, what also occurs is that the aggregation state changes into an inter-state, which causes shape stability even after pressing force influence and returning the object into primary state of aggregation. In order to make a change from a solid state into an inter state which is between liquid and solid states, the lumber scraps must be warmed up during the pressing. Therefore, the pressing speed and friction must be increased, and the friction energy will be transformed into thermal energy which will lead to the object's state of aggregation change. Under such conditions, it comes to lignin secreting, which serves as connective means, and it prevents wood pellet decomposing after the pressing force stops affecting and after cooling.

By pressing lumber scraps using the pelleting technology, the friction appears on surfaces of contact between cylinders and sawdust, as well as friction between material and walls of the holes through which it is pressed out. The friction energy transforms into thermal energy and it warms up the input material to the temperature of 80°C to 90°C, and the lignin secreting begins at 70°C.

The previous analysis, the contradiction defining and their solving with the use of Altschuller's innovative principles and contradiction matrixes, have given the solution that confirms the present pelleting technology. This conformation can mean that this research way is correct.

By further analysis of this problem, we come to knowledge that is beyond the present use and the description of pelleting technology. This knowledge can be considered as an innovative solution. A little courage is needed to mention that in this paper, but still the solution seems quite possible and probable.

Namely, it is about the following:

After the decomposition of pelleting function after the model of function is made, we come to the conclusion that it is necessary to do grinding and drying of raw material before the pelleting process. The moisture as a harmful factor which is in an object is extracted by drying. At the same time, the temperature of the object is increased by drying and then pressing. In the process of pelleting, the material is warmed up to the 90°C temperature, so it is necessary to do cooling after pelleting, so that obtained product keeps appropriate shape and structure.

Material is first dried and warmed, and after that it is cooled, which requires much energy.

The functions of drying and cooling represent two opposite processes, and with the elimination of mentioned functions, the function of lumber scrap pressing would be simplified considerably. By elimination of drying and cooling functions, we would avoid unnecessary loss of energy.

The question is if it is possible to do lumber scrap pelleting without drying and cooling (Fig. 6)**?**

From the economical viewpoint, in addition to achieving considerable energy saving which is spent on these two functions, we would avoid investments in development and in making drying and cooling systems. The price of making these systems individually is approximately equal to the price of making a pressing system. It has already been mentioned that the lumber scrap pelleting system would be much simpler, and the expenses for systems maintaining would be avoided.

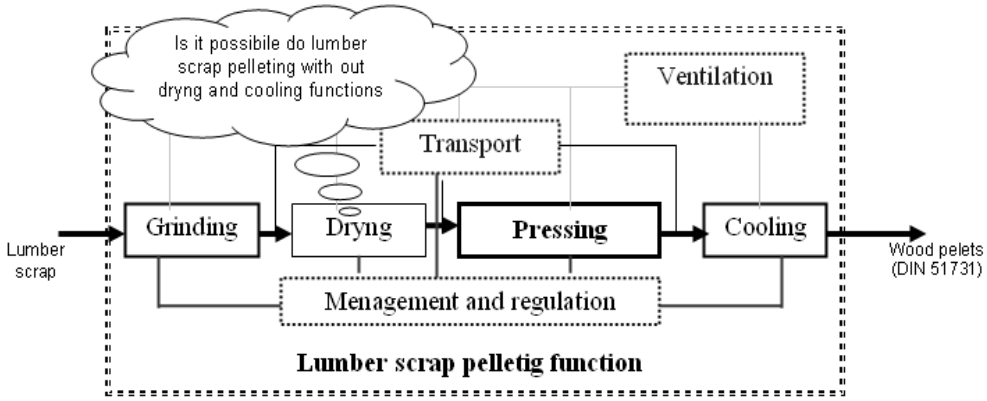

Fig. 6. Decomposition of a lumber scrap pelleting function

The parameter of a system that aggravates (change is not allowed) / What are requirements for the appropriate change of a system that need be improved		1	..	17	..	39
		Mass of movable object	..	**Temperature**	..	Productivity
1	Mass of movable object					35,3,24,37
…						
31	The harmful factors that induces inside the object			**22,35,2, 24**		
…	…					
39	Productivity	35,26,24,37		1,35,10,28		

Fig.7. The matrix of contradictions – Contradiction 3

Special attention must be paid to the proper contradiction defining and its correct formulation which is expected to take us to the right solution.

On the basis of the previously explained things about drying function, the logical question follows, namely, whether it is possible to solve the following **contradiction:**

To decrease the level of harmful factors (moisture) which are induced in an object without increasing the object's temperature.

By using contradiction matrix (Fig. 7) we can see that the mentioned contradiction can be solved by using the following principles (number 2,22,24,35) which say:

2. The principle of Separation

a) the "disturbing" parts or "disturbing" characteristics can be separated from an object,
b) particular parts or particular needed characteristics can be separated from the object

22. The principle of Transforming the Harmful into Useful

a) The harmful factors (especially the harmful influence of environment) are used for achieving the positive effect;
b) One harmful factor can be overcome through the connections with other harmful factors [(-) x (-) =(+)];
c) A harmful factor is increased to the extent of stopping a harmful influence.

24. The Principle of "Mediator"

a) To use the inter – object for transferring or forwarding the influence;
b) The other object (easily removable) is connected to the first one, and it will take over the activity.

