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LORENZO RUNEBERG

PLASTICS AS A RAW-MATERIAL BASE FOR THE PAPER INDUSTRY IN FINLAND

MUOVIT PAPERITEOLLISUUDEN RAAKA-AINEENA SUOMESSA

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Lorenzo Runeberg

PLASTICS AS A RAW-MATERIAL BASE FOR THE PAPER INDUSTRY IN FINLAND

Muovit paperiteollisuuden raaka-aineena Suomessa

Suomenkielinen tiivistelmä sivulla 4

FOREWORD

This work is part of a larger research project concerning the interaction between plastics and wood in Europe which the Forest Research Institute has on its programme. The main project has been delayed due to difficulties in obtaining original source material (i.e. due to lack of travelling funds). The infiltration of plastics in the field of paper products which has already occurred and not least the question of synthetic paper production are matters of current interest which may significantly influence the structure of the industry and the demand for pulpwood.

The Forest Research Institute wishes to thank all the forest as well as plastics enterprises who by kindly completing the questionnaires have made this publication possible.

Helsinki, August 1971

Lauri Heikinheimo

13856—71/80

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0. TIIVISTELMÄ

Muovin käyttö paperiteollisuuden raaka-aineena on huomattavasti laajentunut ja kasvanut viimeisten viiden vuoden aikana.

Suulakepuristimia paperin päällystämistä varten on nykyään (1971) 13 kpl, neljässä paperitehtaassa. Muita yrityksiä ei tällä alalla ole toiminnassa. Muovidispersioita paperin pintakäsittelyyn käyttää 10 paperitehdasta ja 4 ulkopuolista yritystä. Muoviaineiden kokonaiskulutus ilmenee taulukoissa 2 ja 3. Tärkein raaka-aine on päällystämispuolella ollut korkeapainepolyeteeni ja dispersiopuolella styreenibutadieeni.

Muovikalvoja valmistavat nykyään myös useat paperitehtaat tai niiden omistuksessa olevat muovifirmat. Taulukosta 4 nähdään, että näiden raaka-ainetarve on kasvanut keskimäärin 31 % vuosivauhdilla ja että 40 % kokonaiskulutuksesta menee nykyään paperiteollisuuden tarpeisiin. Tuotosta käytetään pääasiassa pussien ja säkkien valmistukseen, jotka täten kilpailevat perinteellisten paperivalmisteiden kanssa. Myös tällä alalla polyeteeni on eniten käytetty raaka-aine.

Kuitukangasvalmistuksessa paperiteollisuus on mukana ennen kaikkea Oy W. Rosenlew Ab:n ja Oy Tampella Ab:n ansiosta. Muoviraaka-ainekulutus on toistaiseksi suhteellisen vähäistä, koska tuotanto pohjautuu rayonkuituihin ja muovia käytetään vain sideaineena. Kuitukangastuotanto on tuonut mukanaan teknisiä muunnoksia valmistusmenetelmiin, joita soveltamalla ehkä voidaan ajaa erilaisia muovi-selluloosakombinaatioita myös tavallisilla paperikoneilla suhteellisen pienin muutoskustannuksin. Spunbond menetelmää, jolloin kuitukangasta valmistetaan kokonaan muovista, ei Suomessa ole kokeiltu.

Synteettisen paperin valmistukseen Suomen paperiteollisuus ei ole toistaiseksi osoittanut erityistä kiinnostusta. Muoviteollisuuden puolella sensijaan Upo Oy vuonna 1970 aloitti muovipaperin valmistamisen polyeteenikalvon pohjalta. Myös Wihuri-Yhtymä Oy suunnittelee tuotannon aloittamista. Synteettisen paperin ominaisuuksista verrattuna tavalliseen paperiin voidaan todeta, että puukuitu antaa paperille jäykkyyttä, huokoisuutta, läpinäkymättömyyttä ja ympäristöystävällisyyttä, kun taas muovi tekee paperista vahvan, taipuisan, pinnaltaan tasaisen sekä kosteutta ja kemikaaleja sietävän. Japanissa muovipaperin kehitystyöhön on käytetty paljon voimia ja siellä ennakoidaan tuotannon vuonna 1973 nousevan 300 000 tonniin ja vuonna 1978 2.5 milj. tonniin. Myös USA:ssa ja monissa Euroopan maissa synteettisen paperin tuotanto on päässyt alkuun. Hintasuhde on toistaiseksi huomattavasti tavallisen paperin eduksi, mutta oletetaan, että tämän vuosikymmenen loppupuolella suhde olisi tasaantunut (Kuva 2). Muovipaperin erikoisominaisuuksien ansiosta voidaan odottaa, että tämä tuote lähiaikoina valtaa markkinoita uutena paperilaatuna muun paperin rinnalla.

Paperiteollisuus on ryhtynyt valmistamaan myös vaahtomuovia pakkausteollisuuden tarpeisiin. Muoviraaka-ainepuolella Kymin Oy ja Enso-Gutzeit Oy osallistuvat Pekema Oy:n tuotantoon. Integraatio muovi- ja paperiteollisuuden välillä on täten Suomessa edistynyt jo sangen pitkälle.

Muovien tunkeutuminen paperituotantoon on selvästi havaittavissa sen koostumuksessa. Taulukko 7 esittää muovilla päällystetyn paperin ja kartongin tuotoksen, joka viime vuonna (1970) ensimmäisen kerran ylitti 100 000 tonnia, oltuaan 867 tonnia vuonna 1961. Viennin kehitys ilmenee taulukoista 8 ja 9.

