Slaughterhouse Waste Treatment Equipment to Produce Plant Fertilizer and Fish Feed

Rindi Kusumawardani[1], Putu Dana Karningsih[1], Nani Kurniati[1], Moses Laksono Singgih[1], Hari Supriyanto[1], Sutikno[2], Dwa Desa Warnana[3], and Irene Malilung Sitanggang[1]
[1]Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya
[2]Department of Mechanical Engineering, Institut Teknologi Sepuluh Nopember, Surabaya
[3]Department of Geophysical Engineering, Institut Teknologi Sepuluh Nopember, Surabaya
e-mail: rindi@its.ac.id

***Abstract*—Chicken slaughter process waste is divided into two types, solid waste and liquid waste. Almost all of the waste generated by the chicken slaughter process can be reused. Lately, Vocational High School in Pasuruan, East Java, has Livestock Agribusiness unit that made a waste treatment program to deal with the problem of waste from the surrounding chicken slaughter process. However, some chicken slaughter process waste cannot be reprocessed and is directly dumped into the sewer due to limited technology. The type of waste that cannot reprocess is blood and chicken feather waste. This research aims to process the waste into high-quality fish food by applying the principle of automation and integrating machines with existing chicken cutting machines. The application of this appropriate technology begins with observing the existing conditions and the process of designing, manufacturing, and testing equipment carried out at Vocational High School in Pasuruan. The research resulted in designing and manufacturing machines that support waste treatment of blood and chicken feathers from Livestock Agribusiness. The machine design consists of three main components: a blood and chicken feather grinder, a vertical mixer, and a fish feed press machine. The expectations of this machine design will support productivity and concern for waste management, which can also build environmentally friendly standards in the Livestock Agribusiness unit of Vocational School in Pasuruan.**

***Keywords*—Blood and Chicken Feather Waste, Integrated Machine, Poultry Feed, Waste Treatment.**

I. INTRODUCTION

THE chicken farming industry is promising in Indonesia because of the increased chicken consumption. Based on data from the Indonesia Central Bureau of Statistics and Livestock and Animal Health Statistics from the Directorate General of Livestock and Animal Health, Indonesian Ministry of Agriculture in 2021, the total population of broilers in Indonesia is 3.11 billion. This number indicates an increment of 6.43% compared to the previous year, as seen in Figure 1 [1]. In line with the high consumption and population of broilers, broiler farming companies in Indonesia for the last ten years, from 2011 to 2021 also tend to increase, now at 184 units, as seen in Figure 2 [2]. Although in 2020, it began to decline due to the entry of chicken meat imports from Brazil in line with Indonesia's defeat in Brazil's lawsuit to the WTO in 2017. With this defeat, Brazilian chicken meat can enter Indonesia at a low price [3]. However, judging from the meat quality, Indonesian chicken is more competitive, which can be proven

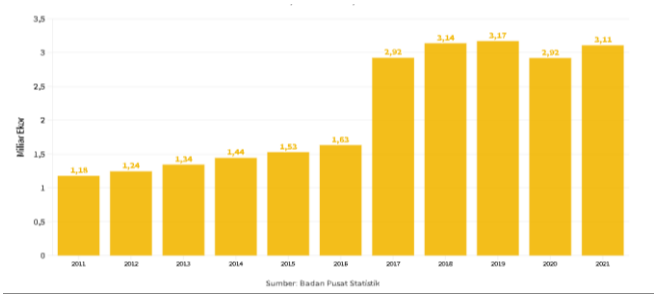

Figure 1. Broiler chicken population in Indonesia in 2011-2021.

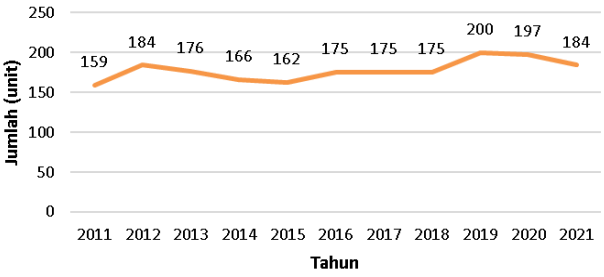

Figure 2. Amount of broiler farmer company in Indonesia.

that in 2022, Indonesia can start exporting its poultry commodities to Singapore.

