ELECTRON BEAM PROCESSING OF INDUSTRIAL MATERIALS AT BRIT-BARC USING ILU-6 EB ACCELERATOR

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ABSTRACT

The program of utilization of high energy electrons for radiation processing of industrial materials started with the installation of a 2 MeV, 20 kW industrial electron beam (EB) accelerator at BARC in Mumbai. During the last four years many EB processed products & related industrial applications have been developed in the fields of polymer modifications (crosslinking, degradation, grafting etc.), color enhancement in precious stones, hydrogels and yielded commercial benefits to the industry. A variety of material handling systems and conveyor systems have been installed in the accelerator facility to enable EB processing on industrial scale for various applications and the accelerator is being used as a product, process development and service rendering facility.

keywords

Industrial electron beam accelerator; radiation processing; polymer crosslinking; degradation; diamond coloration;

INTRODUCTION

Industrial electron beam accelerators upto 10 MeV are commonly employed for radiation processing applications [1] to bring modifications in polymer materials, sterilization and hygienization of health care products, color enhancement in gemstones etc. World wide there are more than 1000 accelerators operating on three shift basis for such applications. The advantages of EB process are well known, to mention a few, viz., clean, room temperature process; requirement of lesser or total elimination of addition of chemicals; ease of machine operation (on-off type); possibility of hooking up to factory on-line process. Last few years, BARC has extensively carried out studies, developed and demonstrated the EB process & related technology to the Indian industry on laboratory/pilot scale using a 2 MeV electron accelerator. This includes crosslinking of wire and cable insulation, PE 'O' rings for high temperature applications, heat shrinkable sleeves & sheets to impart shape memory, degradation of PTFE scrap to obtain micro-fine powder and diamond coloration in collaboration with various Indian industry.

ACCELERATOR

The industrial electron beam accelerator is ILU-6 type, pulse linear accelerator (fig.1) and can be operated up to energy 2 MeV and 20 kW power[2]. The machine is designed to deliver a dose (average) of ~ 33 kGy/s at the centre. The beam is uniformly scanned over a length, thus constituting an irradiation area of 10 x 100 cm. The machine is housed in a shielded cell having a labyrinth with separate entry and exit ports where power roller conveyor system has been installed for the material transport in & out of the irradiation zone.

APPLICATIONS DEVELOPED AT BARC

1. *EB crosslinking of polyethylene 'O' rings* : Process optimization studies have been carried out for radiation crosslinking of polyethylene 'O' rings to impart high temperature (200^0C) dimensional stability to these products. In order to uniformly crosslink these 'O' rings (2 mm wall thickness and 50mm &15 mm inner dia.) on a commercial scale, a rotating multi spindle conveyor system has been designed which can meet the desired dose uniformity and throughput. The physico-chemical characteristics of the finished product have been studied using techniques like DSC, sol-gel, melt-flow index and thermo-mechanical analysis[3]. A multi- spindle under beam geometry is being employed to irradiate one lakh rings per day for the industry on a commercial basis.

2. *Degradation of Polytetraflouro- ethylene (PTFE) :* Process parameters have been optimized to reduce uniformly the molecular weight of PTFE (teflon) scrap without the need of any additives, on a pilot-plant scale. Microfine powder <10μm has been obtained from the electron beam irradiated scrap using conventional grinding techniques to use as industrial lubricants and coatings. The product has been tested by the user industries and found to meet their requirements.

3. *EB crosslinkable formulations for wire & cables:* The advantages of EB crosslinking of wire & cables are well established and it is the most important commercial application of radiation technology. The process results in a product that offers many advantages over chemically crosslinked cables *viz.* higher operating temperature of 120^{o}C, much lesser thickness of the insulating material, high throughput and energy savings in consumption since crosslinking is done at room temperature. In collaboration with Indian cable industry[4], EPR/EPDM based formulations that can be crosslinked using EB accelerator have been developed to meet the customer specifications. Some of the cables are already being used by Indian Railways in high power diesel locomotives.

4. Heat shrinkable products: Another important application is production of heat shrinkable products based on shape memory effect. These include sheets, cable end joints, films for bunching, wrapping etc. In collaboration with the related industry, parameters have been optimized to process heat shrinkable sheets on longer lengths, processed & successfully expanded at the factory on-line conditions.

5. *Colour enhancement of precious stones* : To impart/enhance the colour in precious stones like diamonds and topaz, the accelerator process parameters and the irradiation system have been standardized. EB irradiation service for diamond coloration is offered on a commercial basis.

6. Special grade paper pulp for viscose rayon industry: EB treatment has been utilized to bring down the degree of polymerization of paper pulp so as to reduce the requirement of reagents such as NaOH and CS_2 in the viscose-rayon process. The feasibility of using EB for the process on a pilot-plant scale has been demonstrated in collaboration with Indian rayon industry. Upto 40% reduction in the quantity of CS_2, $NaOH/H_2SO_4$ can be achieved by using the irradiated pulp instead of conventionally aged pulp. Reduction of the CS_2 concentration leads to much less pollution of atmosphere as the emission levels of H_2S are significantly reduced.

7. Surface Curing Studies : Surface curing applications have been carried out with 900 keV energy electrons. Epoxy based formulations are developed to cure (polymerize and crosslink) thin coatings on wood base.

FUTURE SCENARIO

Expertise has been developed in processing industrial materials using electron beams and EB dosimetry. BARC-BRIT rendered necessary expertise to set up industrial EB accelerators by the Indian cable industry and two such machines are in operation for multi product irradiation. Two more EB accelerators covering energies upto 10 MeV are being indigenously developed by BARC in NaviMumbai and are nearing completion. More applications viz. food irradiation, sterilization of health care products, recycling of scrap butyl rubber, hygienization of sewage sludge, detoxification of chemical effluents, new polymer blends for high engineering applications are being actively pursued.

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