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授与した学位	博士
専攻分野の名称	工学
学位授与番号	博甲第4421号
学位授与の日付	平成23年 9月30日
学位授与の要件	自然科学研究科 産業創成工学専攻 (学位規則第5条第1項該当)
学位論文の題目	Development of intelligent evaluation system for product end-of-life selection strategy (製品の寿命選定方策のための知的評価システム開発)
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学位論文内容の要旨

As the world population increases exponentially, the amount of products purchased and consumed is also increasing. The rapid pace of technological changes renders some products obsolete even though they are still new and in an excellent condition. Consequently, the amount of natural resources decreases severely. Additionally, the amount of waste generated at the end-of-life of products has become serious problems in most countries. In response, the manufacturers have to seek other essential resources to provide for the input of the materials for manufacturing their products. This gives a strong demand for the secondary resources such as refurbished parts and recycled materials. This goal can be best achieved by promoting the end-of-life (EOL) selection strategies.

The main objective of this research is to develop an evaluation system for selecting EOL strategy specifically for remanufacturing. The development framework consists of several sub-objectives. The first sub-objective is to evaluate the remanufacturing selection strategy at the product level. In order to achieve this, the integration of analytic hierarchical process (AHP) and case-based reasoning (CBR) is used to evaluate the EOL options at the product level. The AHP, which allows the pair-wise comparison and consistent judgement, is used to determine the weight in nearest neighbourhood (NN) algorithm of CBR. The second sub-objective is to evaluate EOL of parts and components. The integration of the economic and environmental cost (EOL cost) model is used to determine the EOL of parts and components. The third sub-objective is to optimize the disassembly sequence of the EOL product. This study integrates the traveling salesman problem with genetic algorithm (TSP-GA) for finding the optimal disassembly sequence and disassembling the EOL product. Additionally, this study uses EOL profits and net present value (NPV) of parts and subassemblies of the EOL product to determine the best EOL option of components and parts of the EOL product.

The model validation, using five commercial products, has confirmed the usefulness of the integration of AHP and CBR method for supporting the judgement toward remanufacturing as the EOL strategy at the product level. This method also enables the decision makers to evaluate the EOL strategy of the EOL products in a sensible and quick decision-making manner. A desk phone is used to validate the EOL cost model, for selecting the best EOL option of parts and subassemblies of the EOL product. The result has confirmed the usefulness of the EOL cost model. The EOL cost enables decision makers to evaluate the EOL options from economic and environmental perspectives. Moreover, the results of the integrated AHP-CBR method are compared with an established traditional method of the previous works. These results are in good agreement with the previous established studies.

In evaluating the optimal disassembly sequence, the disassembly of a body of the desk phone is used to confirm the usefulness of the TSP-GA in optimizing the disassembly sequence, and supporting the decision-making for selecting the best EOL options of parts and subassemblies of the EOL product. The results show that the TSP-GA has corresponded well with the traditional TSP and GA methods. Additionally, the results also demonstrate that the EOL profits and NPV enable the decision makers to evaluate and select the EOL options of the parts and subassemblies of the EOL product. The results are in good agreement with the previous established studies.

論文審査結果の要旨

世界的な人口増加とともに、商品の購買・消費量が増え、製品の寿命等による廃棄物の量は増え続ける一方である。そこで、リサイクルや部品の再生 (remanufacturing) によってこの傾向に対処する動きが世界各国で活発化している。本論文では、製品の部品やコンポーネントの再生に向けた製品の寿命選定のための知的評価システムを提案することを目的とした。

まず、階層化意思決定法AHP (Analytic Hierarchical Process) とCBR(Case-Based Reasoning)を用いて、製品レベルで再生戦略を評価するためのシステムを提案・開発し、他のシステムと比較し、その有用性を検証した。5種類の製品を用いて、提案モデルの妥当性を検証した結果、階層化意思決定法AHPとCBRを組み合わせた方法は、迅速かつ正確な再生の有無の意思決定につながるということが分かった。さらには、提案法はこれまでに提案されたモデルよりも経済的観点および環境に配慮した観点から意思決定をスムーズに行えることがわかった。

次に、経済的、環境的費用を統合化したモデルによって、寿命に達した製品の部品とコンポーネントの再生可能性の有無を決定する方法を提案した。巡回セールスマン問題と遺伝的アルゴリズムを組み合わせた方法を用いて、寿命となった製品を部品とコンポーネントの再生のために分解するプロセスを最適化するための手法を提案した。寿命を過ぎて廃棄されたオフィス用固定電話の分解実験によって、提案法は、部品とコンポーネントの再生可能性の有無の決定のために有効であることが示された。

本論文において提案された製品の寿命選定方策決定のため知的評価システムは、種々の再生やリサイクルの現場において寿命選定のために有効活用されることが期待できる。学位審査委員会は、学位論文の内容、公聴会における発表内容等を総合的に判断し、本論文は博士(工学)に値するものと判断した。