The livestock industry has great opportunities as employment providers also play a role in educating the nation, so the livestock sector has a strategic role in improving welfare [4]. To support the sustainability and optimization of the livestock industry some subject related to livestock has even been appointed as teaching material at both the Vocational High School and the University level in Indonesia and other countries. The importance of the study of animal husbandry results from its definition. It is related to the main character and characteristics of farm animals, regulates the evolution, growth and development of animal organisms. In this context, we should maintain animal health by properly handling the relationship between animals and animal breeding technology, and in the other hand, we need to control and oversee the achievement of healthy animal production [5].

One educational institution raises the major of Animal Husbandry or Livestock Agribusiness, which is the object of the author's research, a Vocational High School in Pasuruan Regency, East Java Province. This major has several supporting facilities for learning practices, from cages for laying hens, cages for broilers, chicken slaughterhouses, and

Table 1.
Slaughterhouse Wastes and Their Potential Uses

Type of by-product	% of live weight	Uses
Poultry litter and manure	–	Recycled feed, surface dressing of agricultural land
Egg shells, infertile eggs, unhatched eggs and dead and culled chicks	–	Hatchery by-product meal upto 3–5% into feed. Egg shell meal as high calcium diet
Feathers	7–8	Bedding material, decorative purpose, sporting equipment, manure or fertilizers, feather meal.
Heads	2,5–3,0	Poultry meal.
Blood	3,2–3,7	Blood meal.
Gizzard and proventriculus	3,5–4,2	Edible, source of chitinolytic enzyme.
Feet	3,5–4,0	Soup, technical fat/poultry grease
Intestines and glands	8,5–9,0	Sportgats,, meat meal, poultry grease and active principles (hormones and enzymes)

feed grinding rooms. Most of these four facilities have implemented the principles of automation.

A chicken slaughterhouse is an important facility often used by the livestock industry in selling or marketing its broiler products. The process of cutting the chicken is still an important concern regarding to its waste treatment system. Slaughterhouse wastes are a potential reservoir of bacteria, viruses, prions, and parasitic pathogens, which are capable of infecting animals and humans [6]. Disposal of poultry slaughter waste is one of poultry meat production's main everyday problems. Efficient utilization of by-products has a direct impact on the economy and environmental pollution.

Table 1 contains some of the by-products or waste from the chicken slaughtering industry. These wastes including animal waste, blood, fur, and processing waste can be turned into useful resources [7]. The main waste from their slaughtering process are solid and liquid waste, which are blood and chicken feathers. Where there is no waste treatment system, the disposal is still conventional to rivers or landfills. Slaughterhouse solid waste in Indonesia is generally disposed of in an open landfill (TPA). This solid waste can cause odors and air pollution if discharged directly into the environment.

In addition, it can spread disease due to nesting vectors, and consequently, leachate can cause groundwater contamination [8]. Chicken slaughterhouse wastewater is a waste that is highly polluted with organic matter, including protein, blood residue, and lard. Therefore, chickens that are not treated are immediately discarded slaughterhouse waste into the environment is associated with the eutrophication phenomenon. It can be concluded that direct disposal of chicken slaughterhouse wastewater has a negative contribution to the environment's biodiversity and as such, they must be treated effectively before final disposal [9].

Therefore, the author tries to find a method of managing this waste. Feathers are another source of 75-90% crude protein. Feathers are high in protein but have a complex keratin structure that makes them difficult to digest. It also has structural unsuitability for preparing animal feed as well as poultry feed. Currently, in Turkey feathers are processed in rendering at high pressures and over 130^{O}C to obtain feather flour and are used for animal feed components. However, the hydrothermal treatment destroys essential amino acids such as methionine, lysine, tyrosine, and tryptophan leading to poor digestibility and low nutritional value. Processed fur can also be used for humans' bedding, clothing, and other niche market items. Feather is also converted into a feather meal as a slow-release organic fertilizer as it is >90% protein and is rich in nitrogen [7]. Blood is a waste material resulting from slaughter and bloody steps. Blood can be turned into a blood meal or used as fish bait or fertilizer. During blood meal preparation, blood must first be given. Water evaporates from blood on the stove to low water content. The cake is pressed to lower its fat content to about 10% and then ground to pass through the 8~12 mesh screen. The material is mixed with mineral supplements and spices to form a blood meal. Alternatively, the blood can be mixed with offal and feathers to make a combined meal. The given blood meal is rich in protein and is mainly used for animal feed, where they are a valuable source of protein [10]. Feathers can also be processed into feather flour or as a combination of blood meal and feather meal and are used as an efficient source of protein in animal feed. Blood meal and feather meal complement each other with blood meal supplies lysine, while feather meal supplies sulfur amino acids (cysteine and methionine).

