INDUSTRIAL APPROACH TO RECYCLING, RE-USE AND DISPOSAL OF BITUMINOUS WASTE

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KEY WORDS

Bituminous roofing membranes, waste, recycling, re-use in road asphalt

ABSTRACT

The Icopal Group produces bitumen-based membranes at 15 plants in 11 countries. This paper presents Icopal's ways of handling bituminous waste in the various countries through recycling, re-use, incineration and landfill. The paper also discusses the Group's activities to further develop processes for the use of the waste in the production of roofing membranes and road asphalt. These activities will allow Icopal to satisfy both environmental and economic requirements even better than today in its handling of bituminous waste.

RÉSUMÉ

Le groupe Icopal produit des membranes d'étanchéité bitumineuses dans 15 usines, elles-mêmes situées dans 11 pays différents. Cette communication fait le point sur la manière dont le groupe Icopal aborde la problématique des rebus de fabrication et des déchets, que ce soit en termes de recyclage, de réintégration ou d'évacuation. Elle présente également les développements récents, visant à parfaire les procédés de recyclage intégral, que ce soit dans les feuilles elles-mêmes ou dans les liants routiers. Ces développements vont permettre à Icopal, encore mieux qu'aujourd'hui, de satisfaire aux contraintes environnementales et économiques liées à son activité.

ZUSAMMENFASSUNG

Die Icopal Gruppe produziert bituminöse Abdichtungsbahnen in 15 verschiedenen Fabriken die sich in 11 europäischen Länder befinden. Dieser Vortrag gibt einen Überblick über die

Wege die eingeschlagen wurden um Produktionsabfälle und Baustellenrückstände auszuwerten. Um vollständige Rückgewinnung zu erreichen, wurden an sich bekannte Methoden verbessert. Sie ermöglichen, daß ältere oder nicht geeignete Bahnen so gut in die herkömmliche Produktion als auch, zum Beispiel, in Straßenbelägen eingemischt werden können. Diese Entwicklung entspricht dem heutigen Trend, Abfälle und Rückstände, zu vermeiden.

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1. INTRODUCTION

The environmental issue in relation to the production, handling, installation and disposal of bituminous roofing membranes is, as in most other industries, of major importance. We need to consider all impacts on the environment during the life cycle of the products and try to restrict these impacts to a reasonable level. In the past, this was often considered to be a balance or compromise between economics and environment, and between practicality and environment. However, due to improved and new technologies, governmental regulations and taxes, and changes in customer attitudes towards "environmental friendly" products, compromise is no longer always necessary.

For instance, in the handling of bituminous waste from the production of roofing membranes, the balance has shifted towards implementation of new technical processes which reduce the overall environmental impact from the product. New and better technologies and increased taxes on e.g. landfilling make it feasible in several countries to implement recycling and re-use processes which both minimise environmental impact and improve the economics of the operation. This paper describes how Icopal handles waste from the production of bituminous roofing membranes and how we try to develop and optimise processes which satisfy both environmental and economic aspects.

2. OVERVIEW OF METHODS TO ELIMINATE WASTE FROM THE PRODUCTION OF BITUMINOUS ROOFING MEMBRANES

From a general point of view there are five different ways of eliminating waste:

1. Recycle the waste into production of the same or a similar type of product
2. Re-use the waste in another type of product (e.g. road asphalt)
3. Incinerate the waste and recover the energy
4. Use the waste as landfill
5. Sell the waste as second or third-class products

All these methods have both advantages and disadvantages in terms of technical aspects, investment and operational costs, environmental issues and availability. In Figure 1, some of these aspects are summarised on a general level. The practical conditions do in many circumstances vary significantly from country to country.

