

3. В модифицировании древесины с заданными показателями качества и управления качеством конечной продукции.
4. В научном обосновании создания комплексных защитных лесных насаждений высокого качества эколого-ресурсного назначения.

Успешное решение проблемы создания насаждений эколого-ресурсного назначения позволит разработать проекты организации КЛП с КЗЛН и приступить к созданию электронных карт с автоматизированными информационно-поисковыми системами, позволяющими осуществить планирование и управление качеством воспроизводства леса и использования лесных ресурсов.

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OPTIMIZATION OF TECHNOLOGIES BASED ON GROWTH SIMULATION

The work presents a quite general draft procedure of technology optimization, based on new lessons learnt in the theory of the operational reliability of machines, technical logistics and qualimetric procedures of quality assessment. The methods are modified for the requirements of manufacturing conditions in the Czech Republic and for expected model situations, which provides for their fast responding to the special status of forest protection, size of forest property and economic situation of the user. Combined with the commonly used optimization procedures the submitted methodology may become a part of the decision-making process supporting expert system which links up with the SILVA 2.2 growth simulator. The synergic effect from the interconnection of all information systems involved will enable an entirely new approach to the system as it provides integral indicators to facilitate quick and correct decision making.

Keywords: forest technology, multiple criteria optimization, growth stimulator

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Оптимізація технології на основі моделювання росту

Праця представляє досить узагальнену схему технологічної оптимізації, яка оперта на нові знання з теорії операційної надійності машин, технічної логістики та кваліметричних процедур якісної оцінки. Використані методи модифіковані залежно від лісоексплуатаційних умов Чеської республіки для модельних ситуацій, що забезпечує швидке реагування на екологічний і лісоексплуатаційний стан лісового масиву, а також на економічну спроможність лісокористувача.

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Поєднання запропонованої методики з найбільш вживаною оптимізаційною процедурою може стати частиною процесу базової експертної оцінки лісоексплуатаційної технології, яка пов'язана із програмними засобами моделювання росту лісових насаджень SILVA 2.2. Перевага запропонованого підходу полягає в пришвидшенні отримання правильного технологічного рішення.

Ключові слова: лісова технологія, багатокритеріальна оптимізація, моделювання росту.

Introduction

Most works published so far have gradually slipped into the optimization of an actual problem, i.e. usually to the selection of technology optimal for the given workplace by either assessing the technologies available (i.e. already used and employing machines already purchased) or a problem has been focused on the choice and purchase of machines and equipment for the new technologies.

The submitted paper brings a draft general procedure based on the theory of management and the theory of machine operational reliability with making use of some technical logistics elements, those from the field of qualimetry in particular.

In the authors' opinion the presented draft procedure will facilitate an actual optimization of technologies, which means not only to choose from the technologies locally available but from the procedures known and used elsewhere and/or to help in the formulation of task assignment for either purchase or development of a brand new technology.

The procedure can become a constituent of an expert system to support the process of decision making linking up with the SILVA 2.2 growth simulator. The synergic effect from the interconnection of all information systems involved will enable an entirely new approach to the problem solution providing integral indicators for an instant and correct decision.

Draft procedure of optimization

Selection of the basic optimization criterion

Problem solution calls for the use of a multiple criteria optimization method which would include not only the economic and technical aspects as it was common in the hitherto procedures, but also the biological, environmental, ergonomic, hygienic aspects, reliability, etc. and labour safety requirements.

In a process of optimization of the given character, the very first decision to be made is that on the used optimization criteria whose individual parameters will have to be quantified. It is also necessary to decide on the method for the inclusion of qualitative indicators that cannot be quantified but rather expressed in another way such as a verbal form. The most important step consists however in the selection of the main optimization criterion. The criterion should be cost minimization per unit production, which can be at the same time added –with respect to the type of activity- the requirement of maximum output which can be achieved through proper log-making. Nevertheless, should we include also the other criteria mentioned above, in which parameters cannot be often precisely quantified and hence directly expressed in terms of costs or losses, it is advised to employ a so called **integral indicator of quality**, which in fact also indicates what technology is most beneficial for the user.

