



Investigation of the effect of municipal solid waste fragmentation to gaseous formation

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Abstract

Municipal Solid Waste disintegration and size reduction are often used in the material recovery sector under integrated solid waste management, ie in recycling. Historically, the benefits of size reduction are examined under three headings. The first of these is the separation of the waste pile into the main components of raw municipal solid waste paper, plastic and glass packages to make material recovery and separation more efficient. The second is the reduction of the Municipal Solid Waste fragmentation to an easier size for any equipment or personnel that follows the average grain size. Finally, and most importantly for material recovery facilities, the disintegration process enables automatic material separation processes such as air classifiers, sieves and optical separators by producing different size distributions for different municipal solid waste components. Prior to 1985, the main principle used in the design of a dimension reduction device was focused solely on the application of impact force. The results of such an idea were larger and heavier machines, which led to an increase in capital and operating costs. The composition of municipal solid waste is so diverse that machines designed for municipal solid waste must be strong enough to handle both soft and ductile materials, as well as hard and durable materials such as metals and dense plastics.

Keywords: municipal solid waste, fragmentation, machine design.

1. Introduction

Solid waste can be defined as the substances that are formed in simple terms by domestic, commercial and industrial functions and disposed of by the consumer on the grounds that they are no longer working, but which must be removed regularly due to environmental and human health and other social benefits. Although the concept of solid waste is used in the waste management literature for wastes other than liquid, gas or radioactive wastes, it is also used for solid or semi-solid materials, which no longer means more waste due to the re-production and processing of these solid wastes.

The definition of CCA is encountered in many different ways in the literature. All of these definitions are statements that indicate that the PPEs are unused residues. However, PPEs are not lost when they are evaluated under appropriate conditions and become a source of great benefit to humanity. Mankind will consume as long as it exists in the future, as it has in the past and today, and as a result, will lead to an unlimited accumulation of waste. If human beings do not know what to do with this accumulation of waste and just wait for it to

accumulate in nature, then the CCPs become a globally unsolved problem. However, if PPEs are considered as renewable energy sources and treated accordingly; if they can be recycled as energy with the necessary thermal processes, they become a global resource for humanity. CCAs are defined in one definition as residues of no value or useless residues [1]. In a similar definition, PPEs are referred to as substances produced by dwellings, commercial enterprises (restaurants, cafes, shopping centers, independent shops) and public institutions (police stations, hospitals, schools, etc.). A more common definition is solid wastes; manufacturer of undesirable human and environmental health in terms of solids that need to be disposed of in a regular way, [2]. Wastes according to their physical state (solid, liquid and gas), material structures (glass, plastic, paper, etc.), physical properties (flammable, biodegradable, recyclable), usage area (commercial, agricultural, industrial) or according to the level of safety (dangerous and non-hazardous). If these classifications are made for practical purposes, recycling efficiency can be improved by identifying the most appropriate recycling processes for PPEs.

2. Municipal solid waste management

Waste management; is a form of management which includes the reduction, collection, collection, temporary storage, intermediate storage, recovery, transportation, disposal and post-disposal control and similar processes of waste at source. Integrated waste management; waste management is integrated to all wastes together. Solid waste management includes:

- Prevention and reduction at source,
- Sorting according to total, transport and feature,
- Reuse, recovery and composting,
- Energy use,
- Disposal in the form of regular storage,
- Control after disposal.

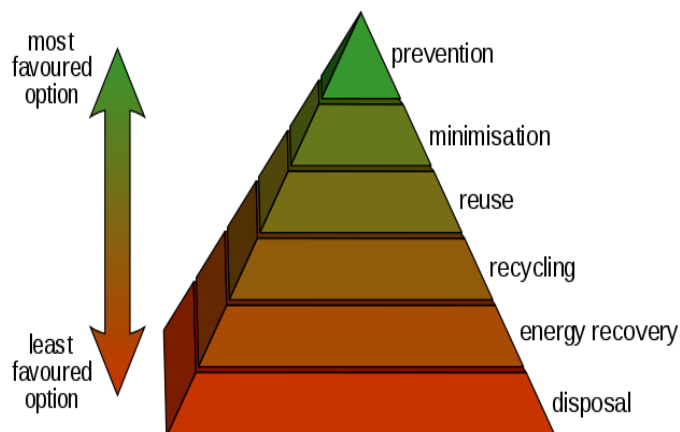


Figure 1. Municipal solid waste hierarchy.

