

METHOD FOR CALCULATING DISSIPATION OF CARBON EMISSIONS OF RECYCLABLE MATERIAL IN SINGLE CYCLE PERIOD

TECHNICAL FIELD

The present invention relates to the technical field of carbon emission calculation, and particularly relates to a method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period.

BACKGROUND

At present, a product carbon footprint calculation system in China has not been perfect yet. Particularly, there is lack of a unified standard for a carbon emission calculation method especially for consideration of recycling and reusing of a recyclable material. For example, *Standard for Building Carbon Emission Calculation* GB/T 51366-2019 in the building field only provides an approximate method for considering the recycling and reusing of the material, there is lack of a theoretical model and a derivation process, which is unfavorable for the cyclic utilization of the recyclable material.

According to *Standard for Building Carbon Emission Calculation* GB/T 51366-2019, “6.2.5 When producing building materials, if low-value waste is used as raw material, the carbon emission in the upstream process can be ignored. When other renewable raw materials are used, they shall be calculated based on 50% of the carbon emissions of the primary raw materials they replace. For the renewable construction waste generated during the building construction and demolition stages, it can be calculated based on 50% of the carbon emissions of the primary raw materials they can replace; meanwhile it shall be deducted from the building’s carbon emissions.” This description is converted into a formula shown as follows:

$$E = \frac{1}{2}RE_v + (1-R)E_v - \frac{1}{2}rE_v + E_d \quad (\text{Formula 1})$$

In Formula 1, E_v represents a carbon emission factor of a primary material, E_d represents a carbon emission factor of waste disposal, R represents a proportion of a recycled ingredient in a current material production process, c represents an input-output ratio of a material recycling process, P represents a proportion of the mass of materials for cyclic regeneration at the end of a current material use period to the total mass of materials in

the current period, and r represents a proportion of the mass of ingredients obtained through cyclic regeneration at the end of the current material use period to the total mass of materials in the current period, i.e., $r = pc$.

In Formula 1, there is lack of carbon emission input at the recycling stage, the accounting boundary is incomplete, and physical significance of $1/2$ coefficients in the formula is unclear, which causes some limitations on its use and popularization.

SUMMARY

The objective of the present invention is to overcome the defects in the prior art and provide a method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period, and solves the problems that the existing carbon emission calculation standard is lack of the carbon emission input at the recycling stage, and the accounting boundary is incomplete, which causes some limitations on its use and popularization, and it is difficult to provide guidance for industry policies and studies, so on.

In order to achieve the above objective, the present invention adopts the following technical solution:

The present invention provides a method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period, including the following steps:

obtaining carbon emissions generated from the production of the recyclable material as carbon emissions from the production of a primary material;

in a process of recycling and reusing the recyclable material, obtaining carbon emissions from the production of a recycled material and carbon emissions of a recycled primary material; and

calculating the dissipation of carbon emissions in a single cycle period according to the obtained carbon emissions from the production of the primary material, the carbon emissions from the production of the recycled material and the carbon emissions of the recycled primary material, where a calculation formula of the dissipation of carbon emissions is as follows:

$$E_{\text{dissipation}} = m(1-r)mE_v + RmE_R + (1-p)mE_d$$

in the formula, $E_{\text{dissipation}}$ represents the dissipation of carbon emissions in a single cycle period,

m represents a total mass of materials used in the current cycle,

E_v represents a carbon emission factor of the primary material,

E_d represents a carbon emission factor of waste disposal,

E_R represents carbon emission needing to be consumed for recycling a unit mass of the recyclable material,

r represents a proportion of a mass of ingredients obtained through cyclic regeneration at the end of a current material use period to the total amount of materials in the current period, i.e., $r = pc$,

P represents a proportion of a mass of materials for cyclic regeneration at the end of the current material use period to the total amount of materials in the current period,

c represents an input-output ratio in a material recycling process, and

R represents a proportion of recycled ingredients in a current material production process.