This is applicable at a full responsibility also in cases when we cannot make a precise estimation of future yields and losses affected for example by the execution of tending measure when several options or alternatives of the technological solution are to be compared.

Should we be unable to quantify e.g. a future production loss due to soil compaction, timber quality loss due to rots infesting trees mechanically damaged at felling or extraction, etc., we can always make use of limiting conditions defined as insurmountable (fixed) limits.

The limiting conditions will not concern only the adverse impact of machines on environment but also the labour hygiene and safety.

Quantitative criteria

- Quantitative criteria can be divided into two groups as follows:
- Criteria with a maximum or minimum limiting value (e.g. minimum tractive force, maximum concentration of noxious substances in exhaust gases);

Criteria with an optimum value where deviation to both sides is considered a disadvantage (e.g. debranching near the stem surface with neither branch stubs being left behind nor the stem suffering a damage).

Quality level of the i^{th} criterion for the first group is to be calculated as follows:

$$K_i = \exp\left(\pm \frac{P_i - P_{mi}}{P_{mi}}\right),$$

where: K_i – quality level according to the i^{th} criterion; P_i – parameter of the i^{th} criterion; P_{mi} – limiting value for the i^{th} criterion.

Positive value of the expression in brackets is to be used if the parameter is desired to reach a value higher than the limiting value; it follows that negative value is to be used if the parameter is desired to reach a lower than limiting value. This concept does not place a veto on the use of a machine or technology surmounting or not reaching the limiting value; it will however considerably impair quality level in the overall evaluation. Should we actually wish to prevent the use of the technology in the case that the limiting value is defined as insurmountable (fixed), then we have to use a zero in place of the given criterion quality level.

Quality level of the i^{th} criterion for the second, much smaller group is to be calculated as follows:

$$K_i = m_0 \exp\left(-\left|\frac{P_i - P_i^{\text{et}}}{P_i^{\text{et}}}\right|\right),$$

where: m_0 – conventional value constant (e.g. $m_0 = 0.8$ if performance efficiency required is 80 %); P_i^{et} – standard value, i.e. conventional value of the optimum.

Qualitative criteria

Where the criterion parameter cannot be expressed by any of the above specified methods, it comes to the following verbal classification: Excellent – 1.20; Good – 0.95; Satisfactory – 0.60; Unsatisfactory – 0.30.

In order to be optimized, the quality level must be expressed in such a way that a group of experts from involved industries are inquired about the given crite-

rion in kind of a public inquiry and by them expressed figures are to be used as the only quality Figure expressed by arithmetic mean, i.e.

$$K_i = \frac{1}{n} \sum_{j=1}^n K_{ij},$$

where: n – number of experts; K_{ij} – opinion of the j^{th} expert.

And again – similarly as mentioned above, should the machine or the technology be not included into the selection for the insurmountable (fixed) value of the criterion – $K_i = 0$.

Regarding the fact that a total quality level of the assessed machine or technology is calculated as weighted harmonical mean, the machine or technology is to be logically disqualified from the selection.

Determining the weight coefficients of individual criteria

a) Method of paired comparison

This method is to make a mutual comparison of two partial characteristics (criteria) and to specify which of the two compared characteristics is more significant. The assessment is to be made by a group of experts of whom each fills a pre-printed table in such a way that the serial number of the criterion which is – by their judgement-more important is written into the respective windows.

The sought weight of the i^{th} characteristic can be calculated from the following relation:

$$M_i = \frac{1}{n \cdot I} \sum_{j=1}^n f_{ij},$$

where: M_i – weight of the i^{th} product's characteristic; f_{ij} – absolute frequency of the occurrence of the i^{th} characteristic serial number in the table of the j^{th} expert; n – number of experts; I – number of opinions issued by one expert.

The number of opinions by one expert depends on the number of studied criteria and equals the number of 2^{nd} class combinations from the number of criteria.

$$I = \frac{k \cdot (k - 1)}{2},$$

where k – number of assessed oil properties (criteria).

