Design, Fabrication of Solar Operated Pelletizing Machine & Optimization of Biomass Pellets Mixture using Taguchi Method

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Abstract - The pelletizing machine is mainly found in production industries, railway/coal corporations and steel industries. The design & Optimization of pelletizing machine which will operate on solar energy for the production of pellets from a mixture of Biomass. The process of producing pellets for the purpose of strength measurements of powder agglomerates/pellets for good handling of waste materials for usage. The machine consist a mixer. As this machine will operate on solar energy the cost will be reduced& further the optimization biomass pellets mixture will be studied. The project is of benefit and as a teaching aid. Consequently, from this benefit, the machine is recommended to manufacturers for usage.

Index Terms– *Pelletization, solar power,optimization,design of solar pelletization machine, taguchi method.*

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I. Introduction

Pelletizing machine is specialized equipment. It is used for pelletizing of powder materials into pellets. It is original and peculiar with large scale disc-pellet machine and designed on the basis of the large scale disc pellet machine that is used in industries like iron and steel industry, chemical industry, pharmaceutical industry, cement industry, ceramics industry, railway corporations, seen in metallurgical workshops and some related industries. This machine adapts to pelletizing many kinds of powder material provided it is mixed with a particular solvent.

They are of different kinds and forms ranging from its sizes, shapes, method of operation (manual or automatic), capacity, function, etc.

Types of Pelletizing Machine

a) Pelletizing machine (Balling disc): Balling disc machine is mainly used for production of balls and agglomerates pellets.
b) Floating feed pellet machine: This type of pelletizing machine is used for production of feed for animals.
c) Wood pellets machine: This type of palletizing machine is used for making pellets of wood, plastics etc.
d) Biomass pellet machine: This type of palletizing

II. Literature Review

In 2005, ChristoferRhe´n a,, Rolf Gref a, Michael Sjo¨ stro¨m b, IwanWa¨sterlund a, [1]. In order to study the pelletizing process, Norway spruce sawdust pellets were produced under strictly controlled conditions on a laboratory scale. The aim of the work was to investigate how the moisture content of raw material and the densification parameters, pressure and temperature, affect compression strength, dry density and moisture uptake of the formed pellets. In the experiments performed, temperature (26–144 ^{0}C), moisture content (6.3–14.7 wt. % of db.) and pressure (46–114 MPa) were the factors which varied according to a prescribed central composite design. The relationships between the factor settings and the responses (dry density, moisture uptake and compression strength) were evaluated by multiple linear regressions. In the present study, it was found that high compression strength was strongly correlated with the density of the pellets. High temperature (at least up to 144 ^{0}C) and low moisture content at the start of compression (down to 6.3 wt.% of d.b.) increased the dry density of the pellets. Remarkably, compression force had very little effect in the tested range of 46–114 MPa, indicating that pressure in the die does not need to be higher than 50 MPa. Similarly, compression force had very little effect on moisture uptake in the pellets. The least moisture uptake occurred when the pellets were produced at 90 ^{0}C.

In 2007, C. Tari ∗, N. G¨ogus, F. Tokatli[2].A two-step optimization procedure using central composite design with four factors (concentrations of maltrin and corn steep liquor (CSL), agitation speed and inoculation ratio) was used in order to investigate the effect of these parameters on the polygalacturonase (PG) enzyme activity, mycelia growth (biomass) and morphology (pellet size) of Aspergillussojae

ATCC 20235. According to the results of response surface methodology (RSM), initial concentrations of maltrin and CSL and agitation speed were significant ($p < 0.05$) on both PG enzyme production and biomass formation. As a result of this optimization, maximum PG activity (13.5 U/ml) was achievable at high maltrin (120 g/l), at low CSL (0 g/l), high agitation speed (350 rpm) and high inoculation ratio (2×107 total spore). Similarly, maximum biomass (26 g/l) could be obtained under the same conditions with only the difference for higher level of CSL requirement. The diameter of pellets in all optimization experiments ranged between 0.05 and 0.76 cm. The second optimization step improved the PG activity by 74% and the biomass by 40%.

