PROJECT FINAL REPORT

Final Publishable Summary Report

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Project acronym: FOIRCEV

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1. Executive Summary

The forest fire hoses market sector demands better performance of the fire hoses, optimized manufacturing processes and lower costs. In that sense, the objectives of the FOIRCEV project are twofold. On the one side we developed a new rubber blend formulation that allows us to achieve better properties in fire hoses and lower rejection rates in the manufacturing process. On the other side FOIRCEV developed an innovative continuous vulcanisation method that will allow hose manufacturers achieve longer hoses with reduced costs.

The new blend formulation reduces the rejection rate currently caused by pores in the outer layer of the hose produced during vulcanisation. The method used at the moment vulcanises the hose from the inside to the outside. During this process gas bubbles are produced in the outer layer of the hose. These bubbles do not affect the basic properties of the hose, but unfortunately they are highly apparent in the external surface. Hoses with such defects do not pass the strict quality controls enforced in these kinds of products. Current rejection rates can be as high as 30%. That implies important losses for hose manufacturers and the fact is these additional costs are then cumulated into the cost of the final product.

The second innovative development in the FOIRCEV project is the continuous vulcanisation method. Currently, a complete hose is obtained from the extrusion process and then it is vulcanised all at the same time. In this approach, the hose coming out of the extrusion machine is laid out on a vulcanisation table of the length of the hose. The longer the hose, the longer it must be the vulcanisation table and also the manufacturing plant since these hoses cannot be bent before vulcanisation. As hoses become larger, the cost of equipment and the space required becomes prohibitively expensive. In practice the length of the hose must be limited to between 150 and 200 m.

On the contrary, in FOIRCEV we have developed a combination of IR and Microwave ovens that allow us to vulcanise the hose in a continuous process, as it comes out of the extrusion machine. In that way it is possible to produce hoses of any length and the footprint of the plant required for the process is reduced to the bare minimum. The continuous vulcanisation process also contributes to reduce rejection rates since vulcanisation is now uniform through the complete thickness of the walls of the hose and the chances for pores formation is now much reduced.

2. Summary description of project context and objectives

The fire hose is probably the most important piece of equipment used by forest fire-fighting brigades. It is the fire-fighter's lifeline; the umbilical cord connecting the fire-fighter with the water source; a water supply that cannot fail even in the most critical situations.

Fire-fighters place huge demands on lay-flat delivered fire hoses. Forest fires imply additional constraints for the water hose since there can be several hundred meters of very harsh ground between the fire and the water tank; including foliage, stones and hot ashes. In consequence, the composition and structure of a fire hose must be designed so as to ensure proper performance under the most difficult work conditions and to provide maximum safety to the fire-fighter. These requirements imply high mechanical resistance for pressurised water and convey anti-abrasive properties to ensure integrity in rough environments and resistance to oil and hydrocarbons in the outer layer. In addition, fire hoses must be flexible enough so that they can be transported flat.

The main types of lay-flat delivered fire hoses are described in the British Standards Institution BS6391 Specification, which can be considered the industry standard worldwide. Most advanced fire hoses (i.e. Type 3) are manufactured by extruding a rubber compound "through the weave" to form an internal lining and external cover chemically bonded to a circular woven synthetic jacket sandwiched in the middle. Only a handful of manufacturers in Europe and USA have the technological ability to produce them and, until very recently, this technological advantage had avoided competition from Far East countries.

If we analyse the problem from the perspective of the fire brigades, we notice forest fire fighting must normally operate in remote areas. Typically long water line systems are needed from the pump track to the fire front. These water lines are built by connecting shorter hoses, but the whole line can reach up to 3 km and its weight can rise up to 2.000 Kg due to the added weight of hose, joints and couplings. The mobility and agility of the fire-fighter wearing a heavy hose is very much reduced under these circumstances. Also, water pressure drops at every joint and leaking at the weak point of the joint becomes a critical problem with longest hoses. These facts combined often set an important limitation to the efficiency of the fire-fighters in forest fires. For that reason, conditions would improve significantly if longer, lighter and more flexible hoses could be produced with the same or better levels of performance. Unfortunately, these long hoses are not available in the market at the moment.

On the side of the manufacturer, the composition and mixing process of present coloured rubber compounds seem to be a major source of complications at vulcanization stage. Due to some reasons inherent to the manufacturing process, the rate of product rejection of Type- 3 fire hose manufacturing is astonishingly high (up to 30%). This is a critical source of no-return costs and the most important problem of the sector which has been unsuccessfully tackled several times in the last decade.

On the other hand, the present manufacturing processes, using vapour vulcanisation, place practical limitations on the maximum length it is possible to achieve with a fire hose. Presently, the problem is the batch process requires a vulcanisation table of the same length of the hose.

Also vapour pressure is more difficult and more expensive to achieve in longer hoses. Current technological constraints limit the length of the hose to between 150 and 200 m; far below the market expectations.

In summary, market needs are fairly unsatisfied at the moment because there is a high demand in the fire fighting sector for a continuous vulcanisation system able to produce longer hoses, with lower rejection rates and using more costs effective production methods.

The specific objectives of the project can be described as follows:

- Development of rubber compounds for thin products:
    - without surface defects or pores produced during vulcanization
    - with adherence to the textile reinforcement and physical properties required by standards
- Development of a surface vulcanization method that will:
    - Give the surface of the extruded hose enough strength to suppress plasticity during vulcanization
    - Hold the shape of the hose during vulcanization
    - Reduce vulcanization time when the current discontinuous vulcanization is applied
- Development of a reliable continuous vulcanization method that will:
    - Be able to produce longer hoses
    - Increase productivity
    - Have a reduced footprint on the industrial manufacturing plant
- Development of a more appealing finished rubber hose that:
    - will be lighter
    - Will be more flexible.

