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APPLICATION OF HARVESTER TECHNOLOGIES OF TIMBER LOGGING IN THE PROCESS-ORIENTED ENVIRONMENT

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Abstract

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Harvester technologies of timber logging currently represent the high spot of technologies used in forestry for timber harvesting and forwarding. A typical feature of the "harvester– forwarder" combination is production rate, which is many times higher than in the commonly used technology of "power chainsaw–tractor" (Lukáč, T., 2005). Other major features prevailing in harvester technologies include an appreciably high level of work hygiene and a significant reduction of environmental burden, which is certainly beneficial for the environment.
Harvester technologies of timber logging are currently an integral part of sustainable forest management.
This paper focuses on finding options for the application of harvester technologies in selected entities based on the analysis of selected factors that can be greatly affected by the technologies.

harvester technologies, harvester, forwarder, process model, process

The current market environment requires both permanent effort aimed at keeping ahead of competition and continuous endeavour focused on being faster in the innovative technologies than competitors. Leading organisations of all types – governments, institutions, large corporations as well as small- and medium-sized companies have to address the following complex issues:

- How may a company improve standards of customer service and increase productivity without simultaneous cost increase?
- How can a company manage risks and comply with regulations without loss of competitive (business) advantage?
- How can a company stimulate every one of its employees to innovations, development of new products, search for new markets and/or development of more effective methods to satisfy the customers?

These and similar issues are not typical only of the present time. Initiatives in the area of performance management, such as Total Quality Management systems and Business Process Reengineering, have already been known since 1950s, informs R. Half (2007).

The purpose of this contribution is to help clarify the issue of possible applications of multi-operational machinery in the process-oriented environment on the basis of the analysis of natural, technological and economic conditions, and to propose application of these technologies.

Application of harvester technology in the implementation of economic tasks in the Czech forestry, and this applies to all types of forest ownership, is currently an absolute necessity. Main requirement of the forest owner in the application of any technology of timber logging and skidding is compliance of the technology with the existing environmental conditions at a simultaneous respecting of the production and social functions of the forest and relevant economic aspects (Ulrich, R. et al., 2006). It may certainly be assumed that technologies using manual power chainsaws and choker skidding will be retained. On the other hand, one needs to be aware of extensive advantages offered by the technology of multi-operational machines, not only the harvester technologies themselves but their combinations with for example forest cableways (the so called mountain processors) or even with the manual power chainsaws, allowing

for replacement of wood mass choker skidding by haulage with forwarders (Šajánek, Vl., 2007).

Management of corporate processes, including the application of multi-operational machinery technologies, largely supports bridging of various systems, people and processes. Models of corporate processes then help coordinate works and synchronize data across the existing systems, thus helping the organisations to achieve better results by utilising what already exists in them and what they already possess. An important prerequisite for the creation of process models is expert activity. Expert activity is defined e.g. by D. Linhartová (2008) as performance of the role of a highly knowledgeable specialist or advisor in either educational or technical matters.

MATERIAL AND METHODS

A source for the preparation of this contribution was analysis and description of natural conditions under which the selected entities operate. In order to meet the paper objectives, it was necessary to obtain data on natural conditions and their spatial integrity.

These characteristics were important for the evaluation of general conclusions determining the possibilities for using harvester technologies.

- Characteristics of field conditions at the selected entities:
  - Representation of terrain types and terrain classes (in ares and percentages). Here, data were used of forest management plans currently in force for the selected entities. The evaluation of tabulated data showed realistic possibilities for the employment and utilisation of multi-operational machines with respect to their capacity of terrain accessibility;
  - Representation of cuts in the individual terrain classes (in m^3 and percentages).
- Evaluation of tree species representation at the selected entities.
  - Decision about the employment of harvester technology by the selected entity required analysis of the share of individual tree species in the territory operated by the entity.
  - The result from the analysis of the representation of individual tree species is considered a very important factor for decision-making on the application of modern timber harvesting technologies in the logging process.
- Characteristics and surveys of existing logging and hauling technologies used by the analysed entities.
- Specification of conditions and proposal of recommendations and measures for the low-impact application of harvester technologies in the process of timber logging by the analysed entities.

The performed analysis was used to formulate a recommendation for the application of modern logging technologies - harvesters.

RESULTS

Method used for terrain classification on the sites of the surveyed entities was the forest site classification developed by Lesprojekt (used since 1980). The results of the classification are presented in Tab. I. The table includes areas of the individual site classes including their expression in percent of the total area of the entity. It covers all analysed entities. The A+B column summarises data on the area and percentage of sites suitable for the employment of tractor and harvester technologies.

