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भारतीय मानक मसौदा

बायोमास से बने पैलेट्स के उत्पादन के लिए प्लांट अभिन्यास और इष्टतम प्रक्रिया – दिशानिर्देश

Draft Indian Standard

PLANT LAYOUT & OPTIMAL PROCESS FOR PRODUCTION OF BIOMASS PELLETS – GUIDELINES

Agriculture And Food Processing Equipment Sectional Committee, FAD 20	Last date of comments **: 24 October 2025**

FOREWORD

Climate change and global warming are serious problems that the world has been facing for a long time. One of the major reasons for these problems is the use of fossil fuels like coal, oil, and gas. Significant amount of the electricity is still produced by burning coal in thermal power plants. To reduce the use of coal and protect the environment, the Government of India is promoting the use of clean and renewable sources of energy like solar and wind power.

The Ministry of Power, Government of India has set up a mission known as 'Sustainable Agrarian Mission on use of Agro Residue in Thermal Power Plants' (SAMARTH) to promote the use of crop residues such as rice straw, wheat straw, mustard straw, and other agricultural waste (after conversion into pellets) along with coal for power production.

Biomass co-firing helps in two ways – it reduces the amount of coal used and also provides a solution to the problem of burning crop residue in open fields, which causes air pollution. Farmers can now earn money by selling their crop waste instead of burning it.

The pellets used in power plants should be of good quality to ensure smooth operation and efficient burning. Numerous pellet manufacturing plants are required to be established to cater to the demand of pellets in energy producing industries. A need was felt to develop a standard which provides common guidance to all pellet manufacturers by stipulating definitions, plant layouts, and types of equipment for respective unit operations in plants.

This standard will support the endeavor of the mission and provide guidance to the pellet manufacturers in designing the plant layout, selecting the equipment, and optimizing the use of resources in order to utilize the maximum capacity of the plant.

A series of Indian Standards are being developed for various equipment used in the production of biomass pellet. Apart from this standard, four other standards under development are as under:

a) FAD 20(27726)WC Biomass Shredder – Specification and Test Code

b) FAD 20(27727)WC Biomass Hammer Mill – Specification and Test Code
c) FAD 20(27728)WC Biomass Pelletiser – Ring Die Type – Specifications and Test Code
d) FAD 20(27729)WC Biomass Pelletiser – Crank, Piston, and Cylinder Type – Specifications and Test Code

1 SCOPE

This standard provides guidelines for the operations, machineries and layout of the plant for manufacturing non-torrefied and torrefied pellet from non-woody biomass primarily from agro residues.

NOTE — The use of Municipal solid waste (MSW) is not covered in this standard.

2 REFERENCES

The standards listed in contain provisions which, through reference in this text constitute provisions of this Indian Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Indian Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
Doc. No. FAD 20(27726)WC	Biomass Shredder – Specification and Test Code
Doc. No. FAD 20(27727)WC	Biomass Hammer Mill – Specification and Test Code
Doc. No. FAD 20(27728)WC	Biomass Pelletiser – Ring Die Type – Specifications and Test Code
Doc. No. FAD 20(27729)WC	Biomass Pelletiser – Crank, Piston, and Cylinder Type – Specifications and Test Code

3 TERMINOLOGY

Following terminology shall be used for the purpose of this standard.

3.1 Agro Residues — Non-woody ligno-cellulosic material and a rich source of cellulose with lignin such as rice straw, wheat straw, rice husk, and corn stover, maize stalk etc. which are mostly left on the fields after harvest and used for fodder and landfill material or burnt in many places.

3.2 Biomass — The total mass of living matter, or organic material, derived from plants, animals, and other living organisms within a given area or ecosystem. This organic matter can be used for energy production or other purposes.

3.3 Drying — A process of reducing moisture content in biomass before pelletization.

3.4 Herbaceous Residue — Parts of plants that have a nonwoody stem and which die back at the end of the growing season such as grasses, flowers, oilseed crops, tubers, legumes etc.

