

DESCRIPTION

Title of Invention: PRODUCT CIRCULATION SUPPORT METHOD AND
PRODUCT CIRCULATION SUPPORT SYSTEM

Incorporation by Reference

[0001]

This application claims priority to Japanese Patent Application No. 2023-112108 filed on July 7, 2023 (Reiwa 5), the contents of which are incorporated herein by reference.

Technical Field

[0002]

The present invention relates to a technology for supporting circulation of products.

Background Art

[0003]

As techniques for evaluating the environmental load of a product, for example, there are techniques described in JP 2006-252271 A (PTL 1) and JP 2003-203138 A (PTL 2). PTL 1 describes that “there are included an LOM storage unit that stores a life cycle option model obtained by modeling resource circulation related to a product over a life cycle, an LFM storage unit that stores a life cycle flow model obtained by modeling a flow of a product among a plurality

of processes, a BCM storage unit that stores a business constraint model obtained by modeling resource circulation related to the product so as to satisfy a predetermined constraint condition when resource circulation is performed on the basis of the option model and the flow model, an environmental load storage unit that stores basic unit factors when the environmental load is calculated, and a life cycle simulation unit that repeats processing of aggregating the environmental load for each unit period of the process on the basis of each of the models described above."

[0004]

PTL 2 discloses that "information regarding a target of reuse and recycling is stored, a target of reuse and recycling that can be diverted from a recovered product to a newly produced product is selected by using the information, life cycle modeling of combining the selected target of reuse and recycling for assembling a newly produced product is performed, a collection distribution of a product to be reused is approximately predicted as superimposition of two or more arbitrary shapes in order to predict a collection amount of the target of reuse and recycling by using a life cycle model, at least one of the arbitrary shapes is set as a peak of a product value life or a product service life, and from a prediction result, an environmental influence and

cost to be borne in a case of reuse and recycling are evaluated."

Citation List

Patent Literature

[0005]

PTL 1: JP 2006-252271 A

PTL 2: JP 2003-203138 A

Summary of Invention

Technical Problem

[0006]

In recent years, there has been a demand for a cyclical economic system that takes the environment into consideration, rather than the conventional linear economy, which has been accompanied by the promotion of the industrial revolution 4.0 and a change in consumer perception due to factors such as growing environmental problems and depletion of resources.

[0007]

Environmental consideration is very important in a circular economy. By reusing resources and minimizing waste, the environmental load is reduced. This can prevent various problems such as resource depletion, air pollution, and an increase in waste treatment cost.

[0008]

There are various circular strategies in the circulation, such as reuse of products as they are, repair to reuse, refurbishment to repair reusable components and resell them as the same product to another customer, remanufacturing to repair reusable components and re-manufacture them into another product, and recycling back to the level of materials.

[0009]

Life cycle assessment (LCA) is used as a method for evaluating the influence of environmental load across the entire life cycle from product design to use and disposal phases. In LCA, the environmental load is statically evaluated using the representative value of each phase.

[0010]

In addition, as a method for evaluating not only evaluation itself but also dynamic environmental load and economic efficiency across the entire product life cycle and the surrounding social system as a whole, there is life cycle simulation (LCS). The LCS expresses the entire product life cycle by a statistical model or a mathematical model, and simulates behavior thereof.

[0011]

Here, LCA and LCS focus not on each individual of the product, but on the life cycle of the entire product of the same product type. On the other hand, in practice, even in

products of the same type, the configuration of components varies depending on the individual, or the use status (for example, usage by a user such as frequency of use, whether each component is new or remanufactured, or the like) varies depending on the components, so that the environmental load, cost, and the like caused by the subsequent handling of the product may vary depending on the individual. For this reason, it is difficult to use the conventional LCA and LCS to determine whether to reuse, repair, refurbish, remanufacture, recycle, or continue to use each individual of the product from the viewpoint of product utilization in a circulation scenario.

Solution to Problem

[0012]

In order to solve at least one of the above problems, one aspect of the present invention is a product circulation support method executed by a computer system including a processor and a storage device, in which the storage device holds product configuration information indicating a plurality of components constituting a product and circulation pattern information indicating a plurality of circulation strategies for resource circulation applicable to the plurality of components, and the product circulation support method includes a first procedure in which the

processor generates a plurality of circulation scenarios defining a circulation strategy to be applied to each of the components constituting the product on the basis of the product configuration information and the circulation pattern information, and a second procedure in which the processor calculates an environmental load and a cost when the product is used for a predetermined period by applying each of a plurality of the circulation scenarios.

Advantageous Effects of Invention

[0013]

According to an aspect of the present invention, it is possible to support determination of a circulation scenario to be applied to each individual of a product.

[0014]

Problems, configurations, and effects other than those described above will be clarified by the following description of embodiments.

Brief Description of Drawings

[0015]

FIG. 1 is a block diagram illustrating a configuration of a product circulation support system according to an embodiment of the present invention.

FIG. 2 is a block diagram illustrating a hardware

configuration of a computer system that implements the product circulation support system according to the embodiment of the present invention.

FIG. 3 is an explanatory diagram of a circulation pattern for each component held by the product circulation support system according to the embodiment of the present invention.

FIG. 4 is an explanatory diagram of product configuration information held by the product circulation support system according to the embodiment of the present invention.

FIG. 5 is an explanatory diagram of replacement component information/replacement product information held by the product circulation support system according to the embodiment of the present invention.

FIG. 6 is an explanatory diagram of a component residual value evaluation model held by the product circulation support system according to the embodiment of the present invention.

FIG. 7 is an explanatory diagram of a component configuration influence characteristic model held by the product circulation support system according to the embodiment of the present invention.

FIG. 8 is an explanatory diagram of a product use characteristic held by the product circulation support

system according to the embodiment of the present invention.

FIG. 9 is an explanatory diagram of an environmental load value table held by the product circulation support system according to the embodiment of the present invention.

FIG. 10 is an explanatory diagram of a cost table held by the product circulation support system according to the embodiment of the present invention.