In the nutritional evaluation of feather meal, it found that the total amino acid availability (TAA) of foods ranged from 62.1% (aspartic acid) to 82.4% (arginine). The metabolizable energy from food range from 2,877 kcal/kg dry weight for turkey/ chicken feather meal to 3,122 kcal/kg dry weight for chicken feather meal [10]. Poultry and livestock by-products such as poultry meat meal, feathers, and blood meal are essential sources of protein for use in fish feeds. Unlike plant proteins, they contain basic amino acids, vitamins and minerals and are virtually free of anti-nutrients [11]. Another study states that in every slaughterhouse, the feathers obtained are ±6% of the live body weight of broiler chickens. Before being given to poultry as their food, chicken feathers must first be processed into food. Processing of chicken feathers into food is carried out to weaken or break the bonds in keratin by a hydrolysis process.

Various processing methods have been studied to improve the digestibility of chicken feather food. Chicken feather flour is a potential source of poultry feed due to its high crude protein content of 81.7-85.8%6. Processed chicken feather flour can be used as a protein source feed material in broiler chickens in three processing types: Steam pressure processing, soaking and steam pressure cooking, fermented by Bacillus moss. This research concluded that broiler chicken feed with 2.5% chicken feather meal could reduce the

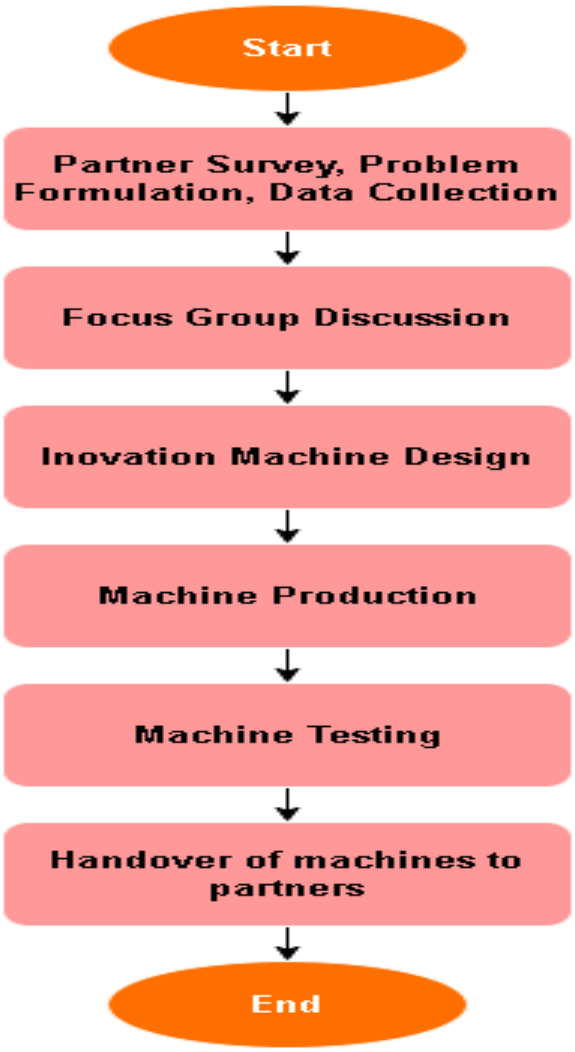

Figure 3. Research methodology.

