New technique and technology of industrial splitting of stacked wood – log-splitter WS 800

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ABSTRACT: Wood splitting, manual as well as mechanized one is a heavy work. It follows from the fact that usually the wood of the least quality, knot wood with scroll fibres, directed for less valuable assortments from the point of view of the price. Present technique on the contrary is relatively price demanding, requesting besides 2–4 members of operating personnel also adequate concentration of wood mass for the reason of the complete process economic efficiency. We submit in this paper technology analysis of the splitter WS 800 performance with the original concept for the wood manipulation and splitting process as well. Essential advantages of the mentioned splitter comparing with the stationary equipments are operational and interoperational wood manipulation, physical effort and operating personnel elimination, while the efficiency and work safety is increasing.

Keywords: wood splitter; wedge; splitting knife; technology; efficiency

Wood splitting, i.e. longitudinal wood dividing by the wedge tools fibres decoupling belong to the oldest technologies of the specific technical processing however also simple wood disintegration of larger dimensions wood (Koreň 1983). Typical assortments of raw wood, which is treated according to the need by the splitting are assortments of the IV., V., VI. quality class according to the STN 48 0055 and STN 48 0056. Due to the utilization purpose it is the wood indicated for cellulose paper industry, chemical processing, charcoal production, selected kinds of large area agglomerating materials, wood for small utilities, etc. A very dynamically developing separate group, represents wood indicated for the heat production, as the energy medium – fuel. Nowadays wood included in the STN as fuel wood does not correspond to the European Union standard. Cardinal difference is especially in the product quality, connected with the expression "fuel wood" (Lukáč, Lieskovský 2003).

Manual wood splitting is an extremely laborious work. It results as a matter of fact that quality wood (smooth, faultless) is assigned for another utilization. Generally the knot wood is split, having spiral fibres, i.e. wood of less quality, causing major energy release app. 17–19 kJ/min, and this ranges the manual splitting among the most heavy operations within the forestry logging activity. Time consumption for the split wood production is at the same time too large comparing with another operations. In the system of forest economy generally the stacked wood is split of 1 m length, less it is stacked wood of 2 m. For manual splitting the simple tools are used, as splitting axes, splitting machines and the wedges.

Low efficiency of the manual splitting gradually changed the solution of lumbed wood disintegration from the forest to the main stocks or directly to the manufacturers. Splitting is gradually replaced by the wood cutting (chipping). It is not a universal solution, because energy balance (input, output) is incomparable during cutting and chipping. During the chipping the energy consumption for wood disintegration is considerably higher than in the case of the splitting (Stanovský 2003).

During the chips production the energy consumption is significantly increasing with the wood thickness. During the splitting the input of necessary energy is less dependent on the wood thickness. The essential reason of such difference is a fact that wood is chipped across the fibres and wood is split along the fibres with well known strain effect of the wedge tools (Lukáč 2003).

One of the reasons of the wood splitting regression is the fact that for wood splitting of low sale price level wood (fibrous material, fuel) there is not available an efficient technique. Splitting machines,

developed in Europe during last 40 years (here e.g. PHS 1200, HPŠ 1000, HPŠ 600) are comparatively cumbrous. They request high input costs for the machine purchase, large work concentration at one place, wood feeding, lifting, removing, request from 2 to 4 members of operating personnel. It is clear that such technological principle request great share of physical heavy work and only few of productive manual work.

Several important companies as e.g. German company POSCH developed system of quality machines for the splitting, chipping, cutting and further commercial and customer treatment of the fuel wood. Although they are quality and very often top machines at the world market, they did not change the splitting philosophy. Wood (logs) have to be moved to the splitter, which is fixed at one place and after the classical way of the split in the horizontal or vertical position, the splitwood must be put away and laid manually.

New splitting equipment WS 800, developed and prepared for the production by the company KOVACO, s. r. o., established in Veľká Lehota, radically changes the technical principles as well as splitting technology. Splitter construction and technological splitting procedure enable the operational and at the same time the interoperational wood manipulation. This feature is different from the point of view of the category and is unique comparing with the stationary splitting machines used in Europe and in the world as well. Operating personnel practically is not in the contact with split wood and the consequence is the work safety increasing and the physical effort elimination.

