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The Impact of Paper Recycling in the Society

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I. INTRODUCTION

It is well known the paper production (likewise the other brands of industry) has enormous effects on the environment. The using and processing of raw materials has a variety of negative effects on the environment.

At the other hand there are technologies which can moderate the negative impacts on the environment and they also have a positive economical effect. One of these processes is the recycling, which is not only the next use of the wastes. The main benefit of the recycling is a double decrease of the environment loading, known as an environmental impact reducing. From the first view point, the natural resources conserves at side of the manufacturing process inputs, from the second view point, the harmful compounds amount leaking to the environment decreases at side of the manufacturing process outputs.

The paper production from the recycled fibers consumes less energy; conserves the natural resources viz. wood and decreases the environmental pollution. The conflict between economic optimization and environmental protection has received wide attention in recent research programs for waste management system planning. This has also resulted in a set of new waste management goals in reverse logistics system planning. Pati et al. (2008) have proposed a mixed integer goal programming (MIGP) model to capture the inter- relationships among the paper recycling network system. Use of this model can bring indirectly benefit to the environment as well as improve the quality of waste paper reaching the recycling unit.

In 2005, the total production of paper in Europe was 99.3 million tonnes which generated 11 million tonnes of waste, representing about 11% in relation to the total paper production. The production of recycled paper, during the same period, was 47.3 million tonnes generating 7.7 million tonnes of solid waste (about 70% of total generated waste in papermaking) which represents 16% of the total production from this raw material (CEPI 2006).

The consumption of recovered paper has been in continuous growth during the past decades. According to the Confederation of European Paper Industries (CEPI), the use of recovered paper was almost even with the use of virgin fiber in 2005. This development has been boosted by technological progress and the good price competitiveness of recycled fiber, but also by environmental awareness – at both the producer and consumer ends – and regulation that has influenced the demand for recovered paper. The European paper industry suffered a very difficult year in 2009 during which the industry encountered more.Down-time and capacity closures as a result of the weakened global economy. Recovered paper utilisation in Europe decreased in 2009, but exports of recovered paper to countries outside CEPI continued to rise, especially to Asian markets (96.3%). However, recycling rate expressed as "volume of paper recycling/volume of paper consumption" resulted in a record high 72.2% recycling rate after having reached 66.7% the year before (Fig. 1) (Hujala et al. 2010; CEPI 2006; European Declaration on Paper Recycling 2010; Huhtala & Samakovlis 2002; CEPI Annual Statistic 2010).

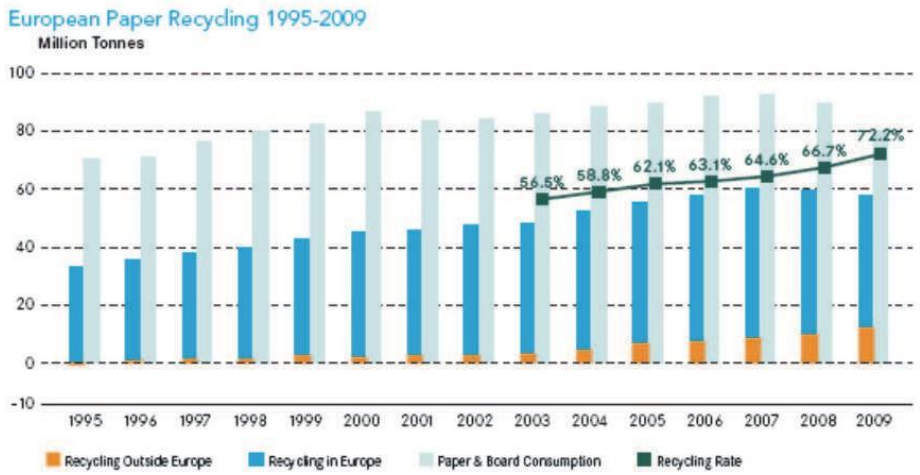

Fig. 1. European paper recycling 1995-2009 in million tonnes (European Declaration on Paper Recycling 2006 – 2010, Monitoring Report 2009 (2010) (www.erpa.info)

Recycling is not a new technology. It has become a commercial proposition since Matthias Koops established the Neckinger mill, in 1826, which produced white paper from printed waste paper. However, there were very few investigations into the effect of recycling on sheet properties until late 1960's. From then until the late 1970's, a considerable amount of work was carried out to identify the effects of recycling on pulp properties and the cause of these effects (Nazhad 2005; Nazhad & Paszner 1994). In the late 1980's and early 1990's, recycling issues have emerged stronger than before due to the higher cost of landfills in developed countries and an evolution in human awareness. The findings of the early 70's on recycling effects have since been confirmed, although attempts to trace the cause of these effects are still not resolved (Howard & Bichard 1992).

