

## **EFFICIENT REDUCTION OF BOTANICAL MATERIAL INTO FINE PARTICLES**

### **Field of the Invention**

[0001] The present invention relates to processing of botanical materials to usable downstream products.

[0002] In particular, this invention relates to an apparatus for shredding felled trees into a form usable for subsequent downstream products in a single-step.

[0003] More particularly, this invention relates to an apparatus for shredding oil palm stems into a usable form of biomass in a single step.

### **Background of the Invention**

[0004] The oil palm *Elaeis guineensis* is a plant of great economic importance for many tropical and sub-tropical countries such as Malaysia, Indonesia, Nigeria, Ivory Coast, Brazil and Colombia. Its main product, palm oil, has been estimated to exceed eight million tonnes worldwide annually. Besides palm oil and palm kernel oil obtainable from the fruit, its other plant parts such as kernel shells, empty fruit branches, fruit fibers and fronds, can also be processed into usable by-products. These by-products include cheap boiler fuel, absorbents for liquids, plant mulch and animal feed.

[0005] The oil palm can grow up to 10 m with a stem diameter of up to 80 cm. Trees have a useful life-span of 25 to 30 years. Thereafter, the palms are no longer commercially viable. The unviable palm becomes an economical and environmental problem. To leave the palm to age away renders the land non productive. Thereafter, the trees have to be felled as they are susceptible to diseases and insect pests. After felling, the tree

must be removed as they take a long time to decompose in the field. Leaving the felled trees to rot on their own also hinders replanting, thereby tying up valuable arable land. Current methods of disposal of the trunk/stem are expensive and can be environmentally unfriendly.

[0006] The removal of felled stems is expensive due to high cost of transportation. As such, the oil palm stems may be burned in situ, but this is not environmentally friendly and many governments have banned such practice. The disposal of oil palm stems remains a logistic and financial burden for oil palm plantation owners. The current method of the art is to render the stem into smaller pieces or chips using a chipper. Some chippers require the stem to be sawn into shorter pieces (billets) with chain saws while inventions such as US 3,651,845 feed the stem downwards, directly against a rotating tooth member. Another machine, the CBI Magnum Force Wood Hog, feeds stems horizontally against a toothed rotor to reduce the stem to chips. Both of these use drum-type cutting heads, such as **110** illustrated in FIG 1A.

[0007] The outputs of these machines are chips that are inconsistent in size. While this size range of botanical material is useful in some applications, most downstream applications (e.g., conversion of the material into pulp or mulch) require the stems to be further flaked or shredded into consistent material less than a millimeter in diameter and down to a few millimeters in length.

[0008] The most common methods of shredding are the hammer type, the flail type, the grinder type and the disc type of shredders. The common principle behind these methods is that material is first reduced in size by a cutting or tearing means **120**, followed by forcing the reduced material against a screen **130** to further reduce the size as illustrated in FIG. 1B.

[0009] Thus, shredding may be viewed as distinct from chipping by requiring a subsequent step where the material is forced against a screen to further reduce the size of the particles.

[0010] Now, the anatomy of the oil palm stem renders it difficult to shred into fine particles for subsequent downstream use. The oil palm *Elaeis*

*guineensis* is a monocotyledenous plant which is made up of two components (1) vascular bundles in the forms of fibres and (2) parenchyma tissue which binds and cements the fibres. The stem has a density ranging from 200 to 600 kg/m<sup>3</sup>, decreasing from the base of the stem to the top. With this range of density, the lower parts of the stem have hardness values comparable to that of spruce and poplar.

[0011] While the hardness values are only moderate, it is known that oil palm stems have density and are tough on saw blades, rapidly dulling conventional blades made of tool steel. Stellite alloy or tungsten carbide teeth will allow the saw blade to last longer. Research into use of oil palm stems by the Forest Research Institute Malaysia (FRIM; Research Pamphlet No 107, Oil Palm Stem Utilization – Review of Research) showed that it is possible to produce sawn boards, fiber boards, particle boards and paper from the stems. However, while the problems of fast dulling of saw blades may be solved with alloy toothed blades, the processing of the stem chips to flakes or shreds present other problems.