The method for calculating dissipation of carbon emissions provided by the present invention is a practical dissipation method, represents the carbon emissions that are consumed in a current life cycle in a production process of a specific product and is unrecyclable, including initial production emissions of a nonrecycled portion material, carbon emissions consumed by current recycling and carbon emissions generated through demolition recycling, is an emission level in the single cycle period, has a microscopic concrete meaning, and can provide guidance for carbon reduction design in product production, use and recycle processes.

The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period provided by the present invention has a further improvement that the carbon emissions of the recycled primary material equal to the carbon emissions of the primary material minus the carbon emissions of an unrecyclable portion.

The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period provided by the present invention has a further improvement that the carbon emissions from the production of the primary material are obtained through practical measurement.

The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period provided by the present invention has a further improvement that the carbon emissions of the recycled material and the carbon emissions of the recycled primary material are obtained through practical measurement.

The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period provided by the present invention has a further improvement that the

carbon emissions from the production of the primary material are obtained through energy input estimation.

The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period provided by the present invention has a further improvement that the carbon emissions from the production of the recycled material and the carbon emissions of the recycled primary material are obtained through energy input estimation.

DETAILED DESCRIPTION

The present invention will be further illustrated hereafter in combination with specific embodiments.

The present invention provides a method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period. The unrecyclable carbon emissions in each cycle may be calculated. Variables in the present invention have accurate physical significance. When considering the distribution of favorable effects from regeneration cycles between life cycles, the methods for distribution and calculation become clearer, while the boundaries for accounting of carbon emissions become clearer and more complete. The present invention can accurately calculate the carbon emission condition of the recyclable material, and is favorable to promoting the sufficient cyclic utilization of the recyclable material. The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period of the present invention will be illustrated hereafter.

The present invention provides a method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period, including the following steps:

obtaining carbon emissions generated from the production of the recyclable material as carbon emissions from the production of a primary material;

in a process of recycling and reusing the recyclable material, obtaining carbon emissions from the production of a recycled material and carbon emissions of a recycled primary material; and

calculating dissipation of carbon emissions in a single cycle period is calculated according to the obtained carbon emissions from the production of the primary material, the carbon emissions from the production of the recycled material and the carbon emissions of the recycled primary material, where a calculation formula of the dissipation of carbon emissions is as follows:

$$E_{\text{dissipation}} = (1-r)mE_v + RmE_R + (1-p)mE_d$$

in the formula, $E_{\text{dissipation}} m$ represents the dissipation of carbon emissions in a single cycle period,

m represents a total mass of materials used in the current cycle,

E_v represents a carbon emission factor of the primary material,

E_d represents a carbon emission factor of waste disposal,

E_R represents carbon emission needing to be consumed for recycling a unit mass of the recyclable material,

r represents a proportion of a mass of ingredients obtained through cyclic regeneration at the end of a current material use period to the total amount of materials in the current period, i.e., $r = pc$,

p represents a proportion of a mass of materials for cyclic regeneration at the end of the current material use period to the total amount of materials in the current period,

c represents an input-output ratio in a material recycling process, and

R represents a proportion of recycled ingredients in a current material production process.

In a specific implementation of the present invention, the carbon emissions of the recycled primary material equal to the carbon emissions of the primary material minus the carbon emissions of an unrecyclable portion.

In a specific implementation of the present invention, the dissipation of carbon emissions = the carbon emissions from the production of the primary material + the carbon emissions from the production of the recycled material - the carbon emissions of the recycled primary material, and the carbon emissions of the recycled primary material = the carbon emissions of the primary material - the carbon emissions of the unrecyclable portion.

A formula is shown as follows:

$$\begin{aligned} E_{\text{dissipation}} m &= (1-R)mE_v + RmE_R + (1-p)mE_d - ((1-R) - (1-pc))mE_v \\ &= (1-pc)mE_v + RmE_R + (1-p)mE_d \\ &= (1-r)mE_v + RmE_R + (1-p)mE_d \end{aligned}$$

In the formula, $(1-R)m$ represents a mass of a primary portion in the materials, because a part of primary materials may be added into and mixed with the recycled material in a use process of the recycled material to meet the material performance.