Muovien kulutus paperiteollisuustuotteiden valmistuksessa tulee tänä vuonna (1971) nousemaan 70 000 tonniin eli 1/3 koko Suomen muovituonnista. Käytetystä määrästä yli 60 % jalostetaan paperiteollisuuden omistamissa yrityksissä. Taulukko 11 esittää miten muovien käyttö jakaantuu puuvanuketta täydentäviin ja kilpaileviin osuuksiin. Suoraan symbioosisuhteessa oleviin tuotteisiin ei tämän mukaan käytetä enempää kuin 38 % muovimäärästä. Jos kuitenkin otetaan huomioon kaikki paperiteollisuuden omistamat muoviyritykset yhteistyöpuolelle kuuluviksi, nousee prosenttiluku 62:een. Vuonna 1971 Suomen koko paperituotantoon sisältyy 1.5 % muovia. Voimapaperista 6 % ja kartongista 7 % on muovipäällystettyä. Itse asiassa muovin osuus on usein tärkeämpi kuin mitä suora painovertailu näyttää.

Yhteistyö muovi- ja paperiteollisuuden välillä on epäilemättä eduksi monesta näkökulmasta. Ennen kaikkea vaikea puuraaka-ainetilanne helpottuu. Lopputuotteiden jalostusaste myös nousee. On ilmeistä, että raakaöljyn tuonti tulee tulevaisuudessakin muodostumaan halvemmaksi kuin raakapuun tuonti kaukaisista maista. Raakaöljyä on myös riittävästi saatavissa, kun sen sijaan raakapuun saanti ulkomailta on epävarmaa. Kuten taulukosta 14 ilmenee, on todennäköistä, että jo lähivuosina selluloosan ja polymeerien hinnat tulevat suurin piirtein yhtymään, joten paperiteollisuus voi raaka-aineena käyttää molempia. Koska ennakkolaskelmien mukaan paperituotteiden tarve Euroopassa nousee nopeammin kuin mitä metsänparannustöiden avulla hakkuita voidaan lisätä, on syytä suosia muovin käyttöä. Taulukko 15 esittää muoviraaka-aineiden ennakoidun tarpeen Suomessa vuoteen 1980. Koska muovin käyttö raaka-aineena pienentää puun käyttöä, saattaa olla mahdollista laajentaa paperiteollisuutta nopeammin kuin pelkästään puuraaka-aineeseen perustuvat tuotantolaskelmat osoittavat.

1. INTRODUCTION

The infiltration of plastics into the Finnish forest industry both as a competitive and as a co-operative material was first investigated in 1966–67 (RUNEBERG 1967). Since the rapid development indicated by this study has clearly continued, the time seems ripe to survey the present position of the plastics and forest industries. On the basis of earlier experience, a questionnaire was sent to all factories in Finland manufacturing paper, paperboard, plywood, chipboard and fibreboard, as well as to all plastics factories whose production touches in this field. The results for the paper and paperboard industry are presented and analysed in this paper. The results for the board industry will be published separately. The tables cover the period 1967–71, the last year consisting of forecasts based on material from the first half of the year. Where material was available, 1961 has been included to show developments throughout the last decade.

The following generally accepted abbreviations for plastics are used:

MF	melamine
PA	polyamide
PE	polyethylene – LD low density – HD high density
PF	phenol
PP	polypropylene
PS	polystyrene
PUR	polyurethane
PVAC	polyvinyl acetate
PVAL	polyvinyl alcohol
PVC	polyvinyl chloride
PVCA	polyvinyl chloride acetate
PVDC	polyvinylidene chloride
UF	urea formaldehyde

The term paper industry is used in the following to cover both paper and paperboard factories.

2. SURVEY OF ENTERPRISES STUDIED AND FIELDS OF PRODUCTION

2.1. Paper-coating

The last five years have seen a powerful expansion of plastics as a raw-material base in the paper industry. If we first examine the situation with regard to coating, Table 1 shows the total number of extruder installations in 1971 for direct lamination of plastic onto the underlying paper.

A. Ahlström Oy has decided to set up a further installation with two extruders in 1972. For comparison, it can be mentioned that at the beginning of 1967 the number of installations was 5, of which only one was equipped with double extruders for coating both sides of the paper. It can also be noted that Yhtyneet Paperitehtaat Oy's new installation is probably unique in Scandinavia, in that the double extruders allow coating with different plastics on the same side of the paper. Enso-Gutzeit Oy's new machine is also particularly sophisticated, with all three extruders in a line. No new enterprises have entered this field since the beginning of the 1960s, however, and it continues to be dominated by only four paper mills. No enterprise independent of the forest industry is undertaking such operations, either. The consumption of plastic raw-material has developed since 1967 as shown in Table 2. The material used has been almost 100 % LDPE. Less than 100 tons annually consists of PVC. The rate of growth appears to have eased off in recent years but continues to be substantial.

The use of plastics as binders for paper coating has grown even faster. At present, the paper industry has 17 surface-treating installations, distributed among 10 enterprises, while a further two firms intend to install machines in 1972. Consumption is shown in Table 3.

Table 1. Extruder installations for coating at paper factories in Finland in 1971.
Taulukko 1. Suomen paperitehtaisiin asennetut suulakepuristimet paperin päällystämistä varten v. 1971.