3.5 Non-Torrefied Pellets — Pellets made from agro residue without being torrefied. These are made by shredding and grinding biomass, and then compressing it into pellets with or without binders such as sawdust, bagasse, molasses, or starch etc.

3.6 Non-Woody Biomass — Biomass originating from agro residue, herbaceous, fruit or aquatic biomass as well as blends or mixtures of non-woody biomass.

3.7 Non-Woody Pellet — Pellet made from non-woody biomass.

3.8 Pellet — Densified biomass made with or without additives usually in a cylindrical form with broken ends which has a length ranging from 3 mm to 40 mm and diameter up to 25 mm. It has high energy density, efficient combustion, and ease of handling and storage. It is alternative to fossil fuels and can be used for heating and power generation.

3.9 Pelletization — A process of densifying biomass into small, uniform pellets for easier handling, storage, and use, often for fuel or industrial applications.

3.10 Solid Fuel — A combustible material in solid form (densified or not), such as coal or biomass, used to generate energy. It undergoes combustion by reacting with oxygen, releasing heat and energy

3.11 Torrefaction — A thermochemical process that heats biomass at 200°C to 300°C in the absence of oxygen, removing moisture and volatiles, and improving its energy density and stability for use as a renewable fuel.

3.12 Torrefied Pellet — Pellet made from the biomass which has undergone the process of torrefaction. It is ideal for efficient combustion in power plants and industrial boilers.

4 PROCESS FOR PRODUCTION OF NON-TORRIFIED PELLETS

The process of production of non-torrefied pellets involves the following main steps:

4.1 Raw Material Preparation — Biomass shall be collected and ground into smaller particles of size less than 3.15 mm to achieve a uniform size for effective pellet formation.

4.2 Moisture Equilibration — The ground material should be conditioned by adding moisture or by drying to bring it in between 10 % to 14 % moisture content to enhance binding during pellet formation and improve the quality of the pellets.

4.3 Pelletization — The moist biomass is compressed in a pelletizer, forcing the material through a die under high pressure. This process causes the particles to bind together, forming small, solid pellets.

4.4 Cooling — After pellet formation, the hot pellets are cooled to solidify and stabilize, making them easier to handle and store.

4.5 Packaging and Storage — The cooled pellets are packed and stored for use, typically as a fuel for heating or power generation.

5 MACHINERY USED IN PRODUTION OF NON-TORRIFIED PELLETS

5.1 A typical process flow diagram for production of non-torrefied pellets is given in Fig. 1 for the guidance of the manufacturers.