FIG. 11 is an explanatory diagram of a recommendation rule held by the product circulation support system according to the embodiment of the present invention.

FIG. 12 is a flowchart illustrating processing executed by the product circulation support system according to the embodiment of the present invention.

FIG. 13 is an explanatory diagram illustrating a first example of a scenario recommended by the product circulation support system according to the embodiment of the present invention.

FIG. 14 is an explanatory diagram illustrating a second example of a scenario recommended by the product circulation support system according to the embodiment of the present invention.

Description of Embodiments

[0016]

Hereinafter, embodiments of the present invention will

be described with reference to the drawings.

[0017]

FIG. 1 is a block diagram illustrating a configuration of a product circulation support system 100 according to an embodiment of the present invention.

[0018]

The product circulation support system 100 includes a product circulation scenario simulation unit 101, a product circulation scenario generation unit 102, and a simulation result recommendation unit 103. The product circulation scenario simulation unit 101 includes a product configuration information generation/update unit 104, a recovered component residual value evaluation unit 105, and an environmental load/cost integration simulation unit 106. These functions will be described later (see FIG. 2 and the like).

[0019]

Further, the product circulation support system 100 holds a circulation pattern 107 for each component, product configuration information (Bill of Material, BOM) 108, replacement component information/replacement product information 109, a component residual value evaluation model 110, a recommendation rule 111, an environmental load value table 112, a cost table 113, a product use characteristic 114, and a component configuration influence characteristic

model 115. Details thereof will be described later.

[0020]

FIG. 2 is a block diagram illustrating a hardware configuration of a computer system that implements the product circulation support system 100 according to the embodiment of the present invention.

[0021]

The product circulation support system 100 according to the present embodiment illustrated in FIG. 1 can be implemented by a computer system. FIG. 2 illustrates a computer system 200 as an example of the computer system.

[0022]

The computer system 200 includes a processor 201, a memory (main storage device) 202, an auxiliary storage device 203, an output device 204, an input device 205, and a communication interface (I/F) 206. The above components are connected to each other by a bus. The memory 202 and the auxiliary storage device 203 are storage devices, and store programs and data used by the processor 201.

[0023]

The memory 202 includes, for example, a semiconductor memory, and is mainly used to hold a program and data being executed. The processor 201 executes various processes according to a program stored in the memory 202. The processor 201 operates according to the program, thereby

implementing various functional units (for example, the product circulation scenario simulation unit 101, the product circulation scenario generation unit 102, and the simulation result recommendation unit illustrated in FIG. 1).

[0024]

The auxiliary storage device 203 includes, for example, a large-capacity storage device such as a hard disk drive or a solid state drive, and is used to hold programs and data for a long period of time. For example, the circulation pattern 107 to the component configuration influence characteristic model 115 for each component may be held in the auxiliary storage device 203.

[0025]

The processor 201 may be composed of a single processing unit or multiple processing units, and may include a single or multiple arithmetic units or multiple processing cores. The processor 201 may be implemented as one or more central processing units, microprocessors, microcomputers, microcontrollers, digital signal processors, state machines, logic circuits, graphical processing units, chip-on-system, and/or any device that manipulates signals based on control instructions.

[0026]

The programs and data stored in the auxiliary storage

device 203 are loaded into the memory 202 at the time of startup or when necessary, and the processor 201 executes the programs to execute various processes of the computer system 200.

[0027]

The input device 205 is a hardware device for the user to input instructions, information, and the like. The output device 204 is a hardware device that presents various images for input and output, and is, for example, a display device or a print device. The communication I/F 206 is an interface for connection with the network 140.

[0028]

Note that the computer system 200 may include two or more processors 201. Furthermore, the functions of the system of the present embodiment can be implemented in a plurality of computer systems 200. In this case, the plurality of computer systems 200 communicate via a network. For example, a part of the plurality of functions of the system of the present embodiment may be implemented in one computer system 200, and another part may be implemented in another computer system 200.

[0029]

For example, the computer system 200 may be a PC owned by a user (for example, a user when the user of a certain product intends to use the function of the product

circulation support system 100 to determine the future handling of the product) of the product circulation support system 100, or may be a server or the like accessed by the user via a network. In the latter case, the computer system 200 may be a virtual server or the like on a cloud. In the latter case, the computer system 200 illustrated in FIG. 2 is implemented by computer resources on a cloud.

[0030]

FIG. 3 is an explanatory diagram of a circulation pattern 107 for each component held by the product circulation support system 100 according to the embodiment of the present invention.

[0031]

The circulation pattern 107 for each component includes information indicating a strategy for incorporating each component constituting a product into a circulation economy and execution timing of an action based on the strategy. Information indicating execution times of a plurality of strategies and actions may be included for one component, and in this case, any one of the plurality of strategies and actions can be selected. The above information may be determined in advance for each product, for example, for each component constituting the product.

[0032]

The circulation pattern 107 for each component

illustrated in FIG. 3 includes a component name 301, a component specification 302, a circulation strategy 303, a circulation frequency 304, and a component replacement method 305. The component name 301 is a name for specifying each component. The component specification 302 indicates a specification of each component. The circulation strategy 303 and the circulation frequency 304 indicate a strategy to be applied to each component in order to incorporate each component into resource circulation, and a time (for example, an execution frequency) at which an action based on the strategy is performed. The component replacement method 305 illustrates how each component is replaced (that is, in a case where the action based on the circulation strategy includes replacement of components) when replaced according to the circulation strategy 303.

[0033]

Here, examples of the circulation strategy 303 include continuous use, reuse, repair, refurbishment, remanufacturing, and recycling.

[0034]

Continuous use is to continue to use the product as it is. Components whose circulation strategy 303 is continuous use are continuously used as they are without being removed from the original product.

[0035]

Reuse is to reuse the product as it is. Components for which the circulation strategy 303 is reuse are removed from the original product repaired if necessary when the time determined by the circulation frequency 304 comes, and sold to another user. In this case, a replacement component for the removed component is incorporated into the original product and the use of the original product is continued.

