11th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.

IMPROVEMENT OF PLASTICS PROPERTIES

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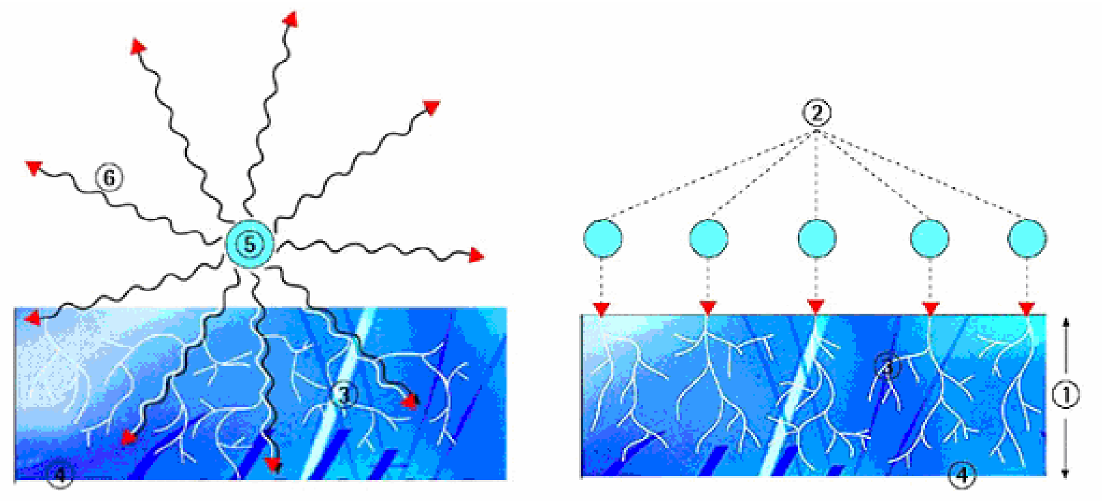
ABSTRACT
Radiation processing involves the use of natural or man – made sources of high energy radiation on an industrial scale. The basic of radiation processing is the ability of the high energy radiation to produce reactive cations, anions, and free radicals in material. Industrial application of radiations processing of plastic and composites include polymerization, cross - linking and degradation, graftin. Radiations processing involves mainly the use of either electron beams from electron accelerators or gamma radiation from Cobalt – 60 sources. Radiation processing does not make product radioactive. A major of industrial applications of radiation processing are cross - linking of wire and cable insulations, tube, heat – shrink cables, components of tires, composites, mould product, for automotive and electrical industry etc. A second major application of radiation processing is sterilization of medical disposables. Comparison of the mechanical and thermal properties of natural and irradiated polypropylene (unfilled and filled – 25% GF) is presented in this lecture.
Keywords: polymer, irradiation, crosslinking, properties

1. INTRODUCTION
The cross – linking of rubbers and thermoplastic polymers is a well – proven process the improvement of the thermal properties:
Chemical cross – linking or vulcanization of rubber normally takes place trough the effect of heating after processing by attendance of curing agent.
The cross – linking process for thermosets takes place in a similar way. In thermosets the polymer molecules are also chemically linked by heat after processing.
Cross – linked rubbers have a wide – meshed molecular network that keeps them soft and their properties change only slightly over a wide temperature range. Thermosets on the other hand are characterized by a very narrow – meshed network. Due to this fact they hardly change their high level of stiffness over a wide temperature wide.
The irradiation crosses – linking of thermoplastic materials via electron beam or cobalt 60 (gamma rays) takes place separately after the processing. The level of cross – linking can be adjusted with the irradiation dosage and in many cases with the help of a cross – linking booster.
The main deference between beta and gamma rays lies in their differing abilities to penetrate the irradiated material. Gamma rays have a high penetration capacity. In the case of electron rays, penetration capacity is depends on the energy of the accelerated electrons.
With electron accelerators, the required dose can be applied within seconds, whereas several hours are required in the gamma radiation plant.
The electron accelerator operators on the principle of the Braun tube, whereby a hot cathode is heated in a vacuum to such a degree that electrons are released.
Simultaneously, high voltage is generated in a pressure vessel filled with insulating gas. The released electrons are accelerates on this vessel and made to fan out by means of a magnetic field, giving rise to a radiation field. The accelerated electrons emerge via a window (Titanium foil which occludes the vacuum) and are projected onto the product.



a b

Fig. 1. Design of Gamma rays (a) and Electron rays (b)
a) 3 – secondary electrons, 4 – irradiated material, 5 – encapsulated Co – 60 radiation source, 6 – Gamma rays
b) 1 – penetration depth of electron, 2 – primary electron, 3 – secondary electron, 4 – irradiated material