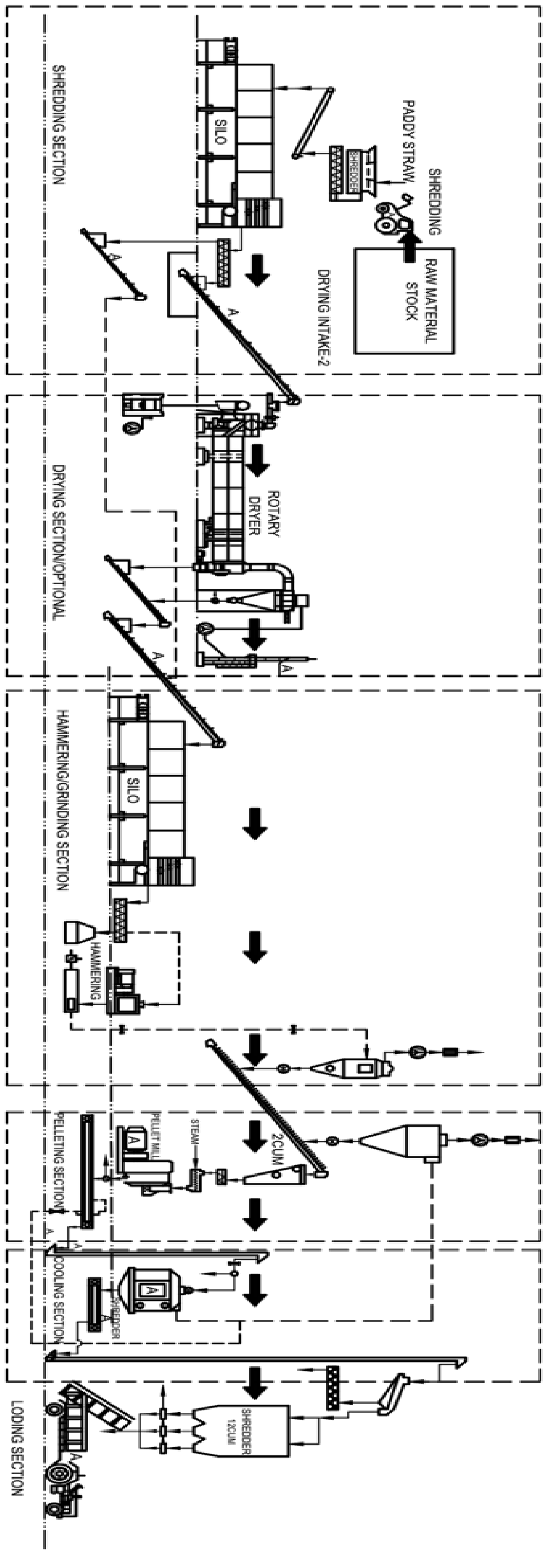

FIG. 1 PROCESS FLOW OF NON-TORREFIED PELLETS PRODUCTION

5.2 Required Machinery

Following machinery may be used for producing non-torrified pellets, selection of machinery may be based upon the size of the plant and the type of raw material being used.

5.2.1 *Bale Opener* — It is used to break apart and loosen bales of biomass material for further processing like shredding, grinding, or pelletizing. It can handle various types of agricultural residues, including paddy straw, sugarcane bagasse, wheat straw, corn stalks, and other fibrous biomass etc. The bale opener can be selected from 1 tons per hour to 10 tons per hour based on the size of plant and type of biomass being processed.

5.2.2 *Twin Shaft Shredder* — It is used to break down the biomass into manageable sizes (length < 75 mm) for further processing, such as hammering and pelletization. The shredder, if used, shall conform to Doc. No. FAD 20(27726) WC.

5.2.3 *Dryer* — It is used to reduce the moisture content of biomass materials such as sawdust, straw, sugarcane bagasse, and other agricultural residues. Reduction of moisture content improves the efficiency of subsequent processes like hammering, pelletizing, or combustion for energy production. Proper drying ensures that biomass materials have the optimal moisture content for efficient, processing, storage, and burning.

5.2.4 *Hammer Mill* — It is used for grinding various raw materials into smaller particles having maximum dimension less than 3.15 mm, preparing them for further processing, such as pelletizing or briquetting. Any type of hammer mill used shall be as per the Indian Standard [Doc. No. FAD 20(27727) WC]. The hammer mill may be of following types.

5.2.4.1 *Full circle hammer mill* — It is designed for optimal grinding efficiency by allowing the material to be struck repeatedly until it passes through the screen. It is ideal for fine grinding applications and ensures uniform particle size.

5.2.4.2 *Half circle hammer* — It features a more focused area for material processing, which allows for higher throughput. It is suitable for coarse grinding where larger particles are acceptable.

5.2.4.3 *Vertical hammer mill* — Biomass material is fed vertically and gets ground as it falls, allowing gravity to assist with the hammering process. It is ideal for grinding fibrous biomass materials like straw, hay, and grass.

5.2.4.4 *Horizontal hammer mill* — Material is fed horizontally, and the hammers rotate horizontally. It may be used for a wide variety of biomass materials including sawdust, agricultural waste, and more.

5.2.5 *Cyclone Dust Collector/Bag Filter* — It is also known as cyclonic separator. It is a device that removes particulates, such as dust, from air or gas streams by using centrifugal force. It is commonly used in industrial and agricultural settings to manage dust, ash, and other fine particulate matter that can be hazardous to health or interfere with machinery.

5.2.6 *Biomass Humidifiers* — It is a specialized device used to add moisture to biomass materials during processing, particularly when the biomass is too dry for optimal downstream applications like pelletizing, briquetting, or combustion. Proper moisture content is crucial for efficient processing and high-quality output in biomass-based industries, and biomass humidifiers help achieve and maintain the desired moisture levels.

