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Estimation of the Exergy-Aggregated Value Generated by a Manufacturing Process Using the Theory of the Exergetic Cost

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Abstract : The production of metal-rubber spares for vehicles is a sequential process that consists in the transformation of raw material through cutting activities and chemical and thermal treatments, which demand electricity and fossil fuels. The energy efficiency analysis for these cases is mostly focused on studying of each machine or production step, but is not common to study of the quality of the production process achieves from aggregated value viewpoint, which can be used as a quality measurement for determining of impact on the environment. In this paper, the theory of exergetic cost is used for determining of aggregated exergy to three metal-rubber spares, from an exergy analysis and thermoeconomic analysis. The manufacturing processing of these spares is based into batch production technique, and therefore is proposed the use of this theory for discontinuous flows from of single models of workstations; subsequently, the complete exergy model of each product is built using flowcharts. These models are a representation of exergy flows between components into the machines according to electrical, mechanical and/or thermal expressions; they determine the demanded exergy to produce the effective transformation in raw materials (aggregated exergy value), the exergy losses caused by equipment and irreversibilities. The energy resources of manufacturing process are electricity and natural gas. The workstations considered are lathes, punching presses, cutters, zinc machine, chemical treatment tanks, hydraulic vulcanizing presses and rubber mixer. The thermoeconomic analysis was done by workstation and by spare; first of them describes the operation of the components of each machine and where the exergy losses are; while the second of them estimates the exergy-aggregated value for finished product and wasted feedstock. Results indicate that exergy efficiency of a mechanical workstation is between 10% and 60% while this value in the thermal workstations is less than 5%; also that each effective exergy-aggregated value is one-thirtieth of total exergy required for operation of manufacturing process, which amounts approximately to 2 MJ. These troubles are caused mainly by technical limitations of machines, oversizing of metal feedstock that demands more mechanical transformation work, and low thermal insulation of chemical treatment tanks and hydraulic vulcanizing presses. From established information, in this case, it is possible to appreciate the usefulness of theory of exergetic cost for analyzing of aggregated value in manufacturing processes.

Keywords : exergy-aggregated value, exergy efficiency, thermoeconomics, exergy modeling
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