na obratovalnost papirnega stroja. Prisotnost kosmičev sicer ni zaželena, vendar je slednje možno s pomočjo dodatne mehanske obdelave razpustiti v papirniška vlakna ali pa jih z dodatnim prebiranjem odstraniti iz procesa.

V nadaljnjih raziskavah bo nujno treba vzpostaviti ocenjevalno lestvico reciklabilnosti, ki bo natančno predpisala kriterije, kdaj je neki izdelek popolnoma ali vsaj delno reciklabilen in kdaj njegova predelava tehnološko ni izvedljiva. Sprejetje enotne metodologije vrednotenja in enotnih kriterijev ocenjevanja je ključnega pomena za dvig kakovosti in nadaljnji razvoj papirne in papirno-predelovalne industrije.

Zavedati se moramo, da le reciklabilni papirni, kartonski ali lepenčni izdelek po poteku uporabnosti lahko postane sekundarna surovina, zato je treba pri njegovem načrtovanju upoštevati ekodizajn, kar pomeni, naj bo produkt izdelan iz ekološko prijaznih materialov (lepila, tiskarske barve, dodatki ...), da bo njegov vpliv na okolje čim manjši. Porabljene izdelke je treba tudi zbrati in sortirati v skladu s standardi in predpisi (SIST EN 643). O pomenu recikliranja je treba ozaveščati strokovno in širšo javnost, hkrati pa moramo vzpostaviti boljšo povezanost med vsemi, ki kakor koli sodelujejo v papirnem krogotoku.

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ENHANCING THE STRENGTH POTENTIAL OF PULP BY ULTRASOUND

IZBOLJŠANJE MEHANSKE ODPORNOSTI PAPIRNIŠKIH VLAKEN Z ULTRAZVOKOM

Tobias BRENNER[1], Harald GROSSMANN[2], Sudipta Kumar MITRA[3]

IZVLEČEK

V proizvodnem procesu izdelave papirja je mletje zelo pomemben del tehnološkega postopka obdelave papirniških celuloznih vlaken: zagotavlja ustrezne tehnološke lastnosti vlaken in pomaga pri doseganju želenih mehanskih jakosti, lastnosti površine in optičnih lastnosti končnega izdelka papirja. Istočasno je mletje tehnološki del postopka, pri katerem je poraba energije zelo velika. V tehnološkem postopku izdelave embalažnih papirjev iz recikliranih vlaken je v današnjem času uporaba mlevnih postopkov omejena predvsem zaradi zmanjšanja sposobnosti na odvodnjavanje, ki je z njim povezana. V okviru raziskav, ki smo jih izvedli na TU Dresden in Papiertechnische Stiftung, smo želeli ugotoviti vpliv obdelave vlakninske suspenzije z ultrazvokom. Rezultati raziskave pri uporabi visokoenergetskega ultrazvoka pri pripravi vlakninske suspenzije so pokazali, da se izboljšajo statične mehanske lastnosti papirja. Zmanjša se sposobnost odvodnjavanja, pa ne v tolikšni meri, kot v primeru uporabe konvencionalnih tehnik rafiniranja oziroma mletja. Rezultati ne kažejo večjega zmanjšanja dolžine vlaken – ne glede na čas trajanja, niti na intenziteto obdelave z visokoenergetskim ultrazvokom.

Ključne besede: ultrazvok, ultrazvočen, mletje, kavitacija, papirniška celulozna vlakna, odpadni papir za ponovno uporabo, reciklirana vlakna.

ABSTRACT

Refining plays an important role in the treatment of pulps for paper production: it ensures the processability of fibres and helps to develop the desired strength, surface and optical properties in the final paper product. At the same time, refining is a process step that requires very high amounts of energy. In recycled fibre pulps for packaging paper production, refining is applicable only to a limited extent today mainly because of the increase in drainage resistance associated with it. Studies carried out at TU Dresden and Papiertechnische Stiftung to investigate the ultrasound treatment of pulp suspensions has shown that the application of high-power ultrasound to pulp suspensions can improve the static strength properties of paper. The resulting increase in drainage resistance was smaller than in the case of conventional refining methods. There was no significant reduction in fibre lengths – neither by the duration nor by the intensity of high-power ultrasound treatment.