5.2.7 *Pelletizer* — It is used to process biomass into compact, energy-dense pellets. These pellets are commonly used as a renewable fuel source in industrial boilers, power plants, and residential heating systems. The pelletizer, if used, shall conform to the Indian Standards [Doc. No. FAD 20(27728) WC & No. FAD 20(27729) WC].

6 PROCESS FOR PRODUCTION OF TORRIFIED PELLETS

Torrefied pellets have a higher energy density, better stability, and improved combustion properties compared to non-torrefied pellets, making them more efficient for energy production. The process for the production of torrefied pellets involves following main steps.

6.1 Biomass Preparation — Raw biomass is collected, screened, and pre-processed (chipped or shredded) to the required size.

6.2 Drying — Biomass is dried to remove excess moisture before it enters the torrefaction reactor which ensures an efficient torrefaction.

6.3 Torrefaction — In the reactor, biomass shall be heated in a low-oxygen environment and the temperature shall be maintained between 200°C to 400°C for a duration of 20 min to 60 min, depending on the feedstock type and desired output.

6.4 Pelletizing — The torrefied biomass is then compacted under high pressure in a pellet mill, forming uniform, solid pellets. The high temperature during torrefaction makes the material more brittle, aiding in the pelletizing process.

6.5 Cooling — After pellet formation, the hot pellets are cooled to harden and stabilize them, making them easier to handle and store.

6.6 Storage and Packaging — The cooled torrefied pellets are packaged and stored, ready for use as a high-energy fuel in industrial boilers, power plants, or heating systems.

6.7 Gas Management — The gases produced during the torrefaction process shall be either flared or captured and used for heating purposes in the plant.

7 MACHINERY USED IN PRODUTION OF TORRIFIED PELLETS

7.1 A typical process flow diagram for production of torrefied pellets is given in Fig. 2 for the guidance of the manufacturers.