METHODS AND BASIC RESEARCH

Analysis dealing with the entire performance efficiency of the splitter WS 800 has been included into the research programme at the Department of Forest Exploitation and Mechanization within the projects VEGA 1/0633/03 and KEGA 3/118203. Tests of the performance parameters have been carried out for the splitting of different wood species, of different wood thicknesses and in different working surroundings (main store, forest store), different basis machines with drive aggregates were used. The evaluation was focused on the performance, performance efficiency, reliability as well as on the economic efficiency of the splitter.

Fig. 1. WS 800 splitter adapted to the UNC 060

Fig. 2. Splitter fixed to the three-point suspension of the universal tractor (cross knife is clearly visible, as well as the protective covers and operating stings)

Three technological variants of the possible splitter utilization have been verified – assembly at the skid-steered loader UNC-060 (Fig. 1), assembly at the universal wheeled tractor Zetor 7245 HORAL (Fig. 2) and assembly at the hydromanipulator HARA 60 at the vehicle.

Performance analysis results of the WS 800 adapted to the UNC-060 are given in the paper being submitted. The data have been processed by the standard methods of mathematical statistics (regression analyses, variance analyses, etc.).

Within the time consumption analysis related to the technological line UNC 061 performance and the splitter WS 800 the following time data were observed:

A1 – machine passage to the wood pile assigned for the splitting. At the same time the cylinders disengaging appeared.

A2 – finish of the cylinders disengaging – the splitter throw open.

A3 – log throwing to the ground by the machine stroked with the help of the manipulation stings and its catching between the pressure plate and the knife.

A4 – logs passing to the split log stacking and contemporary wood splitting beginning.

A5 – splitting and wood stacking (till 2 m height).

A6 – casual stacking arrangement by the machine movement (logs even ends).

