The runnability and the printability of recycled newsprint

The production and use of recycled fibre-containing newsprint became an absolute necessity because of economical (energy savings) and ecological (lack of landfill space) reasons. After some hesitant starts with 30% recycled content, the good results encouraged papermakers to go up to 70-80%. The newest mills built in Central Europe will even use 100% recycled fibres as raw material to make newsprint. The waste paper used for deinking and making newsprint is a mixture of old newspapers and magazines and, when correctly collected and sorted, enables the manufacture of a good quality product.

However, the use of this new raw material may change some paper properties and will require other adjustments when this paper is used on the rotary press. Some critical voices have been raised among the newspaper printers. On the initiative of Erwin Krauthauf of Haindl Papier and with the support of Clemens Mühl from Druck- und Verlagshaus Frankfurt/Main, IFRA organised a Forum (in the German language) on March 3, 1994 in Darmstadt to discuss these problems in an open way. This report gives a summary of the discussions of this group of experts. Under paragraph 8, some advice is given from all parties involved in producing and using newsprint containing a high percentage of deinked pulp.

We do hope that this Special Report will enable our members to gain a clearer view on the problems related to the use of recycled newsprint, which often suffers from a negative image.

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For IFRA members only

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1. Introduction

As IFRA founded its Newsprint Committee in 1972, the Nordic newsprint manufacturers started to propose a newsprint with a lower grammage. This evolution was possible because of the development of thermo-mechanical pulp (TMP), which is of better quality than the traditional groundwood pulp. At that time, the reaction of the Central European newsprint makers was to stay with higher grammages (52 g/m²) and to use waste paper as a raw material to reduce costs. In the beginning, this trend was driven by economical reasons rather than ecological reasons. Much later this economical necessity turned out to become an ecological virtue.

With the increased use of waste paper, the deinking techniques have to be improved to be able to produce a newsprint with a quality equal to virgin fibre paper. It is getting more and more difficult to achieve a good deinking result because more and more newspapers are using colour. The PTS (Papiertechnische Stiftung) in Munich has set the minimum deinking coefficient DEM = 60 % for a printed product to be called “good deinkable”. This deinking coefficient is calculated as a percentage of brightness gains before and after deinking, using a standard method (see also IFRA Special Report 1.6: “Paper recycling and deinking – What is their importance for the newspaper industry?”). Fig. 1 shows results obtained by the PTS for different printed products.

It can be seen that a significant number of printed products are below the acceptable value of 60%. Tests have shown that the average DEM value obtained for offset printed newspapers is about 50%. This rather low value can be explained by the fact that newsinks dry exclusively by penetration in the structure of the paper. In general, newspapers printed in letterpress are better deinkable than newspapers printed with the offset process.

The deinkability problems with water-based flexo inks

The flexographic printing process was introduced to newspapers in the middle of the eighties. The flexo newsinks are
formed of very fine particles of pigments dissolved in water. In 1988, the IFRA Newsprint Committee decided to start a small research project with the PT that had shown that these inks are not deinkable with the flotation deinking process, which is the main process used in Europe. The publication of the IFRA Special Report 1.3 "Deinkability of flexo printed newspapers" has lead to reactions from the manufacturers of flexo presses. At that time, many comments had been received from the US flexo printers, saying that these inks were only a problem in Europe, but not a problem in the USA where the wash deinking process is mainly used. An IFRA representative had been invited to visit the Garden State newsprint mill in the States and all these activities were reported at an IFRA Symposium later on. Since that time, some deinkable flexo inks and other deinking processes have been developed. However, they have not been used on an industrial scale yet.

The yield problems with vegetable oil-based inks

The recent development of vegetable oil based inks may also be the source of problems concerning deinking. In a research project conducted by IFRA in co-operation with the Technical Research Centre of Finland (VTT), it has been shown that vegetable oil based newsinks are not fully deinkable after a period of storage of three months. These results have been published in Special Report 1.5 "Vegetable oil based newsinks and their printability properties". The repetition of these deinking tests with natural and artificial ageing in two different laboratories (PTS in Munich and Institut für Papierfabrikation of the Technical University in Darmstadt) has given better deinkability coefficients, but with some differences between the two research institutes due to differences in the deinking methods. These tests involved only black inks printed on newspaper on a normal newspaper rotary press. The results are presented in Fig. 2.