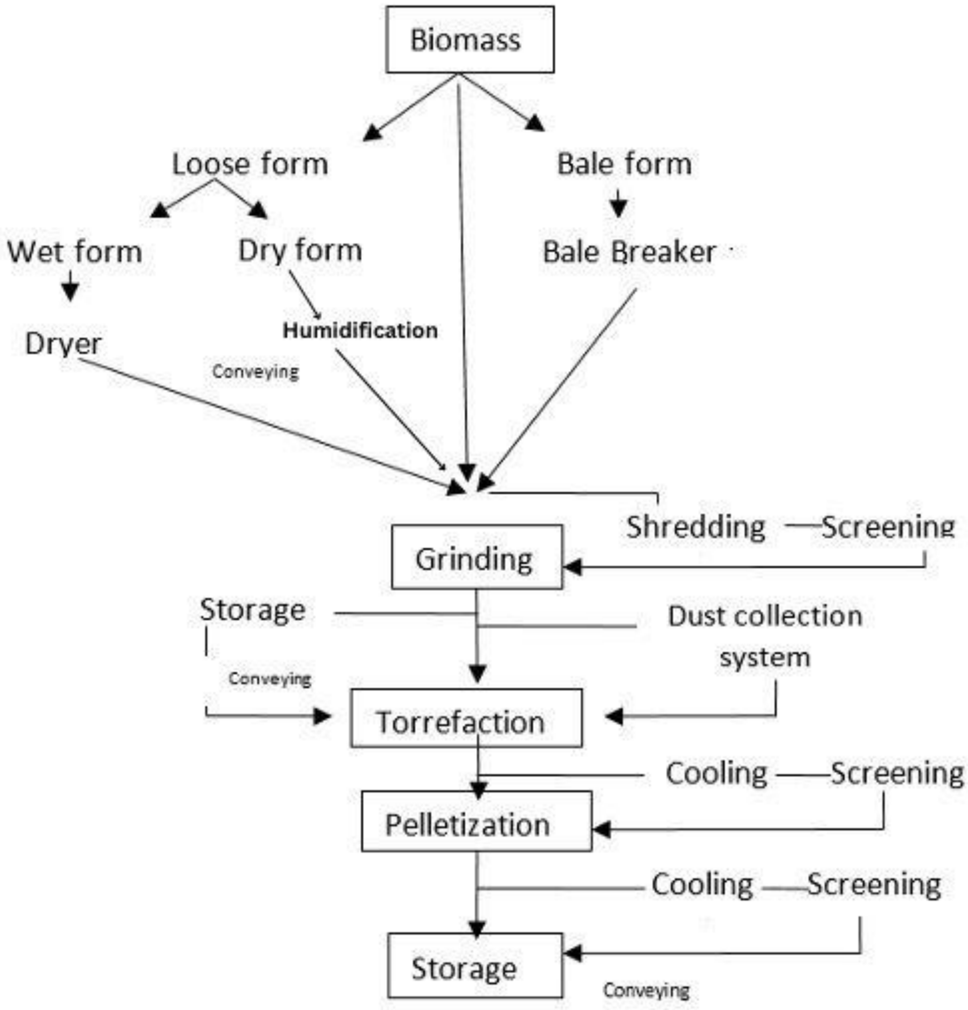

FIG. 2 PROCESS FLOW OF TORREFIED PELLETS PRODUCTION

7.2 Required Machinery

All the machinery such as bale opener, shredder, dryer, hammer, cyclone dust collector/bag filter, biomass humidifier, and pelletizer shall be same as used in production of non-torrefied pellets (*see* **5.2**), however, in addition, a suitable torrefier shall be used for the process of torrefaction.

8 PLANT LAYOUT

8.1 General

Plant design and layout is an arrangement of different machines, flow of material and development of physical relationship among different operations during the production for production of pellet with optimal efficiency. The efficiency and safety in the operations can be greatly increased by careful planning of the location, design, and layout. The following factors should be considered while designing a layout.

a) Type and quantity of pellets to be produced
b) Space available and space requirement
c) Operational convenience and accessibility
d) Guidelines related to health and safety of workers and environment

e) Auxiliary equipment
f) Transport of material within the premises
g) Possible future expansion and development
h) Maintenance required

A set of internally prepared guidelines should be followed to avoid any miss happening arising out from handling of hazardous material in regular operations. The hazardous operation should be identified, and risk assessment should be undertaken. The biomass is prone to fire, therefore, its storage area should be well isolated from main plant with appropriate fire safety audit.

8.2 Planning and Design of Plant Layout

8.2.1 The planning of site is very important for safety to the community including environment. The suggestive plant layouts for the production of non-torrefied pellets are given in Fig. 3A, 3B, and 3C. Fig. 3A depicts the general layout, Fig. 3B depicts option 1 wherein shredder & hammer both are used, and Fig. 3C depicts Option 2 wherein directly hammer is used. The following points should be considered while selecting site:

a) The availability of raw material and product utilization are the primary factors which should be considered while selection of site;
b) The behavior of airborne emissions of all types should be carefully considered;
c) There is dust generated during the process of manufacturing of pellet especially during the grinding of biomass hence the location of size reduction unit should be carefully designed;
d) The space available and space required should be examined before starting the installation process;
e) Crowding of workers should be avoided; and
f) Sufficient space should be maintained between the torrefaction unit and the palletization process to avoid fire accident.

8.2.2 The overall objective for plant design should be satisfactory access for each operation, satisfactory maintenance access, and minimum transport between each operation. The following provisions shall be made and considered while designing the plant layout.

