ABSTRACT

Life cycle engineering of a product which facilitates product life cycle need to be considered at earlier design stage, i.e., at conceptual design stage. However, it is necessary to develop procedures convenient to the designers in the design and development of products, while taking into consideration various aspects of product life cycle, at conceptual design stage. This thesis deals with the development of design methodology for product life cycle engineering. The methodology is based on graph theory and matrix approach. The life cycle engineering aspects included in this thesis are; LCD modelling and evaluation ; life cycle assessment modelling and evaluation; life cycle cost modelling and evaluation, and sustainability modelling and evaluation of products using graph theory and matrix approach.

Product design features such as, design for performance, design for manufacture, design for marketing, design for safety, design for maintainability, design for environment, and design for disposal/recycle which influence the product throughout its life cycle have been identified, in general, and are called LCD attributes. The relationship among these attributes is modelled in terms of a digraph called life cycle attributes digraph. A one-to-one matrix for the digraph is defined to obtain a matrix function and the index of these. A higher value of the index implies better design alternative of product from LCD point of view. This helps the designer to select the best design alternative from life cycle engineering point of view based on product life cycle.

Life cycle assessment modelling and evaluation of product on the basis of tribological applications is obtained using graph theory and matrix approach. Tribological applications which influence the life cycle assessment of a product have been fully identified in a logical and systematic manner and are called life cycle assessment attributes. The attributes are material conservation, energy conservation, lifetime lubrication, environmental preservation and triboelement recycling/reclamation. Modelling and evaluation of life cycle assessment is
carried out by representing life cycle assessment attributes in the form of a digraph and matrix function. Life cycle assessment index is obtained from the matrix function which helps in evaluating life cycle assessment of a product at conceptual design stage. Higher value of index indicates better product design alternative from life cycle assessment point of view.

Life cycle cost attributes of a product, in general, have also been identified on the basis of cost incurred during various phases of life cycle of a product. Life cycle cost evaluation is proposed and is based on life cycle cost attributes relationship digraph which contains all the life cycle cost attributes and their interrelationship. The evaluation of life cycle cost attributes relationship digraph is carried out by means of life cycle cost attributes relationship matrix function. Life cycle cost index is obtained from the matrix function. Higher value of index indicates better design alternative from product life cycle cost point of view.

Sustainability modelling and evaluation of a product is carried out on the basis of sustainability attributes of a product. The attributes of the product are identified on the basis of material properties. These are mechanical properties, tribological properties, economical aspects, and environmental preservation. The attributes and their relationship are represented in the form of a digraph called sustainability attributes relationship digraph. A one-to-one matrix representation of the digraph is defined to obtain the matrix function. The matrix function is used for evaluation of sustainability of the product based on material characteristics in terms of sustainability index. Higher value of index indicates better design alternative of the product from sustainability point of view.

The design methodology suggested in this thesis is useful for designers and practising engineers in the design and development of products at conceptual design stage from life cycle engineering point of view.