These results show that it may be misleading to compare absolute values of deinking coefficients. Different deinking coefficients can be found by different laboratories even if they use the same printed products for their tests. However, both results have shown that the yield with soya oil based inks was lower than with conventional mineral oil-based inks. The yield is the quantity of deinked pulp obtained after the deinking process in relation with the total pulp entering this process. It seems that the soya oil based ink particles are sticking to some paper fibres and both are extracted by the flotation process.

Recycling and deinking activities at IFRA

A few years ago, IFRA has also took part in a multi-client research project conducted by PIRA in Leatherhead (GB).
The aim of this research project was to improve the efficiency of the flotation deinking process. To achieve an improvement, some solutions have been searched for, for example, the use of other flotation gases or trials with different dispersion conditions before and after flotation. Another report "Deinking of wood-containing waste paper" has been written for IFRA by the Institut für Papierfabrikation. All these results have been published in 1991 with Special Report 1.6 “Paper recycling and deinking – What is their importance for the newspaper industry?”.

IFRA has also organised an information service that is free of charge for all interested persons. This service provides information at irregular intervals on the developments of the recycling techniques, the last trends in this area and the planned legislation concerning paper recycling in different countries.

More and more recycled fibre will be used for the production of all paper grades

The reason to increase paper recycling is not to save forests. The main reason for recycling paper is the shortage of landfill space in many countries and the savings in energy and fresh water consumption. The recycling of fibres is not possible without the availability of a constant supply of virgin fibres. These fibres are produced from forests which need to be efficiently cultivated. Young and healthy trees are much more efficient for removing carbon dioxide from the atmosphere and the production of oxygen.

Figure 3 shows the reduction of the total energy needed in one deinking plant with the development of the deinking techniques. The energy required for producing TMP is about seven times higher than the energy needed to produce deinked pulp. When old newspapers and magazines are collected together with board, the mixture will have to be sorted later on by a manual operation which is less efficient than a separation by the public, and very costly. A separate collection of newspaper and magazines is the best solution and has been implemented with success, for example, in Switzerland.

According to the Finnish company Jaako Pöyry, the proportion of recycled fibre will increase up to the year 2000 for all paper types. As Fig. 4 shows, more and more deinked pulp will be used.

Even the “Nordic” newsprint producers (from Scandinavia and Canada) will use more and more recycled fibre for the production of newsprint. The role played by these countries is very important because they will export paper containing virgin fibres to highly populated countries where a high level of recycled fibres is used. Germany, for example, has a high percentage of paper imports from Scandinavian countries, which will ensure the availability of virgin fibres. This raises once again the question of the recyclability of the paper fibres.

The age distribution of fibres

A model, the so-called “Munich experiment” has been quoted a number of times in some publications. This trial showed that after three cycles (papermaking, printing and deinking) of the same fibre furnish, it was impossible to...
print on the recycled paper. This experiment was reported in the mid-seventies by Professor Schweizer in Munich but has never been published. New research is needed to obtain more knowledge in that field.

The papermakers are often asked “How many times can fibres be recycled?”. No expert is in a position to give a reliable answer bearing in mind that many factors (such as paper grade, waste paper grade, type of fibres, use of additives or market requirements) affect the number of cycles that fibres can pass through the recycling systems before deterioration sets in. The number of cycles a fibre will have to pass never arises in practice. It is more important to know the age distribution of deinked pulp which can only be calculated by statistical means.