8.2.2.1 *Control room* – There should be one control room to monitor each operation in the plant. It is located separately from the main plant for safety. A separate section should be provided to control emergencies

8.2.2.2 *Layout of equipment* – An effective equipment layout should focus on the following points:

a) Ensure efficient arrangement of equipment to maximize space utilization and enable smooth production flow.
b) Include clear hazard zones, accessible emergency exits, proper ventilation, fire safety measures, and adherence to relevant safety protocols.
c) Provide adequate clearance around machinery for routine inspection, servicing, and repairs.
d) Design layout to support seamless movement of raw materials to finished products with minimal handling and delays.
e) Position equipment at appropriate heights and access points to reduce physical strain on workers.

f) Incorporate energy-saving practices along with effective ventilation, lighting, and power supply systems.
g) Align layout with applicable local and international safety, health, and environmental standards.
h) Design with adaptability in mind to accommodate future changes or scaling of operations.
j) Ensure easy access to control panels and communication systems for effective monitoring and operation.

8.2.2.3 *Ventilation and Escape* – The following points shall be considered while designing ventilation & escape.

a) Maintain air quality, control temperature, and manage dust especially from biomass grinding.
b) Use exhaust systems to capture and filter airborne particulates, reducing health risks and environmental impact.
c) Provide at least two escape routes per workspace.
d) Ensure exits are located within 45 meters.
e) Avoid dead ends longer than 8 meters.
f) Solid flooring should be provided over mesh-covered areas.
g) Stairways should be straight and located outside the building.
h) Fixed ladders may be used if occupancy is fewer than 10 people.
j) Width of escape paths should range between 0.7 to 1.2 meters to ensure safe evacuation.
k) Install emergency controls along or near escape routes for quick access.
m) Equip high-occupancy areas and escape paths with emergency lighting.

8.2.2.4 *Electrical equipment* – The following points shall be considered during installation and maintenance of electrical equipment.

a) Locate in safe areas, away from flammable materials.
b) Avoid using flameproof equipment where not necessary.
c) Position near control rooms for better operational coordination.
d) Keep transformers isolated from combustible substances.
e) Clearly mark Motor Control Centers (MCCs).
f) Shield MCCs from electromagnetic interference.
g) Use protective devices rated for expected short-circuit currents.
h) Test grounding systems regularly for reliability.
j) Ensure proper ventilation and physical isolation.
k) Design electrical systems to allow section-wise maintenance without full shutdown.
m) Install proper lightning arrestors and surge protection.
n) Use three-wire systems and equip with Earth Leakage Circuit Breakers (ELCBs) to prevent electric shocks.

8.2.2.5 *Receiving and dispatching*

a) Receiving and dispatching facilities should align with the plant's overall material flow to ensure efficiency.
b) Design should aim to minimize heating losses during handling.

c) Equipment such as trucks, dozers, and cranes should support smooth loading and unloading operations.
d) Stores or load offices should be located near the material gate to streamline goods receipt.
e) Separate truck siding and parking areas should be provided to organize vehicle movement.
f) Toilets and canteens should be available for drivers to reduce unnecessary movement inside the plant.
g) Finished goods must be dispatched from a designated area, distinct from the production zone.
h) The quality lab should be easily accessible to perform checks during receiving and dispatching.