Factory – *Tehdas*	Installations *Asennuksia*	Number of extruders *Puristimien lukumäärä*
A. Ahlström Oy, Kauttua	2	2
Enso-Gutzeit Oy, Vuoksenniska	3	7
Joutseno Pulp Oy, Lohja	1	1
Yhtyneet Paperitehtaat Oy, Valkeakoski	2	3
Total	8	13

Table 2. Consumption of plastic raw material by extruders for coating in the paper industry in Finland, 1967–71, in tons.
Täulukko 2. Paperiteollisuuden suulakepuristimissa päällystämiseen käytetty muoviraaka-aine Suomessa v. 1967–71, tonnia.

Year – *Vuosi*	Tons – *Tonnia*	Increase in % from previous year *Kasvu vuodessa %*
1961	250	
1967	6 740	
1968	9 633	43
1969	11 658	21
1970	14 226	22
1971	16 800	15

Table 3. Consumption of plastic dispersions for coating in the paper industry in Finland, 1967–71, in tons.
Taulukko 3. Paperin päällystämiseen käytetty muovidispersio Suomen paperiteollisuudessa v. 1967–71, tonnia.

Year – *Vuosi*	Tons – *Tonnia*	Increase in % from previous year *Kasvu vuodessa %*
1967	2 285	
1968	3 609	58
1969	4 702	30
1970	6 105	30
1971	8 015	31

The material used has been mainly 50 % styrene-butadiene latex, while small quantities of PVC, PVDC and PVAC have been utilized. According to the forecast for 1971, the last three materials will make up about 3 % of the total consumption.

In addition, at least four firms unconnected with the forest industry are operating in this field. These have 6 binder installations, but their combined consumption is not significant (150–170 tons annually).

2.2. Film and foils

A number of extruders owned by forest concerns are also used for manufacturing film and foils by the blowing method. G. A. Serlachius Oy in Kolho has installed an extruder with a production capacity of about 250 tons a year. The enterprise produces HDPE film which is reminiscent of silk paper, although the production should not really be considered as plastic paper. Similarly, Tervakoski Oy is currently building a new section for the manufacture of PP film for the production of condensers. Production will begin at about 500 tons a year using one extruder for film manufacture, although the section is planned from the beginning for double this capacity. In both cases, the final product consists entirely of plastic. Lamination with paper based on wood fibre does not occur.

In the sphere of film and foil, attention should also be paid to the operations of Oy W. Rosenlew Ab and Oy Tampella Ab. The former has developed its own foil production at R-Pak in Pori. This is used mainly for the manufacture of plastic bags and sacks. Oy Tampella Ab has obtained a similar capacity through the direct purchase of two plastics enterprises. Besides these forest enterprises, 12 other independent factories produce film and foil. The total consumption of raw material in this field is shown by the figures in Table 4.

Table 4. Consumption of plastic raw material for the manufacture of film and foil in Finland, 1967–71, in tons.
Taulukko 4. Filmin ja kalvon valmistukseen käytetty muoviraaka-aine Suomessa v. 1967–71, tonnia.

Year *Vuosi*	Total consumption *Kokonaiskäyttö*	Increase in % from previous year *Kasvu vuodessa %*	Of which integrated in the paper industry *Paperiteollisuuteen integroituneissa yrityksissä*	Integration % *Integroitumis %*
1961	550		–	0
1967	14 620		4 700	32
1968	19 970	37	6 580	33
1969	28 810	44	12 370	42
1970	36 160	26	15 290	42
1971	42 950	19	17 000	40

In contrast to consumption on the coating and surface-treating side, film and foil production obviously competes with forest products based on wood fibre. However, it can be seen from the figures that the paper industry has kept itself forward in this sphere and now controls about 40 % of the market through production in its own factories. The major part of production is used for manufacturing bags and sacks, while a little more than 10 % of the raw material is used for producing building foil. PE is the predominant material. Various special films are manufactured from PVC and PP, while PA has won ground in recent years; these materials altogether account for less than 10 % of the total consumption.

2.3. Non-woven products

The paper industry has also come into the picture in the field of non-woven products. One enterprise began production in Ahvenanmaa in 1960, and from 1968 has been owned by SOK and Oy W. Rosenlew Ab. Under the name Bilon Ab, the firm has greatly expanded operations and now produces 15 million metres in length annually, which involves an acrylic consumption of about 150 tons. The owners divide out the production, each continuing the processing and marketing of its own share. The final products, based on rayon, include sheets, pillow-slips, towels, table-cloths and disposable hospital supplies. Similar production was begun in 1970 at Oy Tampella Ab's non-woven factory in Tampere. At full capacity, the requirements of plastic amount to about 200 tons a year. In addition, Oy W. Rosenlew Ab is planning its own plant at Pori to manufacture fabrics by the wet process. G. A. Serlachius Oy has also shown interest in non-woven products and is making trial production using the method developed by Neste Oy, although the decision concerning final production has not yet been taken.

Two major firms unconnected with the forest industry also operate in this field. Suomen Vanutehdas Oy — Finnwad Ltd. in Jokela has been selling non-woven products based on rayon since the mid-1960s. The consumption of plastic has now risen to about 400 tons annually. J. W. Suominen Oy in Nakkila manufactures non-woven products from both leather waste and synthetic fibres. About 600 tons a year of acrylic, PP, polyester and nylon fibre are used. The consumption of rayon is comparatively small, some 150 tons a year. In addition, some 110 tons of PVAC, PVC and acrylic plastics are consumed each year as latex in the synthetic-fibre branch.

The development of non-woven products is illustrated by Table 5. At the present time, the forest industry accounts for something over 30 % of the total use.