Keywords: Ultrasound, Ultrasonic, Refining, Cavitation, Pulp, Recovered paper, Recycled fibres.

1 INTRODUCTION

The properties of pulps intended for papermaking must be specifically adjusted to the envisaged product. The strength requirements of the finished paper are certainly the key criteria here, which is why the strength potential and especially the bonding power of single fibres are of major importance. This applies to both graphic and – especially – packaging papers. The ongoing trend toward higher machine speeds and lower grammages results in higher strength requirements to ensure the runnability and adequate converting behaviour of paper.

Depending on the type of pulp, fresh or native fibres have a relatively high initial strength potential which may be realized by targeted treatment. Fibres obtained from recovered paper, by contrast – especially those from ordinary grades – have already been recycled several times, which leave them with only limited bonding power and strength potential. Increasing the number of process cycles in paper production and recovered paper treatment lead to the following problems and effects:

- Hornification of fibres through cyclic compaction and drying processes. This manifests itself in reduced swelling capacity, flexibility and, thus, bonding area of the fibres (interfibre bonds) (1), (2),
- Mechanical damage to fibres, for example through refining, which may include fibre shortening and fines formation resulting in drainability losses (3),
- Increasing shares of inorganic material (ash) in recovered paper and RCF pulps obtained from them, as well as increasing contaminant loads (4).

Conventional refining

Refining is the key process step in the preparation of pulp for paper making. Like pulp selection, it has decisive effects on the resulting paper quality. Refining is usually employed to increase the strength and bulk of paper. This is achieved by increasing the swelling capacity of fibres and bonding-active contact areas between them. (5)

The increase in strength potential by refining strongly depends on the parameters of refining as specific edge load or the design of the fillings as well as the refined pulp. The following information is only indications. The strength potential (tensile strength) of virgin pulp can be doubled by refining with a specific energy consumption of 200 kWh/t (6). Refining of recycled fibre pulp with a specific energy consumption of 150 kWh/t increases the strength potential (tensile strength) by 10 % to 40 %. (7)

To this day, a considerable share of the energy input cannot be used for fibre treatment in refining because it is converted into heat (nearly 90 % of the dedicated energy is transformed into heat). In terms of energy efficiency, the refining process is very uneconomical. (8), (9)

Refining aims at improving the bonds between fibres by modifying their structure so as to cause fibrillation. This improves the strength properties of the paper produced. Recovered paper treatment aims at reactivating the potential of RCF pulps by increasing the surface area of fibres to mitigate hornification and the resulting bonding power losses caused by drying (10). Refining today is carried out in disc, conical or cylindrical refiners designed for mechanical fibre treatment. However, this process causes not only fibrillation but also an – undesirable – shortening of fibres resulting in fibre debris and fines (11). In addition, refining increases the drainage resistance of the pulp. For the production of virgin pulp based papers this is – in a specific range – desired. Recovered paper from ordinary grades (in particular OCC) has already a high drainage resistance. A further increase of the drainage resistance is slowing the speed of the paper machine considerably. (12)

Because of the importance of refining for the overall papermaking process, papermakers had been looking for ways to significantly reduce the specific energy requirements for refining by means of new technologies even before the sharp rise in energy costs. The use of high-power ultrasound is considered an alternative to traditional refining.

Ultrasound refining

Starting as early as the 1950's, scientists and papermakers have repeatedly attempted to use ultrasound as an aid for pulp refining. Previous studies have shown that the use of ultrasound can have positive effects on fibre properties and resulting paper quality (13), (14), (15), (16), in particular:

- increased fibrillation of fibres,
- formation of fines and fibrils with particularly high bonding activity,
- increased retention of fines and filler particles,
- increased swelling capacity or water absorbency,
- increased paper strength (tensile strength),
- reduced or no shortening of fibres.