[0012] It was found that during flaking or shredding, the clusters of fibrous strands in the stem become entangled with the knives of the flaker and may even jam it. In the case of the hammer mill the backing plate becomes clogged and ineffective in its operation. With this problem of further reducing the size of the stem chips, there is little incentive to develop downstream products from shredded oil palm stems.

[0013] Therefore, a need clearly exists for an apparatus that can reduce oil palm stems into a form, on site or off site, that is easily disposable to facilitate clearing of the land for subsequent use. A new process of converting oil palm stems and similar biological material into usable downstream materials beyond that of sawn lumber is also needed. A third need is to expand the uses of this hitherto under-utilized material in a wider range of useful, environmentally friendly products.

### **Summary of the Invention**

[0014] The present invention reduces botanical matters into consistent size that are suitable for downstream environmental uses.

[0015] Accordingly, the present invention segregates with a shredding assembly the vascular fibres from the parenchyma tissues of botanical matters simultaneously and efficiently.

[0016] Accordingly, in another aspect, the present invention provides a conveyor and shredding assembly that reduces botanical matters into consistent size in one single step.

[0017] Accordingly, in yet another aspect, the present invention teaches a portable, conveyor and shredding assembly that unlocks the un-utilized resources from unproductive palm trees and facilitates an environmental method of disposing the same.

[0018] In another aspect, the present invention provides a generic method of disposing unproductive monocotyledonous plants, fronds and trunks efficiently and in environmental friendly manner.

[0019] In yet another aspect, the present invention facilitates the control of infestation of insects in unproductive monocotyledonous plants such as red weevil and rhinoceros pupae by destroying their pupae and disrupting their breeding cycle.

### **Brief Description of the Drawings**

[0020] A preferred embodiment of the present invention will now be more fully described, by way of example, with reference to the drawings of which:

[0021] FIG. 1A illustrates the method of the prior art for chipping botanical materials, while FIG. 1B shows another prior art process for shredding botanical materials such as palm oil stems;

[0022] FIG. 2 showing the apparatus of the present invention to shred botanical materials such as oil palm stems into particles in one step;

[0023] FIG. 3A shows one arrangement of the teeth of the cutting head of the present invention while FIG. 3B shows another arrangement of the

teeth, FIG. 3C shows how a cutting tooth comprises of a cutting tool is mounted onto a holder on the surface of the cutting drum; and

[0024] FIGS. 4 A - C show alternative arrangements of the main components of the present invention for other embodiments of the present invention.

### **Detailed Description of the Drawings**

[0025] A conclusion may be drawn from the information on the oil palm given in the Background section above, that the potential of converting the oil palm stem into other useful products is hampered by the problems of uncontrollable and inconsistent shredded material size. The present invention overcomes the problems of shredding oil palm stems and other similar botanical materials.

[0026] In accordance with a preferred embodiment of the invention is described. In the following description, details are provided to describe the preferred embodiment. It shall be apparent to one skilled in the art, however, that the invention may be practiced without such details. Some of these details may not be described at length so as not to obscure the invention.

[0027] While the preferred embodiment of the present invention is directed towards oil palm stems, a person skilled in the art will appreciate that the present invention may also be used for the processing of other botanical materials. As such, while oil palm stems are mentioned, the invention may be readily used for other monocotyledonous plants (such as date palms and others), palm fronds and trunks and branches of dicotyledonous trees and plants.

[0028] There are many advantages of the preferred embodiment of the invention. One advantage of the preferred embodiment is that oil palm stems may be reduced to an easily-handled and transportable form, in situ, close to where the trees are felled.