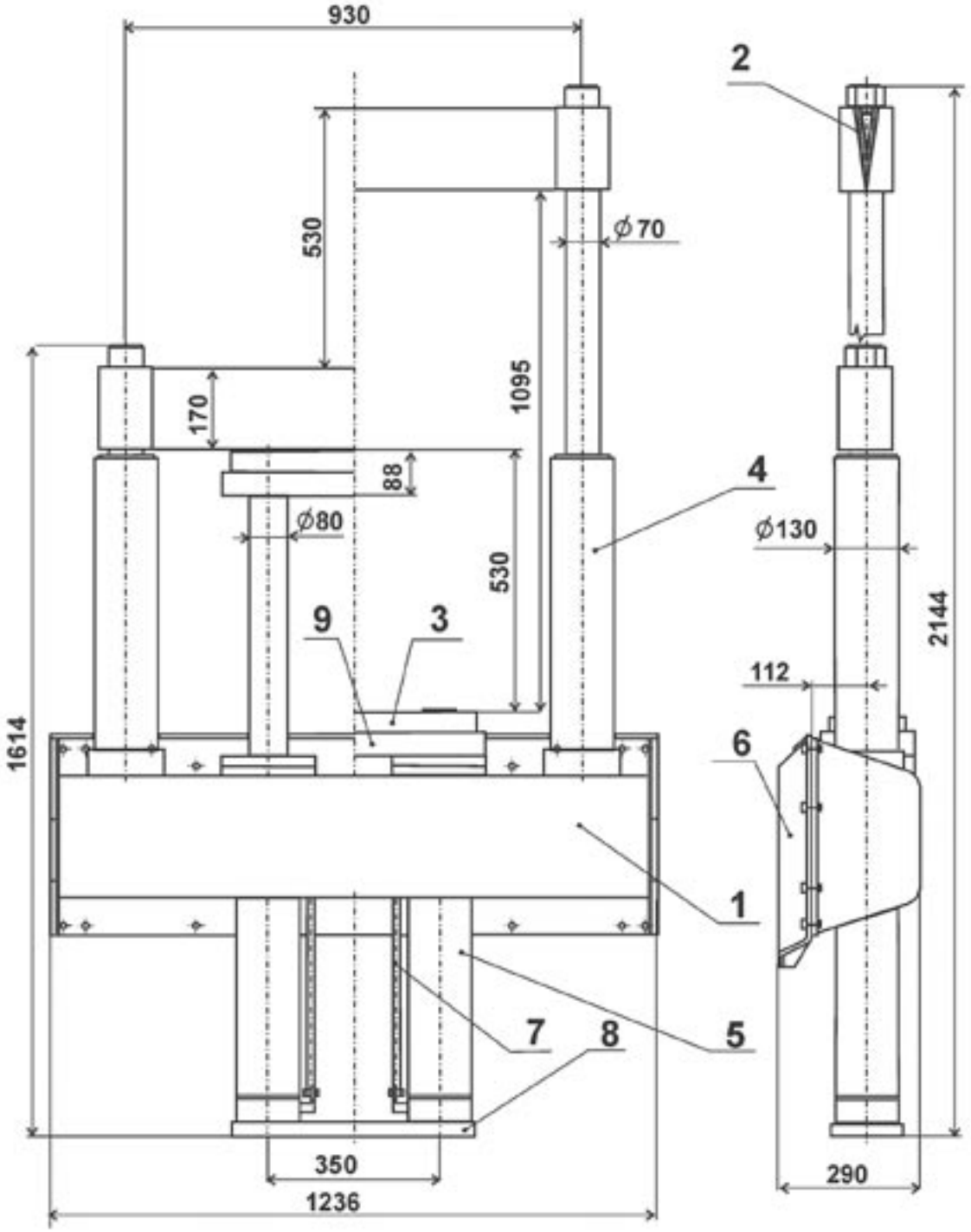

Fig. 3. Splitter WS 800 scheme
1 – bridge, 2 – wedge (cutter), 3 – table (mat), 4 – outside hydraulic cylinders, 5 – inside hydraulic cylinders, 6 – holder, 7 – hydraulics distribution, 8 – hydraulics cover

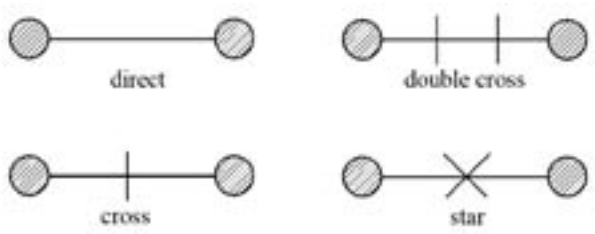

Fig. 4. Examples of the splitting wedges construction – direct, double cross, cross, star

B1 – mounting.
B2 – dismounting.

Performance efficiency of the technological line UNC-WS 800 was observed in three basic variants of the different efficiency:
– wood species: spruce, fir, beech, oak,
– distance of passing: to 10, to 15, to 20 m,
– wood thickness: up to 40 cm, up to 60 cm, up to 80 cm.

Technical parameters and the WS 800 splitter characteristics

Splitter WS 800 is the attachement for mobile machines, equipped by any type of the boom, three point suspension or the arm, on which the splitter is assembled. Basic description and dimension scheme of the splitter WS 800 is included in Fig. 3.

Dimensions:
– maximum distance between the cutting wedge edge and support at full open – 1,090 mm,
– distance between the outside hydraulic cylinders (maximum diameter of the wood, which can be split through the centre): construction without protection cover – 800 mm, construction with protection cover – 770 mm.

Splitting performance speed (support and wedge are moving towards one another):
– support – 28.5 mm/s,
– wedge – 38.5 mm/s,
– diameter – 32.7 mm/s,
– feedback speed is the same as the splitting speed.

Typical suitable basis machines with which the splitter can be assembled are represented by: skid steered loader (e.g. UNC 060), front or front wheel loader (e.g. UN 053), tractor with three point suspension, any hydraulic arm, arms of hydraulically-operated ploughshare, etc. (Lukáč 2003). As the condition is relatively powerful hydraulic system with the pressure of ca. 150–160 bar and with the fluid overflow ca. 30–40 l/min. Reached splitting force and speed is higher in the case that the hydraulic parameters are higher, too. Taking into consideration e.g. the pressure 170 bar and fluid speed 60 l/min the wedge splitting force is 194 kN

Table 1. Variation analysis results

Working operation time	Factor	f	α	$P\,\%_{(1-\alpha)}$	Significance
Total working cycle	wood species	12.50	0.0000	100.00	+
Splitting		2.98	0.0552	94.48	
Logs even ends		6.33	0.0025	99.75	+
Splitting + logs even ends		6.94	0.0015	99.85	+
Shoot of wood		1.74	0.1812	81.88	
Operations without drive (A2–6)		7.26	0.0011	99.89	+
No load drive	distance	21.52	0.0000	100.00	+
Drive with the wood to wood pile		21.63	0.0000	100.00	+
Total drive		32.09	0.0000	100.00	+

f – statistical characteristics of Fischer-Snedecor distribution, α – level of statistical significance, $P\,\%_{(1-\alpha)}$ – probability of the factor influence