A study about the age distribution of fibres in Germany has been made by the Institut für Papierfabrikation at the Technical University in Darmstadt under the guidance of Lothar Gottsching. Several models have been developed by the scientists in Darmstadt to calculate the age distribution of fibres. For the so-called “one-parameter model”, it has been assumed that all paper and board grades produced are based on the same waste paper content (90 % in this particular example). Furthermore, this “model country” neither imports nor exports any paper or waste paper. For simplification, it is also assumed that the yield of the recycling and deinking processes is 100%. The result of the calculation can be seen in Fig. 5 under “one-parameter model”.

The one-parameter model has been replaced by the multi-parameter model which takes into account newsprint as well as SC and LWC grades, containing a maximum percentage of DIP. The amount of imported paper for each grade is also part of this new calculation. The multi-parameter model was modified to include the yield of the deinking process (modified multi-parameter model). The results presented in Figure 5 are based on the estimated paper consumption for Germany for the year 2000. This interesting study shows that the first and second generations of fibres still represent the major part of the total furnish. These results show that a country like Germany with a high percentage of paper imports containing virgin fibres can achieve a high degree of waste paper usage without endangering the quality of the recycled paper produced.

For more information, the complete study has been published in the German magazine “Das Papier”, edition 10a 1993, under the title “Wie alt ist Altpapier heute und morgen?”. The Institut für Papierfabrikation has started a project in which six generations of deinked pulp will be produced on a pilot scale. Each generation will go through the following stages: papermaking, calendering, printing and deinking. From these generations, paper will be produced according to the calculated distribution of total furnish, %

Fig. 4: Estimated use of deinked pulp as a percentage of total furnish for the main grades

Fig. 5: Age distribution of fibres for German newsprint (Scenario 2000)
of fibre generations and its quality will be tested by printing results and laboratory evaluation. The results are going to be very interesting.

**Laboratory evaluation shows that physical properties of mechanical pulps do not deteriorate with multiple recycling**

It has been assessed in the laboratory that paper made with thermo-mechanical pulp (TMP) is less affected by recycling than a paper made of bleached sulphate chemical pulp. As can be seen in Fig. 6, even after 9 cycles, the physical properties of TMP are still stable. These so-called "mother curves" are obtained by the recycling of the same fibres (without input of virgin fibres). At each cycle, the physical properties of the paper are measured.

On an industrial scale, the fibres would be treated differently and it is expected that the results would be slightly modified. However, the trends would still be the same.

Figure 7 compares the physical strength of different pulps used by Haindl at its Schongau mill. It shows that TMP and DIP have about the same level of strength, whereas the level for groundwood pulp is about 40% less. The figures also show the increase of the strength index during the last years.

From the experimental and the papermakers point of view, recycled newsprint should not show more web breaks compared to virgin fibre paper grades. To find out whether this is the case also in practice was the main goal of this Forum. To follow a guideline in these discussions, the following seven questions had been proposed to the participants. No personal quotes are given in this report, a common practice with IFRA Forums.
2. Question: “Why has the use of recycled newsprint been rejected in some newspaper printing plants?”

It is important to note that all the six newspaper printers present at the Forum expressed their positive attitude towards the use of newsprint containing a high percentage of DIP. In some cases, difficulties might arise when both types of newsprints (virgin fiber-based and recycled) are used in the same printing plants, but they can be solved if these problems are discussed in an open way.

Recycled newsprint is less bulky than virgin fibre newsprint. The sheet is “harder” than with conventional paper. There was a discussion whether recycled newsprint needs more or less web tension on the press.

It seems that more web breaks may occur with recycled newsprint (see paragraph 3).

Some printability problems may be due to the pH of the paper surface. The surface pH of recycled paper is neutral while the pH of newsprint made with virgin fibres is on the acid side (see paragraph 7).

The speckiness of recycled paper, which is due to the residual ink and glue particles, has lead to complaints from some advertising agencies.

3. Question: “What are the main reasons for web breaks?”

In some cases, it has been reported that there were more web breaks observed with recycled newsprint. However, web breaks are often counted in breaks per 100 reels. For reels of the same diameter, there is more paper in the case of recycled newsprint compared to virgin-fibre newsprint, because the recycled paper has a lower bulk. If web breaks are reported per unit of length, the reported difference might lose its statistical significance.