[0036]

Note that the replacement component may be a component of the same type as the extracted component, or may be a component of another type capable of substituting the extracted component. In addition, the replacement component may be a new part (that is, an unused part), or may be a component having a use history (for example, a reconditioned part taken out from another product).

[0037]

Repair is to repair and reuse the product. Components for which the circulation strategy 303 is repair are removed from the original product and repaired when the time determined by the circulation frequency 304 comes, and then re-incorporated into the original product and used by the original user. In this case, no replacement component is required.

[0038]

Refurbishment is to repair a reusable component and

resell it as the same product to another user. Components for which the circulation strategy 303 is refurbishment are removed from the original product when the time determined by the circulation frequency 304 comes, and in combination with another component a product of the same type as the original product is manufactured and sold to another user. As in the case of reuse, the original product is continuously used with a replacement component incorporated therein, or the original product is discarded if no other component is available.

[0039]

Remanufacturing is to repair a reusable component to remake it into a different product. Components for which the circulation strategy 303 is remanufacturing are removed from the original product when the time determined by the circulation frequency 304 comes, and in combination with another component a product of a different variety from the original product is manufactured and sold to another user. As in the case of reuse, the original product is continuously used with a replacement component incorporated therein, or the original product is discarded if no other component is available.

[0040]

Recycling is to return the product to the level of the material. Components for which the circulation strategy 303

is recycling are removed from the original product when the time determined by the circulation frequency 304 comes, and disassembled to the material for reuse. As in the case of reuse, the original product is continuously used with a replacement component incorporated therein, or the original product is discarded if no other component is available.

[0041]

In the example of FIG. 3, two patterns of remanufacturing once every three years and remanufacturing once every six years are registered as the circulation pattern of the component a1. In any case, the component a1 is replaced with a reconditioned part corresponding to the component a1 at the time of remanufacturing.

[0042]

Similarly, in the example of FIG. 3, three patterns are registered as the circulation pattern of the component b1. In the first pattern, the component b1 is repaired five years later, then three years later, then one year later, and then every year thereafter. In this case, since the component b1 is repaired and still used in the original product, no component replacement occurs. In the second pattern, the component b1 is remanufactured once in five years and replaced with a new part. In the third pattern, the component b1 is repaired after five years, discarded after another five years, and replaced with a reconditioned

part.

[0043]

FIG. 4 is an explanatory diagram of product configuration information 108 held by the product circulation support system 100 according to the embodiment of the present invention.

[0044]

The product configuration information 108 includes information covering components and the like constituting a product for each product type. FIG. 4 illustrates, as an example, information regarding components of one product type. The product includes a unit a, a unit b, a unit c, a component d, a component e, and the like. The unit a includes a component a1, a component a2, and a component a3. The component a2 includes a component a2-1 and a component a2-2. Other units and components may similarly be constituted by lower components. As described above, the product configuration information 108 includes, for each component, information such as a part number, a parent part number (that is, the part number of a higher-level component, unit, or product constituted by the component), a child part number (that is, the part number of a lower-level component or the like constituting the component), a part name, a specification, and a quantity.

[0045]

FIG. 5 is an explanatory diagram of the replacement component information/replacement product information 109 held by the product circulation support system 100 according to the embodiment of the present invention.

[0046]

The replacement component information/replacement product information 109 includes information regarding a component that can be used as a replacement component for a component removed from the original product for reuse, refurbishment, remanufacturing, or recycling. Specifically, the replacement component information/replacement product information 109 includes a component name 501, a component specification 502, a replaceable component name 503, a replacement component specification 504, a type 505 of the replacement component, a remaining life 506 of the replacement component, and quality information 507 of the replacement component.

[0047]

The component name 501 is a name that is incorporated in an original product and identifies a component to be removed and replaced with a replacement component in the future. The component specification 502 indicates a specification of a component to be replaced. The replaceable component name 503 is a name that identifies a replacement component of the component to be replaced. The replacement

component specification 504 indicates a replacement component specification. The type 505 of the replacement component is information indicating the type of the replacement component, for example, any of a reconditioned part, a new part, a reused part, or the like. The remaining life 506 of the replacement component is indicative of the remaining life of the replacement component at the time of replacement. The quality information 507 of the replacement component indicates the quality of the replacement component.

[0048]

FIG. 6 is an explanatory diagram of the component residual value evaluation model 110 held by the product circulation support system 100 according to the embodiment of the present invention.

[0049]

The component residual value evaluation model 110 indicates a residual value according to the operating status of each component, for example, a price assumed when the component is sold as a reconditioned part. In general, the longer the number of times of operation or the operating time of a product, the lower the residual value of a component constituting the product, but how the residual value is lowered (that is, residual value characteristics) varies depending on the nature, use form, and the like of the component.

[0050]

In the example of FIG. 6, residual value characteristics of the component a1 and the component b2 are illustrated. Although the residual value of each component decreases as the operating time or the number of times of operation increases, in the component a1, the residual value gradually decreases at the beginning, and the residual value rapidly decreases when the operating time or the number of times of operation reaches a certain level. On the other hand, in the component b2, the residual value decreases so as to be approximately inversely proportional to the operating time or the number of times of operation.

[0051]

Although a graph is illustrated in FIG. 6 as an example of the component residual value evaluation model 110, the actual component residual value evaluation model 110 may be tabular data indicating the residual value with respect to the operating time or the number of times of operation, or may be a mathematical expression, and the format is not limited.

[0052]

FIG. 7 is an explanatory diagram of a component configuration influence characteristic model 115 held by the product circulation support system 100 according to the embodiment of the present invention.

[0053]

Operating a product causes an environmental load such as power consumption and accompanying carbon dioxide (CO₂) emission. The magnitude of the environmental load (for example, the power consumption amount or the CO₂ emission amount) may depend on the combination of components constituting the product. The component configuration influence characteristic model 115 includes information that associates a combination of operating statuses (for example, operating time or the number of times of operation) of a plurality of components constituting a product with an increase in environmental load.