Laboratory studies performed so far have shown that the best results are achieved with pulps subjected to gentle pre-treatment, i.e. preliminary refining at low specific energy inputs and subsequent ultrasound treatment of the suspension. Most of these publications and test reports admit that their test designs or the application point of ultrasound has yet to be improved, resulting in relatively high or even increased specific energy requirements of these systems as compared with conventional refining.

A typical and very important phenomenon accompanying the generation of strong ultrasound fields in liquids is acoustic cavitation. Most of the effects utilised for pulp treatment can be attributed to cavitation. Cavitation is defined as the formation and collapse of gas- or vapour-filled bubbles in liquids due to dynamic alternating pressures caused by sound waves. The enormous compression of bubble contents causes shock pressures of up to 100 MPa and temperature peaks of up to 1000 K. These shock pressures are responsible for mechanical effects such as material erosion by shear forces in the liquid and so-called bubble jets (speed of several hundred meters per second) occurring in the vicinity of interfaces (like suspended solids particles). (17), (18)

The occurrence and extent of cavitation depend mainly on ultrasound field parameters and are influenced by frequency, sound wave amplitude, energy density, operating pressure, temperature and media properties (19), (20). At high frequencies (>10³ kHz), cavitation is impaired or even prevented by the inertia of the medium (21). Bubbles can grow larger at low frequencies (20–500 kHz), which in turn means that they will collapse more vigorously. The energy content of bubbles and, consequently, the magnitude of the effects caused when they collapse, generally increase with increasing radius.

Basically, most of the studies agreed that high-power ultrasound technology has the potential to improve the traditional refining process with regard to the development of fibre properties without affecting fibre length distribution.

Despite the quite promising results, no real attempt has been made so far to develop a method based on ultrasound technology for full-scale application in these areas. The investigations in this publication are aiming at the use of cavitation effects to modify the morphology of pulp in such a way, that the strength potential of the pulp increases comparable or better to conventional refining.

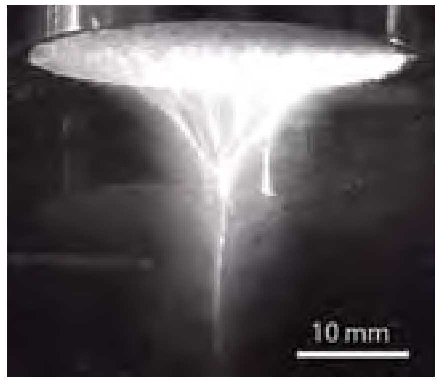

Figure 1: Cavitation in water below a sonotrode (frequency 20 kHz, intensity 30 W/cm²), scattered light, Keyence Motion Analysing Microscop VW 6000
Slika1: Kavitacija v vodi pod izvorom ultrazvoka (frekvenca 20 kHz, intenziteta 30 W/cm²), razpršena svetloba, analitski mikroskop VW 6000, Keyence Motion

2 EXPERIMENTAL SET-UP

Methods

The experimental set-up consists of an ultrasound device (Hielscher Ultrasonics GmbH) with a shaft Sonotrode (frequency 20 kHz, maximum power 1000 W). The ultrasound device was integrated in a laboratory plant where a pump transports the pulp from a vessel through a flow cell and afterward into the same vessel. The flow cell FC100L1-1S was used in combination with the flow cell Insert-34 (both from Hielscher Ultrasonics GmbH). The treated pulp volume was in the range of 3 up to 7 litres and the maximum static pressure was 5 bar.

Refining in a conventional refiner was carried out in the pilot plant refiner of PTS, Heidenau (Kraft hardwood pulp, recycled fibre pulp) and in the laboratory refiner of TU Dresden (Kraft softwood pulp). The machine settings used were a conical refiner plate with a specific edge load of 1.0 Ws/m for the kraft hardwood pulp, a disc refiner plate with a specific edge load of 3.0 Ws/m for the kraft softwood pulp and a disc refiner plate with a specific edge load of 0.4 Ws/m (SEC 30 kWh/t), 0.6 Ws/m (SEC 50 kWh/t), 0.9 Ws/m (SEC 75 kWh/t) and 1.2 Ws/m (SEC 100 kWh/t) for the recycled fibre pulp.