I: *Forest site classification – Lesprojekt (used since 1980)*

Entity	Analysed parameters		Site class						Σ
			A	B	A+B	C	D	E	
Potštát	Area	ares	382 190	41 674	423 864	7 837	45 887	20 649	498 237
		%	76.72	8.36	85.08	1.57	9.21	4.14	100.00
Libavá	Area	ares	244 721	86 634	331 355	24 836	104 169	32 745	493 105
		%	49.62	17.57	67.19	5.04	21.13	6.64	100.00
Hlubočky	Area	ares	141 640	51 371	193 011	28 486	163 156	13 617	398 270
		%	35.56	12.90	48.46	7.15	40.97	3.42	100.00
V. Újezd	Area	ares	186 849	51 542	238 391	8 605	226 702	28 424	502 122
		%	37.22	10.26	47.48	1.71	45.15	5.66	100.00
Bruntál	Area	ares	302 611	71 813	374 424	162	47 728	947	423 261
		%	71.49	16.97	88.46	0.04	11.28	0.22	100.00
Division Lipník total	Area	ares	1 258 011	303 034	1 561 045	69 926	587 642	96 382	2 314 995
		%	54.35	13.09	67.44	3.02	25.38	4.16	100.00
ŠP Valšovice	Area	ares	75 255	12 430	87 685	8 805	668	867	98 025
		%	76.77	12.68	89.45	8.99	0.68	0.88	100.00
MěLZ Val. Mez.	Area	ares	59 070	12 216	71 286	2 427	0	0	73 713
		%	80.14	16.57	96.71	3.29	0.00	0.00	100.00

Source: Authors

Felling volumes in the respective site classes

An important factor affecting the decision-making of the forest owner on using the harvester technology is the knowledge of actual timber volume that can be processed by the technology. Tables II., III. and IV. present actual timber volumes in m³ for the individual site classes.

These data make it possible to deduce actual potential for the application of harvesters and forwarders both for individual forest districts and for the division as a whole. The actually available timber in site classes A and B in the entire division of Military Forests and Farms, State enterprise (VLS, s.p.) amounts to 67.98 %, which represents 1,113,466 m³. At the Training Forest District of Valšovice (ŠP Valšovice), the amount of timber available in site classes A and B is 78,684 m³, which represents 91.94 % of the total timber volume. In the Municipal Forests and Greenery in Valašské Meziříčí (MěLZ Valašské Meziříčí), the amount of timber occurring in site classes A and B is 99,564 m³ or 96.09 %.

II: *Timber volumes in site classes of Division Lipník nad Bečvou (m³ and %)*

Site class		Forest districts					Σ per division	%
		Potštát	Libavá	Hlubočky	V.Újezd	Bruntál		
A	m³	311 469	173 820	114 967	134 637	192 849	927 742	56.64
	%	33.57	18.74	12.39	14.51	20.79	100.00	
B	m³	25 995	63 828	27 046	32 146	36 709	185 724	11.34
	%	14.00	34.37	14.56	17.31	19.76	100.00	
A+B	m³	337 464	237 648	142 013	166 783	229 558	1 113 466	67.98
	%	30.31	21.34	12.75	14.98	20.62	100.00	
C	m³	9 402	18 715	23 473	4 717	27	56 334	3.44
	%	16.69	33.22	41.67	8.37	0.05	100.00	
D	m³	33 234	105 815	85 458	130 721	33 928	389 156	23.76
	%	8.54	27.19	21.96	33.59	8.72	100.00	
E	m³	18 248	26 385	14 056	19 756	487	78 932	4.82
	%	23.12	33.43	17.81	25.03	0.61	100.00	
Σ	m³	398 348	388 563	265 000	321 977	264 000	1 637 888	100.00

Source: Authors

III: *Timber volumes in site classes of the Training Forest District (ŠP) (m³ and %)*

	Site class						Σ
	A	B	A+B	C	D	E	
m³	69 556	9 128	78 684	6 338	197	359	85 578
%	81.28	10.67	91.94	7.41	0.23	0.42	100.00

Source: Authors

IV: *Timber volumes in site classes of MěLZ Valašské Meziříčí (in m³ and %)*

	Site class						Σ
	A	B	A+B	C	D	E	
m³	83 037	16 527	99 564	4 041	0	0	103 605
%	80.14	16.57	96.09	3.91	0.00	0.00	100.00

Source: Authors

The current situation in the application of felling methods by the analysed entities is shown in Tab. V. The table covers the recent five years (2003 to 2007) and presents the volumes of processed timber in m³ and in percentages.