[0054]

FIG. 7 illustrates, as an example, an increase in the environmental load corresponding to the combination of the operating time of the component a1 and the operating time of the component a2. In this example, the increase in the environmental load corresponding to the combination of the operating time of the component a1 and the operating time of the component a2 is displayed in a three-dimensional graph. For example, when calculating the environmental load of a certain product by a predetermined method, in a case where the product includes a combination of the component a1 and the component a2, the environmental load of the product is calculated by adding an increase of the environmental load

corresponding to each operating time specified on the basis of the graph illustrated in FIG. 7 to the calculated environmental load.

[0055]

Even in a case of a component constituting the same product, the operating time, the number of times of operation, and the like may vary depending on whether the component is a reconditioned part or a new part, whether the component has been replaced, and the like. The component configuration influence characteristic model 115 includes information indicating an increase in the environmental load corresponding to the combination of the operating statuses of the plurality of components. Note that, in general, the increase in the environmental load tends to increase as the operating time or the number of times of operation of each component increases.

[0056]

Note that, in practice, there may be a combination of components effective for reducing the environmental load. For such a combination, the increase in the environmental load may be a negative value. In addition, there is a case where it actually depends on a combination of three or more components. In this case, the correspondence relationship between the operating statuses of three or more components and the increase in environmental load is expressed by a

multi-dimensional graph.

[0057]

Similarly to the component residual value evaluation model 110 illustrated in FIG. 6, the format of the component configuration influence characteristic model 115 is not limited, and may be, for example, tabular data, a formula, or the like.

[0058]

FIG. 8 is an explanatory diagram of the product use characteristic 114 held by the product circulation support system 100 according to the embodiment of the present invention.

[0059]

Because characteristics of use (for example, how the user uses the product, frequency of use, and the like) differ depending on the individual of the product even in the case of products of the same product type, how deterioration of components constituting the product progresses and the like also differ, and as a result, the environmental load may also differ. The product use characteristic 114 includes information indicating a use characteristic (for example, an operating status such as an operating time, an operation frequency, and the number of times of operation) for each part of the individual of the product.

[0060]

The product use characteristic 114 illustrated in FIG. 8 includes a product part name 801, an operating time 802, an operation frequency 803, and a number of times of operation 804. The product part name 801 is a name that specifies a part (for example, a unit, a component, or the like) constituting a product. The operating time 802, the operation frequency 803, and the number of times of operation 804 indicate the operating time, the operation frequency, and the number of times of operation of each part, respectively.

[0061]

FIG. 9 is an explanatory diagram of an environmental load value table 112 held by the product circulation support system 100 according to the embodiment of the present invention.

[0062]

Use of a product causes an environmental load such as power consumption and CO2 emission, and in addition to this, an action for incorporating the product into resource circulation, such as replacement of components, also causes the environmental load. The environmental load value table 112 includes information regarding the environmental load value caused by such an action for resource circulation.

[0063]

The environmental load value table 112 illustrated in

FIG. 9 includes a type 901, a circulation content 902, and an environmental load value 903. The type 901 indicates an object of an action for resource circulation (for example, a unit or a component) and the action (for example, replacement, reconditioning, disposal, and the like). The circulation content 902 indicates a circulation strategy (for example, repair, remanufacturing, and the like) corresponding to the action. The environmental load value 903 indicates the magnitude of the environmental load (for example, power consumption amount or CO2 emission amount) caused by an action.

[0064]

In the example of FIG. 9, an environmental load value when the component a1 is replaced for remanufacturing, an environmental load value when a replacement component for the component a1 is reconditioned for remanufacturing, and an environmental load value when the component a1 is discarded are registered.

[0065]

FIG. 10 is an explanatory diagram of a cost table 113 held by the product circulation support system 100 according to the embodiment of the present invention.

[0066]

The cost table 113 includes information regarding costs caused by an action for resource circulation. The

cost table 113 illustrated in FIG. 10 includes a type 1001, a circulation content 1002, and a cost 1003. The type 1001 indicates an object (for example, a unit or a component) of an action for resource circulation and the action (for example, replacement, reconditioning, disposal, and the like), and is similar to the type 901 of the environmental load value table 112 (FIG. 9). The circulation content 1002 indicates a circulation strategy (for example, repair, remanufacturing, and the like) corresponding to the action. The cost 1003 indicates the magnitude of the cost (for example, the amount of money) caused by the action.

[0067]

In the example of FIG. 10, a cost for replacing the component a1 for remanufacturing, a cost for acquiring a replacement component for the component a1 for remanufacturing, and a cost for discarding the component a1 are registered.

[0068]

FIG. 11 is an explanatory diagram of the recommendation rule 111 held by the product circulation support system 100 according to the embodiment of the present invention.

[0069]

As will be described later, the product circulation support system 100 generates a plurality of scenarios (also referred to as product circulation scenarios) defining the

contents and execution timings of actions to be executed to incorporate products into resource circulation, calculates the respective environmental loads and costs, and recommends at least one of the scenarios on the basis of the results. The recommendation rule 111 includes a rule applied at the time of recommendation.

[0070]

The recommendation rule 111 illustrated in FIG. 11 includes a recommended scenario name 1101 and a recommendation determination 1102. The recommended scenario name 1101 is a name for identifying a rule for determining a scenario to be recommended. The recommendation determination 1102 indicates content of a rule for determining a scenario to be recommended.

[0071]

FIG. 11 illustrates, as an example, a first rule of recommending a scenario in which the environmental load is minimized, a second rule of recommending a scenario in which the cost is minimized, and a third rule of recommending a scenario in which the environmental load and the cost are balanced. In the first rule, a scenario in which the cumulative environmental load value after a lapse of a predetermined period (described as X years in the drawing) is minimized is recommended. In the second rule, a scenario in which the cumulative cost after the lapse of the

predetermined period is minimized is recommended. In the third rule, a scenario in which the harmonic average of the cumulative environmental load value and the cumulative cost is minimized is recommended.

[0072]

FIG. 12 is a flowchart illustrating processing executed by the product circulation support system 100 according to the embodiment of the present invention.