Cobalt 60 serves as the source of radiation in the gamma radiation plant. Many of these radiation sources are arranged in a frame in such a way that the radiation field is as uniform as possible. The palleted products are conveyed trough the radiation field. The radiation dose is applied gradually, that is to say, in several stages, whereby the palleted products are conveyed around the Co – 60 radiation sources several times. This process also permits the application of different radiation doses from one type of product to the next. The dimensional stability, strength, chemical resistance and wear of polymers can be improved by irradiation. Irradiation cross – linking normally creates higher strength as well as reduced creep under load if the application temperature is above the glass transition temperature (T_g) and below the former melting point. Irradiation cross – linking leads to a huge improvement in the resistance to the most chemical and often leads to improvement of the wear behaviour.
The thermoplastic which are used for production of various types of products have very different properties. The main group presents standard polymers which are easy obtainable with favourable price conditions [1]. Disadvantage of standard polymers are limited both mechanical and thermal properties. The group of standard polymers is the most considerable and its share in production of all polymers is as high as 90%.
The engineering polymers are very important group of polymers which offer much better properties in comparison with standard polymers. Both mechanical and thermal properties are much better than in case of standard polymers. Production of these types of polymers is less than 10 %.
High performance polymers have the best both mechanical and thermal properties but the share in production and use of all polymers is less than 1%.
But it is necessary to say that in decision – making process which kind of polymers will be in the end used is the application area and price. The differences in price are exorbitant – from (unit) euros (standard polymers) to hundred euros in the case of some types of high performance polymers [2].
In connection with these dates we have to ask if it is necessary to use engineering polymers or even high performance polymers in some application. In many cases it would be possible to use standard or engineering polymers and improve their properties, e.g. by irradiation.

2. EXPERIMENTAL

Properties of natural (not irradiated) and irradiated polypropylene (PP) both unfilled and filled with 25% of glass fibres have been compared. Injection moulding machine DEMAG – EGROTECH 50 – 200 has been used for sample preparation. The radiation dose reaches the level of 15 and 33 kGy.

Used polymers:

- PTS – Crealen EP – 2300L1 – M800 (unfilled PP)
- PTS – Crealen EP8G5HS* M0083 (PP filled 25% glass fibres)

Irradiation was realized in the work of the firm BGS Beta Gamma Service GmbH & Co, KG, Saal am Donau, Germany with the electron rays, electron energy 10MeV, doses minimum of 15 and 33 kGy.
In comparison of unfilled PP and PP 25GF the crosslinking grade (measured by xylol gel test) is at about 15 % higher after irradiation. The doses of irradiation have only limited influence on the crosslinking grade. The big differences of all measured mechanical properties have been observed.
The crosslinking improve the tensile strength and modulus (Fig.2, 3). The same could be state in case of flexural strength (Fig 4, 5). The improvement of these properties is as high as 15 to 25 %.The improvement of mentioned mechanical properties is not free. We have to pay for this by degreasing of impact strength mainly by unfilled PP (Fig.6,7) .