The main objective of managerial structures that aim to provide solid waste services is to collect and remove wastes produced by the society efficiently and efficiently in the most economical, environmental, technical and social terms. The success of these procedures depends largely on the public participation and support. Therefore, informing the public beyond the decision-makers, technocrats, bureaucrats and similar interested parties in solid waste management is a necessity rather than an intellectual activity. The following steps are

necessary for a viable and efficient waste management.

- Identify authorized / responsible
- Identification of waste
- Separate collection at source
- Personnel training
- Establishment of temporary waste storage area
- Pre-treatment
- Disposal / recycling of waste
- Keeping records

2.1. Solid waste disposal stages

Solid waste management is grouped into six functional stages, from the production of waste to the disposal of the final pulp.

- Waste generation
- Storage and processing

- Collection
- Transfer and transport
- Processing and recovery
- The pulp is destroyed

2.2 Municipal solid waste recycling

Recyclable food packaging wastes such as glass, metal, plastic, paper / cardboard are processed through various physical and chemical processes and converted into a new raw material or product. Recycling of these wastes into a production process as a second raw material after a series of processes is called. This process differs for each type of waste

according to the type and nature of the material. Recycling is the conversion of constituents into other products or energy by physical, chemical and biochemical methods by taking advantage of the characteristics of the wastes. Recycling is defined as the whole collection, classification, recycling of physical wastes by physical and chemical methods to other products or energy. The main issue for

producing new products and materials from recyclable wastes is to collect these wastes clean and separated according to their types. If the evaluable wastes are mixed with the other wastes, the quality of the new product to be obtained will be low. Therefore, recyclable wastes should be collected separately and clean from other wastes. It is called

3. Waste shredder machine types

Particle size is known as one of the most important parameters affecting the product distribution of pyrolysis. This is because the particle size affects the combustion rate of the fuel in the pyrolysis reactor. The growth of the particle size causes the char yield to increase by reducing the heating rate. When working at small particle sizes, the retention time of the volatiles in the reactor increases and the amount of hydrogen formed by the decomposition of hydrocarbons increases. Thus, it is possible to say that the formation of liquid products in pyrolysis of small particle size biomass samples and the formation of solid products in pyrolysis of large particle size biomass samples is maximum.

When pyrolysis effect of particle size is evaluated; Since heat and mass transfer takes place in pyrolysis, particle size may affect the product composition / yield due to the heat / mass transfer resistance to be generated. In free-fall and entrained flow reactors, particle size affects the residence time and in fluidized bed reactors, the minimum fluidization rate is affected.

Studies have shown that particle size can have an effect, not on its own, but with the rate of heating of the particle. The change in particle size alone does not affect product yields much. During the pyrolysis process, biomass samples of large particle size will warm up more slowly and therefore average particle temperatures will be lower and less volatiles will be formed. This may result in less liquid product yield. In the pyrolysis process, the passage of the volatiles into the gas atmosphere is accelerated by increasing the particle size, thus limiting the mass transfer. The volatiles interact with the surface for a longer period of time and may cause secondary reactions (re-polymerization and various decomposition reactions on the hot solid surface). While polymerization reduces pyrolysis efficiency, surface disintegration reactions decrease liquid yield and increase gas yield. Shredding machine is used to break up, divide. With very few exceptions, low-speed shredders are used to reduce the size of waste materials. These materials are, for example, municipal solid waste, discarded

re-use of the wastes without being subjected to any treatment other than collection and cleaning until the economic life of the same form is repeated. Recycling is important in terms of protecting our natural resources, saving energy, facilitating waste processing by reducing the amount of waste and helping us to invest in the future and the economy.

car tires, old electronic appliances often white goods, industrial and structural debris and scrap electrical wires and cables.

The main purpose of the rapid pyrolysis process is to produce the most liquid from the biomass. In order to achieve this efficiency, rapid heating, short retention time of the gas formed in the reactor and rapid cooling of the condensable gas are required. In order to prevent carbonization, rapid heating is required, and therefore the particle size of the biomass should be as small as possible. In addition, the time from cooling to gas cooling must be quite short to avoid further side reactions.