[0073]

For example, when a user intends to determine future handling of an individual of a product that the user is using, processing of the product circulation support system 100 is executed to support the determination. In the following description, unless otherwise specified, "product" refers to a specific individual of a product of a certain variety (for example, an individual owned or managed by a user).

[0074]

First, the product circulation scenario generation unit 102 generates a product circulation scenario (step 1201). For example, the product circulation scenario generation unit 102 specifies, for a target product (for example, an individual of a product used by a user), units, components, and the like configured with reference to the product configuration information 108. Then, the product circulation scenario generation unit 102 refers to the

circulation pattern 107 for each product, and generates a product circulation scenario by assigning a circulation strategy to each specified component.

[0075]

At this time, as illustrated in the example of FIG. 3, since a plurality of circulation strategies may be registered for each component, a plurality of product circulation scenarios can be generated by changing the circulation strategy to be selected. For example, a product circulation scenario including a circulation strategy of remanufacturing the component a1 once every three years and a product circulation scenario including a circulation strategy of remanufacturing the component a2 once every six years can be generated. The same applies to the other components, and a plurality of product circulation scenarios can be generated by combining a selectable circulation strategy for each.

[0076]

Next, the product configuration information generation/update unit 104 of the product circulation scenario simulation unit 101 generates product configuration information one year after the target year (the initial value is the current time when the processing is executed, and then one year is added incrementally thereafter) from each product circulation scenario and the product configuration information for the target year (step 1202). For example,

when there is a part to be replaced by one year later on the basis of a certain product circulation scenario, the product configuration information generation/update unit 104 specifies a replacement component for the component on the basis of the replacement component information/replacement product information 109. Then, the product configuration information generation/update unit 104 updates the product configuration information 108 of the target year with the specified replacement component, thereby generating the product configuration information 108 of one year after the target year.

[0077]

Next, the product circulation scenario simulation unit 101 executes step 1203 and step 1204. These may be executed in parallel.

[0078]

In step 1203, the recovered component residual value evaluation unit 105 of the product circulation scenario simulation unit 101 calculates a residual value (that is, a trade-in price) of the recovered component. Specifically, the recovered component residual value evaluation unit 105 specifies all components to be replaced by one year from the target year on the basis of the product circulation scenario. Then, the recovered component residual value evaluation unit 105 specifies the use status of each component recovered

from the product by replacement on the basis of the product use characteristic 114. Then, the recovered component residual value evaluation unit 105 specifies the residual value of each component recovered from the product by replacement on the basis of the specified use status and the component residual value evaluation model 110, and calculates the sum thereof.

[0079]

In step 1204, the environmental load/cost integration simulation unit 106 of the product circulation scenario simulation unit 101 calculates the influence of the change in the component. Specifically, the environmental load/cost integration simulation unit 106 specifies the operating time or the number of times of operation for each combination of the replacement component specified in step 1202 and other components on the basis of the product use characteristic 114. Then, the environmental load/cost integration simulation unit 106 calculates an increase or a decrease in the environmental load value on the basis of the specified operating time or number of times of operation and the component configuration influence characteristic model 115.

[0080]

Next, the environmental load/cost integration simulation unit 106 integrates the environmental load and the cost in the product configuration information after one

year of the target year generated in step 1202 on the basis of the environmental load value table 112 and the cost table 113 on the basis of the calculation results of step 1203 and step 1204 (step 1205).

[0081]

For example, the environmental load/cost integration simulation unit 106 may refer to the product configuration information 108 to specify the units and components constituting the individual of the product to be calculated, refer to the product use characteristics 114 to specify the operating status of each component (unit, component, or the like) of the individual of the product, and calculate the running environmental load value and the running cost of the individual of the product for one year from the target year to one year after the target year on the basis of the operating status of each component or the like.

[0082]

Furthermore, the environmental load/cost integration simulation unit 106 refers to the environmental load value table 112 and the cost table 113, and calculates an environmental load value and a cost caused by an action (for example, replacement and reconditioning of components for remanufacturing) performed in the target year on the basis of the product circulation scenario in the target year.

[0083]

Then, the environmental load/cost integration simulation unit 106 may calculate the cost for the target year by subtracting the residual value of the recovered component calculated in step 1203 from the calculated running cost and further adding the cost caused by the action performed in the target year on the basis of the product circulation scenario. Further, the environmental load/cost integration simulation unit 106 may calculate the environmental load value for the target year by adding the increase in the environmental load value calculated in step 1204 to the calculated running environmental load value (or subtracting the reduction in the environmental load value), and further adding the environmental load value caused by the action performed in the target year on the basis of the product circulation scenario.

[0084]

Next, the product circulation scenario simulation unit 101 determines whether the processing of steps 1202 to 1205 has been completed for the entire period (step 1206). For example, when the integration of the environmental load and the cost is performed for a period from the current point of time to 6 years later, the product circulation scenario simulation unit 101 determines whether the integration of the environmental load and the cost after 6 years has ended. If the processing has not been completed (step 1206: No),

the processing returns to step 1202, and steps 1202 to 1204 are executed by adding one year to the target year.

[0085]

If the processing of steps 1202 to 1205 has been completed for the entire period (step 1206: Yes), the product circulation scenario simulation unit 101 determines whether the processing of steps 1201 to 1205 has been completed for all scenarios (step 1207). If the processing of steps 1201 to 1205 has not been completed for at least one of the plurality of product circulation scenarios generated in step 1201 (step 1207: No), the product circulation scenario simulation unit 101 executes steps 1202 to 1205 for the product circulation scenario that has not yet been completed.

[0086]

In a case where the processing of steps 1201 to 1205 is completed for all of the plurality of product circulation scenarios generated in step 1201 (step 1207: Yes), the simulation result recommendation unit 103 recommends an optimal plan from the integration simulation result of each product circulation scenario on the basis of the recommendation rule 111 (step 1208).