Method	Advantages	Disadvantage
Recycling into same type of product	True recycling Save virgin raw materials Create positive image Improved LCA performance Save cost/tax of landfill/incineration	Large investment High operational costs Technically complicated process Extended quality control work
Re-use in other types of product	Save cost/tax of landfill/incineration Less technically complicated than true recycling into same type of products	Dependency of "external" partners and processes
Incineration	Energy recovery	Technically complicated process Bitumen waste must be diluted into other waste to avoid problems in the incinerator
Landfill	Simple, no investment	Increasing tax on landfilling In some countries landfill sites are reduced or closed
Selling of downgraded products	No investment and only limited operational costs	Compete with first-class products

Figure 1. Methods of waste elimination

3. HOW ICOPAL HANDLES THE WASTE

Country	Approx. amount of waste* from production in 1999 (tons)	Method applied to dispose the waste	Costs Euro/ton
US	800	Landfill	~15
		Sold as non-first quality products	—
Poland	1400	Landfill	~ 9
		Sold as non-first quality products	—
France	2300	Landfill	~ 60
		Re-use in road asphalt	—
		Sold as non-first quality products	—
UK	800	Landfill	~70
		Re-use in other products	—
Germany	1000	Landfill	~150
		Incineration	~140
		Re-use in other products	—
		Sold as non-first quality products	—
Norway	900	Landfill	~140
		Incineration	~125
		Sold as non-first quality products	—
Finland	200	Landfill	~50
		Sold as non-first quality products	—
Sweden	600	Incineration	~70
Denmark	400	Landfill	~110
		Incineration	~110

* This includes bitumen, reinforcement, polymer, filler, granules, etc.

Figure 2. Handling of waste from some plants

As mentioned above, the conditions and possibilities for eliminating waste differ from country to country. This means that the present system for waste handling at plants depends on geographical location. Some plants have a public incineration facility located nearby that is suitable for the incineration of bituminous waste. For others, the best disposal method is to use the material as landfill. Figure 2 gives an overview of the present waste handling arrangements at some plants.

4. ACTIVITIES FURTHER TO IMPROVE OUR PROCESSES

As already pointed out, we currently have suitable ways of disposing of production waste from our plants. Nevertheless, we of course also investigate the possibilities for developing better or new processes for recycling or reusing the waste. Our recent experience in the re-use of waste in the production of bituminous roofing membrane and road asphalt is described below.

4.1. RECYCLING WASTE INTO THE PRODUCTION OF ROOFING MEMBRANE

As a company we produce more than 500,000 tons of roofing materials annually. Inevitably, as can be seen in Figure 2, a proportion of that material does not meet our high quality standards. These non-commercial materials are mainly in the form of rolls and sometimes as small cutouts.

Besides this production waste, the Group's involvement in contracting activities also necessitates the handling of waste from the old waterproofing systems which are replaced by retrofitted roofing.

For these reasons, the optimal solution is a process that enables us to recycle most of the bituminous waste coming from production and to use old roofing membranes in our production. <u>But it has to be kept in mind that the quality of the new materials being produced should never suffer from this.</u> Moreover, the process should neither produce new waste nor generate huge amounts of "polluted" raw material to be handled.

Such a recycling process can be broken down into the following steps:

1. Preparation of the materials to be recycled
2. Shredding into small solid particles
3. Intermediate storage and solid-state homogenisation of waste composition
4. Digestion from solid state into liquid form
5. Final refining before reintegration
6. Analysis of quality and consistency
7. Integration of the recycled blend into the production of new membranes

Our activities so far have focused on identifying technically and economically sound solutions for each of the above steps.

Step 1. Preparation process

Allows recovery of any material that can easily be re-used (cardboard cores and mandrels) in the process and ensures separation of constituents that have their own recycling circuit (wrapping papers, etc.). When roofing felts reclaimed during retrofitting activity are treated, direct visual inspection to segregate polluting constituents is advisable.

The step mainly consists of unrolling production goods on conveyor belts and preparing larger non-rolled materials for further handling. This also allows foreign constituents to be detected and discarded. Sheet material from the conveyors is easily fed into the shredder, as illustrated in Fig. 3.

Figure 3. Feeding of shredder

Step 2. Shredding

Whatever the recycling process, shredding is always the first step. Many equipment manufacturers have machines specifically designed for this purpose. Dusting is mandatory to eliminate the stickiness of bared bituminous particles. A closed, noise-insulated shredding process is therefore recommended.

In our experience, to regulate the size-distribution of the particles without increasing the heat in the equipment, it is preferable to have two shredding machines working in line. Figure 4 shows the transport of waste between the two shredders.