The pulp suspension is characterized by the drainage resistance (Schopper Riegler) according to DIN ISO 5267/1:2000 whereby the results are the average of two readings for each sample. The water retention value (WRV) was determined according to Zellcheming Merkblatt ZM IV/33/57 whereby the results are the average of two readings for each sample.

The characterization of the strength properties of the pulp required the preparation of laboratory sheets for physical testing (RapidKöthen method according to ISO 52692:2004). The tensile strength test was carried out according to DIN EN ISO 1924 2:2009.

To visualize the morphological changes, the pulp suspensions were observed by LEICA DM4000B, light microscope and laboratory sheets were observed by a JEOL JSM 6510, scanning electron microscope (SEM).

Materials

The used virgin pulps were a bleached softwood kraft pulp with 80 % spruce (Picea abies) and 20 % pine (Pinus sylvestris) and a bleached hardwood kraft pulp of eucalyptus (Eucalyptus globulus). The ultrasound trials for both pulps were carried out at a specific energy consumption (SEC) in the range from 170 to 1000 kWh/t.

The softwood kraft pulp was treated with a 20 mm wide cyclindrical sonotrode at ambient pressure in the flow cell, at a stock consistency of 1 % and at an amplitude of 120 µm (peak to peak) of the sonotrode. The hardwood kraft pulp was treated at overpressure in the flow cell of 1 bar, a stock consistency of 2 %, a 34 mm (diameter) sonotrode and with an amplitude of 28 µm (peak to peak).

The used recycled fibre pulp was an industrially produced fluting (without surface starch) with a raw material input of 50 % of recovered paper grade 1.02 and 50 % of recovered paper grade 1.04 (according to EN 643). This pulp was treated at ambient pressure in the flow cell, a stock consistency of 2 %, a 34 mm (diameter) sonotrode and with amplitude of 10 µm (peak to peak).

3 RESULTS AND DISCUSSION

Virgin pulp

As mentioned before it was expected that the treatment of pulp suspension with cavitation would modify the morphology of the fibres. This modification can be the internal delamination within the fibres that will have a huge impact on their flexibility and the swelling behaviour of the pulp. A further modification of morphology is the external fibrillation of the fibres whereby fibrils from the surface of the fibre wall are partially sheared off. A total cutting off of the fibrils of the fibre wall creates fines.

The change in swelling behaviour can be measured with the water retention value (WRV) which is shown in figures 3 and 5 for softwood hardwood respectively. The water retention value of both pulps is slightly increased by the ultrasound treatment. In contrast, the drainage resistance of the pulps was not changed by ultrasound treatment (Figure 2 and Figure 4). A huge external fibrillation that occurs during the refining of pulp in a disc refiner is not visible after ultrasound treatment. Furthermore, fibre length distribution as measured with the METSO Fibre-Lab showed no change due to ultrasound treatment (without figure).

The increase in tensile strength by ultrasound treatment is – compared to the refining treatment in refiners – much less for the same specific energy consumption (Figure 3 and Figure 5). The increase of the water retention value of the pulp correlates with the development of tensile strength in the handsheets. Moreover, ultrasound treatment causes a rise in fines (without figure) that increases the surface of interfibre bonding in the fibre network. Therefore the increase in static strength in the paper sheet is caused mainly by the increase in flexibility of the fibres and a larger share of fines.

Ultrasound treatment causes a rougher surface of the fibres, tears in the fibre wall and a peeling of the outer layers of the fibre wall and, thus, damages the fibre (Figure 6 and Figure 7).