[0029] Another advantage is that the stems can be shredded by the present invention to a usable form in one step instead of several steps as in the methods of the prior art.

[0030] A third advantage is that the shredded material or biomass obtained by the apparatus of the present invention may be used in many current and novel applications.

[0031] A forth advantage is that the layout of the supporting structure of the invention facilitates the collection of shredded material as opposed to other apparatus that indiscriminately disperse the material from there operation around the site.

[0032] Referring now to FIG. 2, the apparatus of the present invention may be seen in a cross sectional, elevational view comprising of several modules. One stem at a time is fed into the first module, the conveyor module **22**. Here, the stem is moved against the next module, the shredding module **24**. The last module is the drive module **26** that powers the conveyor and cutting modules.

[0033] In operation, felled stems are loaded onto the conveyor module by suitable equipment such as a hydraulic crane equipped with grippers. The weight of the stem allows it to lie on the track **222** of the conveyor which resembles the continuous tracks of a bulldozer or similar apparatus. The stem is then moved against the cutting head **242** of the shredding module **24**.

[0034] In the preferred embodiment, the cutting head is a metal drum rotating on an axis substantially perpendicular to the axis **25** of feeding of the stem. While the arrangement of the modules of the present invention appear to resemble that of the prior art, it is the arrangement of the cutting teeth **244** of the cutting head **242** that is novel and inventive.

[0035] In FIG. 3A, it may be seen from the top plan view, that the cutting teeth **244** are disposed substantially concentrically on the outsider surface of the drum with respect to the axis of the drum **244**. This arrangement of the teeth ensures that, when the oil palm stem is fed substantially perpendicular to the axis of rotation of the cutting head, the continuous

fibers of the stem that would have clogged and jammed the blades of prior art flakers, are cut.

[0036] Material produced is of specified grade. Obtaining the consistency in specification that enables the produced biomass material to be utilized without the need of further breakdown. There is no particular preferred size as this is determined by the trunk/stem density, blade configuration, speed of feeding trunk/stem.

[0037] The staggered arrangements of the cutting teeth as seen in FIG. 3A and 3B allow an 8 to 10 m long oil palm stem to be processed in about 10 minutes. Prior art inventions and apparatuses are unable to process oil palm stems having dimensions of 10m long x 500mm diameter in one operation. Therefore, the arrangement of cutting teeth in the present invention is novel and inventive. The cutting heads of prior art inventions and apparatuses are not capable of generating fine particles of consistent fibre size in a single step. In the prior art, subsequent steps such as sieving or flaking are always needed. The arrangement of the cutting teeth of the present invention allows the teeth not only to cut but also to shred the stem at the same time.

[0038] The cutting teeth **244** of the present invention is preferably made of removable and replaceable tungsten carbide tools **332** affixed by being brazed onto holders **334** on the external surface **336** of the cutting head **242**. Refer to FIG. 3C. The arrangement of the cutting teeth of the present invention allows fine particles of processed biomass to be obtained from oil palm stem without the need a backing screen, unlike the inventions of the prior art. Just as important are the design and orientation of the cutting teeth **244** which is self sharpening.

[0039] The cutting drum has an external diameter of 78.7cm with cutting blades mounted at 11.5cm x 24.72cm centre to centre around the cutting drum.

[0040] Only a few embodiments of the arrangement of the cutting teeth are shown, particularly those with teeth evenly disposed over the external surface of the rotating drum(s). However, arrangements wherein teeth that

are not evenly disposed also fall under the scope of the present invention. This arrangement allows the cutting head to be optimized to handle a stem or trunk where the outer regions of the trunk or stem may be harder than that in the core.

[0041] After contact with the cutting teeth, the stem is ripped and shredded and the shredded particles then drop by gravity into a bin or collection area **246** of the shredding module. Refer to FIG. 2. Here, the particles may be collected and removed.