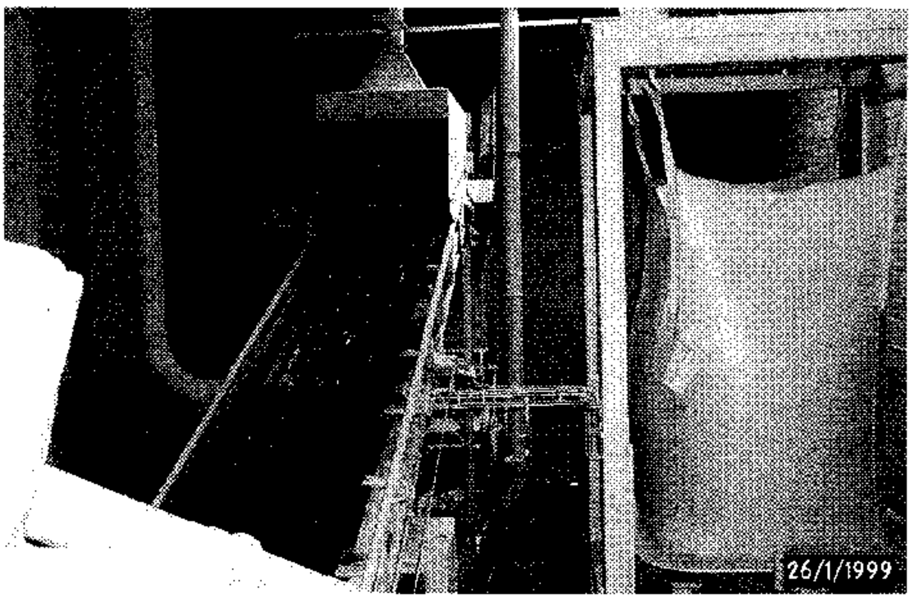

Figure 4. Transport between two shredding machines

Step 3. Intermediate storage and solid-state homogenisation of waste

Storage of waste particles from the shredding process is advisable. It allows simple solid-state mixing of waste with different compositions, enabling the next process step to be fed with "raw materials" with a more or less constant average composition in terms of bitumen, polymer and fibres.

Intermediate storage also avoids the direct linking of dissimilar process steps with different throughputs. But it does necessitate the addition of anti-sticking particles and physical protection of stored waste from direct exposure to the sun, as illustrated in Figure 5.

Figure 5. Intermediate storage of shredded waste

<u>Step 4. Digestion from solid state into liquid form</u>

For the new production to benefit from the fibres in the waste, the reinforcement in the waste particles must be distributed thoroughly when the waste is applied in a new bituminous coating. Complementary size reduction is also needed to avoid severe viscosity increase and clogging.

For these reasons, digestion and liquefying of the waste is necessary. Standard high-shear mixing equipment, working in batches of approximately 1 ton per hour, is well suited to the purpose. Wetting with fresh bitumen supports the transfer of energy from the high-shear stirring vessel to the solid waste. It is important to note that the objective is not dissolution, but simply "digestion" of any solid fibres and fine homogenisation of the blend.

Step 5. Final refining before reintegration

This step reduces the size of the remaining mineral and solid particles in the liquid obtained in Step 4. Standard equipment for milling solids dispersed in a liquid can be used for this purpose. A good understanding of the milling process enables a final size distribution with less than 5 % of non-soluble particles larger than 100 microns and no particles of more than 500 microns. The output of such equipment is approximately 500 kg per hour.

Our trials show that this fully homogeneous liquid can be mixed with polymer-modified blends at rates of up to 10% with a positive influence on the performances of these blends, both at the initial stage and after ageing.

Step 6. Analysis of quality and consistency

As mentioned earlier, proper handling of waste upstream of the process and thorough observation during the different process steps ensure consistent quality for a significant proportion of the digested and refined mix.

Of course, the blend recovered cannot be considered a regular polymer-modified mix in terms of the requirements set for our industry. With regard to polymer content, for example, successive dilution by solid-dusting materials and fresh bitumen divides the polymer concentration by almost two.

However, none of the steps mentioned above degrade any of the constituents of this final recyclable blend significantly. Our tests show that the digestion step (Step 4) in particular must be carefully analysed and optimised. This step improves the chemical stability of the blend, but it also causes most of the structural modification of the polymer and, perhaps most importantly, most of the strong links between the polymer and the continuous phase. For these reasons, systematic control of the recycled blend must be an integrated part of the plant quality control work. Figure 6 gives an idea of the typical properties of recycled blends.