One of the most important parameters affecting the thermal decomposition processes such as carbonization is the particle size of the sample to be carbonized. Since the thermal decomposition proceeds from the surface of the particle to its center, it is difficult to completely degrade the large diameter particles and requires more time. In this study, the reason of the decrease in solid product yield due to the decrease in particle size is the decrease in heat and mass transfer resistance and effects due to the more uniform heating of small particles. Thus, in the carbonization processes carried out under the same conditions, the mass loss due to the heat of small particles was higher and the solid product yield decreased. On the other hand, due to the heat transfer resistance of the coarse particles, the temperature profile formed in the particle reduces the volatile yield and increases the solid product yield [3-5]. Furthermore, the path through which the volatile components formed during the carbonization of the coarse particles passes through is prolonged and the particle contact time is prolonged. This results in secondary reactions that increase solid product yield. In this section, most of the following theoretical approaches are based on studies in [1, 6-8].

There are two major categories of shredders used in municipal waste management; high speed, low torque (HSLT) impact crushers and low speed, high torque (LSHT) cutting shredders. There is little

resemblance to the size reduction principles of HSLT grinders and LSHT cutters. This difference is acceptable by nature. It has some advantages and disadvantages in terms of product distribution and process capacity as well as municipal waste feeding. HSLT machines are available in a wider range in size and capacity due to their maturity in municipal waste treatment. The drum crusher type impact crushers can reach a capacity of 300 tons per hour, this number being largely dependent on the desired particle size as well as the composition of the raw municipal waste material. On larger machines like this, the more realistic value of the grinders for continuous operation will increase to 150 tons per hour. The first shredders used for size reduction are

not specifically designed to process a mix having a variety of composition and material properties, such as municipal waste. Grinders and cutting shredders should be designed according to the characteristics of the material being fed to optimize output and minimize wear and tear of cutting surfaces. The first shredders for municipal waste processing belonged to the family of impact crushers and were adapted from the function of shredding grains or brittle materials, such as rock and coal, to which they were popularly used.

Impact crushers were originally designed for processing materials such as steel with higher rigidity, as well as brittle materials such as glass and granite.

3.1. Impact shredder



Figure 2.1600 Impact shredder.

Low-torque shredders, such as top-feed horizontal impact crushers, use high-speed rotary shafts (700-1200rpm) with rammers fixed or bonded to them to shred incoming material. The main difference between these machines and LSHT devices is that impact crushers rely solely on impact and abrasive forces to separate waste into smaller pieces. Figure 2 shows the axial section of the rotary shaft and the tractor; this drawing highlights the impact forces used on these machines to reduce the size of waste [9-11].

It is important to realize that impact crushers do not have critical tolerances between hammers and cutter or sizing bars; This is because the size reduction

process is primarily a result of the tractor that breaks down municipal waste. Due to their impact strength, impact crushers are generally more efficient in processing brittle materials, and problems with fabric and fibrous materials, which may cause overload by winding onto the shaft and stopping the operation as shown in Figure 2, are caused by the low torque of the system. The hammer's impact force is reduced by ductile materials, while energy is absorbed and consumed by softening mechanisms that reduce the intensity of the impact force. Pulse shredders give less quality products with brittle materials and give better quality results than ductile materials. This is particularly true for glass, non-flammable materials, which result in unnecessary size reduction [4,12].

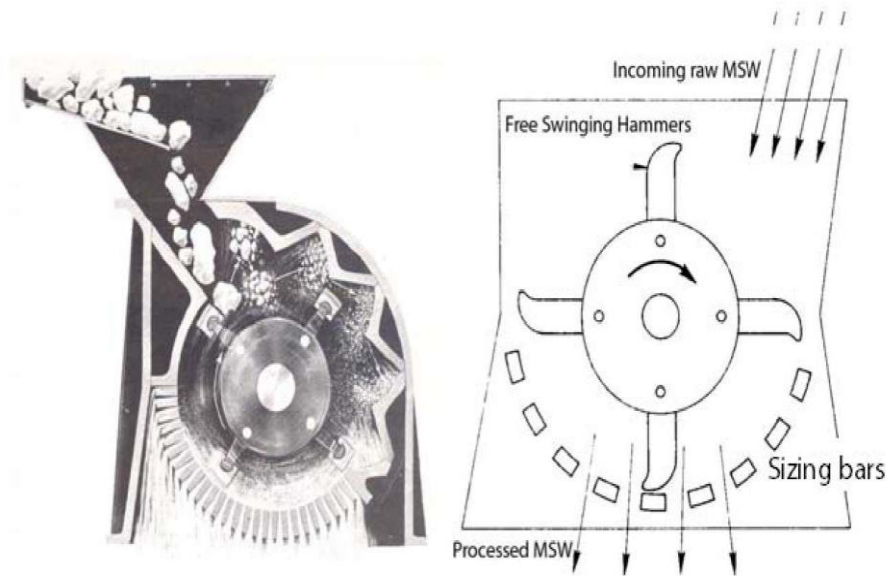


Figure 3. Internal arrangement of an impact shredder.