In further investigations the impact of the amplitude at the top of the ultrasound sonotrode on the strength potential of the virgin pulp as well as recovered paper pulp was determined. These investigations showed that even with huge amplitude of 170 µm (sonotrode diameter 10 mm, intensity 440 W/cm², SEC up to 900 kWh/t) the development of the strength potential (tensile strength) is below 25 %.

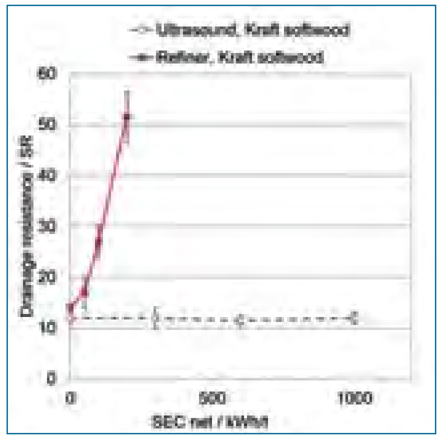

Figure 2: Comparison of the development of drainage resistance (Schopper Riegler) of a softwood kraft pulp as a function of SEC for refining (laboratory refiner) and ultrasound treatment.
Slika 2: Vpliv porabe specifične energije SEC pri mletju vlaken sulfatne celuloze iglavcev na laboratorijskem rafinerju in pri obdelavi z ultrazvokom, na sposobnost odvodnjavanja, SR.

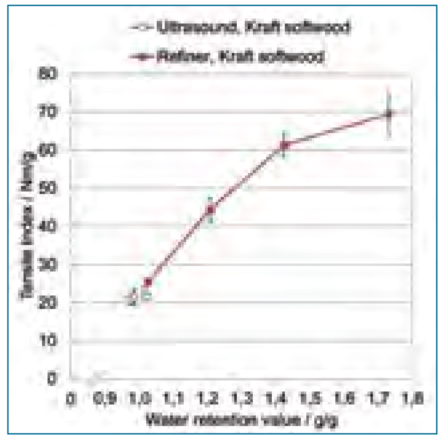

Figure 3: Development of tensile strength (Rapid-Köthen sheets) of a softwood kraft pulp as a function of water retention for refining (laboratory refiner) and ultrasound treatment.
Slika 3: Vpliv sposobnosti retencije vode pri mletju vlaken sulfatne celuloze iglavcev na laboratorijskem rafinerju in pri obdelavi z ultrazvokom, na spremembo indeksa utržne jakosti laboratorijskih vzorcev papirja (Rapid-Köthen).

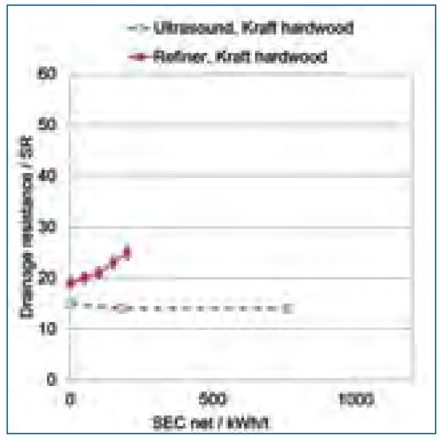

Figure 4: Development of drainage resistance (Schopper Riegler) of a hardwood kraft pulp as a function of SEC for refining (pilot plant refiner) and ultrasound treatment.
Slika 4: Vpliv porabe specifične energije SEC, pri mletju vlaken sulfatne celuloze listavcev na laboratorijskem rafinerju in pri obdelavi z ultrazvokom, na sposobnost odvodnjavanja, SR.