In 2008, Dan Bergström a, , Samuel Israelsson b, Marcus Öhman c, Sten-Axel Dahlqvist d, Rolf Gref a, ChristofferBoman b, IwanWästerlund a. [3]. In order to study the influence of raw material particle size distribution on the pelletizing process and the physical and thermo mechanical characteristics of typical fuel pellets, saw dust of Scots pine was used as raw material for producing pellets in a semi industrial scaled mill (~300 kg h−1). The raw materials were screened to a narrow particle size distribution and mixed into four different batches and then pelletized under controlled conditions. Physical pellet characteristics like compression strength, densities, moisture content, moisture absorption and abrasion resistance were determined. In addition, the thermochemical characteristics, i.e. drying and initial pyrolysis, flaming pyrolysis, char combustion and char yield were determined at different experimental conditions by using a laboratory-scaled furnace. The results indicate that the particle size distribution had some effect on current consumption and compression strength but no evident effect on single pellet and bulk density, moisture content, moisture absorption during storage and abrasion resistance. Differences in average total conversion time determined for pellet batches tested under the same combustion conditions was less than 5% and not significant. The results are of practical importance suggesting that grinding of saw dust particle sizes below 8 mm is probably needless when producing softwood pellets. Thus it seem that less energy could be used if only over sized particles are grinded before pelletizing.

In 2008, MehrdadArshadi a,, Rolf Gref b, Paul Geladi a, Sten-Axel Dahlqvist c, TorbjörnLestander a [4]. Industrial pelletizing of sawdust was carried out as a designed experiment in the factors: sawdust moisture content, fractions of fresh pine, stored pine and spruce. The process parameters and response variables were energy consumption, pellet flow rate, pellet bulk density, durability and moisture content. The final data consisted of twelve industrial scale runs. Because of the many response variables, data evaluation was by principal component analysis of a 12×9 data matrix. The two principal component model showed a clustering of samples, with a good reproducibility of the center points. It also showed a positive correlation of energy consumption, bulk density and durability all negatively correlated to flow rate and moisture content. The stored pine was more related to high durability and bulk density. The role of the spruce fraction was unclear. The design matrix, augmented with the process parameters was a 12×6 matrix. Partial least squares regression showed excellent results for pellet moisture content and bulk density. The model for durability was promising. A 12×21 data matrix of fatty- and resin acid concentrations measured by GC–MS showed the differences between fresh and stored pine very clearly. The influence of the spruce fraction has less clear. However, the influence of the fatty- and resin acids on the pelletizing process could not be confirmed, indicating that other differences between fresh and stored pine sawdust have to be investigated. This work shows that it is possible to design the pelletizing process for moderate energy consumption and high pellet quality.

In 2009, Robert Samuelsson a,, Mikael Thyrel a, Michael Sjöström b, Torbjörn A. Lestander a. [5]. Sawdust of conifers as a by-product from saw mills is the most commonly used biomaterial for pellet production in Sweden today. Experiences from the biofuel pellet industry indicate that different biomaterial properties influence the final pellet quality. A systematic study was conducted where five factors were varied according to a two level fractional factorial design. The factors were: tree species (Scots pine, Norway spruce); origin of growth-place (latitudes 57 and 64°N); storage time of sawdust (0 and 140 days), moisture content (9 and 12%) and steam treatment (2 and 6 kg/h). The measured responses bulk density and mechanical durability represented the pellet quality while the press current and the fines produced in the pelletizing process were measures of the pelletizing property. The results showed that low moisture content and long storage time resulted in increased bulk densities and press currents. For mechanical durability and fines, a long storage time and intermediate moisture contents were found favorable. In addition, indications were found that the reduction of fatty and resin acids during the storage also influenced the pelletizing properties and the pellet quality.