3.2. Low speed high torque (cutter shredders)



Figure 4. LSHT shredder cutting shaft [SSI 3600 H].

Low-speed, high-torque shredders, such as rotary cutter shredders, operate on a different principle than impact crushers. Rotary cutting devices are designed on shear and shear forces with little or no impact force. Rotary cutters have single, double and quadruple shaft configurations so that the increased number of spindles yields a smaller average particle size. Cutter shredders used in municipal waste processing are often limited to a dual shaft design to avoid unnecessary downsizing and energy consumption. The counter-rotating shafts are equipped with interlocking cutting blades and generate greater cutting forces on any material

trapped between them. These cutting blades or hooks are shown in Figure 4 in the double shaft configuration. The hooks must be designed to hold the incoming MSW and pull it between the shafts to reach the cutting forces. The definition of LSHT disintegrants generally requires a speed between 10 and 50 rpm. Low spindle speed may have some inhibitory effects as it is available at lower capacity than HSLT. The capacity of the shredder depends on the rotor speed and the volume between the cutting blades. Although commercially available cutting shredders have a capacity of around 150 tons per hour, they offer many positive features that meet

these shortcomings.

3.3. Type 1 shredder machine

Figure 5 is one of the first examples of cutting machines built for the special-use application in the last 10 years. This is the pre-cutting process for feeding non-ferrous, insulated scrap wire and cable to a mechanical recovery system. In this example, the raw material is very homogeneous in composition (relative to solid wastes) but varies in shape. In a

typical scrap processing operation, this material may be in the form of a stack of coils, bundles or loose wires weighing 900 kg. A material of this weight needs to be converted into 15-60 cm long, relatively looser and free-flow particles that can be fed to the primary process operation (tight tolerance radial blade mill). [4]

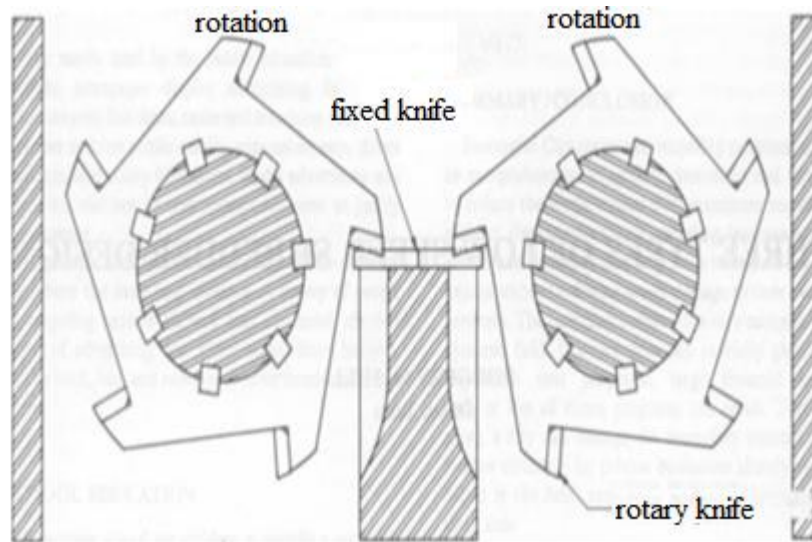


Figure 5. Type 1 shredder's knives

There are three factors to consider in the design of such cutting machines:

- Limitations of alternate process methods: small, hand-fed breaks were labor-intensive (but also unsafe), while hydraulic guillotine shears tended to pinch the wires as dense blocks. None of these methods could economically pre-cut dense, bulky parts (process effect).
- The sensitivity of the downstream grinders to increase loads or apply shock to them: any of the above-mentioned methods could overfeed the downstream system, and the compressed material from the hydraulic shears would cause a faster wear on the grinder (a repeat process effect).
- The structure of the material to be fed: Dense and bulky masses had to be shredded, but the wires had to be cut, they did not need to be broken up like big masses. [4]

The resultant design shown in Figure 6 consists of two non-engaging reverse-turn shafts. These shafts cut against an immobile anvil arm prepared with replaceable and adjustable blades. At the same time, these blades are of sufficient design to pull and separate the dense mass of the wire and cable. As the blades on the two wheels pass through the stationary blades, they divide the complex mass of the raw material into short length pieces.