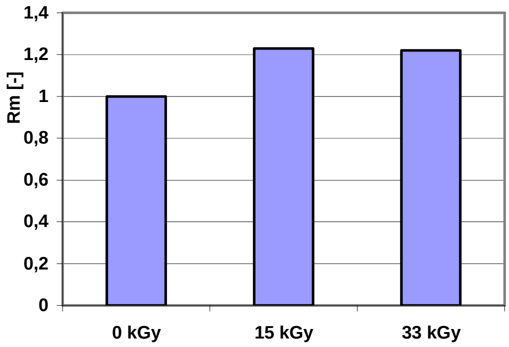


Fig.2 Tensile strength – PP

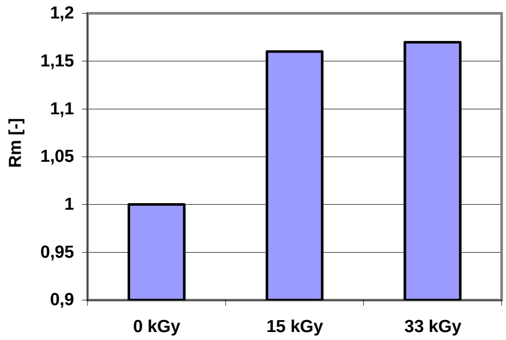


Fig.3 Tensile strength – PP 25 GF

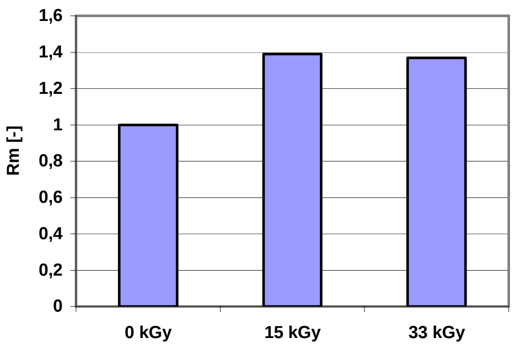


Fig.4 Bend test – PP

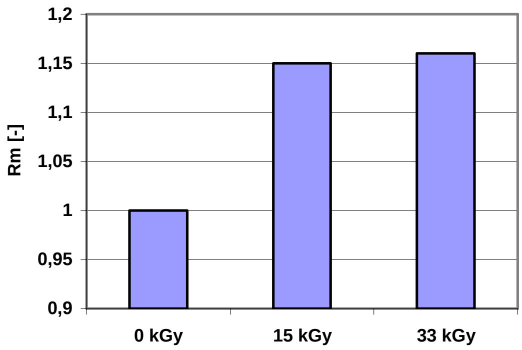


Fig.5 Bend test – PP 25 GF

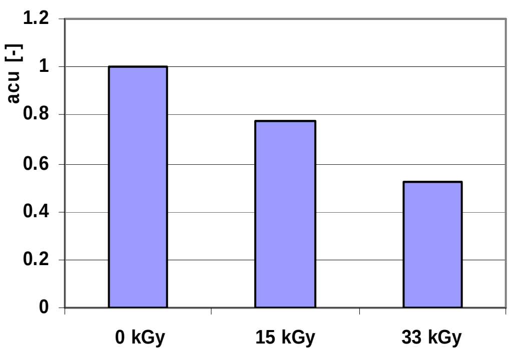


Fig. 6 Impact strength – PP

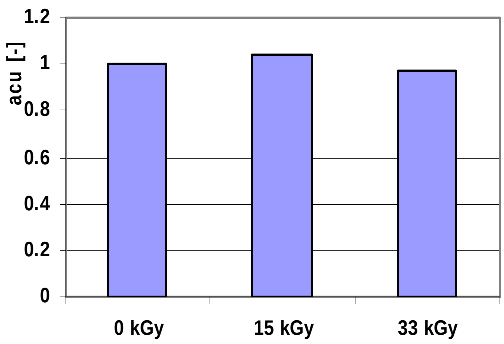


Fig. 7 Impact strength – PP 25 GF

The most important changes of properties have been found by TMA. The improvement of thermal stability of irradiated PP even by temperature much higher than its former melt temperature has been observed. Better thermal stability has been found by irradiated filled PP (Fig. 8)

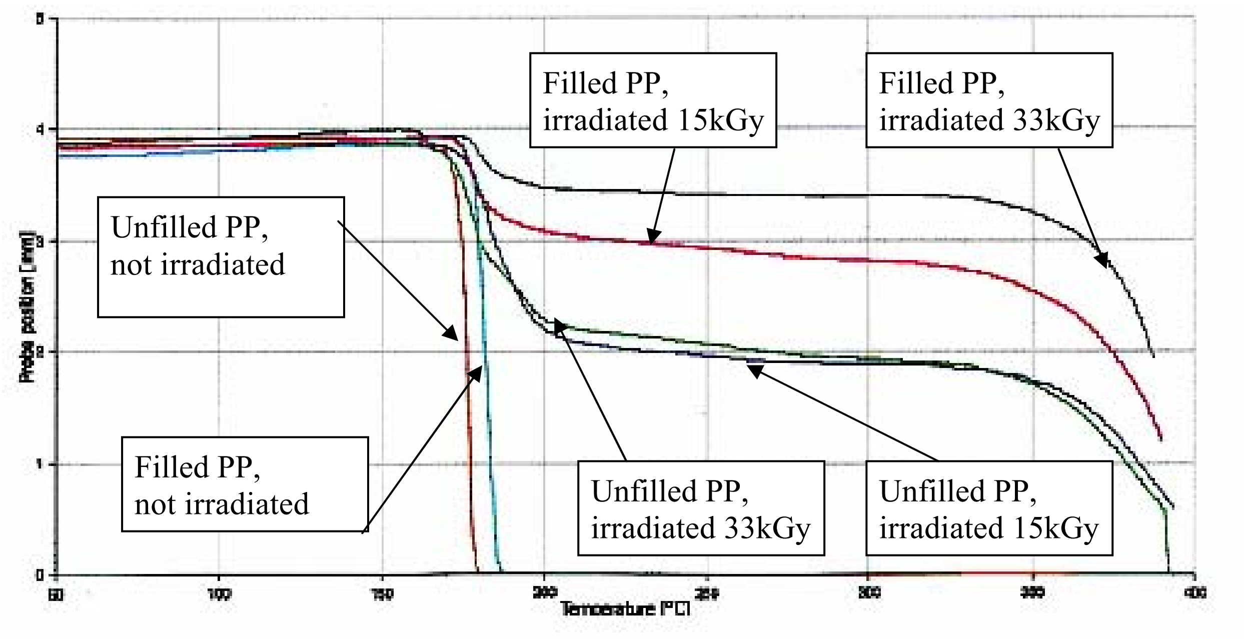


Fig. 9 Results of thermal stability

3. CONCLUSION

The differences of mechanical and thermal properties of irradiated and natural PP have been found. From the point of view of practise use the most important is the enormous improvement of thermal stability of irradiated PP. Important details:

- Irradiation will be realized on the final parts, for example injection moulded parts
- The product after irradiation is not radioactive
- The processability of polymers is not effected by booster content
- The irradiation is an additional process which is not free of charge. Irradiation needs additional costs. It is necessary to take in account all benefits coming from irradiation process already during the designing stage of plastic product.

4. ACKNOWLEDGEMENT

This article is financially supported by the Czech Ministry of Education, Youth and Sports in the R&D project under the title ‘Modelling and Control of Processing Procedures of Natural and Synthetic Polymers’, No. MSM 7088352102.

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