[0042] As the stem is consumed, converted into fine particles by the cutting head **242**, the conveyor **222** feeds another stump (not shown in figures but understood) and yet another stump behind it at a predetermined speed and direction **25** into the cutting drum **24**.

[0043] While the arrangement of the cutting teeth is non-obvious, a person skilled in the art will recognize that alternative, equivalent arrangements of the modules fall under the scope and spirit of the present invention. FIG. 4A shows the top plan view of an alternative configuration of the cutting drum **242** where the drum is not cylindrical in shape. However, the direction of feeding of the stem is still substantially perpendicular to the axis of rotation of the cutting head. FIG. 4B shows a shredding module comprising two cutting heads **2422** and **2424** rotating at an angle to each other. Accordingly, more than two cutting heads may also be possible under the scope of the present invention. FIG. 4C shows a tilted conveyor module **22** that uses gravity to assist in the feeding of the stem **10**, allowing less power to be used in the conveyor module **26**.

[0044] The last module of the present invention is the drive module **26** (see FIG. 2) which comprises at least one motor and at least one associated gear reduction and transmission train. The drive module may power the conveyor module and the shredding module with two separate motors or one motor with two separate reduction and transmission trains. In the preferred embodiment, two separate motors are used. With the efficiency offered by the novel and inventive arrangement of cutting teeth of the present invention, a motor with only 400 hp is required. This is compared to

CBI Magnum Force Wood Hog which requires a 860 to 1030 hp engine to drive a hammer mill with 24 hammer heads to produce large chips.

[0045] The present invention may be mounted onto a trailer bed to be towed, or directly onto a five-tonne truck and driven to the area of an oil palm plantation where old trees need to be cleared. The trees may be felled by conventional means such as chain saws or pushed over, and then the stems loaded onto the feeding module of the present invention. By rendering the stems into easily handled particles, the present invention therefor significantly alleviate the burden of clearing oil palm plantations of old trees. As the stems are not left to rot, the area cleared is not conducive to fungal and insect infestation and newly planted young trees are thus not compromised. Significantly, the present invention speeds up replanting programs without the need to clear additional land areas as the value of the shredded material justifies the investment.

[0046] It is discovered that the conveyor and shredding assemblies of the present invention are able not only segregate the viscular fibres from the parenchyma tissues but also destroy pupating insects such as the red weevil and rhinoceros pupae in the process of reducing nonproductive monocotyledonous plants, fronds and trunks into consistent fine particles. Prior art of chemical treatment, burning, chipping/shredding of felled palm stems fail to break the breeding cycle of insect infestation.

[0047] The present invention therefore provides an apparatus for converting oil palm stems to overcome, or at least alleviate, the problems of the prior art.

[0048] Tests by the inventor have shown that the present invention may be used for processing trunks of dicotyledonous soft to medium hardwood trees, and to obtain particles of a similar size range to that of oil palm stems. The dimensions of the invention may be scaled to handle botanical materials of different sizes as appropriate.

[0049] It will be appreciated that although one preferred embodiment has been described in detail, various modifications and improvements can be

made by a person skilled in the art without departing from the scope of the present invention.

### Claims

1. An apparatus for reducing botanical material, the apparatus comprising:  
at least one conveyor module for feeding said botanical material;  
at least one shredding module coupled with said conveyor module for receiving there from said botanical material; and  
at least one drive module coupled to said shredding module for shredding said botanical material,  
wherein  
the apparatus being adapted to reduce said botanical material to a consistent fibre size in one step.
2. An apparatus according to Claim 1 wherein the conveyor module has at least one track driven by the drive module.
3. An apparatus according to Claim 1 wherein the conveyor module is substantially horizontal.
4. An apparatus according to Claim 1 wherein the conveyor module is not horizontal but tilted towards the shredding module.
5. An apparatus according to Claim 1 wherein the shredding module comprises:  
at least one rotating drum with an external surface, the rotating drum further comprising a plurality of cutting teeth disposed on the external surface of the at least one drum.
6. An apparatus according to Claim 1 wherein the shredding module is driven by the drive module.
7. An apparatus according to Claim 5 wherein the cutting teeth are removable and replaceable, the cutting teeth being affixed on holders.