Figure 6. Structure of the shaft.

4. Conclusion

When the effect of particle size is evaluated; Since heat and mass transfer takes place in pyrolysis, particle size may affect the product composition / yield due to the heat / mass transfer resistance to be generated. In free-fall and entrained flow reactors, particle size affects the residence time and in

fluidized bed reactors, effects the minimum fluidization rate. It was observed that the amount of gas product increased as the particle size decreased. Product amounts obtained as a result of pyrolysis experiments are shown in Figure 7.

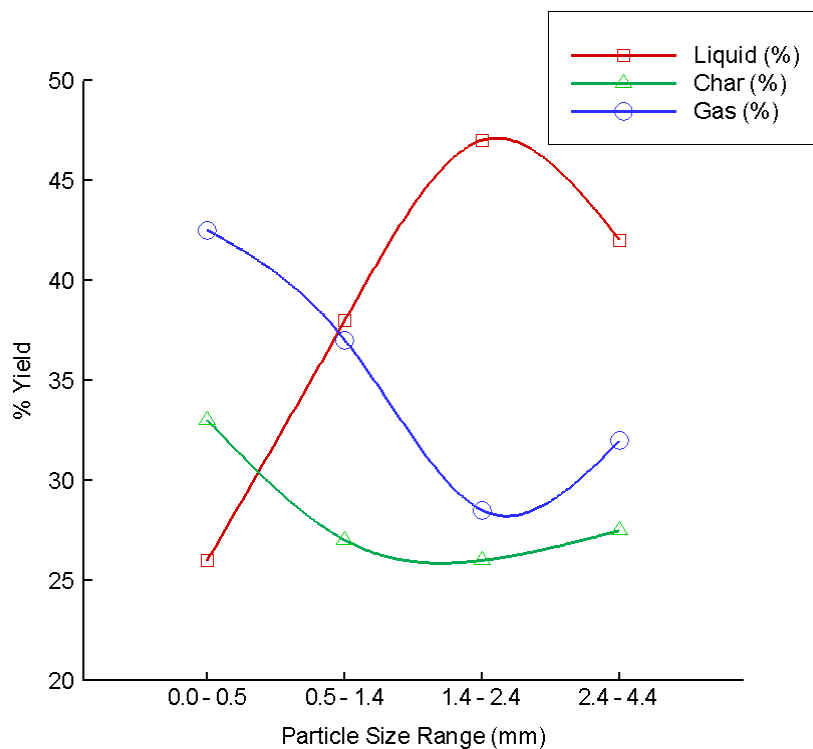


Figure 7. Solid, liquid and gas product mass ratios.

As can be seen from Figure 8, by varying the temperature between 600 and 900 ° C, the gas yield

increased significantly, while the solid and liquid yield decreased sharply for all particle sizes. The increase in gas yield can be mainly attributed to the decomposition of char and tar vapor as the temperature increases, since more solid and liquid vapor can be converted to gas by Boudouard reactions and thermal cracking reaction, respectively.

The yield and composition of the pyrolysis product depends on the heating rate of the particles. At higher heating speeds, less coal and condensation were produced, as well as more gas. Small particles contributed to a larger surface area and faster heating rates.