[0087]

For example, when the environmental load minimizing scenario is adopted, the product circulation scenario in which the cumulative value of the environmental load value

obtained by the simulation is minimum is recommended. On the other hand, when the environmental load minimizing scenario is adopted, the product circulation scenario in which the cumulative value of the cost obtained by the simulation is minimum is recommended. When the balance scenario is adopted, the product circulation scenario in which the balance between the environmental load value and the cost obtained by the simulation is the best (for example, the harmonic average of both is minimum) is recommended.

[0088]

FIG. 13 is an explanatory diagram illustrating a first example of a scenario recommended by the product circulation support system 100 according to the embodiment of the present invention.

[0089]

FIG. 13 illustrates, as an example, a product circulation scenario recommended in step 1208 of FIG. 12 in a case where the environmental load minimizing scenario is adopted. That is, among the plurality of product circulation scenarios generated in step 1201, the product circulation scenario in which the cumulative value of the environmental load after the lapse of a predetermined period (for example, 6 years) is minimized is recommended. In this example, the cumulative value of costs is not considered.

[0090]

In the product circulation scenario of FIG. 13, among the components constituting the target product, the component a1 is replaced after 3 years and 6 years, and the replaced component a1 is remanufactured (denoted as "REMAN" in the drawing). The component a2 is replaced after six years, and the component a2 after replacement is remanufactured. The component a3 is replaced with a new part after two years, and the replaced component a3 is remanufactured. The component b1 is replaced after three years, and the component after replacement is recycled. The product in question may in fact include more components, in which case the product circulation scenario involves a circulation strategy that applies to each component, but for the sake of convenience of explanation, it will now be described that the product in question includes the above four components (the same applies to FIG. 14 described below).

[0091]

In the example of FIG. 13, the cumulative value of the environmental load in each year is indicated by a stacked bar graph, and the cumulative value of the cost in each year is indicated by a line graph. Here, an example of the cumulative value of the environmental load will be described. The initial value of the environmental load may be, for example, an environmental load caused by manufacturing of a target product.

[0092]

The cumulative value of the environmental load in one year of use (that is, the cumulative value of the environmental load after the lapse of the first one year) is obtained by adding the environmental load value calculated for the subsequent one year to the initial value of the environmental load. The environmental load value for the one year is calculated, for example, on the basis of the running environmental load according to the operating status of each component. At this time, an increase in the environmental load value corresponding to the combination of the plurality of components is added (or a decrement is subtracted) on the basis of the component configuration influence characteristic model 115.

[0093]

The cumulative value of the environmental load with two years of use is obtained by adding the environmental load value calculated for the subsequent one year to the cumulative value of the environmental load with one year of use. The environmental load value for the one year is calculated, for example, on the basis of the running environmental load according to the operating status of each component. Further, an increase in the environmental load value corresponding to the combination of the plurality of components is added (or a decrement is subtracted) on the

basis of the component configuration influence characteristic model 115. In general, as the operating time of a component and the like increase, the increase in the environmental load value also tends to increase, and thus the environmental load value for the next year tends to increase from the environmental load value for one year in the previous year.

[0094]

However, in the product circulation scenario illustrated in FIG. 13, the component a3 is replaced with a new part at the time when the number of years of use is 2 years, and the replaced component a3 is used for remanufacturing. For this reason, since the operating time and the like of the component a3 are reset, the increase in the environmental load value may be reduced. On the other hand, as illustrated in the environmental load value table 112, since an environmental load for replacement and remanufacturing of the component a3 occurs, the corresponding environmental load value increases. The increase and decrease of the environmental load value are reflected in the environmental load value for the one year.

[0095]

Thereafter, similarly, for each year, the environmental load value is calculated and accumulated on the basis of the running environmental load value according

to the operating status of the product and the increase/decrease in the environmental load value based on the component configuration influence characteristic model 115 and the environmental load value table 112 according to the action performed in the year on the basis of the product circulation scenario.

[0096]

Although detailed description of the cumulative value of the cost is omitted, similarly to the cumulative value of the environmental load, for each year, the environmental load value is calculated and accumulated on the basis of the running cost according to the operating status of the product and the increase in cost based on the cost table 113 according to the action performed in the year on the basis of the product circulation scenario.

[0097]

However, when the cost is calculated, the residual value when the component is replaced is also used. For example, in a case where the number of years of use is 2, since the component a3 is replaced, the residual value of the component a3 at that time is specified on the basis of the component residual value evaluation model 110, and the price is subtracted from the cost calculated on the basis of the running cost or the like.

[0098]

FIG. 14 is an explanatory diagram illustrating a second example of a scenario recommended by the product circulation support system 100 according to the embodiment of the present invention.

[0099]

FIG. 14 illustrates, as an example, a product circulation scenario recommended in step 1208 of FIG. 12 when the cost minimum scenario is adopted. That is, among the plurality of product circulation scenarios generated in step 1201, the product circulation scenario in which the cumulative value of the cost after the lapse of a predetermined period (for example, 6 years) is minimized is recommended. In this example, the cumulative value of the environmental load is not considered.

[0100]

In the product circulation scenario of FIG. 14, among the components constituting the target product, the component a1 is replaced after 6 years, and the replaced component a1 is remanufactured. The component a2 is replaced after six years, and the component a2 after replacement is remanufactured. The component a3 is repaired after two and six years. The component b1 is replaced with a new part after six years, and the replaced component b1 is discarded.

[0101]

The method of calculating the cumulative value of the

environmental load and the cumulative value of the cost in the example of FIG. 14 is similar to that described with reference to FIG. 13. However, since the product circulation scenario illustrated in FIG. 14 is different from that illustrated in FIG. 13, the action performed based on the product circulation scenario differs in each year, and as a result, the calculated cumulative value of the environmental load and the cumulative value of the cost are different from those illustrated in FIG. 13.

[0102]

The product circulation support system 100 may present information as illustrated in FIG. 13 or 14 to the user. The user can refer to this information to determine whether to execute the recommended product circulation scenario. For example, when the product circulation support system 100 recommends a plurality of product circulation scenarios based on a plurality of rules included in the recommendation rule 111, the user may select a desired product circulation scenario with reference to the product circulation scenarios. Alternatively, when the product circulation support system 100 recommends one product circulation scenario based on one rule included in the recommendation rule 111, the user may determine whether or not it is appropriate, and when the user determines that it is not appropriate, the user may designate another rule and instruct the recommendation of

the product circulation scenario again.