FCR (Feed Conversion Ratio) value without being followed by changes in blood lipid profile. Therefore, chicken feather flour can be used as an alternative material for broiler feed to reduce production costs [12]. A study from Malaysia also states that blood meal as an animal feed supplement supports agricultural sustainability. Blood flour which is high in protein content lacks certain nutrients, so it is expected to impact the behavior and welfare of chickens. This study was conducted to determine the impact of blood meal supplements on the behavior of chickens. It was concluded from this study that blood food supplements affect welfare in chicken farms in terms of exploration, fear, and escape behavior. Therefore, the amount of dietary blood as an animal feed supplement in poultry production should be determined carefully to avoid any potential adverse impact on poultry welfare [13]. From the problem and previous research, the authors design the chicken slaughterhouse waste treatment system using the integration of a disk mill machine, vertical mixer, and also feed printer. These products will support the sustainability of the livestock industry and minimize resources in producing feed or fertilizers. The application of the technology will start from observing the existing conditions, designing, building, producing, and testing the equipment, then the machine implementation process, which is expected to support productivity and concern for waste treatment which can also build friendly environmental

Table 2.
Components of A Cylindrical Pellet Feed Molding Machine

No	Component
1	Pully
2	V-belt
3	Gear box
4	Bearing
5	Shaft Rod Bar
6	Shaft Rod Bar
7	Extruder/screw
8	Funnel (input)
9	Funnel (output)
10	Steel plate
11	Motor starter
12	Flat die

standards. The environment in the Livestock Agribusiness unit of Vocational High School in Pasuruan.

II. METHOD

The method used in designing and implementing this program is the Participatory Rural Appraisal (PRA) method. This method places the community (the Pasuruan vocational high school) as the program's actors so they can participate actively. In addition, this method can bring the level of program suitability closer to the needs of the object of observation, in this case, the Livestock Agribusiness Unit of Pasuruan vocational school, so that the success and sustainability of the program will be guaranteed. The following is a flowchart of a series of methods carried out. Figure 3 shows the flowchart of the research methodology.

A. Partner Survey, Problem Formulation, Data Source

This stage is carried out to find out the problems experienced by partners, surveys carried out directly can provide an overview as well as important data that can be used to find out what problems are experienced by partners and aim to determine the relevant target groups.

B. Focus Group Discussion (FGD)

The next stage is a Focus Group Discussion (FGD) with the target group related to existing problems (the Livestock Agribusiness Unit in Pasuruan vocational high school). FGD aims to find innovations that match the needs and desires of the observed object.

C. Innovation Engine Design

At this stage, the data obtained both primary data through surveys and discussions as well as secondary data will be used to design an innovation engine that is in accordance with the needs and desires of the target group.

D. Machine Production

If the design of the machine innovation has been agreed upon by both parties, then the machine is made according to the innovation that has been designed previously.

E. Machine Testing Control

After the machine has been produced at the vendor, a machine test will be carried out according to the initial design

objectives. This test includes physical testing, whether if it is turned on it can operate without fail and trying to treat the waste blood or chicken feathers directly. If a system fails, improvement, redesign, and retesting will be carried out until the machine can work properly.

F. Handover of Machines to Partner

After the machine has been tested and can working properly, it will be immediately handed over to the partner. The handover of this machine is accompanied by socialization by the author to all teachers and students, especially students who are majoring in livestock agribusiness so that school residents can operate them.

III. RESULT AND DISCUSSION

This results section will discuss how the author develops integrated machines for waste management system innovations. Processing blood or chicken feathers into feed goes through several processes. Generally, the process is: Cooking blood or chicken feathers, then drying blood or chicken feathers, after that grinding dried blood or feathers to become blood meal and feather meal, using a disk mill machine. Mixing of raw materials in the form of blood flour or feather flour, soybean meal, onggok (processed tapioca flour), papaya flour, bran, tapioca flour, pollard, burger feed sauce, molasses, and water, using a vertical mixer. After the mixing process, fish or poultry feed pellets are printed from blood meal or feathers mixed with other materials using an automatic feed molding machine. The last feed or pellets are temporarily dried and then ready to be given to farmed chickens or fish. As for the production of plant fertilizers, the process is enough through grinding blood or dry feathers because blood flour or raw feathers can already be used as fertilizer [14]. This process concludes that three main machines are required to process blood or feathers into feed and fertilizer products: disk mill machines, vertical mixer machines, and feed molding machines. The three machines that are already widely available in the market and the common feed processing processes encourage the author to create innovations in these machines and processes for processing optimization purposes. The process of generating innovative ideas is assisted by two tools that the author uses, namely the SCAMPER and DFA methods.