In 2011, Wolfgang Stelte a, Jens K. Holm b, Anand R. Sanadi c, SørenBarsberg c, JesperAhrenfeldt a, Ulrik B. Henriksen a [6]. The aim of the present study was to identify the key factors affecting the pelletizing pressure in biomass pillarization processes. The impact of raw material type, pellet length, temperature, moisture content and particle size on the pressure build up in the press channel of a pellet mill was studied using a single pellet press unit. It was shown that the pelletizing pressure increased exponentially with the pellet length. The rate of increase was dependent on biomass species, temperature, moisture content and particle size. A mathematical model, predicting the pelletizing pressure, was in good accordance with experimental data. It was shown that increasing the temperature resulted in a decrease of the pelletizing pressure. Infrared spectra taken from the pellets surface, indicated hydrophobic extractives on the pellet surface, for pellets produced at higher temperatures. The extractives act as lubricants, lowering the friction between the biomass and the press channel walls. The effect of moisture content on the pelletizing pressure was dependent on the raw material species. Different particle size fractions, from below 0.5 mm up to 2.8 mm diameter, were tested, and it was shown that the pelletizing pressure increased with decreasing particle size. The impact of pelletizing pressure on pellet density was determined, and it was shown that a pelletizing pressure above 200 MPa resulted only in minor increase in pellet density.

In 2014, Markus Segerström, Sylvia H. Larsson[7]. A pilot scale pelletizer with a custom-made die temperature control system was used for pelletizing of a typical Nordic softwood blend in an experimental design where die temperature, moisture content, and steam conditioning were varied independently. Steam conditioning, expressed as material temperature, showed a strong negative correlation with the pelletizer motor current, but had no significant effect on other responses. Die temperature was negatively correlated to bulk density and durability. This negative correlation is contradictory to results from a pilot scale study where die temperature co-varied with other factors, and to results from single pelletizing studies that do not mimic the friction originated pressure build-up that is required for pellet formation in a continuous process.

In 2015, K. O. Ikebudu, Chukwumuanya E. O., Swift O. N. K., and NwokeochaToochukwu [8].the design of pelletizing machine for the production of pellets from a mixture either in its powder or molten form. This idea came up during the process of producing pellets for the purpose of strength measurements of powder agglomerates/pellets for good handling of powder materials for usage and during transportation. The machine consist a mixer. This machine is mainly found in production industries, railway/coal corporations and steel industries.

In 2016, Maria Puig-Arnavat, Lei Shang, ZsuzsaSárossy, JesperAhrenfeldt, Ulrik B. Henriksen [9]. The increasing demand for biomass pellets requires the investigation of alternative raw materials for pelletization. In the present paper, the pelletization process of fescue, alfalfa, sorghum, triticale, miscanthus and willow is studied to determine if results obtained in a single pellet press (SPP) can be extrapolated to larger scale pellet mills. The single pellet press was used to find the optimum moisture content and die operating temperature for pellet production. Then, these results were compared with those obtained from a bench-scale pellet mill. A moisture content of around 10 wt.% was found to be optimal for the six biomass feedstocks. A friction increase was seen .when the die temperature increased from room temperature to 60–90 °C for most biomass types, and then a friction decrease when the die temperature increased further. The results obtained in the bench-scale pellet mill support the proposed theory that good quality pellets and satisfactory pelletizing should occur in the region where the friction decreases with die temperature. Therefore, the friction vs. die temperature curve measured for each biomass in the SPP can be used as an indication of the right die temperature in large-scale pellet production

III. Objectives

i) Design of the pelletizing Machine
ii) Fabrication of Pelletizing Machine
iii) Optimization of biomass materials using taguchi method

IV. Problem Definition

Biomass pellets are used for residential heating and for industrial scale combined heat and power production. The market for pellets is still relatively young but rapidly growing in terms of usage and capacity building. For Energy saving& cost reduction. We will use solar energy for functional working of machine.

V. Methodology

One of the basic factors that affect the choice of a project is the availability of materials, selection of materials, and the cost of the materials for the design or fabrication of the project. The materials selection for the design function depends on the following:

i) The availability of these materials in our local markets.
ii) The strength of these materials
iii) The cost of the materials
iv) The possession of simple mode of the operation
iv) The appearance of these materials
v) The ability of these materials to serve the purpose for which the project is intent to be designed.

A. Metallic Gear

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque, in most cases with teeth on the one gear being of identical shape, and often also with that shape on the other gear. Two or more gears working in a sequence (train) are called a gear_train or, in many cases, a transmission; such gear arrangements can produce a mechanical_advantage through a gear_ratio and thus may be considered a simple_machine. Geared devices can change the speed, torque, and direction of a power_source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation.

