ISSN: 2834-7706

Research Article

Journal of Mathematical Techniques and Computational Mathematics

Material; Waste; Energy and Environment Relationship in Sustainable Development

Taiwo O. Asonja[1]*, Taiwo Alare[2]

[1]* Department of Mechanical Engineering, Federal University of Technology, Akure, Nigeria.

[2] Department of Mechanical Engineering, Federal University of Technology Akure, Nigeria.

*Corresponding Author:
Taiwo O. Asonja. Department of Mechanical Engineering, Federal University of Technology, Akure, Nigeria.

Submitted: 02 Dec 2022; **Accepted:** 19 Dec 2022; **Published:** 26 Dec 2022

Citation: Asonja, T. O., Alare, T. (2022). Material; Waste; Energy and Environment Relationship in Sustainable Development. *J Math Techniques Comput Math*, 1(3), 238-241.

Abstract

To have a sustainable development; material, waste, energy and environment must be under-checked. Materials generate both energy and waste; the waste generated maybe harmful to environment causing pollution of all kind. We therefore developed a mathematical relationship between, material-waste, Energy- waste, waste- environment and material-waste-energy- environment. The aim is to provide a model which can determine the sustainability of an environment considering material production, energy generation and waste management.

Likewise, the paper shows that energy stored in waste is a function of materials produced and usage time. It also reduces with the period of redundancy of waste. Also, to achieve a sustainable environment, the redundancy period of waste should be minimized. Minimizing this will also reduce land area cover by waste.

Keywords: Sustainability; Environment; Material; Energy; Waste; Mathematical Modeling.

Nomenclature

w_g :*Waste generated from production in Kg/day*
m_p :*Quantity of materials produced in Kg*
U_t :*Usage time of material produced in Day(s)*
m_w :*weight of shaft in Kg*
m_o :*Weight of workpiece before cutting operations in Kg*
m_i :*Weight of item produced after cutting in Kg*
n:*Number of items produced at a batch*
t:*Operational time in hours*
w_m:*Accumalated weight of shaft in Kgh*
c_l: *Reuseability*
θ:*reuseability factor*
w_T : *Quantity of total weight generated in Kg*
K:*reduction constant*
N:*Quantity of waste generated per day in kg/day*
T_o:*Period in days*
E_{in} :*Energy in waste in J*
A:*Waste Area in* m^2
T_r:*Redundancy period in days*
$\in_r$:*Enviromental factor in m^2.day*
$\in_s$:*Environmental sustainability in* $m^{-2}.day$□$^{-1}$
E_c :*Waste combustible energy in J*
E_{rec} □*Waste Recycling energy in J*
e_o:*Energy losses*
M ;*Amount of waste accumulated over a period of time in Kg*

Introduction

Material science is the study of materials; while material is everything outside nothing i.e. material science is the study of everything outside nothing. Every tangible thing in the universe is a material.

Materials are used every day by human for living. Materials can be useful or waste.

Over the years, materials are being transformed using technology available at the material time to make living more comfortable; but as technology continue to advance, materials made with old technology are been abandoned, generating waste. Also, when an equipment fails or stops to perform it primary function, it is abandoned or dumped. This action over the years keep increasing the amount of waste in our environment. As we keep using and developing materials, we keep abandoning old materials causing waste to increase. In most part of the world, waste is beyond control causing environmental hazard.

Ojelola K. et al (2020) studied the waste generation and its management in the most populous city in Africa (Lagos, Nigeria) with the objective of transforming waste in useful products. With aim of transforming waste, Taiwo Alare et al. (2020) presented a model of smart waste cycle which included bioenergy generation, refining and recycling. A lot has been done by researchers on waste transformation especially in the area of biofuel and wastewater purification. It is difficult to know the amount of solid waste available in geographical location [1] and in order to reduce it via transformation the amount of available waste should be known to ensure efficient operations.

In other to increase the exactness of waste data, Taiwo Alare and Kehinde Alare (2021) developed a mathematical formula to calculate amount of solid waste in a location.