Should the method achieve a realistic expression of the mutual weight (significance) of individual criteria, the number of experts to fill the table should be as large as possible (20 as a minimum). The result is therefore affected both by the number of experts and by their subjective opinions. If a suspicion exists about the statements of individual experts mutually differing so much that the variances among the opinions are not only incidental, the objectivity of results can be checked by using the test of statements fit.

b) Method of paired quantitative comparison

Where the weight of individual criteria is to be expressed not by mere determination of which one of the two is more significant but also what is their mutual ratio a method can be used which is not depending on a large number of experts; one assessor is enough for this method of paired quantitative comparison. Criteria are to be mutually compared according to the following scale:

Scale for the quantitative comparison of criteria

Mutual relation of the criteria	Points (weight) v
Criteria of identical significance	1
Criterion of somewhat greater significance	3
Criterion of much greater significance	6
Criterion of much more greater significance	9

The mutual relation between the criteria is to be marked as s_{ij} – i.e. as a relation between the criterion i^{th} and j^{th} . The relation will be expressed as follows:

$$s_{ij} = \frac{v_i}{v_j},$$

where: v_i – number of points (weight) of the i^{th} criterion; v_j – number of points (weight) of the j^{th} criterion.

A table is to be constructed according to the number of criteria at a size of $m \times m$ with m being the number of criteria.

Estimated weight value of the i^{th} criterion M_i is to be calculated according to the following relation:

$$M_i = \frac{R_i}{\sum_{i=1}^m R_i},$$

where

$$R_i = \left(\prod_{j=1}^m s_{ij} \right)^{m-1}$$

and where m – number of criteria.

Calculating the total level of quality

As it follows from the above paragraphs of this chapter, the total level of quality can be calculated on the condition that the limiting values of individual criteria (P_{mi}) and their weights (M_i) have been determined.

It is also necessary to set up the quality indicators for each respective K_i criterion – either by calculation or according to the above presented conversion table in the case of verbally expressed criteria. The level of total quality level (K) will be then calculated according to parameters and weights of the respective criteria by means of a relation as follows:

$$K = \sum_{i=1}^m M_i / \sum_{i=1}^m \frac{M_i}{K_i},$$

where: M_i – weight of the i^{th} criterion; K_i – wear level (quality indicators) according to the i^{th} criterion; M – number of criteria.

In the practical use of results the calculated total numerical value of quality is generally used for a verbal expression of quality degree according to the following table:

Quality range/Quality degree Conversion:

Quality range	Quality degree	Quality degree – Verbal expression
$K > 1.1$	I	excellent
$0.8 < K \leq 1.1$	II	good
$0.4 < K \leq 0.8$	III	satisfactory
$K \leq 0.4$	IV	unsatisfactory

Integral indicator of quality

A more detailed explanation and a definition should be given on the "integral indicator of quality", which is to provide an aggregative information about the technological solution by a direct specification of money that can be saved or wasted over a long time if we decide for a "correct" or "incorrect" technological alternative today.

The concept of quality:

Quality (optimum quality) is a comprehensive term for the capacity of a product (machine, equipment, technology) to meet requirements of the user and public concern under optimum economic conditions. Quality as a whole is therefore to express both its economic and technical characteristics.

Understanding quality as an entirety of properties of the assessed object, i.e. a totality of parameters according to the assessed criteria, we have to use a system approach to its learning. Any characteristic improved according to any criterion improves quality of the product as a whole and in purely technical terms the product can be further improved up to a very top level of the present state-of-the-art. There are some economic boundaries to the improvement, though. Surmounting of the optimum top technical quality limit is apparently useless and improvement of only a single characteristic of the product may induce inadequately growing production costs and hence an increased purchasing price of the product.

This is a basis for the idea of an "optimum quality" where technical quality level is being assessed in relation to manufacturing and operating costs, which is at the same time a definition of the "integral indicator of quality".