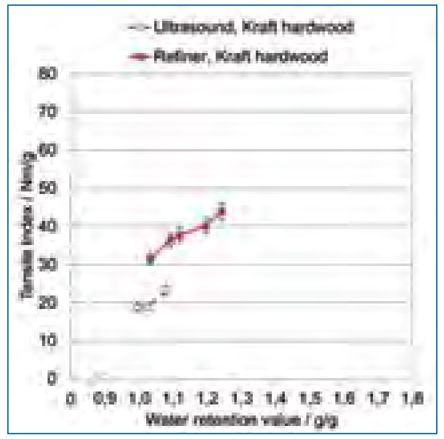

Figure 5: Development of tensile strength (Rapid-Köthen sheets) of a hardwood kraft pulp as a function of water retention for refining (pilot plant refiner) and ultrasound treatment.
Slika 5: Vpliv sposobnosti retencije vode pri mletju vlaken sulfatne celuloze listavcev na laboratorijskem rafinerju in pri obdelavi z ultrazvokom, na spremembo indeksa utržne jakosti laboratorijskih vzorcev papirja (Rapid-Köthen).

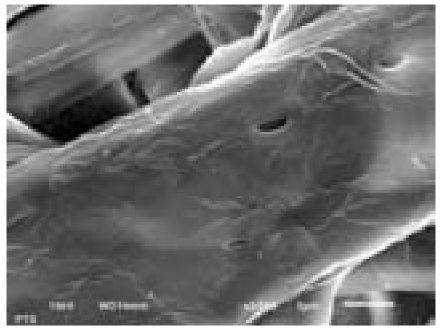

Figure 6: SEM micrographs of hardwood pulp (Eucalyptus globulus), Rapid-Köthen sheet, no treatment.
Slika 6: SEM mikroskopski posnetek neobdelanih celuloznih vlaken listavcev (Eucalyptus globulus), pri laboratorijskem vzorcu papirja (Rapid-Köthen).

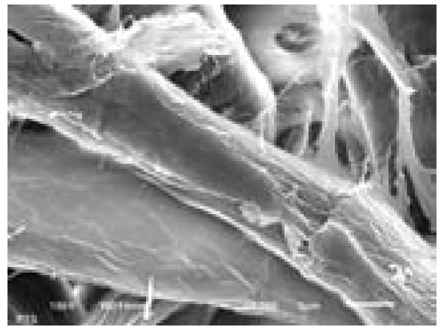

Figure 7: SEM micrographs of hardwood pulp (Eucalyptus globulus), Rapid-Köthen sheet, ultrasound treatment of the suspension at SEC 4000 kWh/t, frequency 20 kHz.
Slika 7: SEM mikroskopski posnetek celuloznih vlaken listavcev (Eucalyptus globulus), obdelanih v suspenziji z ultrazvokom pri porabi specifične energije 4000 kWh/t in frekvenci 20 kHz, pri laboratorijskem vzorcu papirja (Rapid-Köthen).

RAZISKAVE IN RAZVOJ

Recycled fibre pulp

In a second set of experiments the recycled fibre pulp was treated with ultrasound under varying different parameters of the ultrasound system (e.g. specific energy consumption, amplitude, static pressure) and the pulp (e.g. stock consistency, flow velocity, temperature). The comparison between the conventional refining and the ultrasound treatment is shown in (Figure 8 and Figure 9).

The ultrasound treatment with amplitude of 10 µm und a net specific energy consumption of 25 kWh/t improves the strength potential of the recycled fibre pulp by 14 %. The drainage resistance rises by 4 Schopper Riegler. A similar increase in strength with the refiner requires a net SEC of 50 kWh/t. The drainage resistance increases after refining up to 13 Schopper Riegler – significantly more than after ultrasound treatment.

This means that the use of ultrasound treatment provides an opportunity to raise the strength potential of recycled fibre pulps with only limited increase in drainage resistance and thus only a limited impact on the speed of the paper machine.