R&B	Cold bend	P 25	Permanent set
110°C	-15°C	45	30 %

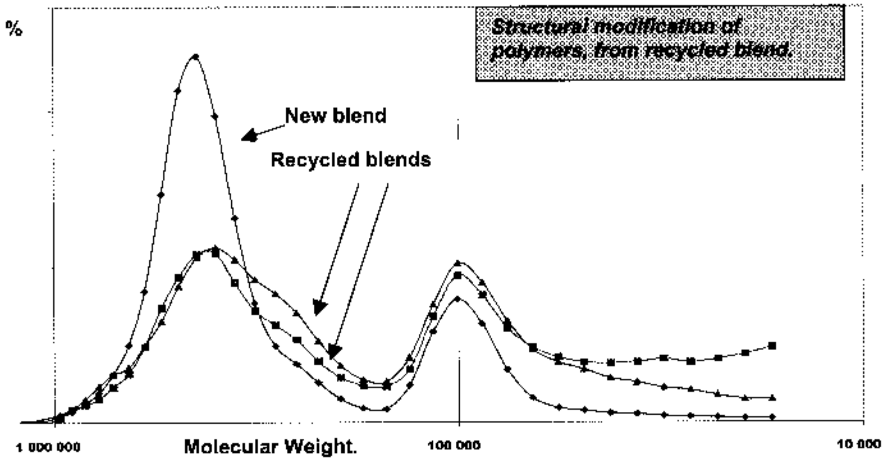

Figure 6. *Typical properties of a recycled blend*

<u>Step 7. Integrating the recycled blend into the production of new membranes</u>

One of our major issues when developing such a recycling process was to improve some of the materials' performance partly based on a recycled blend prepared in the way described above. Actually, our trials show that, even in standard polymeric blends, the addition of one part in ten of this recycled blend is beneficial for the properties of the final product. Mainly, elastic modules and temperature susceptibility of the new membrane are improved. And most important, this improvement is maintained during ageing.

Economics of the process

The process is complicated and involves many steps, using different kinds of equipment. Our calculations show that to obtain a reasonable overall economic performance, several things are essential:

- 100 % of the materials submitted to recycling is actually used.
- Minimal dilution with additives and virgin raw materials.

- Average throughput of the recycling process is in line with the reclaiming rate of waste.
- Improvement of properties in the new membranes is partly based on recycled blends.

These objectives can all be achieved using the process described above. Preliminary calculations show that the cost - including manpower, energy and maintenance - is equivalent to the value of all the major raw materials contained in the recycled blend.

4.2. RE-USE IN ROAD ASPHALT

Besides its business in bituminous roofing, the Icopal Group has substantial activities in Norway and Denmark in the road asphalt industry. Road asphalt is produced at 29 plants. For obvious reasons, re-use of production waste from roofing plants in the production of road asphalt has for some years been considered a suitable way of dealing with the waste. (Some Icopal Group roofing-membrane plants have for many years had agreements with external road companies for the delivery of bituminous waste for use as raw material in road-asphalt production and in road construction).

We have recently intensified our analysis of the technical and economic aspects of reusing the waste in road asphalt. If our findings are positive, the objective is to implement a full-scale, automated process at one or more road asphalt plants to handle waste from several roofing plants. An overall diagram of the process is shown in Figure 7.

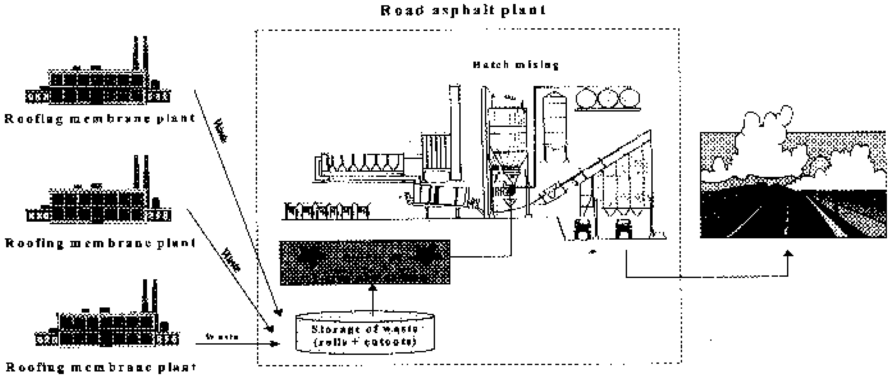

Figure 7. Overall process for reusing waste from bituminous roofing membranes in road asphalt