By applying these principles and thinking accordingly, after the all-inclusive analysis and thinking about possible solutions, we come to the following conclusion:

It is possible to avoid the drying function by using an inter-object (principle 24.a), more exactly by using a chemical substance which will fuse moisture and form a new chemical compound. That chemical compound would be of use for positive effect and at the same time it would serve as connective means instead of lignin which is secreted at the temperature of above 70°C. On the other hand, it can serve as strengthener and it will enable wood pellets to have stable structure (firmness and shape of a wood pellet), even up to 90°C temperatures; hence the cooling function could be avoided. **Naturally, the chemical compound mentioned above should succeed the combustion of wood pellets and should not have any toxic effect on environment. In any case, the price of this chemical compound would be smaller than the price of energy used for raw lumber scrap drying and cooling of finished products – wood pellets, not to mention the price of development, production and maintenance of drying and cooling systems.**

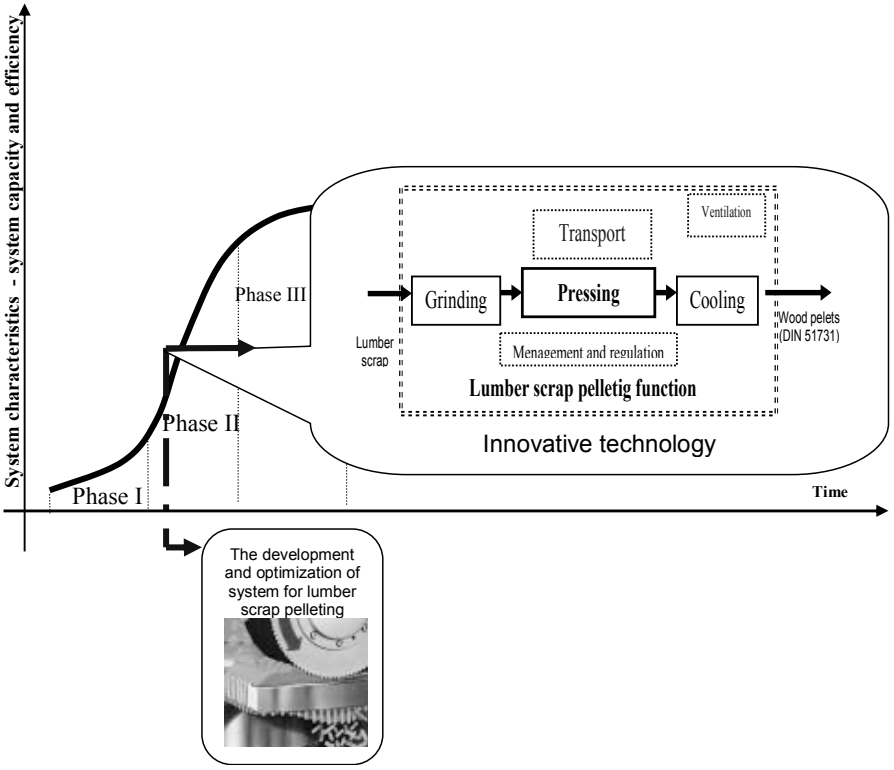

Fig. 8. The innovative technology for lumber scrap pelleting

4. CONCLUSION

The use of evolutionary principles and Altschuller matrixes of contradiction give the results that help us determine further direction of the lumber scrap pelleting system development.

By the use of the evolutionary principles, the system development degree that we find ourselves now, is determined in comparison with the developed countries. But, before all, we have determined and marked the spot, i.e. the system development degree on the technological S-curve. From that point of view, the directions of further system development are perceived. Already in this phase we can recognize two development directions:

1. The development of the existing technology
2. The search for an innovative solution

By applying the TRIZ theory, in other words, by using the Altschuller's innovative principles and contradiction matrixes, we have reached the results that induce new research leading toward patent discoveries. The purpose and use of the TRIZ theory is exactly about finding the right way, more exactly the principle problem solution which will bring progress by further development. In other words, the TRIZ is the theory which

guides-directs the researchers toward an innovation. It is usable and universal for all scientific fields.

On the basis of these results, it is necessary to undertake research in order to find the above-described chemical compound. The chemistry and technology experts should be involved in further research.

This statement is in the favor of fact that development of products, especially the theory of product integral development, is based on team work, where the development team consists of experts in various scientific fields

In the end, we can conclude that a development problem has been opened and defined by using the TRIZ method, and the chemistry and technology experts should work on its solving up. By solving the development task, we would get the innovative solution of technology for lumber scrap pelleting.

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PRIMJENA EVOLUCIONIH PRINCIPA I ALTŠULER MATRICA U UTVRĐIVANJU PRAVCA DALJEG RAZVOJA SISTEMA ZA PELETIRANJE DRVNOG OTPADA

Milan Tica

Rješavanju problema drvnog otpada u razvijenim zemljama zadnjih godina se poklanjalo puno pažnje. Rezultat tih istraživanja je pronalazak i razvoj nove tehnologije za preradu drvnog otpada, tehnologije peletiranja. U okviru globalne strategije integralnog razvoja proizvoda jedna od teorija koja u primjeni daje dobre rezultate pogotovo na polju pronalazaka visogog ranga je TRIZ. Primjenom evolucionih principa i Altšuler matrica kao parcijalnih metoda analiziraće se dosadašnja principska rješenja sistema za presovanje drvnog otpada i pokušati utvrditi dalji tok razvoja i generisati nova principska rješenja sistema za peletiranje drvnog otpada. Ako se uzme u obzir da su i metode koje će biti primjenjene i sistem na kome će biti primjenjene metode relativno novi i nepoznati na našim prostorima, biće interesantno vidjeti do kakvih će rezultata dovesti naredna analiza.

Key words: *drvni otpad, peletiranje, inovativna tehnologija*