Another printer mentioned that it seems to be more difficult to locate the reasons for web breaks with recycled newsprint. It has been reported that 2/3 of the web breaks occur at the beginning or at the end of a reel. More precisely, that means that 2/3 of the breaks are reported on about 1/4 of the paper length.

Modern deinking techniques and twin-wire paper machines now ensure the production of recycled newsprint of good quality with fewer irregularities (such as remaining ink dots or stickies). The physical properties of recycled paper are much higher than the level required on the press, due to the strength of the waste paper fibres and the modern sheet formation techniques.

The stretch behaviour of recycled newsprint is different. With the modern rotary presses used today in newspaper printing, there is the possibility of modifying the web tension to take into account the specific requirement of the paper. But some printers are hesitant to modify parameters that have given good results up to now.

Some printers indicated that they think they would need advice on how to change the level of web tension. The paper manufacturers only indicated that lowering the tension in comparison to virgin fibre newsprint will give a good result.

The twin-wire formers on the paper machines ensure the removal of fillers and fines on the two sides of the paper during its fabrication. There are much less holes in the paper web with these formers, but analyses have shown that weak parts with less fibres per unit area might be present due to stickies adhering to one forming wire, and could cause web breaks. In some cases, stickies (glue particles) present on the paper web are transmitted via the inking rollers to the ink duct. It can take days before they are removed again.

The discussion has shown that there might be some more reasons for web breaks when using recycled newsprint but the causes of breaks are difficult to localise and there is not enough statistical evidence available to prove the difference. Not all the printers have observed a difference in web breaks between the two grades.
4. Question: “Are there significant differences with different grammages, different recycled fibre proportions and different paper production processes?”

The representatives of the rotary press manufacturers said that there are big differences between different newsprints concerning their tension/elongation characteristics. In case of a reel change, for example, if two different papers are used, there is an elevated probability that a web break will occur.

The following curves are part of a study made by Erhard Glückner from Koenig & Bauer/KBA in Würzburg.

The tensile strength of newsprint is determined by applying a force to the ends of a newsprint strip and increasing the force until the strip breaks. In these curves, Δl, which represents the relative stretch (or elongation) of the paper, has been measured when a force (or tension) \( \sigma_B \) is applied to it. The rupture point in the upper part of each curve shows the maximum applicable force \( \sigma_B \) to the paper.

Fig. 8: Comparison of tension/stretch characteristics of different newsprints

Fig. 9: Comparison of tension/stretch characteristics of different newsprints
1. At approx. 25°C and 55% relative humidity, the tensile strength must be greater than 200 daN/m.

2. The ratio between longitudinal and cross tensile limits must be greater than 1:2.5.

3. In the lower range of the longitudinal tension/stretch characteristic (up to approx. 60 daN/m), the ratio between tensions (\(Q_{\text{dry}}\) and \(Q_{\text{hum}}\)) at 10% moisture content must be less than 2:1.

4. In the tension/stretch characteristic in cross direction, the difference between stretch when dry and with 10% water added (\(\Delta l = Q_{\text{hum}} - Q_{\text{dry}}\)) at 10 daN/m should not exceed 0.26%.

Source: E. Glöckner, KBA

Fig. 10: Comparison of tension/stretch characteristics of different newsprints

Fig. 11: Tension/stretch specification for offset newsprints according to E. Glöckner (KBA)
According to Erhard Gölockner, there is hardly any difference to be found between recycled and virgin fibre-based papers in the tension/stretch range that is important for the tension behaviour of the papers in the press (see Fig. 8).

The press manufacturers claim that newsprint should be manufactured according to the specifications given with Fig. 11.

The paper manufacturers said that it is not possible to produce a paper with constant tension/elongation characteristics across the paper machine width. A lot of tests are run on-line on the paper machine and many additional tests are performed in the laboratory of every paper mill. But, it is very difficult to correlate these measurements with the behaviour of the newsprint on the rotary press. However, if a printer asks the paper mill to supply the test data of every lot shipped, he will obtain it.