3. Description of main S & T results/foregrounds

In FOIRCEV we addressed the above needs by means of two outstanding developments: a new rubber blend formulation and an innovative continuous vulcanization system.

The new formulation allowed us to achieve lower rejection rates and better properties of the final product. The new formula, combined with the new vulcanization process, has been optimised to limit significantly gas release from the rubber and hence reduce the number of pores in the outer surface of the hose; the main cause for rejection. On the other hand, the new formulation improves the flexibility for better handling of the hose.

The second innovative development in the FOIRCEV project is the continuous vulcanization system. Our method uses a sophisticated combination of Infrared, Microwave and hot air tunnels to achieve an optimized vulcanization cycle. Furthermore, the batch process is no longer necessary since fire hoses can be vulcanized continuously with no practical limitation in its length.

The new process allows us to achieve faster production rates and lower costs. However, the main benefit is the possibility to produce fire hoses of any length; thus addressing one of the main market needs. Furthermore, since the process is continuous, the size of the production facility is no longer related to the length of the hose. In addition, the new process is more costs effective, both in terms of necessary equipment and energy consumption. The continuous vulcanization process will also contribute to reduce rejection rates since vulcanization is now uniform through the complete thickness of the walls of the hose and the chances for pores formation is much reduced.

Our current solution is based on a thoroughly laboratory analysis of the vulcanization profile of the newly developed formulation. In that sense, the vulcanization cycle has been optimized by implementing a multistage vulcanization system able to progressively increase the temperature of the hose in several steps; each step consisting of a combination of Infrared, Microwave and Hot Air tunnels. In that sense, the Infrared oven is used to preserve the circular shape of the hose when it comes out of the extruder. The Infrared oven only cures the outer surface of the hose but this is sufficient to preserve its shape before entering the next stage. On the other hand, the microwave tunnel is required at each new step of the cycle to apply fast temperature changes to the hose. The advantage of microwave technology is microwave radiation is able to penetrate the complete thickness of the rubber and uniformly increase its temperature in a very short time. Finally, the Hot Air tunnel is used as a cost effective alternative to sustain the temperature of the hose for the time required in the curing cycle.

The result of this complex technology is a new continuous vulcanization system able to produce fire hoses of any length with reduced costs and very low rejection rates. The current solution has reduced vulcanisation time from 1h 30 ´´ to barely 40 ´´; thus optimising the length, and hence the costs of the vulcanization system, and also the energy consumption.

4 Potential impact and main dissemination activities and exploitation results.

The FOIRCEV product is specifically aimed at the forest fire fighting sector. End users for these hoses are fire-fighters from public fire departments of local authorities, government agencies and private fire services. However, the same product can be used with advantage in other fire fighting applications; such as fires in buildings, industrial fires; etc. FOIRCEV hoses are also suitable for other application domains such as: agriculture, mining and industry, for irrigation, compressed air supply, petroleum and flammable non polar liquids transfer, mine dewatering, protection of cables and tubes, and others.

The main competitive advantage of FOIRCEV hoses is that we are able to produce hoses of any length; i.e. we are no longer constrained by the limitations of the production process and hence we can provide hoses according to the demands of the fire fighters. In that sense, we can supply fire hoses several Km long; only limited by the inherent weight of the hose.

Longer hoses offer many advantages for fire fighters. A long hose is faster and easier to deploy because there is no need to use couplings joining the several sections of the hose. We must also consider metal couplings are very heavy and hence FOIRCEV hoses will be significantly more lightweight for the same length. On the other hand, if we do not use couplings, there is no leaking or pressure drop at the joints and, in consequence, the range of the hose can be improved significantly; i.e. more water pressure implies fire fighters are able to reach longer distances from the fire front or increased height, if the fire is in a tall building. Also, no coupling means no jamming when the hose is dragged on the floor and no coupling repairs needed.

Currently, there is no such product in the market. For that reason, we consider FOIRCEV will have an edge over the competition and market expectations are very high. The product can be positioned as a high end product and marketed worldwide by the members of the Consortium. In that sense, the estimated annual global market for Type 3 fire hoses is estimated in 100 M. Euro; half of it only in Europe. FOIRCEV sales may capture a significant share of this market.

Finally, we must highlight the advantages the FOIRCEV hose production technology may contribute to hose manufacturers and other members of the FOIRCEV supply chain. Firstly, FOIRCEV will contribute to improve the competitiveness of the participants in the supply chain by providing a high value product with no competence at the moment. Secondly, FOIRCEV will allow hose manufacturers to develop new products and enter new markets; which have been banned up to the moment due to more aggressive competitors or protective regulations. Also, FOIRCEV will act as a technology barrier against other cheaper but less sophisticated products. Finally, FOIRCEV will contribute to improve hose manufacturers competitiveness which can be measured in terms of lower rejection rates, lower energy consumption and the fact that the size of the manufacturing plant no longer needs to be correlated with the length of the hose.

5. Address of project public website and relevant contact details

5.1. Consortium Members

PARTNER	PARTNER	SHORT NAME	COUNTRY
	European Rubber Compounds S.A.	Eurorubber	Spain
	Elastómeros Riojanos S.A..	ELASTORSA	Spain
	Sapin S.r.l	Sapin	Italy
	Lescuyer et Villeneuve	Lescuyer	France
	Consejo Superior de Investigaciones Científicas	CSIC	Spain
	Tecnologías Avanzadas Inspiralia,S.L.	ITAV	Spain
	Fraunhofer ICT	Fraunhofer	Germany
	Associação Nacional de Bombeiros Profissionais)	ANBP	Portugal

5.2. Project Contact

Any information or request about the project or the FOIRCEV products, please address it to the project contact point:

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