Table 2. Average values of the time consumption of particular wood species performance operations

	Spruce, fir	Beech	Oak	Diameter
Total working cycle	3.10	1.99	2.17	2.35
Splitting	0.59	0.43	0.48	0.50
Logs even ends	1.03	0.58	0.57	0.72
Splitting + logs even ends	1.61	1.01	1.05	1.22
Shoot of wood	0.69	0.56	0.64	0.63
Operations without drive (A2–6)	2.45	1.70	1.83	2.00

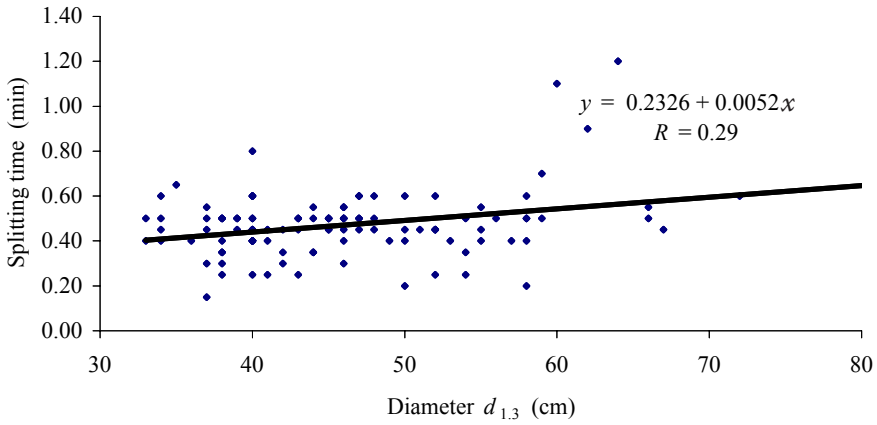

Fig. 5. Dependence of the time splitting on the stacked wood diameter

and the force reached by the table (pinch board) is approximately 323 kN.

The splitter enables utilization of different types of the splitting wedges tools (Fig. 4), construction of which is solved according to the dependence of split pieces width. Thick and excessive wood (> 80 cm) is split by direct or cross wedge, smaller pieces are split by star or double wedge tools.

Information processing and obtained results

Equipment has been tested in the expedition stock Lieskovec. In the working performance hours record there was a review of duration period of particular operations as well as particular performance, resp. technological parameters according to the given methodology.

Characteristics of the working surroundings:
wood species – spruce, fir, oak, beech,
average diameter – 33–84 cm,
length stacked wood ca. 1 m,
average volume – 0.16 m^3,
manipulation space – working distance – 8–25 m,
stock width – 8 m.

Data analysis confirmed important influence of observed factors. In Tables 1 and 2 there are given results of variation analysis.

A typical phenomenon is the higher importance of wood species during the evaluation of the splitting time and even ends altogether comparing with the individual analysis as a consequence of operations conjuction. It is similar in the case of the drive – its complex evaluation depending on the distance is of higher validity than the drive without any load and with the load (Table 1, Fig. 6). These connectivities display also in the variability of total working cycle time. During particular splitting the importance of wood species was not confirmed (Table 1) as well as this of the diameter (Fig. 5) due also to the high splitting pressure on the wedge, and the consenquential splitter performance. Splitter efficiency is increased with the growing diameter and volume of stacked wood (Fig. 7).

Frame results of the time consumption analysis and of the technological line UNC-WS 800 efficiency are given in Tables 3–5.

Splitter WS 800 efficiency is influenced also by the structure of working operations creating the splitting