To avoid the above mentioned difficulties, it is recommended not to mix different paper types on the same press during the same production run. The different behaviour of newsprint produced by different forming units on paper machines are evident with the test method developed by E. Gölockner (see Fig. 9). The degree of fibre orientation is different with different forming units. A gap former shows the highest fibre orientation in machine direction, but the orientation does not change very much across the web width.

Due to uneven shrinkage of the web in the drier section of a paper machine, the behaviour of reels cut from the middle of a tambour might differ compared to a reel cut from the edge position. Therefore, the reels from the edge positions might not be used for quality colour works. Modern paper machines equipped with a single tier drying section have reduced the differences between reels cut from the middle and the edge positions. (see Fig. 10)

Modern machines with high-speed twin-wire formers, a fourth press section, less tension in the drying section and a soft-calender before winding will produce a good quality newsprint sheet with and without recycled fibres. The Institut für Papierfabrikation has compared a number of newsprint grades used in a printing plant in Belgium. Recycled newsprint gave the best results.

To summarise the discussion, it can be said that differences between individual paper machines are bigger than differences between grades made with and without recycled fibres.

5. Question: "Is there a dependence on the type of rotary press?"

The production speed of the modern newspaper presses has by far exceeded 10 m/s and is heading towards 15 m/s and maybe even more. Some presses are already running with more than 12 m/s.

A representative of the newspaper printers told that in case of a 180°-wrap of the web on guide rollers there was the formation of wrinkles which could cause web breaks. The rotary press manufacturers said that the configuration of the press has a great influence. With a satellite printing unit, in the worse case there can be up to 23 guide rollers to ensure a trouble-free run of the web through the unit. With a 4-high tower, there are only 2 guide rollers, one before the first unit and one after the last unit. The press manufacturers try to minimise the influence of these guide rollers by developing new materials for the manufacture of these rollers like, for example, plastic material reinforced with carbon fibres.

Concerning the "engineering philosophy" with infeed units, whether their drives should be fixed or variable, we have to distinguish the application cases. With single purpose presses, fixed drives may be of advantage, but when different paper grades including recycled and virgin fibre types have to be run on the same press, the variable drive system is a must.

6. Question: "Have the storage and the conditioning of the paper an influence?"

The newspaper printers told that they have the feeling that recycled newsprint has a lower moisture content than virgin-fibre paper. Some cases were reported of wrinkle formation just after the unpacking of reels. The answer from the papermakers is that between summer and winter there can be some very big differences in relative humidity from 25 to 75%. It is advised to keep the humidity in the paper warehouse as constant as possible.

There are no other specific precautions to be taken for the storage of recycled newsprint, than for virgin-fibre newsprint. If a paper reel has been stored at a low temperature and if the outside temperature increases, it can take days before the inner layers of paper are at the same temperature as the outer layers. This can be very important when for example reels are transported in winter (at low temperatures) and used just a few hours after their delivery to a reelroom at normal temperatures. The paper can suddenly absorb water when it comes into contact with the air, the consequence being the formation of wrinkles.

The control of the temperature and the humidity in the reelroom and in the warehouse can have a very positive effect on web breaks statistics.

A papermaker said that in the board industry, the conditions of temperature and humidity have to be reported during wrapping. In case of problems with the customer and if these conditions are not respected, a reclamation is not allowed.

There are few installed total air conditioning installations (to control temperature and humidity) in paper warehouses. However, winter heating and humidifiers are often installed.

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7. Question: “In terms of printability, what are the problems with recycled newsprint?”

Together with runnability, the printability questions associated with recycled newsprint were also discussed within the Forum. Two representatives of a newsink manufacturer had been invited to join this meeting. Ink manufacturers and technical service people from paper mills have the experience that the inks have to be modified for application on recycled newsprint. There is less ink penetration into the paper. The pigment particles stay more on the surface and consequently are less attached to the paper. Recycled newsprint has a higher density, but in order to regain bulk, it has a lower smoothness for offset printing. One reason for the lower degree of ink penetration is the high filler content of the recycled newsprint. This supports the observation of several printers who have found that the ink consumption with recycled newsprint is reduced by 10 to 15%, as one paper mill technical service man reported.