A. Scamper Analysis

Scamper is a technique for brainstorming an idea in the realm of innovation created by the educational administrator and author Bob Eberle [15]. This technique aims to answer several important points to determine whether the product already has elaborated innovation points [15]. The SCAMPER analysis is starting from, substitute that is to find out whether the innovation idea is obtained from replacing the supporting components, materials, or people in the business. Combine several functions into one in an innovative product, then adapt the addition of certain components in order to change and adapt the product to the needs of the environment. After that, modify in form of a question to find out what modifications should be added or removed so that it remains comfortable to see even though it has a different function advantage from the general tool. Put in another use with an explanation of whether our innovative product can be used for other functions. Eliminate some things that are considered less effective or efficient in using the tool. Elimination can be based on various factors according to the focus being highlighted or analyzed, and the last is make adjustments to the product by removing certain components.

Table 3.
Components of A Round Pellet Feed Molding Machine

No	Component
1.	Pully
2.	V-belt
3.	Gear box
4.	Bearing
5.	Shaft Rod Bar
6.	Extruder/screw
7.	Funnel (input)
8.	Funnel (output)
9.	Steel plate
10.	Motor starter
11.	Flat die

Table 4.
Innovation Machine Components

No	Component
1.	Pully
2.	V-belt
3.	Gear box
4.	Bearing
5.	Flywheel
6.	Flat die (round molding)
7.	Flat die (cylindrical molding)
8.	Funnel (input)
9.	Funnel (output)
10.	Cutting Knife
11.	Steel plate
12.	Motor starter

Based on the previous explanation, the SCAMPER analysis of our innovation products is start from substitute. The function of our tool is to process waste into something that has value through the integration of three main machines (Disk-Mixer-Print Feed). The main focus of the solution offered is for feed processing and as a waste treatment system in the Chicken Slaughterhouse. After that we do the combine process for several machine functions (a total of 3 main machines) into one integrated system. Integration is carried out to optimize time and support continuous processing in which the output from one machine will be directly transferred to another machine. The adaptation step has aims to make it easy for the user to adjust several things to make it easier for the user to carry out the processing according to the existing input and the resulting output. In our system, there is a speed option to set the required speed in disk mill machines and vertical mixers, and automatic filter change system in the disk mill, which aims to minimize the waiting time for filter

change. For the modification, we did not make many modifications to each of the existing machines. However, we focused more on making slight modifications to the use of the tool where the three main machines used were integrated and created a continuous processing system. After the modification, we also design our system in another use, like in the type of feed that can be printed, which can be in the form of pellets or crumbles. In addition, this chicken blood waste treatment machine is also capable of making plant fertilizer by passing through a disk mill and mixing machine. For eliminate stage, we try to eliminate wasting time and wasting place because the tool has become an integrated combination so that handling activities can be carried out automatically because in the initial conditions of using each separate machine, generally handling activities of each engine output are still done manually.

B. Design for Assembly Analysis

Design for assembly (DFA) is one of the assembly design systems planned in the early stages of product design, where each product component and its quantity are analyzed and considered for difficulty in the assembly process to plan the repair of product components for an easier assembly process [16]. As explained, the purpose of DFA is to simplify the product so that assembly costs will be reduced. In addition, DFA in this study was used to improve the quality, reliability, and reduction in production equipment and product components [17].

The innovation given in this study is in the form of a feed printing machine that has the function to print feed with two types, namely, pellets of cylindrical and spherical size. In feed printing machines, only have the function of printing one type of feed. Similarly, this machine makes it easier for operators to print feed according to the desired type with one machine only. Then with this design, the components of the feed printing machine in this study are also different from the feed printing machine in general. Table 2, Table 3, and Table 4 show the detail of components for each machine.

In the initial product, cylindrical and round feed printers cannot be carried out in the same machine, so two different machines are needed according to their functions. In this innovative product, both cylindrical and round feed products can be made in one machine, which facilitates the process and reduces the cost of purchasing the machine.

C. Machine Innovation and Mechanism

To support waste treatment at the Chicken Slaughterhouse facilities while providing added value, innovative machines were introduced in the form of integrated machinery with multiple functions for grinding blood and chicken feathers, mixing and printing fish feed, as well as automatic lighter. Chicken blood and feathers obtained from the production process at the chicken slaughterhouse will be boiled first in hot water until completely dry.