Technical aspects

To implement a process like that shown in Figure 7, optimisation of three technical issues is necessary:

1. Downsizing waste in rolls (and in other shapes) into small particles.
2. Mixing the waste particles with standard road-asphalt raw materials.
3. Impact of the waste on the properties of the final road asphalt product.

1. Downsizing

To obtain sufficient mixing with virgin raw materials in road asphalt production, the complete waste in rolls and in other shapes must be downsized into particles with a maximum size of approximately 10′50 mm. Such shredding processes are well-known but can include some technical obstacles such as the sticking of bitumen to knives, dust from anti-sticking additives, noise and knife wear.

One suitable way of doing this is a dry process similar to the shredding process previous described as Step 2 in the recycling of waste for the production of bituminous roofing membranes. The process consists of two cutting steps (drum cutting), with the addition of 5-20% of anti-sticking agents (e.g. talc, sand). An example of waste downsized to a particle size which allows it to be mixed with virgin raw materials in road-asphalt production is given in Figure 8.

If the downsized waste is introduced directly into the mixer in road-asphalt production, the amount of anti-sticking agent needed is low. But if the waste must be stored before introduction to the mixer, up to 25% is needed to avoid agglomeration during storage.

Using commercially available standard shredding equipment, the shredding process has the following typical characteristics:

- Machinery cost :~ 250-350,000 Euro
- Capacity :~ 1 ton of waste per hour

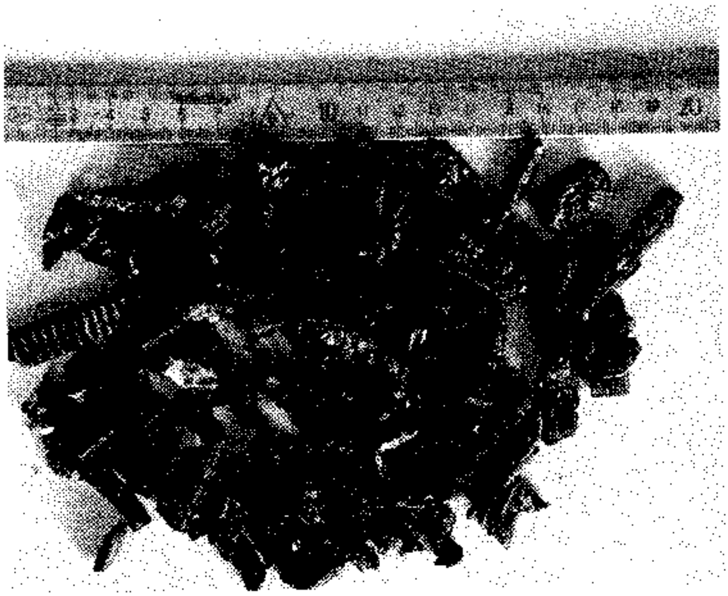

Figure 8. Downsized waste from bituminous membranes in rolls

- Operation costs :~ 50 Euro/ton (incl. manpower, energy, knives, anti-sticking agent)
- Noise and dust : Sound-protection cabin is necessary

2. Mixing waste particles into other road-asphalt raw materials

Our road asphalt production plants are mainly equipped with batch mixers (Figure 9) to which shredded waste can be fed directly. Our preliminary trials show adequate mixed material can be obtained with waste accounting for at least 5% of the total batch weight. A small extension of mixing time is, however, necessary.

3. Impact on properties of final road asphalt product

On a theoretical level, the waste from bituminous roofing membranes should make a positive contribution to the properties of the final road asphalt product, due to the addition of bitumen, polymer modifier and fibre from glass and polyester reinforcements.