Recycling has been thought to reduce the fibre swelling capability, and thus the flexibility of fibres. The restricted swelling of recycled fibres has been ascribed to hornification, which has been introduced as a main cause of poor quality of recycled paper (Scallan & Tydeman 1992). Since 1950's, fibre flexibility among the papermakers has been recognized as a main source of paper strength. Therefore, it is not surprising to see that, for over half a century, papermakers have supported and rationalized hornification as a main source of tensile loss due to drying, even though it has never been fully understood.

Recycled paper has been increasingly produced in various grades in the paper industry. However, there are still technical problems including reduction in mechanical strength for recycled paper. Especially, chemical pulp-origin paper, that is, fine paper requires a certain level of strength. Howard & Bichard (1992) reported that beaten bleached kraft pulp produced handsheets which were bulky and weak in tensile and burst strengths by handsheet recycling. This behaviour could be explained by the reduction in re-swelling capability or the reduction in flexibility of rewetted pulp fibers due to fiber hornification and, possibly, by fines loss during recycling processes, which decrease both total bonding area and the strength of paper (Howard 1995)

Paper recycling is increasingly important for the sustainable development of the paper industry as an environmentally friendly sound. The research related to paper recycling is therefore increasingly crucial for the need of the industry. Even though there are a number of researches ascertained the effect of recycling treatment on properties of softwood pulp fibres (Cao et al. 1999; Horn 1975; Howard & Bichard 1992; Jang et al. 1995), however, it is likely that hardwood pulp fibres have rarely been used in the research operated with recycling treatment. Changes in some morphological properties of hardwood pulp fibres, such as curl, kink, and length of fibre, due to recycling effects also have not been determined considerably. This is possibly because most of the researches were conducted in the countries where softwood pulp fibres are commercial extensively (Khantayanuwong 2003). Therefore, it is the purpose of the present research to crucially determine the effect of recycling treatment on some important properties of softwood pulp fibres.

II. Alterations of Pulp Fibers Properties at Recycling

The goal of a recycled paper or board manufacturer is to make a product that meets customers´ specification and requirements. At the present utilization rate, using recycled fibres in commodity grades such as newsprint and packaging paper and board has not caused noticeable deterioration in product quality and performance (Čabalová et al. 2009). The expected increase in recovery rates of used paper products will require a considerable consumption increase of recycled fibres in higher quality grades such as office paper and magazine paper. To promote expanded use of recovered paper, understanding the fundamental nature of recycled fibres and the differences from virgin fibres is necessary.

Essentially, recycled fibres are contaminated, used fibres. Recycled pulp quality is, therefore, directly affected by the history of the fibres, i.e. by the origins, processes and treatments which these fibres have experienced.

McKinney (1995) classified the history into five periods:

1. fibre furnish and pulp history
2. paper making process history
3. printing and converting history
4. consumer and collection history
5. recycling process history.

To identity changes in fibre properties, many recycling studies have occurred at laboratory. Realistically repeating all the stages of the recycling chain is difficult especially when including printing and deinking. Some insight into changes in fibre structure, cell wall properties, and bonding ability is possible from investigations using various recycling procedures, testing methods, and furnishes.

Mechanical pulp is chemically and physically different from chemical pulp then recycling effect on those furnishes is also different. When chemical fibres undergo repeated drying and rewetting, they are hornified and can significantly lose their originally high bonding potential . The degree of hornification can be measured by water retention value (WRW) (Kim et al. 2000). In contrast to the chemical pulps, originally weaker mechanical pulps do not deteriorate but somewhat even improve bonding potential during a corresponding treatment. Several studies (Maloney et al. 1998; Weise 1998; Ackerman et al. 2000) have shown good recyclability of mechanical fibres.