The production of non-woven products in Finland is based at present, as has been seen above, primarily on rayon fibre produced by Säteri Oy on a cellulose base. The share of plastic is limited to the plastic added as a binding agent (10—20 %). Thanks to non-woven products, which use considerably longer-fibred material than does the traditional paper industry, the wet part of these machines has been developed according to completely new guide lines. With Voith's wet process from Germany, it is possible to use up to 120-mm-long fibre. This development appears to make possible the production of plastic or various plastic-cellulose

Table 5. Consumption of plastic raw material for the manufacture of non-woven products in Finland, 1967—71, in tons.
Taulukko 5. Kuitukangastuotteiden valmistukseen käytetty muoviraaka-aine Suomessa v. 1967—71, tonnia.

Year — *Vuosi*	Tons — *Tonnia*	Increase in % from previous year *Kasvu vuodessa %*
1967	670	
1968	770	15
1969	930	21
1970	1 180	27
1971	1 530	30

combinations on traditional paper machines with relatively modest reconstruction costs. On the other side, this technical development has also led to machines which work by the dry-forming method, for example Kroyer in Denmark. The binding together of the fibre is done by the addition of separate binding agents and only to a small degree by hydrogen bonds. These machines can use practically all types of fibre, and thus produce non-woven or normal paper according to need. The advantage lies in the modest investment costs and the small requirements of water. A drawback is the slow speed of production, which so far remains at less than 100 m per minute.

The latest phase of development as far as non-woven products are concerned is manufacture by the spun-bond method, in which the raw material is 100 % plastic, for example PP fibre. In this method, plastic threads are blown out of a finely divided mouthpiece. A separate binding agent is not required, since the fibre threads at the production stage are sufficiently heated to stick firmly together. Since the threads are thus "spun" into a net, production is undertaken through rollers in the normal way. If necessary, the roll can be heated to strengthen the binding further. Non-woven products based on the spun-bond method are produced at least in the United Kingdom, West Germany and the U.S.A. If this method becomes more widespread, plastic consumption will grow markedly, since, as was mentioned, the raw material consists entirely of plastic. Neither dry-form nor spun-bond production occurs in Finland.

2.4. Synthetic paper

The Finnish paper industry has not so far showed very much interest in the manufacture of plastic paper. The only firm to have invested in this field is Upo Oy's plastics section, which uses particularly high-molecular PE film as a starting point. Manufacture began in 1970, but is so far only in the trial stage. The quality is suitable for the packaging field, and the theoretical capacity is probably around 3000 tons a year. Wihuri-Yhtymä Oy, Wi-pakkaus, has also announced its intention to begin production based on olefin film. On the petro-chemical side, Neste Oy has developed its own method for manufacturing synthetic paper from PVC film, but the method is still untested on a production scale.

It is evident from the above that so far the plastics industry has been the more active in this branch. The paper industry, however, has taken the initiative in convening a major symposium to discuss the question in detail. The following guide lines can be given at this point.

Synthetic paper production can come under consideration for the following reasons:

Shortage of timber raw material
Demand for improved products
Need for new markets for the petro-chemical industry
Shortage of water for the conventional paper industry

In Finland, the prime cause for concern, which may contribute to the development of plastic-paper production, is the timber raw-material situation.

Synthetic paper is defined as a material made from high polymeric chemicals and treated to give paper-like properties, with the product being used for paper-like applications. The treatment in general provides opacity and printability. Various types of paper are already developed and they can be grouped according to the manufacturing process:

1) Methods of surface treatment of basic film
2) Methods of developing the film itself into paper quality
3) Methods of using synthetic fibre as a raw material.

These methods can be further divided into several sub-groups, but it lies outside the frame of this paper to examine the technicalities of production. A general comparison of the respective properties of plastic and conventional paper is, however, in order (cf. EIDEM 1971, p. 63). The figures are presented in Table 6. To sum up, EIDEM states "that cellulose gives paper pliability, porosity, opacity and disposibility while plastic gives strength, flexibility, surface smoothness and resistability against damp and chemicals."

Japan is without doubt the country which has gone furthest in the development of synthetic paper. The interest in this branch in Japan stems primarily from shortage of timber

Table 6. Pigment-coated synthetic paper compared with wood-based printing paper.
Taulukko 6. Pigmentti päällystetyn synteettisen paperin ja puukuidusta valmistetun painopaperin ominaisuuksien vertailu.

Property — *Ominaisuus*	Synthetic paper *Synteettinen paperi*	Wood-based paper *Puukuitupaperi*
Dimensional stability	Excellent	Poor
Durability	"	Good
Pliability	Poor	"
Surface smoothness	Excellent	"
Base material's opacity	Poor	"
Printability	Good	"
Waterproof	Yes	No
Mould resistance	"	"
Acid-alkali resistance	"	"
Oil-fat resistance	Good	Poor
Water-damp barrier	"	"
Possibility of reuse	Poor	Good

raw material and industrial water. This has meant that the government has taken a positive attitude towards development work and supported it in many ways. According to calculations, the saving of foreign exchange through importing oil instead of the corresponding requirements of roundwood is something in the order of 50–75 %. This does not take into account by-products from oil-refining such as butadiene, the use of which can improve the position still further. The requirements of water for synthetic manufacture are only 10 % of the water requirements for wood-fibre production, and there is no danger of pollution of water sources. There is also no need for roundwood storage places at factories.

In Japan, no less than 20 firms working primarily in the paper industry have announced plans to invest in synthetic-paper manufacture. Actual production is so far small, however, and concentrated in three enterprises. Substantial expansion is taking place, nevertheless, and should show results in 2–3 years. Figure 1 gives a picture of the estimated demand (cf. Mass production of. . . 1970, p. 23).