8. An apparatus according to Claim 5 wherein the cutting teeth are evenly disposed over the external surface of the at least one rotating drum.
9. An apparatus according to Claim 5 wherein the cutting teeth are not evenly disposed over the external surface of the at least one rotating drum.
10. An apparatus according to Claim 5 wherein the cutting teeth are made of tungsten carbide.
11. An apparatus according to Claim 1 wherein the shredding module comprises a plurality of cutting heads rotating at angles to each other.
12. An apparatus according to Claim 1 wherein the drive module comprises at least one engine.
13. An apparatus according to Claim 1 wherein the drive module comprises at least one drive train.
14. A method of reducing botanical materials, the method comprising:  
providing an apparatus comprising at least one conveyor module, at least one shredding module and at least one drive module; and  
feeding botanical material using the conveyor module against at least one cutting head of the at least one shredding module,  
thereby reducing the botanical material to consistent fibre size in one step.
15. The method of Claim 14 wherein the conveyor module has at least one track driven by the drive module.
16. The method of Claim 14 wherein the conveyor module is substantially horizontal.

17. The method of Claim 14 wherein the conveyor module is not horizontal but tilted towards the shredding module.
18. The method of Claim 14 wherein the shredding module comprises at least one rotating drum with an external surface, the rotating drum further comprising a plurality of cutting teeth disposed on the external surface of the at least one drum.
19. The method of Claim 18 wherein the shredding module is driven by the drive module.
20. The method of Claim 18 wherein the cutting teeth are removable and replaceable, the cutting teeth being affixed on holders.
21. The method of Claim 18 wherein the cutting teeth are evenly disposed over the external surface of the at least one rotating drum.
22. The method of Claim 18 wherein the cutting teeth are not evenly disposed over the external surface of the at least one rotating drum.
23. The method of Claim 18 wherein the cutting teeth are made of tungsten carbide.
24. The method of Claim 14 wherein the shredding module comprises a plurality of cutting heads rotating at angles to each other.
25. The method of Claim 14 wherein the drive module comprises at least one engine.
26. The method of Claim 14 wherein the drive module comprises at least one drive train.

27. A method of controlling insect infestation in botanical material, said botanical material including vascular fibres and parenchyma tissues, the method comprising:  
providing an apparatus comprising at least one conveyor module, at least one shredding module and at least one drive module; and  
feeding botanical material using the conveyor module against at least one cutting head of the at least one shredding module,  
thereby reducing the botanical material to consistent fibre size in one step.
28. The method of Claim 27 wherein the conveyor module has at least one track driven by the drive module.
29. The method of Claim 27 wherein the conveyor module is substantially horizontal.
30. The method of Claim 27 wherein the conveyor module is not horizontal but tilted towards the shredding module.
31. The method of Claim 27 wherein the shredding module comprises at least one rotating drum with an external surface, the rotating drum further comprising a plurality of cutting teeth disposed on the external surface of the at least one drum.
32. The method of Claim 31 wherein the shredding module is driven by the drive module.
33. The method of Claim 31 wherein the cutting teeth are removable and replaceable, the cutting teeth being affixed on holders.
34. The method of Claim 31 wherein the cutting teeth are evenly disposed over the external surface of the at least one rotating drum.
35. The method of Claim 31 wherein the cutting teeth are not evenly disposed over the external surface of the at least one rotating drum.
36. The method of Claim 31 wherein the cutting teeth are made of tungsten carbide.
37. The method of Claim 27 wherein the shredding module comprises a plurality of cutting heads rotating at angles to each other.
38. The method of Claim 27 wherein the shredding module segregates vascular fibres from parenchyma tissues while destroying insects and pupae.