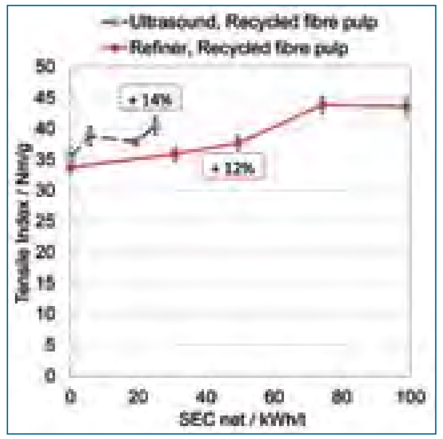

Figure 8: Development of tensile strength (Rapid-Köthen sheets) of a recycled pulp as a function of SEC for refining (pilot plant refiner) and ultrasound treatment
Slika 8: Vpliv mletja recikliranih vlaken na pilotnem rafinerju in pri obdelavi z ultrazvokom, na spremembo utržne jakosti laboratorijskih vzorcev papirja (Rapid-Köthen).

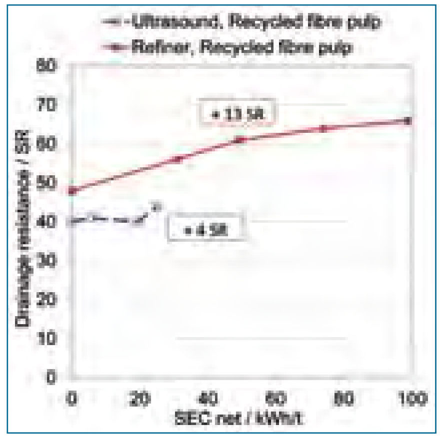

Figure 9: Development of drainage resistance (Schopper Riegler) of a recycled pulp as a function of SEC for refining (pilot plant refiner) and ultrasound treatment
Slika 9: Vpliv mletja recikliranih vlaken na pilotnem rafinerju in pri obdelavi z ultrazvokom, na spremembo sposobnosti odvodnjavanja (Schopper Riegler).

The recovered paper contains not only fibre and fines but also inorganic particles as calcium carbonate or kaolin. These minerals are partially washed out during the sheet forming process. The minerals impair the fibre bonding within the paper and decrease therefore the strength of the paper. A change (decrease) of the particle size distribution of the minerals as a result of the ultrasound treatment could increase the washout and therefore increase the strength of the paper. The mineral share (ash content 525 °C) in the sheets without and with ultrasound treatment is in the same range (11,1 % – 11,3 %). The increase of strength in the paper after ultrasound treatment is therefore caused mainly by the change of fibre morphology.

4 CONCLUSIONS

The results show that treating virgin pulp with ultrasound (at least with the experimental set-up used) results in a smaller increase in strength potential in comparison to treating the same pulp in refiners. By contrast, the ultrasound treatment of recycled fibre pulps increases the strength potential of this pulp in the same way as the refining in disc refiners but with a smaller increase in drainage resistance.

The use of ultrasound treatment in stock preparation, therefore, would allow to increase the strength potential of the pulp without excessive damage to the fibres. This would translate in better paper quality and might also extend the life span by a greater number of recycling cycles, and therefore better use of the recycled fibres potential.

ACKNOWLEDGEMENTS

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SKUPNA UČINKOVITOST OPREME KOT MERILO ZA USPEŠNOST V PREDELOVALNI INDUSTRIJI

OVERALL EQUIPMENT EFFECTIVENESS AS A MEASURE OF SUCCESSFUL IN MANUFACTURING INDUSTRY

Mirko HORVAT[1]

IZVLEČEK

V prispevku podajamo teoretično zasnovo merjenja skupne učinkovitosti opreme (OEE), ki je v metodološkem okviru celovitega produktivnega vzdrževanja (TPM) v segmentu predelovalne industrije lahko osrednja podpora za izboljšanje izkoriščenosti opreme. V nadaljevanju obravnavamo tehnično in stroškovno funkcijo, iz katere je izpeljana zveza med tehnično in stroškovno (ne)učinkovitostjo. Prispevek zaključujemo z rezultati aplikativne raziskave na konkretnem primeru predelave higienskih papirjev.