V: *Felling methods used by the selected entities under study*

Felling method	Year									
	2007		2006		2005		2004		2003	
	m³	%	m³	%	m³	%	m³	%	m³	%
Vojenské lesy a statky [Military Forests and Farms], Division Lipník nad Bečvou										
Short-length	180 245	69.72	157 360	72.26	133 310	67.12	80 455	36.80	135 275	42.72
Tree-length	78 270	30.28	60 400	27.74	65 290	32.88	138 155	63.20	181 350	57.28
Full-tree	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Σ	258 515	100.00	217 760	100.00	198 600	100.00	218 610	100.00	316 625	100.00
Školní polesí [Training Forest District] Valšovice										
Short-length	9 600	92.92	8 000	93.67	6 900	92.88	7 100	93.00	7 000	93.36
Tree-length	732	7.08	541	6.33	529	7.12	534	7.00	498	6.64
Full-tree	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Σ	10 332	100.00	8 541	100.00	7 429	100.00	7 634	100.00	7 498	100.00
Městské lesy a zeleň [Municipal Forests and Greenery] Valašské Meziříčí										
Short-length	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Tree-length	4 975	100.00	3 511	100.00	3 712	100.00	3 910	100.00	4 133	100.00
Full-tree	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Σ	4 975	100.00	3 511	100.00	3 712	100.00	3 910	100.00	4 133	100.00

Source: Authors

Felling volumes of methods suitable for the harvester technology were determined based on data from the former analyses of selected key factors essentially affecting possibilities of employing modern timber harvesting machinery. These factors include:

- Total felling volumes at the concerned entity in m³
- Representation of site classes (A + B) in %;
- Representation of coniferous tree species in %;
- Coefficient for adjustment of results (0.7 to 1.0).

The felling volume of methods suitable for the harvester technology was calculated with using the below formula (L. Bartoš, 2009):

$$Thar_{m^3} = \Sigma\, Tcel_{m^3} * Tts\mathbf{(A+B)}_{\%} * Zdřj_{\%z} * K$$

$Thar_{m^3}$ - Felling volume in m³ suitable for using the harvester technology by the concerned entity in the relevant period,

$\Sigma\, Tcel_{m^3}$ - Total felling volume determined in m³ for the concerned entity in the relevant period,

$Tts(A+B)_{\%}$ - Percentages of felling volumes in site classes A + B for the concerned entity,

$Zdřj_{\%z}$ - Representation of coniferous tree species (%) in total timber reserve,

K - Coefficient for adjustment of results (0.7 to 1.0)

- 0.1 adjustment related to tree species composition
- 0.1 adjustment related to the representation of site classes
- 0.1 adjustment related to labour organisation

6: *Determination of felling volumes for harvester technology*

Assessed entity	$Tcel_{m^3}$	$Tts_{(A+B)\%}$	$Zdřj_{\%z}$	Σ m³*1,0	%	Σ m³*0,7	%
Potštát	398 348	84.82	93.58	316 187	79.37	221 331	55.56
Libavá	388 563	61.16	93.09	221 224	56.93	154 857	39.85
Hlubočky	265 000	53.59	65.45	92 948	35.07	65 063	24.55
V. Újezd	322 000	51.80	61.08	101 879	31.64	71 315	22.15
Bruntál	264 000	86.95	84.29	193 486	73.29	135 440	51.30
Σ for the division	1 637 911	67.97	81.45	906 773	55.36	634 741	38.75
ŠP	85 578	91.94	53.02	41 716	48.75	29 201	34.12
MěLZ	103 605	96.09	85.26	84 880	81.93	59 416	57.35

Source: Authors

DISCUSSION

In order to achieve the defined objective, the authors of this contribution selected three entities with different ownership relations to, area size and management method of the owned forest. The entities in question were Military Forests and Farms, state enterprise (VLS s.p.), Division Lipník nad Bečvou, with about 23,000 ha of wooded land and the special-purpose use as military training area, Training Forest District (ŠP) Valšovice operated by the Secondary Forest School in Hranice with about 975 ha of wooded land and the special-purpose use as training forest district for teaching and vocational training of students, and the Municipal Forests and Greenery (MěLZ) Valašské Meziříčí s.r.o., limited liability company, with about 712 ha of wooded land.

A formula was determined to calculate felling volumes for harvester technologies at the concerned entities. By incorporating concrete values established through the analysis of preceding steps into the formula, we could calculate volumes of possible felling for the harvester technologies. The result may be specified in m^3 or in percent. The coefficient for adjustment of results (coefficient value range 0.7 to 1.0) allows for the determination of minimum and the maximum volumes of the cuts.