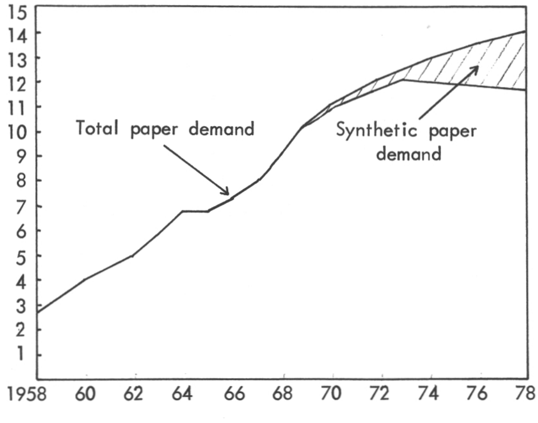

Fig. 1. Demand estimation for synthetic paper in Japan to 1978, in million tons.
Kuva 1. Synteettisen paperin ennustettu tarve Japanissa vuoteen 1978, miljoonaa tonnia.

Demand is estimated to be 300 000 tons in 1973 and 2.5 million tons in 1978 according to the latest available calculations. Since Japan's total plastics production in 1970 was c. 5 million tons, this development is obviously largely dependent on a comparable expansion of the petro-chemical industry in addition to its normal rate of growth.

Synthetic-paper production has also become a topic of current interest in other parts of the world. In North America, where one can so far hardly speak of a shortage of timber raw material, synthetic paper is developing principally to obtain improved products. At present, half-a-dozen firms in the U.S.A. are carrying on production. Their combined capacity in 1969 was c. 70 000 tons and is estimated to rise by 1972 to 300 000 tons. The major part of this consists of paper manufactured by the spun-bond method, while film-based paper only comprises a few thousand tons.

In Europe, at least the United Kingdom, West Germany, Switzerland, Italy and Finland are carrying on synthetic-paper production. The main reason can be considered shortage of timber raw materials. The units of production are so far small and mostly owned by the petrochemical industries. There are no certain figures of total production for 1971, but it can be estimated at between 10 000 and 20 000 tons.

The disadvantages of synthetic paper are the disposal problem and its price level. Since recycling possibilities are poor and the paper does not disintegrate by itself, large-scale burning would probably have to be resorted to. In this respect, there are important differences depending on the basic material. For example, paper based on PE film is much more easily burnt than PVC-based paper, from which hydrochloric acid arises as a by-product. However, it is probable that the disposal problem will be solved as production of synthetic paper increases.

As far as the price level is concerned, synthetic paper is 300–400 % more expensive than traditional paper. A marked price fall is expected, however, as large units of production are created and the price of the raw material falls further. Moreover, there is the rising price trend for wood fibre. Figure 2 gives a picture of the expected development in Japan (cf. Mass production of. . . 1970, p. 25).

(Index: ordinary paper = 100)

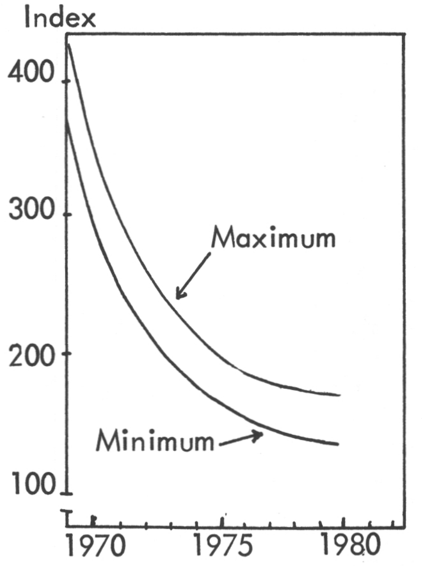

Fig. 2. Expected price reduction of synthetic paper by weight in Japan to 1980.
Kuva 2. Synteettisen paperin arvioitu hintakehitys Japanissa vuoteen 1980.

By the beginning of the 1980s, as can be seen, the price difference is likely to be relatively small. From the plastic paper sold by the Japanese, it is evident that the techniques of printing, including multi-colour printing, have been satisfactorily solved. In Japan, it is even predicted that plastic paper will compete with newsprint in five years, which seems incredible. Even at its present price level, plastic paper has a market, due to the product's special properties. Examples are its use for rain-proof advertisement posters for outdoor use, for packaging of wet products, and for special hard-wearing catalogues and suchlike. Plastic paper can later replace wood-fibre paper to an important extent. We are now in the same situation as when the first plastic bags and sacks began to compete with the corresponding paper products. It is probable that plastic paper will this decade initially win a firm foothold as a new quality in the wide assortment of paper products which a paper-manufacturing country ought to be able to offer as a matter of course to its customers.

2.5. Miscellaneous

As a further field in which the Finnish paper industry has incorporated plastics in manufacturing can be mentioned Yhtyneet Paperitehtaat Oy's section for foam polystyrene. Three automatic machines have been installed and the production will be used primarily for packaging. G.A. Serlachius Oy began developing similar production in 1970.

The participation of the forest industry in the plastics branch has further expanded to include the raw-material side. Among the share-owners of Pekema Oy, which is to process the products obtained by Neste Oy from cracking, are Kymin Oy and Enso-Gutzeit Oy, owning respectively 20 % and 6 % of the shares. Kymin Oy is also independently building a plant for the manufacture of polyester resin and softening agents, and the firm has an interest in Stymer Oy, which is to produce polystyrene.