As material is a necessary tool in production, in order to reduced cost of production Olanrewaju Akinnawo and Taiwo Alare (2021) used waste in production of a paper cutting machine which tend to reduce the cost by 80%. As material scientists, it is high time we stopped wasting waste.
This paper develops mathematical models that give the relationships of material, waste, energy and environmental so that the redundancy of waste can be minimized. The approach of pendulum bulb modeling was used in determining the reusability of manufacturing and maintenance waste.

Material and Waste Relationship

Material been produced eventually turn into waste after been used. This could be solid waste or other forms of waste. It is said that each person generates 0.74Kg of waste in a day worldwide. (Anand, 2010) This generated waste have relation with material and it can be recycle back to material. (cudjoe, 2021) Therefore, it is necessary to know the mathematical relationship between material and waste to know the percentage of the reusable waste and actual waste reused out of the total waste generated so that we can protect our environment and also reduce cost of production.

Production Material and Waste Relationship

In the production industries, solid material is produced either as the main product or as a packaging medium. This material later turns into a waste after it's been used or to say after its usage time/period. Here, we base the function of waste generated as the dependent of material and its usage time in days neglecting recycling and other transformation factors because it will surface later on.

Production ——— Material ——— Usage ——→ Waste

$$w_g = \frac{m_p}{U_t} \quad (1)$$

Manufacturing Material and Waste Relationship

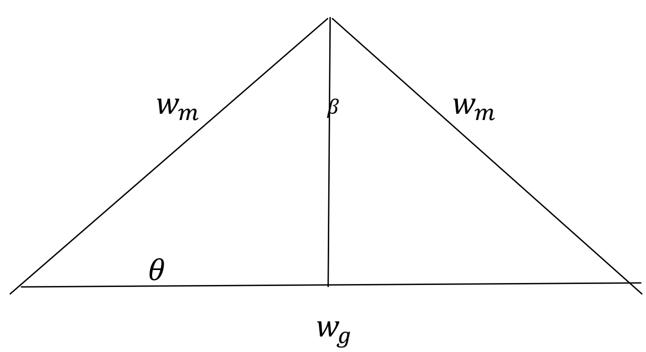
In subtractive manufacturing technologies, waste (chips) are generated from the manufacturing for materials, tools or machine parts which are later used in the production system. (; Yaich M. &., 2017) This waste is accumulated over operation hours and turn out most times useless. This waste is model on weight difference in Kg of work piece before and after operation, and operational time in hours.

$$\Delta_{m_w}.\Delta_t = \Delta_{w_m}, \partial_{m_w}.\partial_t = \partial_{w_m}\ m_w.t = w_m \quad (2)$$

$$m_w = \sum_1^n m_o - m_i \quad (3)$$

Material-Waste Modelling

We considered three waste generation: production, manufacturing and maintenance. We assume the same model for manufacturing waste and maintenance waste: the waste from manufacturing a maintenance can be reuse using reverse manufacturing. (Akinnawo, 2021) The modeling of these solid waste form and considering the usability of manufacturing and maintenance waste was done using pendulum model.



$$w_m B^{"} + c_l \sin\beta = 0 \quad (4)$$

$$\beta = 90 - \theta$$

$\therefore \ \sin\beta = \cos\theta$

$w_m B'' = -c_l \cos\theta \ \ \beta'' = -\frac{c_l}{w_m}\cos\theta \ \int \beta' d\beta = -\frac{c_l}{w_m}\int \sin\theta d\theta + c$

$$\beta = \frac{c_l}{w_m}\cos\theta d\theta + c \qquad (5)$$

neglecting constant $\beta = \frac{c_l}{w_m}\cos\theta d\theta$ since $\beta = 90 - \theta \ \therefore \ 90 - \theta = \frac{c_l}{w_m}\cos\theta d\theta$

$$w_m = \frac{c_l \cos\theta}{90-\theta} d\theta \qquad (6)$$

Also $c_l = \frac{w_m(90-\theta)}{\cos\theta} d\theta$ (7)

$w_m \ and \ c_l \ when \ \theta = 0\ , w_m \ is \ 0 \ at \ \theta = 90^0 \ and \ c_l \ is \ not \ define \ at \ \theta = 90^0$