B. Electric motors (single phase)

An electric motor is an electrical machine that converts electrical_energy into mechanical energy. The reverse of this would be the conversion of mechanical energy into electrical energy and is done by generator. In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction_motors, electric motors can operate in both motoring and generating_or_braking modes to also produce electrical energy from mechanical energy.

Found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives, electric motors can be powered by direct current (DC) sources, such as from batteries, motor vehicles or rectifiers, or by alternating (AC) sources, such as from the power grid, inverters or generators. Small motors may be found in electric watches. General-purpose motors with highly standardized dimensions and characteristics provide convenient mechanical power for industrial use. The largest of electric motors are used for ship propulsion, pipeline compression and pumped-storage applications with ratings reaching 100 megawatts. Electric motors may be classified by electric power source type, internal construction, application, type of motion output, and so on.

Electric motors are used to produce linear or rotary force (torque), and should be distinguished from devices such as magnetic solenoids and loudspeakers that convert electricity into motion but do not generate usable mechanical powers, which are respectively referred to as actuators and transducers.

C. Angle iron

Structural steel is a category of steel used as a construction material for making structural steel shapes. A structural steel shape is a profile, formed with a specific cross section and following certain standards for chemical composition and mechanical properties. Structural steel shapes, sizes, composition, strengths, storage practices, etc., are regulated by standards in most industrialized countries.

D. Battery Fasteners (bolts and nuts)

A nut is a type of fastener with a threaded hole. Nuts are almost always used opposite a mating bolt to fasten a stack of parts together. The two partners are kept together by a combination of their threads' friction, a slight stretch of the bolt, and compression of the parts. In applications where vibration or rotation may work a nut loose, various locking mechanisms may be employed: Adhesives, safety pins or lock wire, nylon inserts, or slightly oval-shaped threads. The most common shape is hexagonal, for similar reasons as the bolt head - 6 sides give a good granularity of angles for a tool to approach from (good in tight spots), but more (and smaller) corners would be vulnerable to being rounded off. It takes only 1/6th of a rotation to obtain the next side of the hexagon and grip is optimal. However polygons with more than 6 sides do not give the requisite grip and polygons with less than 6 sides take more time to be given a complete rotation. Other specialized shapes exist for certain needs, such as wing nuts for finger adjustment and captive nuts for inaccessible areas.

E. Washers

A washer is a thin plate (typically disk-shaped) with a hole (typically in the middle) that is normally used to distribute the load of a threaded_fastener, such as a screw or nut. Other uses are as a spacer, spring (Belleville, wave washer), wear pad, preload indicating device, locking device, and to reduce vibration (rubber__washer). Washers usually have an outer diameter (OD) about twice the width of their inner diameter (ID).Washers are usually metal or plastic. High quality bolted_joints require hardened steel washers to prevent the loss of pre-load due to Brinelling after the torque is applied. Rubber or fibre gaskets used in taps (or faucets, or valves) to stop the flow of water are sometimes referred to colloquially as washers; but, while they may look similar, washers and gaskets are usually designed for different functions and made differently. Washers are also important for preventing galvanic_corrosion, particularly by insulating steel screws from aluminium surfaces.

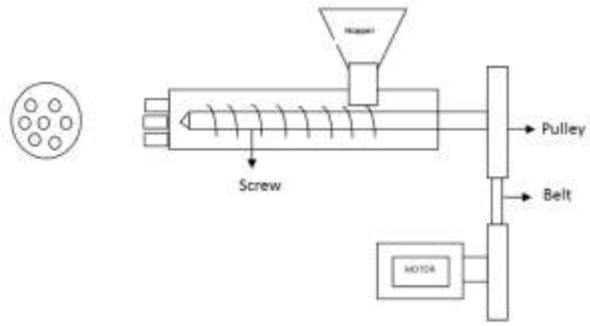
F. shaft

A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power.

G. Vibration Pad

Today the reduction of vibration emission and vibration immission play an important part in the operation of plant and machinery, etc. The constant improvement in machine performance over recent years has generally been accompanied by increased speeds and cutting rates, as well as an increase in impact power in the field of forming. This means an increase in the vibrations transmitted to the surroundings, which must be efficiently controlled.

H. Layout of Biomass pellet machine



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