It can further be mentioned that Myllykosken Paperitehdas Oy has become a share-owner in Paraisten Kalkki Oy, primarily so that the latter can take care of the sale of the former's production of plasterboard. In this way, a further point of contact has been created between paper and plastics. Paraisten Kalkki Oy is engaged in the plastics branch in several spheres, primarily in board production.

The following forestry enterprises are now members of the Finnish Plastics Association (Muoviyhdistys r.y.):

A. Ahlström Oy
Enso-Gutzeit Oy
Kymin Oy
Oy W. Rosenlew Ab
G. A. Serlachius Oy
Oy Tampella Ab
Tervakoski Oy

This association does not concern itself with the members' sales, but looks after their more general interests. The opposite circumstance, in which plastics firms are members of the forest industries' central organizations, has not yet occurred, Upo Oy's application for membership of the Finnish Paper Mills' Association having been refused.

3. ANALYSIS OF PRODUCTION

3.1. Main products

The penetration of plastics has naturally had a marked influence on production output. The figures in Table 7 give a picture of the quantities produced at the extruder installations belonging to the paper industry. These products are divided into the following four sub-groups for the industrial statistics (Official Statistics of Finland XVIII A 85):

4807-7011 Bleached homogenous paperboard with a coating of plastic
7012 Other paperboard
7091 Other with coating of plastic
7092 Other

The paperboard side is dominated by paperboard for milk packaging, which consists primarily of 340 g/m^2 paperboard plus 40 g/m^2 PE, divided between the two sides (14 + 26). Paperboard weighing 460 g/m^2 is also used. In addition, about 10 % of the production consists of bleached-sulphate paperboard (PE 20 + 280 + PE 20). The share of plastics in the paperboard side is between 9 and 15 %.

Production output has furthermore been indirectly influenced by plastics, in that qualities are manufactured for plastic coating at a later stage in the importing country. An example is Enso-Gutzeit Oy's 260 g/m^2 White Top quality, which is coated in Sweden.

On the paper side, production embraces what is known as industrial paper, i.e. bleached, semi-bleached and brown wrapping paper, in which the paper weight is 100–150 g/m^2. Sack paper and various laminates also occur. A quality of great interest for the future is the plastic-coated paper or plastic film beginning to be used as protection for packaged lots of sawn goods. The share of plastic in the paper qualities is about 20 % of the product's total weight.

Table 7. Production of paper and paperboard with plastic coating in Finland, 1967—71, in tons.
Taulukko 7. Muovipäällystetyn paperin ja pahvin tuotos Suomessa v. 1967—71, tonnia.

Year *Vuosi*	Plastic-coated paper *Muovipäällystetty paperi*	Increase in % from previous year *Kasvu vuodessa %*	Plastic-coated paperboard *Muovipäällystetty pahvi*	Increase in % from previous year *Kasvu vuodessa %*	Total *Yhteensä*	Increase in % from previous year *Kasvu vuodessa %*
1961	. .		. .		867	
1967	18 000		33 709		51 816	
1968	19 000	6	53 601	59	72 446	40
1969	23 000	21	65 312	22	88 826	23
1970	28 000	22	80 630	24	108 356	22
1971	31 000	11	90 000	12	121 120	12

Table 8. Finland's exports of plastic-coated paper and paperboard, 1967—71, in tons.
Taulukko 8. Muovipäällystetyn paperin ja pahvin vienti Suomesta v. 1967—71, tonnia.

Year — *Vuosi*	Export — *Vienti*	% of production *Viennin osuus % tuotoksesta*
1967	33 915	65
1968	50 991	70
1969	61 275	69
1970	74 182	68

Table 9. Finland's exports of plastic-coated paper and paperboard by countries, 1967—71, in tons.
Taulukko 9. Suomesta viedyn muovipäällystetyn paperin ja pahvin jakautuminen vientimaittain v. 1967 —71, tonnia.

	1967	1968	1969	1970
Norway	13 395	12 959	14 034	19 449
Sweden	6 786	15 029	13 028	13 366
Denmark	3 263	7 984	9 602	10 131
Netherlands	432	673	4 176	7 810
South Africa	1 480	3 163	4 163	6 587
United Kingdom	1 354	2 301	4 267	5 529
Soviet Union	3 319	2 440	2 894	3 640

3.2. Distribution of exports

Not unexpectedly, a large part of the plastic-coated qualities is exported, as can be seen from the figures in Table 8 (Official Statistics of Finland I A 89). The distribution of exports among the most important countries in tons is presented in Table 9 (Official Statistics of Finland I A 89). In all, the plastic-coated qualities go to 38 countries throughout the world. The figures show that the main exports are to the other Scandinavian countries.

4. ANALYSIS OF RAW-MATERIAL CONSUMPTION

The figures presented so far can be combined to give the total consumption of the new raw material in manufacturing connected with the paper industry. This is done in Table 10.

The question of paramount interest to both the paper and the plastics industries is how the relative shares of competitive and co-operative plastics will develop. A further analysis of the figures in Table 10 results in the figures of Table 11.

Table 10. Consumption of plastics in the manufacture of paper-industry products in Finland, 1967–71, in tons.
Taulukko 10. Paperiteollisuustuotteiden valmistuksessa käytetty muovi Suomessa v. 1967–71, tonnia.