This boiling system utilizes an automatic lighter with a direct current motor as a gas controller to turn the fire on and off the stove. When the ON button on the system is pressed, the relay will give a signal towards the direct current motor to start turning, open the gas line, turn on the lighter, and the other relay will work to provide a signal to turn on the pump

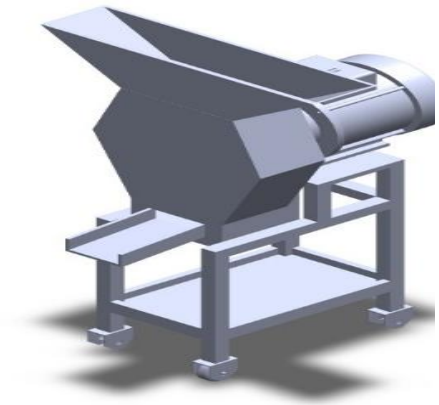

Figure 4. Disk mill machine.

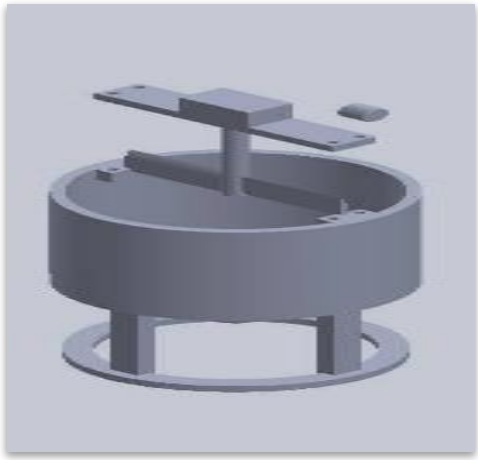

Figure 5. Vertical mixer machine.

motor. The sensor works as a temperature detector in the reactor as the fire starts to heat the reactor tube. When the temperature in the reactor reaches the standard boiling point of water for chicken blood & feathers, the sensor will send a signal to turn the DC motor back to close the gas line to the stove until the fire dies. Thetemperature sensor in the distillation process works as a detector of the temperature of the cooling water in the distillation tube. Then the pump is used to pump the water into the distillation [18].

Then the results of the boiling will be dried over and over naturally beneath the sun for approximately 3-5 days. After that, the dried blood and feathers will be directly inserted into the machine or designed tool. In the initial process, the dry blood and feathers will be milled. Figure 4 show the design of the disk mill machine.

Then the output will go into the mixer machine, where the blood flour or feather flour will be mixed with other ingredients, then mixed automatically. Finally, the output will come out through 2 holes, the first is the hole to remove the mixing results in the container directly, and the second is the hole to deliver the output of the flour that has been mixed earlier to enter the feed printing machine. Then the process of processing blood and chicken feathers into fertilizer and feed was completed. The disk mill machine used to process chicken blood and feather were made of stainless steel. This disk mill is driven by an electric motor power source which will then be transmitted to the disk mill [19]. The innovation

for this disk mill machine is the provision of in-machine speed options (1000-5000 Rpm), according to the standard disk mill machines that are often used in the industry. Then make three variations of mesh in a disk mill machine as research material for flour fineness and reduce manual mesh replacement (unloading wormwood).

Figure 5 shows a vertical mixer machine to mix blood flour or feather flour to allow the mixing of homogeneous ingredients more evenly. The vertical mixer machine is also made of stainless steel material and utilizes gravity to mix feed ingredients. A small driving motor drives this machine to minimize fuel and electricity consumption. It is due to the machine mixing with the help of gravity. In this machine, the stirrer component consists of single and double screws (pipe as threaded). When it rotates, it can lift the inserted feed material [20]. The innovation for this vertical mixer machine is also the provision of speed options in the machine (200-500 Rpm), according to the vertical mixer machine standard that is often used in the industry. Then, Figure 6 is the feed printing machine.