8.2.2.6 Suitable firefighting system should be installed for effective fire safety in plant.

8.2.2.7 Appropriate mechanism and provision should be there for disposal of unused biomass.

8.2.2.8 Plant layout should also have sufficient green area such as gardens, plants, or trees.

9 OPERATIONAL GUIDELINES

9.1 Safety glasses or face shields to protect against flying debris shall be used.

9.2 Ear protection kit shall be used because of the high noise levels during operation.

9.3 Before starting any machine, it shall be ensured that the hopper or cutting chamber is free of foreign objects.

9.4 Gloves having a good grip but not loose enough to get caught in moving parts shall be used.

9.5 Push sticks or other tools shall be used for small pieces of material to keep hands away from moving parts.

9.6 Mask conforming to IS 9473 shall be used by the workers to prevent entry of dust through nose and mouth.

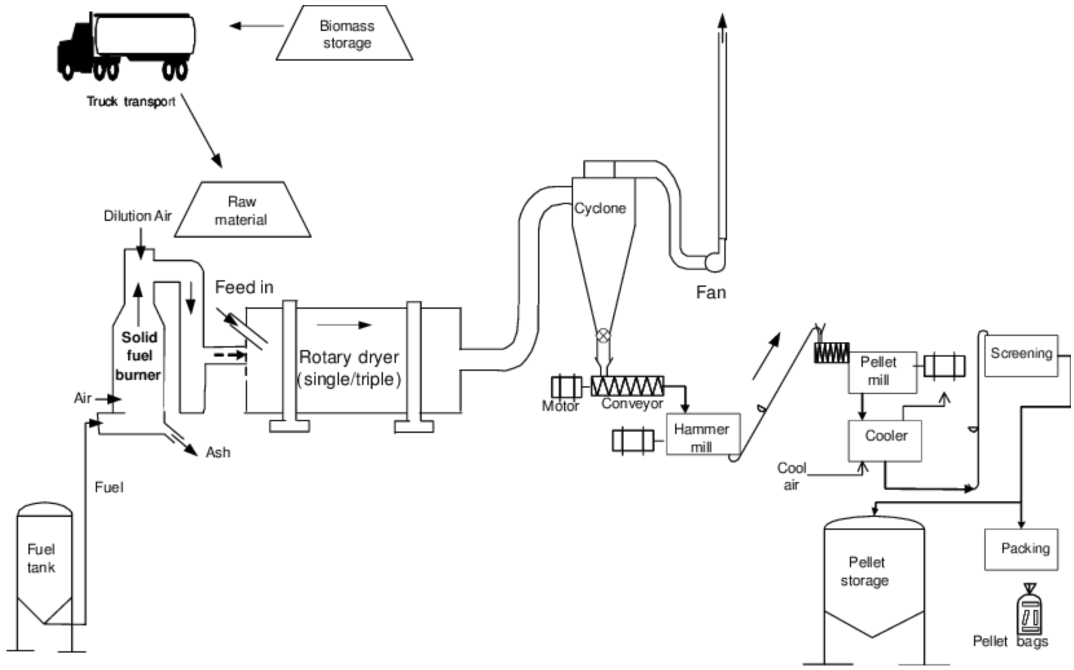

FIG. 3A GENERAL LAYOUT

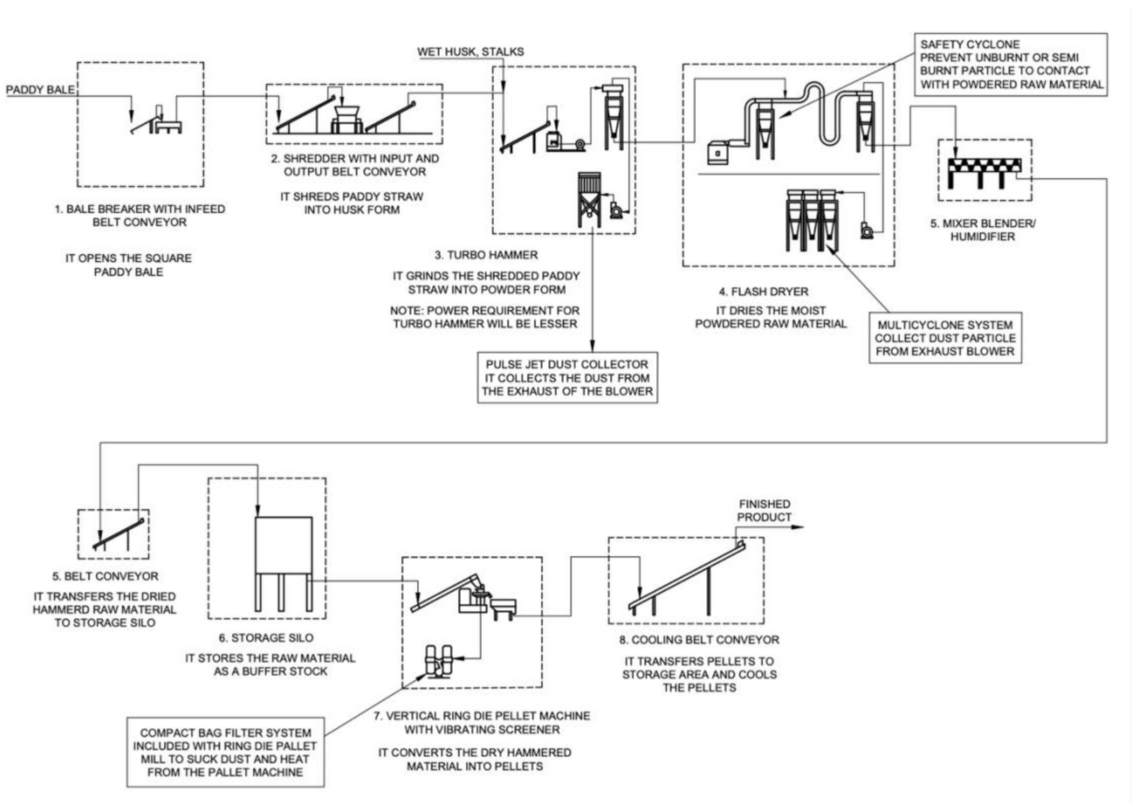

FIG. 3B OPTION 1

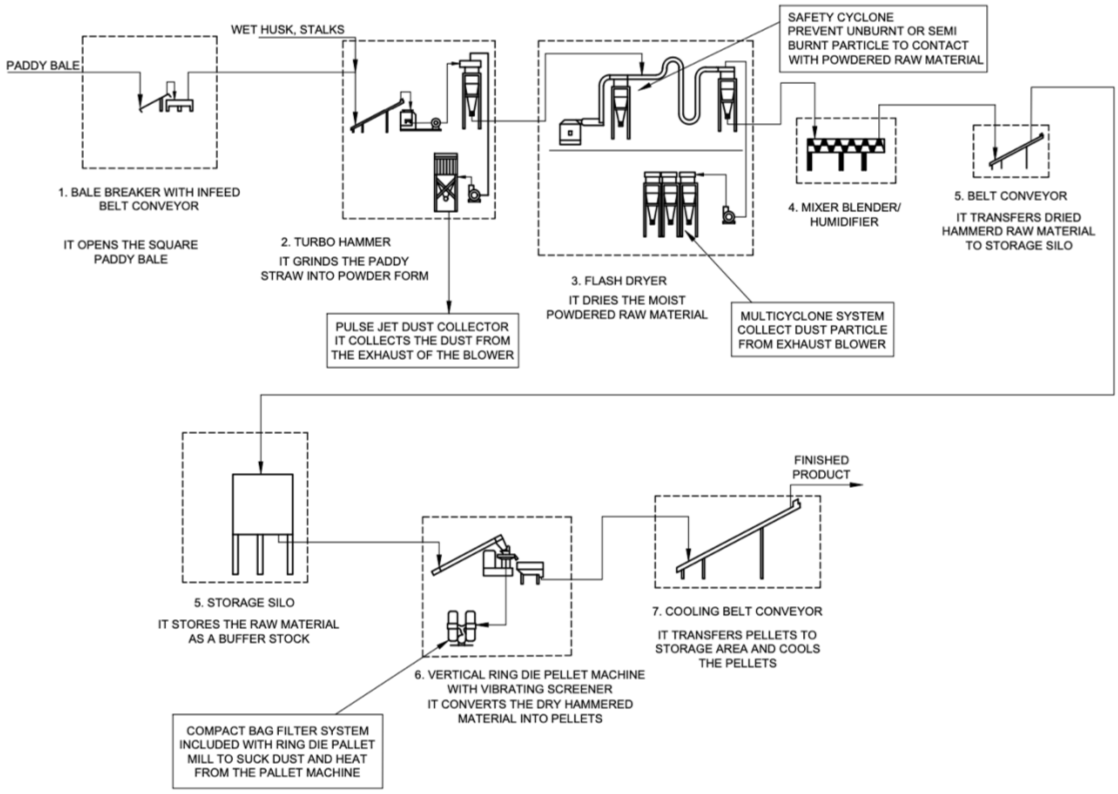

FIG. 3C OPTION 2

FIG. 3 SUGGESTIVE PLANT LAYOUT FOR NON-TORRIFIED PELLETS