In the above formula, m is reduced to obtain: $E_{\text{dissipation}} = (1-r)E_v + RE_R + (1-p)E_d$.

In this formula, $E_{\text{dissipation}}$ represents a carbon dissipation factor of a unit mass of primary

materials in a single cycle period.

In a specific implementation of the present invention, the carbon emissions from the production of the primary material are obtained through practical measurement.

Further, the carbon emissions of the recycled material and the carbon emissions of the recycled primary material are obtained through practical measurement.

Specifically, the total amount of produced carbon dioxide may be detected in a production process to obtain the carbon emissions from the production of the primary material and the carbon emissions from the production of the recycled material, the total amount of the produced carbon dioxide is detected in a recycling process, and the recycling process includes processes of material treatment, transportation, smelting, etc.

In a specific implementation of the present invention, the carbon emissions from the production of the primary material are obtained through energy input estimation.

Further, the carbon emissions from the production of the recycled material and the carbon emissions of the recycled primary material are obtained through energy input estimation.

The carbon emission may be discounted specifically according the energy input. For example, the consumption of coal, electricity and oil fuel may be discounted into carbon emission.

The carbon dissipation calculation formula of the present invention has clear physical significance, representing the practically dissipating carbon emissions in each cycle period. Additionally, in the formula, p is clearly distinguished from r , i.e., a proportion of recycled waste ingredients and a proportion of recovered recycled ingredients, and they may not be easily confused. That is, r is smaller than or equal to c . Even all of the materials are recycled, the limitation by the input-output ratio during recycling also exists. Additionally, a waste disposal manner required by the material recycling process is generally different from an ordinary waste disposal manner. According to the formula, the waste disposal is divided into two portions, the recycled portion is classified into recycling emission, and the demolition recovery portion emission during recycled waste recovery can be more reasonably allocated.

The effect of the calculation method of the present invention will be illustrated by an example hereafter.

Supposed that materials are completely abandoned and exit cycles after two cycles, additionally, materials in the first cycle are pure primary materials, all of the materials are fully recycled, no primary material is added in the second cycle, and materials in the second cycle are all recycled materials obtained through recycling and retreating in the first cycle.

After the period is completed, all of the materials are abandoned and exit the cycles. That is, the first cycle: $R_1 = 0$, $p_1 = 1$, and the second cycle: $R_2 = 1$, $p_2 = 0$.

According to a consideration method given by a building standard in China, values are brought into a formula $E = \frac{1}{2}RE_v + (1-R)E_v - \frac{1}{2}rE_v + E_d$ to obtain emissions in the two cycles respectively:

$$E_1 = E_v - \frac{1}{2}cE_v + E_d \quad \text{and} \quad E_2 = c\left(\frac{1}{2}E_v + E_d\right),$$

$$\text{totally: } E_1 + E_2 = E_v + (1+c)E_d.$$

Therefore, the emissions in the first cycle process and the second cycle process are different from a current production emission and is also different from a current dissipation emission. At the same time, the total emissions include the carbon emissions from the production of this part of materials and the carbon emissions of waste disposal of the materials twice. However, it is obviously lack of the carbon emissions required by a relevant recycling process, and the accounting boundary is incomplete.

According to a calculation formula of the present invention, there are:

$$E_1 = (1-c)E_v \quad \text{and} \quad E_2 = c(E_v + E_R + E_d),$$

$$\text{totally: } E_1 + E_2 = E_v + c(E_R + E_d).$$

The above formula E_1 can express the fact that in the first cycle, only the mass loss in the recycling process, i.e., the carbon emissions of the $(1-c)$ portion, is not reusable. In the second cycle, E_2 represents the dissipated emissions. It can be seen that all the emissions related to materials of the portion with a mass c are not reusable. These emissions include the emissions E_v from initial production of the materials, the emissions E_R from the fully recycling smelting, and the emissions E_D from the waste disposal. From the expression of $E_1 + E_2$, it can be seen that the total emissions are the same as the practical emissions.