Year — *Vuosi*	Total consumption *Käyttö yhteensä*	Of which integrated in the paper industry *Paperiteollisuuteen integroituneissa yrityksissä*	Integration % *Integroitumis-%*
1961	800	250	31
1967	24 469	13 787	56
1968	34 140	19 924	58
1969	46 263	28 871	62
1970	57 864	35 875	62
1971	69 584	42 571	61

Table 11. The shares of co-operative and competitive plastics in the paper industry in Finland, 1967–71, in tons.
Taulukko 11. Paperia täydentävän ja sen kanssa kilpailevan muovin osuus Suomen paperiteollisuudessa v. 1967–71, tonnia.

Year *Vuosi*	Co-operative *Täydentävä muovi*	%	Competitive *Kilpaileva muovi*	%	Total *Yhteensä*	%
1961	250	30	550	70	800	100
1967	9 847	40	14 622	60	24 469	100
1968	14 169	42	19 971	58	34 140	100
1969	17 451	38	28 812	62	46 263	100
1970	21 690	37	36 164	63	57 864	100
1971	26 756	38	42 748	62	69 584	100

As well as plastics from the paper industry's extruder and binder installations, all plastics used for non-woven products are included as co-operative plastics, since these products clearly expand the product range of the forest industry and only compete with the textile branch. Foam polystyrene has similarly been included, although less certainly, as co-operative since its use as inner protective material in packaging often increases paperboard's possibilities of use.

On the competitive side has been placed all film and foil used for bag and sack manufacture and in the building industry. Shrink film is difficult to place, since it is partly used in conjunction with paperboard underlays, especially in the food branch. Since a detailed analysis is practically impossible, all shrink film has been considered to belong to the competitive side. Plastic paper will obviously belong in this group as production gets under way.

The consumption of raw material in the uncertain areas is so far sufficiently limited for it to have only a minor influence on the relationship between the co-operative and competitive sides. The figures indicate that combined products of plastics and paper have increased at a somewhat slower rate during the 5-year period 1967–71 than competitive products. The share of co-operative plastics is now 38 %, against 40 % in 1967. On the other hand, as the earlier given figures indicated, the paper industry has already to an important extent itself begun to produce film and foil. These undoubtedly compete with products based on wood fibre, but do not worsen the enterprise's position as such. If this share is counted as co-operative, then the co-operative share has increased from 60 % to 62 %. In other words, at present 62 % of all plastic which is consumed for the manufacture of paper-industry goods is used either in combined products or in integrated enterprises.

If the production of plastic-coated qualities is compared with total production of paper products, the figures of Table 12 are obtained, giving a picture of the growing penetration of plastics.

The situation has developed somewhat differently on the paper and paperboard side. Coating has primarily been done on paperboard, with the result that the co-operative trend with plastic for this period has increased from 3 % to 7 %. On the paper side, the share of plastic must be chiefly related to kraft paper, in which plastic's share has increased to 6 %.

It is also possible to compare total paper and paperboard production with all plastic which has penetrated this field, i.e. both co-operative and competitive shares, as shown in Table 13.

Table 12. The shares of plastic-coated paper and paperboard produced in Finland, in 1000 tons and % of production.
Taulukko 12. Muovipäällystetyn paperin ja pahvin osuus Suomessa, 1000 tonnia ja % tuotoksesta.

Year *Vuosi*	Kraft paper *Voimapaperia*	Of which plastic-coated *Josta muovipäällystetty*	% of plastic *% muovia*	Paperboard *Pahvia*	Of which plastic-coated *Josta muovipäällystetty*	% of plastic *% muovia*
1961	311	–	0	698	0.5	0
1967	416	18	4	971	34	3
1968	430	19	4	1 069	54	5
1969	480	23	4	1 226	65	5
1970	490	28	5	1 225	81	6
1971	510	31	6	1 286	90	7

Table 13. The share of plastics in paper-industry products in Finland, 1967–71, in 1000 tons and % of production.
Taulukko 13. Muovin osuus paperiteollisuustuotteista Suomessa, 1000 tonnia ja % tuotoksesta.

Year – *Vuosi*	Production of paper and paperboard *Paperin ja pahvin tuotos*	Share of plastics *Muovin osuus*	% of total production *% tuotoksesta*
1961	2 387	1	0.04
1967	3 389	24	0.7
1968	3 629	34	0.9
1969	4 060	46	1.0
1970	4 258	58	1.3
1971	4 400	70	1.5

A direct weight comparison as presented here is not entirely successful, since plastic is often equivalent to more paper than its weight indicates. Plastic can be used in thinner layers than paper to obtain a given quality demand or durability requirement. In Japan, for example, it has been proposed that comparisons should be made on the basis of 2/3–1. The infiltration of plastics can thus effectively be considered to be 1/3 greater than the above figures show.

5. EFFECTS ON THE FUTURE OF THE PAPER INDUSTRY AND RAW-MATERIAL REQUIREMENTS

It can be seen from this investigation that plastics have now established themselves firmly in the paper industry as an important auxiliary material in manufacturing. The close co-operation which exists in a variety of ways between the plastics and paper industries can be regarded with satisfaction, especially as now home production of the most important basic plastics is ensured. In view of the difficult situation regarding timber raw material, it seems that the use of plastics is a natural way both to conserve the forests and to raise the degree of processing of the final products. That it is more advantageous to import from distant countries oil for plastics manufacture rather than roundwood for cellulose seems evident and is supported, for example, by the Japanese calculations. Transport costs always tend to operate as a disadvantage to roundwood. The transport of Persian oil to Finland, for example, costs about $ 10 a ton, while the transport of roundwood from, say, Turkey would cost about $ 18 a ton. Timber purchases from the Soviet Union can perhaps be made advantageously, but there is no security of future deliveries, since every country is attempting to develop its own processing industry. ERVASTI *et al.* (1969) assume that timber imports from the Soviet Union will end at the latest in 1990. The supplies of crude oil in the world, on the other hand, are so important that no supply difficulties should arise during the next few generations, despite the fact that the world's total demand in the year 2000 is estimated at 5000 million tons annually. The price of timber raw materials at pulp mills is at present still cheaper (in Finland on average 79 mk/ton for spruce pulpwood) than the same quality of oil at the refinery (c. 97 mk/ton). However, if the price development for processed cellulose and