If the use of vegetable oil based inks or high-pigmented newsinks will change these properties is still unclear according to the ink manufacturers. One trial was to reduce the concentration of the binding agent but the result was the formation of more ink mist on the press. It has also been tried to change the composition of the binding agent by adding more high molecular resins and using a mix of big and small pigment particles.

Some paper mills equipped with soft calenders have reduced the smoothness of recycled newsprint for standard offset printing. The printing results are as good as before and the printers are more satisfied with the runnability of this paper.

The newsink manufacturers told that some research and development work was still necessary from their side. The IFRA Newsprint Committee has recently decided to expand and incorporate representatives of the newsink manufacturers. Three or four ink manufacturers will be invited to the next meeting of this newly formed “IFRA Newsprint and Newsink Committee”, and become full members of this Committee. These questions could be discussed within this Committee.

8. Question: “What can be done to improve the situation?”

By the newspaper printers:

- Different newsprints (different types from different manufacturers) should not be mixed during the same production run.
- Different blanket types should not be mixed on the same press.
- The newspaper printer has to be willing to modify the web tension on the press according to the needs of recycled newsprint.

By the newsprint manufacturers:

- Inform the newspaper printer about the modification of the web tension on the rotary press.
- The bulk and the surface properties of recycled newsprint should be optimised to ensure a good penetration of the ink into the paper.
- The tension/elongation characteristics of the paper should be as constant as possible.
- The fibre orientation in the width of the paper machine should be as constant as possible.

By the rotary press manufacturers:

- Build different metering units when different papers have to be run in the press.
- The number of guide rollers should be limited. Rollers with lower inertia moments should be developed.
- The web leads should be as short as possible. The remaining drawbacks linked with the use of four-high towers should be eliminated.
- The splice preparation should be further automated to eliminate mistakes due to manual operation.

By all the involved parties:

- Show more co-operation, with at least two meetings per year to discuss open questions. IFRA could act as a moderator.
- Try to learn the language of the others to overcome the problems due to different technical terminology.
9. Is there a nightmare of total recycling?

Lothar Götsching, who is head of the department of paper technology at the University in Darmstadt, has been responsible for the computer simulation tests to describe the situation in Germany. He commented on the results of these computer tests with the following words: “According to our calculations, it is clear that the import of paper containing no or few recycled fibres, has a real refreshing influence on the ageing structure of our recycling system. It would be nonsensical to impose legislation on countries like Finland, Sweden, Norway or Canada to use recycled fibres if they want to export paper in Germany. The recycling systems in Central Europe work because they are based on the import of virgin fibre papers from the Nordic countries.”

What would happen if all paper mills in the world would manufacture newsprint from 100% recycled fibres? The answer of the representative of Institut für Papierfabrikation is that the waste paper used to produce recycled newsprint is a mix of old newspapers and magazines. Paper grades used to print magazines contain a great proportion of virgin fibres and act as a refreshing tool for the recycling system. With these grades, the recycled content will be limited. Thus, a collapse is not foreseen in the near future.

An urgent need is a clean collection of newspapers and magazines. The best would be to collect them in bundles as it is done in Switzerland and in some parts of the USA. Too many areas in Germany collect waste paper used for deinking together with board. A very costly but not very effective sorting by hand is necessary and should be avoided. If the quality of the waste paper mixture is too low, it will not be sorted but either used for board manufacturing or go into landfills.

A lot of improvements by all parties taking part in the manufacturing, printing, using and deinking newsprint will be required if the usage of recycled fibres is generalised for higher quality grades. One of the major areas of improvement necessary is in the use of adhesives (for example self-adhesive labels) which cause problems during deinking.

At the close of the Forum, all participants agreed that low quality waste paper should be burned rather than go to landfill. There will always be a surplus of waste paper in Germany which cannot be used in the recycling process and should be used to produce energy, in paper mills, for example.