[0103]

As a result, it is possible to evaluate what kind of result is obtained by applying what kind of circulation strategy to each component constituting a product from the viewpoint of environmental load and cost, and it is possible to support determination of an appropriate product circulation scenario.

[0104]

In addition, the system in the embodiments of the present invention may be configured as follows:

[0105]

(1) A product circulation support method executed by a computer system (for example, the product circulation support system 100 implemented by the computer system 200) including a processor (for example, the processor 201) and a storage device (for example, at least one of the memory 202 or the auxiliary storage device 203), in which the storage device holds product configuration information (for example, the product configuration information 108) indicating a plurality of components constituting a product and circulation pattern information (for example, the circulation pattern 107 for each product) indicating a plurality of circulation strategies for resource circulation applicable to the plurality of components, and the product

circulation support method includes a first procedure (for example, step 1201) in which the processor generates a plurality of circulation scenarios defining a circulation strategy to be applied to each of the components constituting the product on the basis of the product configuration information and the circulation pattern information, and a second procedure (for example, steps 1202 to 1205) in which the processor calculates an environmental load and a cost when the product is used for a predetermined period by applying each of a plurality of the circulation scenarios.

[0106]

Thus, it is possible to support determination of a circulation scenario to be applied to the product on the basis of the configuration of each individual of the product.

[0107]

(2) The product circulation support method according to (1), in which the circulation pattern information includes, for each of the plurality of components, one or more combinations of an applicable circulation strategy (for example, the circulation strategy 303) and a time (for example, the circulation frequency 304) of an action based on the circulation strategy, and in the first procedure, the processor generates the circulation scenario by determining, for each of the plurality of components constituting the product, a circulation strategy to be applied and a time of

an action based on the circulation strategy on the basis of the circulation pattern information, and in the plurality of circulation scenarios, the circulation strategy or the time of the action based on the circulation strategy determined for at least one of the components is different.

[0108]

Thus, a plurality of circulation scenarios having different environmental loads and costs are generated, and various options for determining an appropriate circulation scenario are prepared.

[0109]

(3) The product circulation support method according to (2), in which the storage device further holds environmental load information (for example, the environmental load value table 112) indicating an environmental load caused by an action based on the circulation strategy and cost information (for example, the cost table 113) indicating a cost caused by an action based on the circulation strategy, and in the second procedure, the processor calculates the environmental load and the cost by calculating the environmental load and the cost when an action based on the circulation strategy is performed at a time determined on the basis of the circulation scenario on the basis of the environmental load information and the cost information (for example, step 1205).

[0110]

Thus, the environmental load and the cost for each circulation scenario of each individual of the products can be appropriately calculated.

[0111]

(4) The product circulation support method according to (3), in which the storage device further holds product use characteristic information (for example, the product use characteristic 114) indicating operating statuses of the plurality of components constituting the product, and in the second procedure, the processor calculates the environmental load and the cost on the basis of the product use characteristic information (for example, step 1205).

[0112]

Thus, the environmental load and the cost for each circulation scenario of each individual of the products can be appropriately calculated.

[0113]

(5) The product circulation support method according to (4), in which the storage device further holds component configuration influence characteristic information (for example, the component configuration influence characteristic model 115) that associates a combination of the operating statuses of two or more of the components with the environmental load, and in the second procedure, the

processor calculates the environmental load on the basis of the product use characteristic information and the component configuration influence characteristic information (for example, step 1204).

[0114]

Thus, the environmental load and the cost for each circulation scenario of each individual of the products can be appropriately calculated.

[0115]

(6) The product circulation support method according to (4), in which the storage device further holds component residual value information (for example, the component residual value model 110) that associates an operating status with a residual value for each of the plurality of components, and in the second procedure, when an action performed on the basis of the circulation strategy at a time determined on the basis of the circulation scenario includes replacement of the component, the processor calculates a residual value of the component to be replaced on the basis of the product use characteristic information and the component residual value information (for example, step 1203), and calculates the cost on the basis of the residual value (for example, step 1205).

[0116]

Thus, the environmental load and the cost for each

circulation scenario of each individual of the products can be appropriately calculated.

[0117]

(7) The product circulation support method according to (4), in which the product use characteristic information includes at least one of an operating time (for example, the operating time 802), an operation frequency (for example, the operation frequency 803), or a number of times of operation (for example, the number of times of operation 804) of each of the plurality of components constituting the product as an operating status of the plurality of components constituting the product.

[0118]

Thus, the environmental load and the cost for each circulation scenario of each individual of the products can be appropriately calculated.

[0119]

(8) The product circulation support method according to (2), in which in each combination of the applicable circulation strategy and the time of the action based on the circulation strategy included in the circulation pattern information, the circulation strategy includes at least any one of use continuation, repair, reuse, refurbishment, remanufacturing, or recycling.

[0120]

Thus, the environmental load and the cost for each circulation scenario of each individual of the products can be appropriately calculated.

[0121]

(9) The product circulation support method according to (1), in which the storage device further holds a recommendation rule (for example, the recommendation rule 111) for determining the circulation scenario to be recommended on the basis of the environmental load and the cost, and the product circulation support method further includes a third procedure in which the processor outputs information for recommending the circulation scenario determined on the basis of the recommendation rule and the environmental load and the cost which have been calculated (for example, step 1208).

[0122]

Thus, an appropriate circulation scenario can be recommended on the basis of a predetermined rule.

[0123]

(10) The product circulation support method according to (9), in which the recommendation rule includes at least one of a rule of recommending the circulation scenario in which the environmental load is minimized, a rule of recommending the circulation scenario in which the cost is minimized, and a rule of recommending the circulation

scenario in which a balance between the environmental load and the cost is optimized.

[0124]

Thus, an appropriate circulation scenario can be recommended on the basis of a predetermined rule.