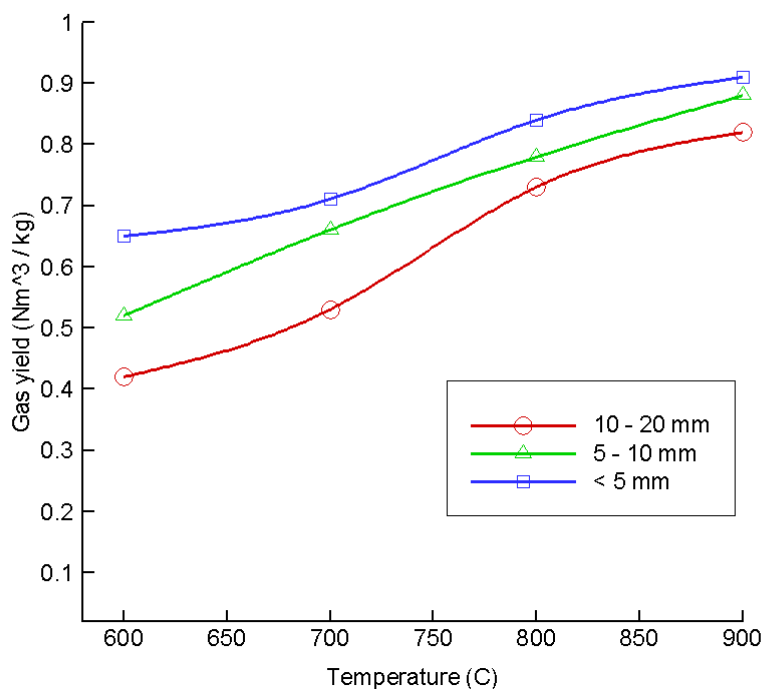


Figure 8. Gas product quantities obtained at different temperatures and particle sizes.

Particle size and temperature have integrated effects in the smallest particles, when the temperature is increased from 600 to 900 ° C, the solid and liquid are reduced from 11.4% to 3.5% and the dry gas yield increases from 0.96 to 1.39 Nm³ / kg . The differences in the composition of the product yield and temperature are due to the fact that firstly more gas is produced in the first pyrolysis (faster at higher

temperatures), the second is the endothermic reactions of gasification of the solid, and thirdly the steam breakage and remodeling of the liquid product.

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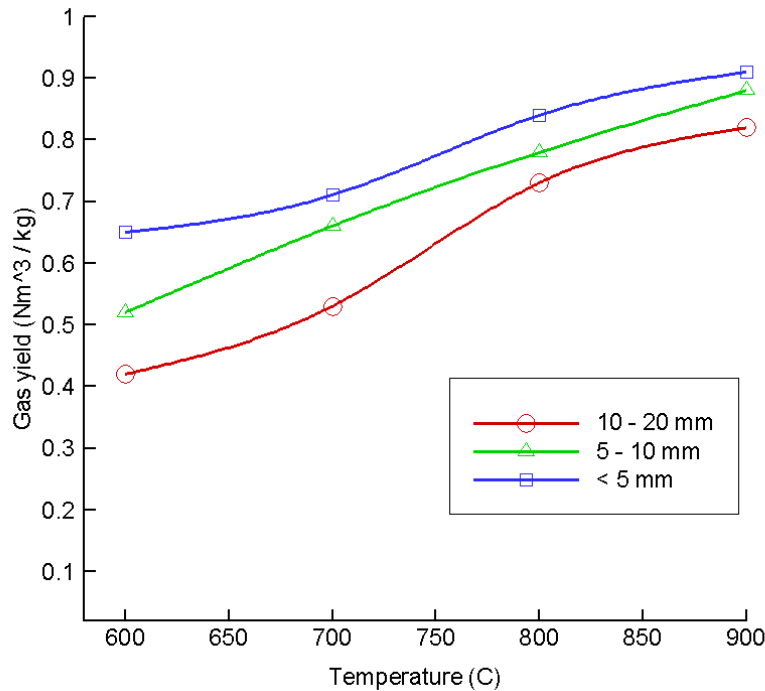


Figure 9. Gas product quantities obtained at different temperatures and particle sizes

Solid waste, which is one of the biggest problems of today's cities, increases with each passing day and causes serious environmental problems in urban areas. In order to solve the solid waste problem, collection, transportation, storage and disposal of wastes should be carried out effectively by local governments. The rapid increase of the world population and the increase in consumption in parallel with this increase causes usable resources to decrease rapidly. The limited availability of resources for the sustainability of life threatens the human future. A shredding machine has been

developed using locally available materials and technologies. The basic concept of the shredder may depend on different design variations. These variation variations adapt the main advantages of shredders to waste handling specific problems and give users a wider choice of equipment. This will require a description of machine performance requirements and an assessment of proposed machine features made by system designers and users. When selecting the machine, all factors that define the behavior of the feed material and the desired performance must be considered.

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