Ključne besede: celovito produktivno vzdrževanje (TPM), skupna učinkovitost opreme (OEE)

ABSTRACT

In the article, the theoretical concept of measuring the overall equipment effectiveness (OEE) is presented, which can be the main support for the equipment usage improvement in the methodological extent of the total productive maintenance (TPM) in the segment of manufacturing industry. Further on, we discuss the technical and expense function, from which the connection between the technical and expense (un)effectiveness is derived. The article is concluded with the results of applicative research on a concrete example of hygienic papers processing.

Key words: total productive maintenance (TPM), overall equipment effectiveness (OEE)

1 UVOD

V času globalizacije je učinkovitost proizvodnje ključnega pomena za obstoj podjetja na trgu. Konkurenčne razmere silijo podjetja v nenehno izboljševanje svojih izdelkov in procesov (Kumar Sharma 2006, 256–257). V delovno intenzivnih panogah, med katere sodi tudi proizvodnja in predelava higienskega papirja, je zaradi racionalizacije in avtomatizacije procesov pritisk konkurence toliko večji (Haas, 2009, 2–3). Za izboljšanje učinkovitosti proizvodnje se je v preteklosti razvilo veliko metod, postopkov in orodij, ki postajajo z implementacijo novejših informacijskih tehnologij čedalje bolj popolna in nepogrešljiva. Različne inovativne tehnologije in načini upravljanja, kot so Celovito produktivno vzdrževanje (TPM), Skupno upravljanje kakovosti (TQM), Prenova poslovnih procesov (BPR), Upravljanje z viri proizvodnje (MRP), načrtovanje virov podjetja (ERP), Management zalog (JIT) itd., postajajo čedalje bolj priljubljene v poslovanju podjetij (Ljungberg 1998, 495–497; Jonsson in Lesshammar 1999, 55–60). Izkušnje so pokazale, da je najboljši način reševanje tovrstne problematike sistematični pristop z integracijo najprimernejših menedžerskih zasnov (Pomorski 2004, 15–66).

2 ZASNOVA ZA DOSEGANJE UČINKOVITEJŠE PROIZVODNJE

V prispevku obravnavamo zasnovo in pristop za doseganje učinkovitejše proizvodnje, ki temelji na širokem metodološkem okviru TPM (Total Productive Maintenance) ter OEE (Overall Equipment Effectiveness). Z implementacijo dosežemo boljše vključevanje operaterjev, urejeno in čisto delovno okolje, izboljšane pogoje za upravljanje in vzdrževanje strojev, daljšo življenjsko dobo delovnih sredstev in višjo produktivnost (Pomorski 2004, 19–97).

2.1 Celovito produktivno vzdrževanje (TPM)

Vpeljava TPM v proizvodnjo pomeni dosleden in sistematičen način spremljanja delovnih procesov, s ciljem revitalizacije in konsolidacije proizvodnih procesov, ter spiralo nenehnega izboljševanja v zasledovanju končnega cilja, to je maksimiranje dobička. Pripadajoča analitična orodja omogočajo strokovno presojo in vrednotenje rezultatov ter učinkovito ukrepanje. V praksi se izkaže, da na videz nepomembni dejavniki ali dogodki pomenijo relativno pomemben delež (ne)učinkovitosti proizvodnega procesa. Temeljna zasnova celovitega produktivnega vzdrževanja podaja pet glavnih ciljev:

- nenehno izboljševanje učinkovitosti opreme (strukturiran pristop),
- razvijanje sistema produktivnega vzdrževanja skozi ves življenjski cikel opreme (izboljševanje zmogljivosti in učinkovitosti vzdrževanja),
- vključitev posluževalcev strojev v operativno vzdrževanje (avtonomno vzdrževanje),
- aktivna vključitev vseh zaposlenih (izboljševanje na temelju timskega dela),
- promocija TPM skozi motivacijski menedžment v celotni hierarhiji organizacije.

V metodologiji TPM je prepoznanih 16 izgub, ki so kategorizirane v osem glavnih izgub na opremi, pet v delovni sili in treh materialnih virih. Vsebinsko so izgube strukturirane tako, da jih zaposleni kar