This simple feed printing machine, which also uses stainless steel material, will print the blood meal or feather flour mixture earlier to form fish and chicken feed. Inside this machine, a flywheel will push the mixed flour into the die plate or small round mold. The die rotation is driven by a motor through a pulley transmission. Then, the flywheel will automatically rotate, and due to pressure and contact with the dies disc, the flywheel is made by free rotation of the bearing and is exerted pressure by the bolt between the ends. Then, the result of the roller pressure with the dies disc will exit through the smallest dies gap and produce a long feed mold. Each of these long round molds is cut by a cutting knife and falls into the output hole. The innovation for feed molding machines is the provision of two types of molds in the machine so that one feed molding machine can be used to mold poultry feed and fish pellets. Later, when the operator wants to use the machine, just press the button for the type of feed to be printed, then the mixed feed flour will come out into the hole according to the type requested.

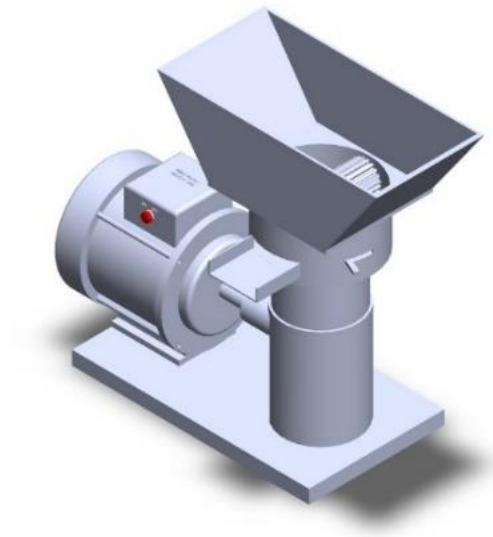

Figure 6. The 2 in 1 feed printing machine.

IV. CONCLUSION

Increased consumption of chicken in 2021, especially in Indonesia has become an opportunity for the livestock agribusiness or chicken farm industry to expand its business. One of the vocational schools in Pasuruan, Indonesia, has started to glance and explore at this opportunity. In this school, livestock agribusiness has been developed and supported by several facilities to maximize learning practices, including feed grinding rooms, chicken slaughterhouses, broiler cages, and laying hen cages. The majority of these four institutions have put automation concepts into practice. However, a chicken slaughterhouse facility is one of the technologies in the livestock industry that produces lots of waste, such as blood and chicken feathers. According to research from the Center for Agrotechnology Innovation, chicken blood can be processed and used as fish feed, because it contains a high enough protein. However, it must be mixed with other ingredients such as water, flour, and molasses. Blood meal can also be used directly as plant fertilizer which can later be used as a selling product to increase the productivity of chicken slaughter. Therefore, it is necessary to develop appropriate technology in the form of a chicken blood waste processing machine that implements automation that is integrated with existing chicken cutting machines. The application of this appropriate technology will start from the existing observation, designing, building, producing and testing the tools that will be carried out at one of the vocational high schools in Pasuruan Indonesia. Then the machine implementation process is expected to support productivity and concern for waste treatment, which can also build environmentally friendly standards in the Livestock Agribusiness unit of this school.

Several analysis were made by implementing SCAMPER and DFA methods to innovate toward livestock agribusiness waste problems. In order to support waste treatment at the Chicken Slaughterhouse facility, innovative machines were introduced as integration machines for blood flour and chicken feather grinders, fish and chicken feed mixing and printing machines, and automatic lighters. This machine is expected to be able to print the blood meal or feather flour mixture earlier to form fish or chicken feed by combining the three functions of processing tools: disk mill machine, vertical mixer machine, and the feed printer machine. By creating this integrated machine, hope that it can optimize the potential of livestock agribusiness, especially the productivity of chicken farming and also implement the SDGs principles by processing industrial waste and making it into product that has added value rather than just being a waste that could damage the environmental conditions.

REFERENCES

[1] Directorate General of Livestock and Animal Health, "Livestock and Animal Health Statistics 2021," Directorate General of Livestock and Animal Health Indonesian Ministry of Agriculture, Jakarta, 2021.

[2] Indonesia Central Bureau of Statistics, "Number of Broiler Companies by Main Activities 2019-2021," Indonesia Central Bureau of Statistics, Jakarta, 2021.

[3] L. M. J. D. Jayanti and I. G. P. Ariana, "Penyelesaian Sengketa Impor Daging Ayam Antara Brazil dengan Indonesia Melalui Disputte

Settlement Body WTO," Bagian Hukum Internasional dan Hukum Bisnis Internasional, Fakultas Hukum, Universitas Udayana, pp. 1-10, 2018.