Total waste generated over a period w_T

$$w_T = \sqrt{24 w_m w_g} \qquad (8)$$

$$w_T = \sqrt{\frac{24 m_p c_l \cos\theta}{U_t(90-\theta)}} \qquad (9)$$

The coefficient increases gradually 0.22 to 0.42 at θ= 0 to 89.9o but 0 at 90o because θ cannot be 90o the lower the conversion factor or factors associated with recycling and reuse of waste the low the waste generated. Taking the reusability factor to be 30o then,

$$W_T = \sqrt{\frac{0.346 m_p c_l}{U_t}} \qquad (10)$$

Also, $w_T = N(KT+1)$ (11)

(Kehinde Alare, 2021)� $and \ T = T_0 - 1$

Therefore, the waste generated per day N

$$N^2 = \left[\left(\frac{1}{(KT+1)^2}\right)\left(\frac{0.346 c_l}{U_t}\right)\right] m_p \qquad (12)$$

Equation (12) show the mathematical relationship the amount of waste generated per day to quantity of material produced and usage time.

Energy and Waste Relationship

Energy are trapped in waste which can be used as biomass or biofuel in combustion engines. Most waste generated are organic, this make them combustible. (al. O. K., 2020) This energy can be related to the inertia of waste generated over a period T and the period of redundancy of waste which tend to reduces the internal energy of waste. In trapping energy from waste its redundancy and the area cover by the waste are the determining factor.

$$E_{in} = \frac{w_T A}{{T_r}^2}$$

From equation (10) $W_T = \sqrt{\frac{0.346 m_p c_l}{U_t}}$ therefore,

$$E_{in} = \frac{A\sqrt{\frac{0.346 m_p c_l}{U_t}}}{{T_r}^2} \qquad (13)$$

The quantity of the material produced, the reusability of manufacturing and maintenance waste using reversed manufacturing (Akinnawo, 2021), are factors to analyze waste energy. Also, waste occupying area and its redundancy period are factor of environment and it can be used to model environment.

Environmental factor

Environmental factor of waste is dependent on the waste occupying area and its redundancy period.

$$\epsilon_r = A.T_r \qquad (14)$$

ϵ_r Indicate alternation to environmental sustainability and it is the measure of the degree of environmental pollution and damage. Therefore, environmental sustainability is,

$$\epsilon_s = \frac{1}{\epsilon_r} \qquad (15)$$

Energy, Environment and Material

Relationship between energy store in waste and environmental factor is given below.

$$E_{in} = \frac{\epsilon_r \sqrt{\frac{0.346 m_p c_l}{U_t}}}{{T_r}^3} \qquad (17)$$

To promote environmental sustainability, the energy stored should either be convert to useable energy such as combustion or be recycle into a new material. Therefore,

$$E_{in} = E_c + E_{rec} + E_o$$

$$E_{rec} = \epsilon_s \sqrt{\frac{0.346 m_p c_l}{U_t}}$$

Conclusion

This paper has shown the amount of waste generated over a period M= KTN+N (Kehinde Alare, 2021) is also a function of material produced $M=\sqrt{\frac{24 m_p c_l \cos\theta}{U_t(90-\theta)}}$.

Likewise, energy stored in waste is a function of material produced and usage time. It also reduces with the period of redundancy of waste. Also, to achieve a sustainable environment, the redundancy period of waste should be minimized. Minimizing this will also reduce land area cover by waste.

References

1. Akinnawo[1], O., & Alare, T. Development of an Eco-Efficient Automatic Paper Cutting Machine Using Reverse Manufacturing.
2. Ojelola K.S et al. (2020). Waste: an environmental degrable agent in lagos state. Research gate.
3. Anand, s. (2010). Solid Waste Mangement. Mittal Publication.
4. Cudjoe, D., Wang, H., & Zhu, B. (2021). Assessment of the potential energy and environmental benefits of solid waste recycling in China. Journal of Environmental Management, 295, 113072.
5. Alare, T., & Alare, K. (2021). Development of A Mathematical Model for Calculating Accumulated Solid Waste: An Experimental and Statistical Sampling.
6. Yaich, M., Ayed, Y., Bouaziz, Z., & Germain, G. (2017). Numerical analysis of constitutive coefficients effects on FE simulation of the 2D orthogonal cutting process: application to the Ti6Al4V. The International Journal of Advanced Manufacturing Technology, 93(1), 283-303.