The dependence of beating degree and WRV from the relative length of hardwood and softwood pulps. From their results we can see the WRV increase in dependence on the pulp length alteration is more rapid at hardwood pulp, but finally this value is higher at softwood pulps. Kim et al. (2000) determined the WRV decrease at softwood pulps with the higher number of recycling (at zero recycling about cca 1.5 g/g at fifth recycling about cca 1.1 g/g). Utilisation of the secondary fibres to furnish at paper production decrease of the initial need of woody raw (less of cutting tress) but the paper quality is not significantly worse.

III. Paper Recycling

The primary raw material for the paper production is pulps fibres obtaining by a complicated chemical process from natural materials, mainly from wood. This fibres production is very energy demanding and at the manufacturing process there are used many of the chemical matters which are very problematic from view point of the environment protection. The suitable alternative is obtaining of the pulp fibres from already made paper. This process is far less demanding on energy and chemicals utilisation. The paper recycling, simplified, means the repeated defibring, grinding and drying, when there are altered the mechanical properties of the secondary stock, the chemical properties of fibres, the polymerisation degree of pulp polysaccharidic components, mainly of cellulose, their supramolecular structure, the morphological structure of fibres, range and level of

interfibres bonds e.g.. The cause of above mentioned alterations is the fibres ageing at the paper recycling and manufacturing, mainly the drying process.

At the repeat use of the secondary fibres, it need deliberate the paper properties alter due to the fiber deterioration during the recycling, when many alteration are irreversible. The alteration depth depends on the cycle's number and way to the fibres use. The main problem is the decrease of the secondary pulp mechanical properties with the continuing recycling, mainly the paper strength (Khantayanuwong et al. 2002; Jahan 2003; Hubbe & Zhang 2005; Garg & Singh 2006; Geffertová et al. 2008; Sutjipto et al. 2008). This decrease is an effect of many alterations, which can but need not arise in the secondary pulp during the recycling process. The recycling causes the hornification of the cell walls that result in the decline of some pulp properties. It is due to the irreversible alterations in the cells structure during the drying (Oksanen et al. 1997; Kim et al. 2000; Diniz et al. 2004).

The worse properties of the recycled fibres in comparison with the primary fibres can be caused by hornification but also by the decrease of the hydrophilic properties of the fibres surface during the drying due to the redistribution or migration of resin and fat acids to the surface (Nazhad & Paszner 1994; Nazhad 2005). Okayama (2002) observed the enormous increase of the contact angle with water which is related to the fiber inactivation at the recycling. This process is known as „irreversible horrification.

Paper recycling saves the natural wood raw stock, decreases the operation and capital costs to paper unit, decrease water consumption and last but not least this paper processing gives rise to the environment preservation (e.g. 1 t of waste paper can replace cca 2.5 m^3 of wood). A key issue in paper recycling is the impact of energy use in manufacturing. Processing waste paper for paper and board manufacture requires energy that is usually derived from fossil fuels, such as oil and coal. In contrast to the production of virgin fibre-based chemical pulp, waste paper processing does not yield a thermal surplus and thus thermal energy must be supplied to dry the paper web. If, however, the waste paper was recovered for energy purposes the need for fossil fuel would be reduced and this reduction would have a favourable impact on the carbon dioxide balance and the greenhouse effect. Moreover, pulp production based on virgin fibres requires consumption of round wood and causes emissions of air-polluting compounds as does the collection of waste paper. For better paper utilization, an interactive model, the Optimal Fibre Flow Model, considers both a quality (age) and an environmental measure of waste paper recycling was developed.

IV. Conclusion

The recycling is a necessity of this civilisation. The paper manufacturing is from its beginning affiliated with the recycling, because the paper was primarily manufactured from the 100 % furnish of rag. It is increasingly assented the trend of the recycled fibers use from the European and world criterion. The present European papermaking industry is based on the recycling.

The presence of the secondary fibres from the waste paper, their quality and amount is various in the time intervals, the seasons and the regional conditions. It depends on the manufacturing conditions in the paper making industry of the country.

At present the recycling is understood in larger sense than the material recycling, which has a big importance from view point of the paper recycling. Repeatedly used fibres do not fully regenerate their properties, so they cannot be recycled ad anfinitum. It allows to use the alternative possibilities of the paper utilisation in the building industry, at the soil reclamation, it the agriculture, in the power industry. The most important aim is, however, the recycled paper utilization for the paper manufacturing.

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