The method of the present invention is a practical dissipation method, which represents the carbon emissions that are consumed in a current life cycle in a production process of a specific product and unrecyclable, including the initial production emissions of a nonrecycled portion material, the carbon emissions consumed by the current recycling and the carbon emissions generated through demolition recycling, is an emission level in the single cycle period, has a microscopic concrete meaning, and can provide guidance for carbon reduction design in product production, use and recycle processes.

For example, some materials have relatively low primary production emissions, but have

poor recycling capability and high recycling loss, whereas some materials have high primary production emissions, but have strong recycling capability and low recycling loss. If the carbon emissions are only calculated according to a proportion of recycled ingredients in initial ingredients of the materials, the favorable effect of the effective recycling for waste reduction on carbon emission reduction cannot be reflected.

In terms of use, the method may be used for guiding carbon emission reduction design of a single product. According to the calculation formulas, key points of design may include: 1. improving a recycling rate to reduce waste; 2. improving a recycling process to reduce the recycling carbon emission intensity; 3. implementing recycling-oriented product design, such as an easy-to-dismount system and an easy-to-stack component shape finding, and establishing an efficient recycling system, such as a haul distance reduced recycling station and recycling enterprise layout to reduce the recycling emissions.

The present invention has been illustrated in detail by the above embodiments. Those of ordinary skill in the art may obtain various variation examples on the present invention according to the above descriptions. Therefore, some details in the embodiments shall not construct the limitation to the present invention. The protection scope of the present invention will be defined by the claims of the present invention.

CLAIMS

What is claimed is:

1. A method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period, comprising the following steps:

obtaining carbon emissions generated from the production of the recyclable material as carbon emissions from the production of a primary material;

in a process of recycling and reusing the recyclable material, obtaining carbon emissions from the production of a recycled material and carbon emissions of a recycled primary material; and

calculating the dissipation of carbon emissions in a single cycle period according to the obtained carbon emissions from the production of the primary material, the carbon emissions from the production of the recycled material and the carbon emissions of the recycled primary material, wherein a calculation formula of the dissipation of carbon emissions is as follows:

$$E_{\text{dissipation}} = m(1-r)mE_v + RmE_R + (1-p)mE_d$$

in the formula, $E_{\text{dissipation}}$ represents the dissipation of carbon emissions in a single cycle period,

m represents a total mass of materials used in the current cycle,

E_v represents a carbon emission factor of the primary material,

E_d represents a carbon emission factor of waste disposal,

E_R represents carbon emission needing to be consumed for recycling a unit mass of the recyclable material,

r represents a proportion of a mass of ingredients obtained through cyclic regeneration at the end of a current material use period to the total amount of materials in the current period, i.e., $r = pc$,

p represents a proportion of a mass of materials for cyclic regeneration at the end of the current material use period to the total amount of materials in the current period,

c represents an input-output ratio in a material recycling process, and

R represents a proportion of recycled ingredients in a current material production process.

2. The method for calculating dissipation of carbon emissions of a recyclable material in

a single cycle period according to claim 1, wherein the carbon emissions of the recycled primary material equal to the carbon emissions of the primary material minus the carbon emissions of an unrecyclable portion.

3. The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period according to claim 1, wherein the carbon emissions from the production of the primary material are obtained through practical measurement.

4. The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period according to claim 1, wherein the carbon emissions of the recycled material and the carbon emissions of the recycled primary material are obtained through practical measurement.

5. The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period according to claim 1, wherein the carbon emissions from the production of the primary material are obtained through energy input estimation.

6. The method for calculating dissipation of carbon emissions of a recyclable material in a single cycle period according to claim 1, wherein the carbon emissions from the production of the recycled material and the carbon emissions of the recycled primary material are obtained through energy input estimation.