[4] E. Subekti, "Peranan Bidang Peternakan dalam Upaya," MEDIAGRO, vol. IV, no. 2, pp. 32-38, 2008.

[5] I. Hutu, K. Oldenbroek and L. v. d. Waaij, Introduction in Animal Husbandry, Romania: Agroprint Publishing House, Timisoara, 2020.

[6] I. F. Whittle and H. Insam, "Treatment alternatives of slaughterhouse wastes, and their effect on the inactivation of different pathogens: A review," National Center for Biotechnology Information, vol. 39, no. 2, pp. 139-151, 2013.

[7] O. . F. Sari, S. Ozdemir and A. Celebi, "Utilization and Management of Poultry Slaughterhouse Wastes with New Methods," in Eurasia 2016 Waste Management Symposium, Istanbul, 2016.

[8] R. Ratnawati and Y. Trihadiningrum, "Slaughter House Solid Waste Management in Indonesia," Journal of BiologicalRresearches, vol. 19, pp. 69-73, 2014.

[9] M. A. Yaakob, R. M. S. R. Mohamed, A. A. S. Al-Gheethi and A. H. M. Kassim, "Characteristics of Chicken Slaughterhouse Wastewater," Chemical Engineering Transactions, vol. 63, pp. 637-638, 2018.

[10] L. G. Fonkwe, R. K. Singh and J. H. Lee, "Utilization of Poultry Processing Wastes," Jurnal Food Science Nutrition, vol. 6, no. 4, pp. 257-262, 2001.

[11] A. V. K. D. L. N.-N. a. A. M. P. Sergei V. Beketov, "Qualitative characteristics of blood meal and feather meal in connection with the possibility of its use in fish feed," in BIO Web of Conferences, 2020.

[12] M. P. M. A. N. W. Aris Haryanto, "Effect of Chicken Feather Meal on the Feed Conversion Ratio and Blood Lipid Profile of Broiler Chickens," Asian Journal of Poultry Science, vol. 11, no. 2, pp. 64-69, 2017.

[13] M. T. R. I. A. S. Nur Atiqah Abdul Rahima, "Blood Meal Supplement Improves Exploration Behaviour but Increases Escape Attempt," Malaysian Journal of Sustainable Agriculture, vol. 6, no. 1, pp. 17-21, 2022.

[14] Pusat Inovasi Agroteknologi (PIAT) UGM, "https://piat.ugm.ac.id/," Universitas Gadjah Mada Pusat Inovasi Agroteknologi, 1 April 2021. [Online]. Available: https://piat.ugm.ac.id/2021/04/01/piat-memanfaatkan-limbah-darah-rumah-potong-ayam-sebagai-bahan-baku-pembuatan-pakan-ikan-berprotein-tinggi/. [Accessed 1 July 2022].

[15] N. G. Zia, "Strategi Pengembangan Produk Inovatif dengan Metode Scamper," 2022. [Online]. Available: https://www.ekipa.co.id/strategi-pengembangan-produk-inovatif-dengan-metode-scamper/. [Accessed 2022].

[16] G. Dalgeish, G. Jared and K. Swift, "Design for assembly: Influencing the design process," ResearchGate, vol. 11, no. 1, 2000.

[17] G. Formentini, N. B. Rodriguez and C. Favi, "Design for manufacturing and assembly methods in the product development process of mechanical products: a systematic literature review," SpringerLink, vol. 120, pp. 4307-4334, 2022.

[18] M. K. A. Wildan Maulana, "Rancang Bangun Kontrol On/Off Pemantik Api Kompor Gas Otomatis pada Mesin Pengolah Plastik Menjadi Bahan Bakar Minyak Berbasis Mikrokontroller," Jurnal Litek, vol. 13, no. 2, pp. 85-90, 2016.

[19] A. M. E. M.-S. Stephanie Klein, "Effects of raw materials grinding with disc mill on feed particle size and digestibility for broiler chicken," in World's Poultry Congress, Beijing, China, 2016.

[20] U. K. Chikwado, "Optimization and Performance Evaluation of Poultry Feed Mixer," International Journal of Science and Research (IJSR) , vol. 4, no. 6, pp. 1303-1307, 2013.