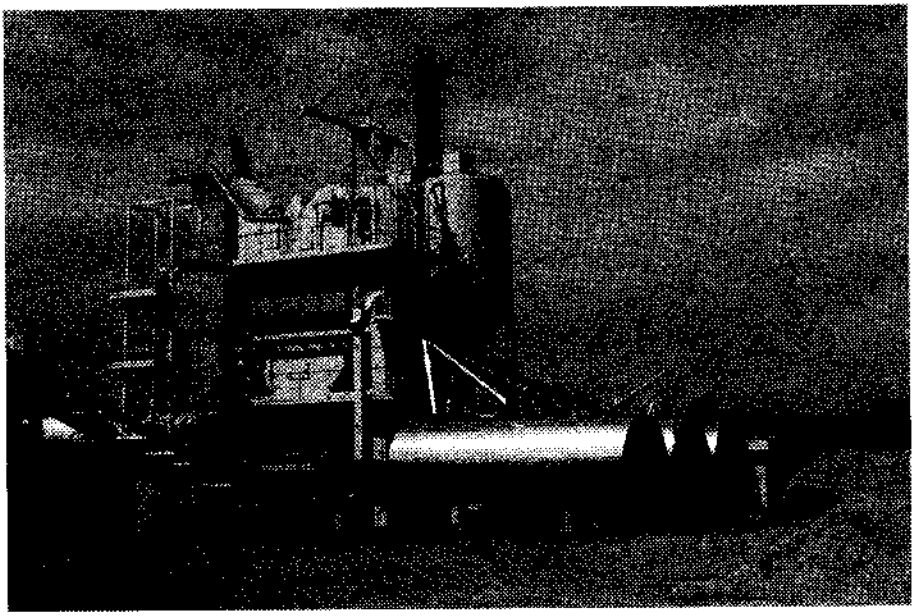

Figure 9. Road Asphalt Plant with Batch Mixer

Our first tests show that adding approximately 5% of "average standard Icopal waste" to the batch mixer results in the following benefits and positive impact on the product properties compared to standard road asphalt products (no modification of binder):

- Bitumen from the waste can substitute 40 to 50% of virgin bitumen.
- Resistance to wheel track deformation is improved.
- Improved temperature susceptibility.
- Expected longer life.
- Other relevant properties are maintained at an acceptable level.

On average, "our standard waste" contains approximately 50-55% bitumen, 3-5% SBS-polymer and 2-4% glass and polyester fibres.

From a practical operational point of view, it is complicated to control the impact on the properties of the final product and to maintain them at a stable level. Composition of the waste varies (and hopefully in some periods, the amount of available waste is quite low).

Economic aspects

The economic viability of the process must also be evaluated. This evaluation should include aspects like:

- Amount of waste to be handled.
- Transportation costs (waste from roofing-felt plant to road-asphalt plant).
- Operational cost (manpower, energy, knives, general maintenance.
- Investment in shredding and waste-handling equipment.
- Raw-material savings in road-asphalt production.
- Savings in the cost of landfilling or incineration.

Other benefits which are more difficult to value in terms of money, but which should also be taken into consideration in the overall evaluation of the process, are:

- Improved performance in life-cycle assessments for the roofing membrane as the waste is re-used instead of being used, for example, as landfill.
- Improved performance in life-cycle assessment of the road asphalt, as less virgin raw materials are consumed.
- General improvement in the environmental image of both products and plants.

Our rough preliminary calculations show that re-use in road asphalt is particularly interesting from an economic point of view when geographical distances allow the re-use of waste from more than one roofing-membrane production plant.

5. CONCLUSION

The recycling or re-use of waste is an important parameter in improving the environmental performance of bituminous roofing membranes. This paper has described how our

Company handles this waste today and how we are working on technical solutions further to improve this handling. The focus is on the processes which allow us to recycle the waste back into production of bituminous membranes and to re-use the waste in the production of road asphalt.

Both processes are technically complicated and involve a number of steps, all of which need to be thoroughly analysed and optimised. Assuming that technically feasible solutions are found, our preliminary analysis shows that, in financial terms, they may be preferable solutions to using waste as landfill.

Currently, our work with the two processes is mainly focused on the handling of waste from production. At a later stage, we shall study extension of the processes to handle waste from renovation jobs.