Based on findings gained from the analysis, the below recommendations could be formulated for the employment of harvester technologies in timber logging and forwarding at the selected entities and hence for any other subject interested in the application of this technology:

1. In the context of tender proceedings for the contracting of logging operations, an emphasis has to be laid on including in the contract requirements related to the quality of performed works, the check and takeover of works and site and to the environmental approach to the nature as a whole.
2. The tender documentation should also include a list of machines with parameters selected in harmony with the natural conditions of concerned forest stands.
3. An increased emphasis should be laid on high-standard professional technological preparation of the site.
4. To find out possibilities for the application of harvester technologies with the concerned entity, it is necessary to analyse natural conditions of the site, to classify the site, to define the proportion of coniferous and deciduous tree species within the area in question, to analyse the felling volumes and to allocate them to the respective site classes.
5. A possible use of harvester technologies cannot be determined on the basis of a mere (be it even professional) estimate.

The results of the performed analysis show that all entities in view undervalued the possibilities of timber processing by harvester technologies. To a certain degree this conclusion may be applied to all forest owners. It can be assumed that with a responsible and expert analysis of necessary data about the concerned workplace and with a subsequent choice of an optimum technological procedure it is possible to achieve **a significant increase in the percentage** of using modern harvester technologies in timber logging and skidding.

SUMMARY

This paper is to contribute in the clarification of possibilities for the use of multi-operational machines in the process-oriented environment on the basis of analysing natural, technical and economic conditions, and to suggest the application of these technologies at a simultaneous consideration for their users of the necessary maintenance of competitiveness on the market.

The results of the presented analysis clearly show that all studied entities underestimate the possibilities of logging by harvester technologies. This conclusion may be more or less applied nearly to all forest owners. It can be assumed that with the help of responsible and professionally sound analyses of the required data at a concrete site and with the subsequent selection of the optimum technological procedure a significantly increased percentage in the application of modern harvester technologies can be attained in timber felling and skidding.

SOUHRN

Využití harvestorových technologií těžby dříví v procesně orientovaném prostředí

Harvestorové technologie těžby dříví jsou v současné době neoddělitelnou součásti trvale udržitelného hospodaření v lesích. Harvestor v kombinaci s vyvážecí soupravou vykazuje mnohonásobně vyšší výkonnost nad běžně používanou technologií „motorová pila a traktor“. Dalšími významnými prvky, které u harvestorových technologií převládají, je nezanedbatelný a vysoký stupeň hygieny práce a také významné snížení environmentální zátěže mající vliv na životní prostředí.

Používání harvestorové techniky při plnění hospodářských úkolů v lesích České republiky, a platí to pro všechny typy vlastnictví lesů, je v současné době nezbytnou nutností. Hlavním požadavkem vlastníka lesa při použití techniky k těžbě a soustřeďování dříví je zajištění jejího souladu s ekologickými podmínkami, při současném respektování produkčních a společenských funkcí lesa a pří-

slušných ekonomických aspektů. S jistotou lze předpokládat, že zůstanou zachovány technologie s využitím ručních motorových řetězových pil a úvazkového soustřeďování. Na druhé straně je ale třeba si uvědomit, jak velké možnosti nabízí technologie víceoperačních strojů, a to nejen jako samostatné harvestorové technologie, ale např. i v kombinaci s lesními lanovkami (tzv. horské procesory) nebo i ručními motorovými řetězovými pilami, kdy je možné nahradit úvazkové soustřeďování dřevní hmoty jejím vyvážením s využitím forwarderů.
Řízení podnikových procesů, k nimž patří i proces řízení technologie víceoperačních strojů, slouží z velké části jako podpora přemostění různorodých systémů, lidí a procesů. Modely podnikových procesů pak pomáhají koordinovat práce a synchronizovat data napříč existujícími systémy a pomáhají tak organizaci dosáhnout lepších výsledků využitím toho, co v nich již existuje a co vlastní.
Ke zpracování stanoveného cíle práce byly vybrány do tohoto příspěvku tři subjekty s různým vlastnickým vztahem, rozlohou i způsobem využívání. Jedná se o VLS, s.p., divize Lipník nad Bečvou, s rozlohou cca 23 000 ha porostní půdy a účelovým využitím jako vojenský výcvikový prostor, ŠP Valšovice při Střední lesnické škole v Hranicích, s rozlohou cca 975 ha porostní půdy a účelovým využitím jako školní polesí pro výuku a výcvik studentů a třetím objektem jsou MěLZ Valašské Meziříčí s.r.o., s rozlohou cca 712 ha porostní půdy.
Z výsledků této práce vyplývá, že u všech sledovaných subjektů dochází k podhodnocení možností zpracování těžeb harvestorovými technologiemi. Tento závěr se dá v určité míře aplikovat téměř na všechny vlastníky lesa. Lze předpokládat, že při zodpovědné a odborné analýze potřebných údajů na daném pracovišti a následné volbě optimálního technologického postupu je možné dosáhnout výrazného procentického navýšení využívání moderních harvestorových technologií při těžbě a soustřeďování dříví.

harvestorové technologie, harvestor, forwarder, procesní model, proces

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