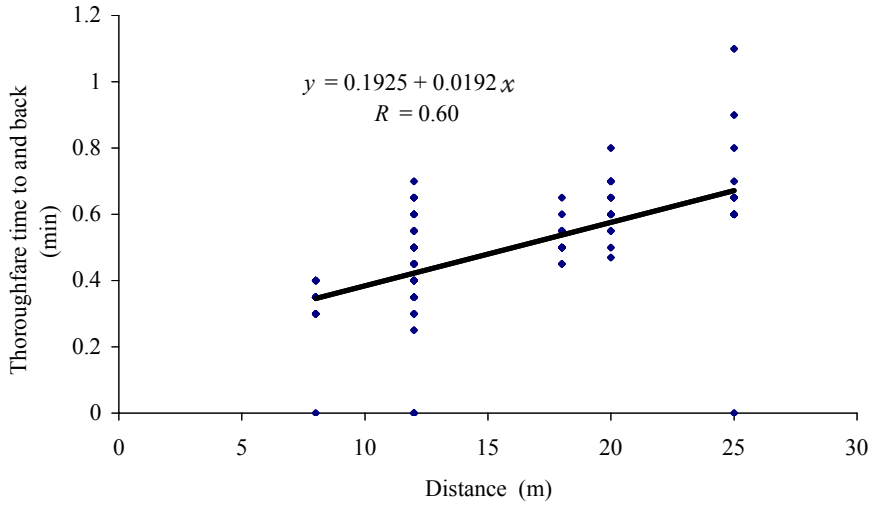

Fig. 6. Thoroughfare total time dependence, without load and with load on the distance

Table 3. Time consumption for 1 working performance cycle in min according to the wood species and the distance of the thoroughfare

Parameter	Thoroughfare distance (m)		
	< 10	< 15	< 20
Spruce/fir	2.79	1.88	2.98
Beech	2.19	2.28	2.37
Oak	2.23	2.32	2.41
ø	2.40	2.50	2.60

Table 4. Splitting time consumption according to the wood species, volume and width at the average thoroughfare distance from 15 m

Parameter	Wood species			
	spruce/fir	beech	oak	ø
ø width (cm)	52.00	46.40	43.10	47.20
ø volume (m^3)	0.20	0.17	0.15	0.18
Time consumption (min/m^3)	13.60	13.50	15.90	14.30

cycle. In Fig. 8 it is visible that more than 50% of the time consumption for the 1 m^3 wood production is the time related to the log removal from the bulk prepared for the splitting (A3), resp. the time for the split wood store (A6). At the mature work and workplace preparation it is possible to correct considerably these times. However during the large average splitter performance (Fig. 8) it is not necessary.

Distinguished advantage of the splitter WS 800 is a short time of adapter assembly and disassembly to the basis machine. Assembly, i.e. adjustment of UNC position in the relation to the position of the splitter on the ground, fastening of the fast tension elements and engagement of the pressure tubes take approximately 1.5 min in average. Disassembly (opposite procedure) takes approximately only 1 minute in

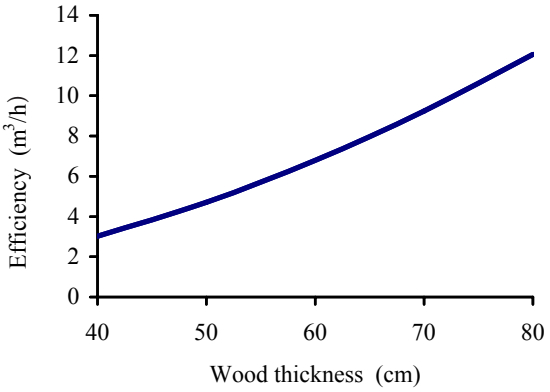

Fig. 7. Average hour efficiency of the WS 800 splitter

Table 5. Efficiency of the technological line UNC 060-WS 800 during beech wood splitting. Wood removal to the distance 15 m

Parameter	Average wood thickness (cm)		
	40	50	60
ø volume (m^3)	0.13	0.20	0.28
Efficiency (m^3/hour)	3.30	5.40	7.50
Day efficiency (m^3/day)	18.50	30.20	42.0

Remark: performance parameters are related to 8 working hours, with change utilization coefficient 0.7 and for the wood dried free on the air

average. Total time necessary for the preparation of the technological line UNC-WS 800 into the working standby position is negligible from the point of view of the performance.

DISCUSSION AND CONCLUSION

Described configuration of the splitting line (UNC 060 + WS 800) ensures fully mechanized performance of the working operations from the log grip, through its removal to the wood pile, wood splitting closely over the wood pile and the wood store in that way to answer the stability needs, safety, resp. wood evidence. Taking into the consideration the maintenance incorporation it was necessary sometimes to adjust the wood pieces manually. Due to the routine of particular operator this operation occurs only sporadically.

