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Recent Advances in Application of EB Technology

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Abstract:
In this paper recent advances in application of electron beam technology are presented. Important industrial and scientific achievements of the international community, together with research by Mediscan, Austria, an operator of a state-of-the art electron beam service center and innovator in the field of EB-Technology are reviewed.
In addition, areas which may play an important role in the future are identified. Special focus is on the use X-ray converters and the potential for industrial applications.

The paper is divided into five sections:
In the first section, a short review of recent developments in accelerator technology is presented. This review is structured in different energy and power regimes and mainstream applications are linked to them.

High energy and high power systems, which have been designed for industrial electron and X-ray applications are presented. In this context, the regulatory issue regarding the energy limit for electrons and X-rays in the revision the ISO 11137 standard "Radiation Sterilization of Health Care products" are discussed.

Medium energy accelerators, the workhorse of EB Technology, gain importance in industrial and environmental applications.
Electron energies around 1 MeV will play an important role in the field of decontamination of food packaging and the pharmaceutical industry. New applications and important market prospects, like the decontamination of food packaging material and are discussed.

As important step in the HACCP (Hazard Analysis and Critical Control Point) of food processing, microbiological uncontaminated food packaging material is of public interest.
"Closed Container" products, like PET-bottles before filling can be sterilized using electrons energies between 1 and 1.5 MeV. The electron beam is usually high enough to penetrate the polymer and deposit the required dose with excellent uniformity in the product volume
In contrast to other decontamination methods, like hot steam or Peroxide, electron treatment is fully residual-free The challenging design of an inline-system which may be part of the in-line filling process is discussed and possible concepts, together with shielding and interface requirements are described.

Low energy systems have a success story in surface treatment. Trends towards lower energies below 100 keV are discussed, which demand new beam extraction design. To illustrate this approach, concepts like "ulta-low-energy machines" are presented.
Low energy electron accelerators play an important role in the decontamination of products, where the sterilized volume is openly facing the beam. Examples are containers for food (cups and various bottle tops and sport caps) and pharmacy.
Interesting research with promising results has been performed in the irradiation of containers through the bottleneck using low energy electrons. If the bottleneck is wide

enough, the dose distribution due to scattering inside the volume is satisfactory for many applications, including sterilization of health-care products.
The synergy between effecient electron beam treatment, lower investment cost and simple shielding, could open the door for a wide range of applications.

Process development for above mentioned applications is substantially assisted by the use of Monte Carlo simulations. A short review of the existing Monte Carlo transport code is presented in section 3. Special focus is devoted to the ITS (Integrated Tiger Series) package, which evolved as quasi standard for electron–photon transport calculations.

Section 4 is devoted to advances in the field of industrial irradiation of polymers. The current research topics in process development include engineering plastics, where Polyamid (PA 6 and PA-66) and PBT are crosslinked with the help of additives to produce polymer structures with superior functional properties.
As example, trends in microelectronics like 3D-MID (three dimensional moulded interconnected devices) are discussed, where the parts have to be highly heat resistant for a short time, to survive the soldering process.
Curing of composites has always been the spearhead of advanced EB, due to the spectacular applications in aerospace technology.
Recent advances are characterized by the use of radiation converters (targets) and small, mobile systems, which can be used for repair of large and bulky systems, e.g. aircraft fuselage and wings.

While the theoretical framework of many applications has be laid may years before, the industrialization of EB and X-ray technology is tightly connected with the economics of the process. Following this idea, the final part of the review is devoted to the task of making the EB process economic feasable and competitive with superior quality of the product.
Several factors like machine and biological shielding design, energy consumption, excess heat recovery and conveyor techniques are reviewed and recent improvements are highlighted.
Special focus is in on the field of information technology and process control, where existing technologies like field bus and Internet can be used to design lean systems which facilitate construction, commissioning and maintencance of state-of-the-art EB systems and easiliy outperform existing quality standards at the same cost.
As an example, a recent design of Mediscan for a fully computerized SPC (Statisitical Process Control) system is presented.