Table 14. Export price of bleached sulphate compared with LDPE, PVC, PS and PP in Sweden, 1960–75, in Kr per kg.
Taulukko 14. Valkaistun sulfaatin vientihinta Ruotsissa verrattuna LDPE, PVC, PS ja PP hintoihin v. 1960–75, Kr/kg.

	1960	1965	1970	1975 (forecasts)
Bleached sulphate	0.80	0.86	1.04	1.20
PVC	2.15	1.53	1.42	1.40
LDPE	3.50	2.14	1.44	1.36
PS general purpose	2.30	1.70	1.56	1.56
PP	7.00	3.50	2.52	2.03

polymer products is compared for the 1960s, it is apparent that the price difference is disappearing. Table 14 illustrates the development (cf. EIDEM 1971, p. 65).

The Swedish prices are most suitable for comparison since there has been no devaluation. It can be seen that the price of plastics is rapidly approaching that of cellulose. The prices of the various base plastics, which still showed substantial differences in 1960, are also evening out. In fact, the price of PP has already (in 1971) fallen to less than 2 kr/kg.

It is evident that the paper industry in the future can from a cost viewpoint equally well use plastics as timber as a raw material for its products. Decisive factors will instead be quality demands and availability of the respective raw materials. As it is known, the Finnish forestry industry has now developed to the limits of the yield capacity of the forests. If the forest-improvement measures are carried out as proposed under the MERA III programme, it is possible that the timber output will rise from 53.6 million m^3 in 1971 to 69.3 million m^3 in the year 2000. The pulp industry's production capacity within the framework of all forest industries has been estimated at 13.5 million tons, requiring 51.5 million m^3 of timber. It is planned that this quantity will be processed entirely into paper in Finland, and that exports of cellulose will have ceased by the year 2000. In actual fact, the financing of the MERA III programme is unclear and this has already resulted in delays in silvicultural measures, putting the final targets in question. According to FAO's estimates, the demand for paper in Europe will meanwhile rise in the same period from 38 million tons to 140 million tons, in other words, it will quadruple (at present, four-fifths of Finland's exports of forest products are directed to Europe). From a European perspective, there are no possibilities of raising timber production at this rate, so that Europe will become increasingly dependent on imports from other parts of the world. Against this background, the possibilities of using plastics as a raw-material base seem especially welcome.

A plastics raw-material base, of course, presupposes home production of the most important plastics, primarily PE. Whether Pekema Oy's production plans are sufficient appears uncertain. The PE factory's capacity is estimated at 80 000 tons a year, which is the same quantity as was imported in 1970. This will perhaps be sufficient for the requirements of the next few years if it is taken into consideration that imports from abroad will retain a certain share of the market. On the basis of developments during the period 1967–71, the plastics requirements of the paper industry for co-operative products and for film and foils (used mainly for bags and sacks) can be estimated for the present decade. However, there is no empirical material on which to base a forecast for the manufacture of synthetic paper and for the miscellaneous group. In Table 15, which shows the probable plastics requirements of the paper industry in Finland in 1975 and 1980, it has been estimated that the manufacture of synthetic paper will double every second year from a production rate of 3000 tons in 1972 (the original Japanese estimate counted on a doubling every year during the 1970s). The miscellaneous group is estimated on the basis of announced construction plans plus an annual growth rate of 30 %, which is the average growth rate for the other four groups.

Table 15. Requirements of plastic raw material for paper-industry products in Finland, 1970–80, in tons.

Taulukko 15. Suomen paperiteollisuustuotteiden muoviraaka-aineen arvioitu käyttö v. 1970–80, tonnia.

	1970	1975	1980
For paper-coating	14 226	43 400	132 500
For binders	6 105	29 500	142 200
For film and foils	36 160	139 500	538 200
For non-woven products	1 180	3 300	9 400
For synthetic paper	10	8 000	48 000
Miscellaneous	310	2 200	8 200
Total	57 991	225 900	878 500

In view of the fact that the main plastics of the paper industry comprise different qualities of PE, it seems that the petro-chemical industry must expand its PE capacity as soon as the first installation is set in operation in 1972. Otherwise, Finland will find itself in the paradoxical situation of being forced to import plastic raw material, which the paper industry processes and then sells again abroad. A bright spot is that the European petro-chemical industry is well developed and is producing 35 % of the world's production of plastics. Thus no import difficulties need arise during a possible development period.

Already this year (1971), the use of plastics as a raw material for paper-industry products has saved a total of 500 000 m^3 timber. In 1975, the saving will be 1 million m^3 and in 1980 3.5 million m^3, i.e. about 10 % of the total raw-material requirements. These quantities are significant enough to be taken into consideration when estimating the industry's raw-material requirements. A paper industry sufficiently oriented towards plastics can perhaps be developed faster than provided for by the pulpwood raw-material estimates which have been made up to the present.

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