The dominant element of the performance efficiency of the WS 800 splitter is the possibility to assembly the splitter to each mobile machine, equipped with

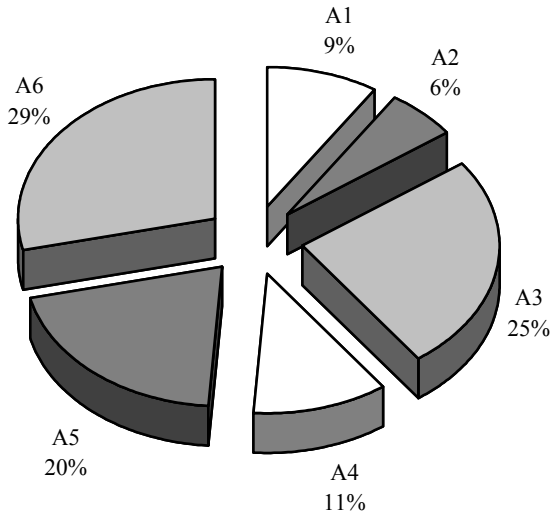

Fig. 8. Structure of the splitter WS 800 performance (see part Methods and basic research)

the hydraulics of the pressure of min. 160 bar and the overflow ca. 30–40 l/min. Higher parameters considerably increase speed and efficiency of the splitting.

The next important factor is rational utilization of human work, the price of which will be certainly increased within the short time. All splitters requested three and more members of the operating personnel up to now. Splitter WS 800 performs in several technological adaptations practically with one worker.

Extraordinary performance advantage is the already mentioned fast assembly and disassembly of WS 800 to the basis machines, more over there are possibilities of operative splitter move from one machine to another machine, resp. to another workplace.

Economic parameters are equally favourable taking into the consideration the splitter performance. Massive, high sofisticated, however marvellous simple construction of the WS 800 splitter does not require maintenance when correctly handled. Performance costs of the splitter alone are negligible and are closely related to the performance costs of the basis machine.

Decisive parameter of every investment efficiency is the economic return of means invested into the production. It depends not only on the assigned price of the mean, however also and especially from the quantity, quality, eventually from the added value of the performed work, closely connected with the production possibilities (Messingerová 1998). At the price of the basic WS 800 configuration (137,500 SK), declared by the producer KOVACO, s. r. o., in January 2004 and at the qualified frequency estimate and the splitting possibility in the standard main wood store, the period of as for economic investment return is approximately 1 year.

The performance efficiency of WS 800 splitter increases also the large variability of the working tools (wedges), which after certain experience related to the splitter performance are able to split any structured (knot) 1 m thick wood slice without any problem, not depending on the wood species.

WS 800 existence and efficiency will be of great importance, realizing the fact that the tendency in the energy consumption in Slovakia is gradually moved to the renewable energy sources, where the wood represents dominant position (Lieskovský 2003).

What can be said as a conclusion? Efficiency analysis as well as performance efficiency of WS 800 splitter efficiency proved in the convincing way that in Slovakia a machine came into being, which can offer an efficient production means for the foresters and wood consumers as well.

Interest for the splitter WS 800 is abroad, too. From the manufacturing and legislative point of view this Slovakian product is prepared for the export – the documentation contains all appropriate certificates.

Considerable importance of the splitter WS 800 is in the rural development in Slovakia, having rich tradition with wood utilization for the energy, ahead with very dynamic perspective.

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Nová technika a technológia priemyselného štiepania rovnaného dreva – štiepačka WS 800

ABSTRAKT: Štiepanie dreva nielen ručné, ale aj mechanizované je namáhavá práca. Vyplýva to zo skutočnosti, že sa štiepa spravidla najmenej kvalitné hrčaté drevo s točitými vláknami, určené na cenove menej hodnotné sortimenty. Naproti tomu

je súčasná technika relatívne cenove náročná a vyžaduje si okrem 2–4-člennej obsluhy aj primeranú koncentráciu drevnej hmoty na to, aby celý proces nebol pre daný subjekt ekonomicky nevýhodný. V práci uvádzame analýzu technológie práce štiepačky WS 800 s originálnou koncepciou manipulácie s drevom a samotným procesom štiepania. Podstatnými výhodami uvedenej štiepačky oproti stacionárnym zariadeniam je operačná a medzioperačná manipulácia s drevom, eliminovanie fyzickej námahy a obsluhy, čím sa zvyšuje efektivita a bezpečnosť práce.

Kľúčové slová: štiepačka dreva; klin; štiepací nôž; technológia; výkonnosť

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