[0125]

(11) The product circulation support method according to (10), in which a rule of recommending the circulation scenario in which a balance between the environmental load and the cost is optimized is a rule of recommending the circulation scenario in which a harmonic average between the environmental load and the cost is minimized.

[0126]

Thus, an appropriate circulation scenario can be recommended on the basis of a predetermined rule.

[0127]

Note that the present invention is not limited to the above-described embodiments, and includes various modifications. For example, the above-described embodiments have been described in detail for better understanding of the present invention, and are not necessarily limited to those having all the configurations of the description. In addition, a part of the configuration of a certain embodiment can be replaced with the configuration of another embodiment, and the configuration of another embodiment can be added to

the configuration of a certain embodiment. Further, it is possible to add, delete, and replace other configurations for a part of the configuration of each embodiment.

[0128]

In addition, some or all of the above-described configurations, functions, processing units, processing means, and the like may be implemented by hardware, for example, by designing with an integrated circuit. Further, each of the above-described configurations, functions, and the like may be implemented by software by a processor interpreting and executing a program for implementing each function. Information such as a program, a table, and a file for realizing each function can be stored in a storage device such as a nonvolatile semiconductor memory, a hard disk drive, and a solid state drive (SSD), or a computer-readable non-transitory data storage medium such as an IC card, an SD card, and a DVD.

[0129]

In addition, the control lines and the information lines indicate what is considered to be necessary for the description, and do not necessarily indicate all the control lines and the information lines on the product. In practice, it may be considered that almost all the configurations are connected to each other.

CLAIMS

[Claim 1]

A product circulation support method executed by a computer system including a processor and a storage device, wherein

the storage device holds product configuration information indicating a plurality of components constituting a product and circulation pattern information indicating a plurality of circulation strategies for resource circulation applicable to the plurality of components, and

the product circulation support method comprises:

a first procedure in which the processor generates a plurality of circulation scenarios defining a circulation strategy to be applied to each of the components constituting the product on a basis of the product configuration information and the circulation pattern information; and

a second procedure in which the processor calculates an environmental load and a cost when the product is used for a predetermined period by applying each of a plurality of the circulation scenarios.

[Claim 2]

The product circulation support method according to claim 1, wherein

the circulation pattern information includes, for each

of the plurality of components, one or more combinations of an applicable circulation strategy and a time of an action based on the circulation strategy, and

in the first procedure, the processor generates the circulation scenario by determining, for each of the plurality of components constituting the product, a circulation strategy to be applied and a time of an action based on the circulation strategy on a basis of the circulation pattern information, and

in the plurality of circulation scenarios, the circulation strategy or the time of the action based on the circulation strategy determined for at least one of the components is different.

[Claim 3]

The product circulation support method according to claim 2, wherein

the storage device further holds environmental load information indicating an environmental load caused by an action based on the circulation strategy and cost information indicating a cost caused by an action based on the circulation strategy, and

in the second procedure, the processor calculates the environmental load and the cost by calculating the environmental load and the cost when an action based on the circulation strategy is performed at a time determined on a

basis of the circulation scenario on a basis of the environmental load information and the cost information.

[Claim 4]

The product circulation support method according to claim 3, wherein

the storage device further holds product use characteristic information indicating operating statuses of the plurality of components constituting the product, and

in the second procedure, the processor calculates the environmental load and the cost on a basis of the product use characteristic information.

[Claim 5]

The product circulation support method according to claim 4, wherein

the storage device further holds component configuration influence characteristic information that associates a combination of the operating statuses of two or more of the components with the environmental load, and

in the second procedure, the processor calculates the environmental load on a basis of the product use characteristic information and the component configuration influence characteristic information.

[Claim 6]

The product circulation support method according to claim 4, wherein

the storage device further holds component residual value information that associates an operating status with a residual value for each of the plurality of components, and

in the second procedure, when an action performed on a basis of the circulation strategy at a time determined on a basis of the circulation scenario includes replacement of the component, the processor calculates a residual value of the component to be replaced on a basis of the product use characteristic information and the component residual value information, and calculates the cost on a basis of the residual value.

[Claim 7]

The product circulation support method according to claim 4, wherein

the product use characteristic information includes at least one of an operating time, an operation frequency, or a number of times of operation of each of the plurality of components constituting the product as an operating status of the plurality of components constituting the product.

[Claim 8]

The product circulation support method according to claim 2, wherein

in each combination of the applicable circulation strategy and the time of the action based on the circulation

strategy included in the circulation pattern information, the circulation strategy includes at least any one of use continuation, repair, reuse, refurbishment, remanufacturing, or recycling.

[Claim 9]

The product circulation support method according to claim 1, wherein

the storage device further holds a recommendation rule for determining the circulation scenario to be recommended on a basis of the environmental load and the cost, and

the product circulation support method further comprises a third procedure in which the processor outputs information for recommending the circulation scenario determined on a basis of the recommendation rule and the environmental load and the cost which have been calculated.

[Claim 10]

The product circulation support method according to claim 9, wherein

the recommendation rule includes at least one of a rule of recommending the circulation scenario in which the environmental load is minimized, a rule of recommending the circulation scenario in which the cost is minimized, and a rule of recommending the circulation scenario in which a balance between the environmental load and the cost is optimized.

[Claim 11]

The product circulation support method according to claim 10, wherein

a rule of recommending the circulation scenario in which a balance between the environmental load and the cost is optimized is a rule of recommending the circulation scenario in which a harmonic average between the environmental load and the cost is minimized.

[Claim 12]

A product circulation support system comprising a processor and a storage device, wherein

the storage device holds product configuration information indicating a plurality of components constituting a product and circulation pattern information indicating a plurality of circulation strategies for resource circulation applicable to the plurality of components, and

the processor

generates a plurality of circulation scenarios defining a circulation strategy to be applied to each of the components constituting the product on a basis of the product configuration information and the circulation pattern information; and

calculates an environmental load and a cost when the product is used for a predetermined period by applying each

of a plurality of the circulation scenarios.