The above statements can be formulated into the following two principal conclusions:

1. There is a tight link between the technical and economic characteristics of the product's quality. A product with high utility value but inadequate price would not be able to fulfil the utility value at an optimal way.
2. A similar tight link exists between the individual partial properties which constitute technical quality. Inadequate development of any product property at a cost of another characteristic may impair the optimum quality of the product as a whole.

Summarizing the above facts, we necessarily arrive at a conclusion that a basis for quality assessment must become the assessment of the level of complex indicators in which changes of any product's characteristic will show. Being assessed separately, any otherwise important partial property of the product cannot express the quality of the entirety. Not being a system approach, such an approach is not objective.

Possible final evaluation of the quality

Regarding the fact that a machine or a technology optimally corresponding with the set-up limiting values and standards will exhibit a quality value of $K = 1$ with a lower and higher level indicating a worse and better result, respectively, the total integral indicator of quality can be expressed in such a way that costs per unit production are multiplied by Indicator K , which makes all aspects studied included in the optimization solution. It is a question of the gradual precision of the method how its inclusion in the optimization solution will eventually show as it is in any case just an optimization with the inclusion of subjective standpoints and opinions of researchers.

Conclusion

Assessment of the quality of used technologies can employ data from the existing economic information systems and data from the application of the SILVA 2.2 growth simulator which is drafted as a computer programme with forest stands being conceived as a set of individual trees whose coexistence can be illustrated as a spatial and temporal dynamic system. The spatial and dynamic system character of the forest stands is taken into account in the SILVA growth model by modelling the spatial stand structure in 5-year time periods, with a quantification of growth constataion for each tree. Changes in the stand structure that would result from intentional tending operations (thinnings, juvenile thinnings) and regeneration measures, disasters or from growth and mortality *per se* have therefore a decisive influence on a further development of the trees including the stand spatial structure. In such a system, the tree increment is then defined on the basis of the growth constataion (competition) and on the basis of initial dimensions. Other external variables conditioning the stand growth and structure entering the system are: stand management methods, risks and site conditions. Integral indicator of quality can then help to compare available technologies and/or do a draft modelling of new technologies. The expert system logically includes both biological and environmental limits, providing within the framework of given possibilities an optimal economic effect expressed for example in the minimization of costs, maximization of profit or minimization of loss in the case of the negative economic result.

Acknowledgement

The paper was prepared within the Research Project of the Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry, No.: MSM434100005 "Sustainable Forest Management. From the Concept to the Implementation."

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УДК 634.31

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АНАЛІЗ РОБОТИ МОБІЛЬНИХ КАНАТНИХ ЛІСОТРАНСПОРТНИХ УСТАНОВОК ТА ОЦІНКА НАПРУЖЕНОГО СТАНУ ЇХ ОСНОВНИХ ЕЛЕМЕНТІВ

Подано аналіз роботи мобільних канатних установок і шляхи вдосконалення їх конструкцій. Оцінено напружений стан канатної оснастки, коліс, блоків барабанів і наведено рекомендації для вибору їх основних параметрів.

Ключові слова: канатна оснастка, напруження, математична модель, оптимальні параметри.

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Analysis of work of mobile cable forest transportation installations and estimation of tense state of their basic elements

The analysis of work of mobile cable installations and ways of perfection of their constructions are given. The tense state of the cable rigging, wheels, and blocks of drums is appraised and the recommendations for the choice of their basic parameters are resulted.

Keywords: cable rigging, tension, mathematical model, optimum parameters.

Гірські ліси Українських Карпат є джерелом цінної деревини для різних галузей промисловості. Однак, освоєння гірських лісів має здійснюватися не тільки з метою отримання цінної деревини, а й для збереження екосистем, як в гірських, так і в прилеглих до них рівнинних районах. Багаторічні дослідження лісозаготівельників і лісівників показали, що найповніше вимогам ведення лісового господарства, при освоєнні гірських лісів, відповідають підвісні канатні лісотранспортні установки [1-4]. Для умов Українських Карпат, де недостатньо розвинута сітка доріг, найбільш ефективним для первинного транспортування деревини є застосування мобільних канатних установок [3, 4]. Підвищити ефективність експлуатації канатних установок можна