# The Manufacturing Process of Geopolymer Mortar Nozzle Construction on Civil Building 3D Printing Machine

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Keywords: Nozzle, Geopolymer Mortar, Manufacturing Process.

Abstract: The geopolymer mortar nozzle is one of the components contained in the 3D printing machine of civil buildings that serves to remove the geopolymer mortar into a certain shape. A civil building 3D printing machine requires a tool or device designed to control the shape or characteristics of the material flow specially to regulate the number of geopolymers when exiting a hopper.
The nozzle will store the geopolymer mortar on the hopper, then with the rotation of the stepper motor and extruder, the geopolymer mortar will come out into a certain shape through the nozzle head. The construction of the geopolymer mortar nozzle on the 3D printing machine of civil buildings is carried out by cutting plates using hand grinding and cutting grinding, turning, bending, and welding for the assembly process. After this geopolymer mortar nozzle is completed and realized at the Manufacturing Engineering Department of the Bandung Manufacturing Polytechnic, this geopolymer mortar nozzle is expected to be used for the manufacture of civil buildings and function properly and benefit the polman academic community, the community, and the State of Indonesia.

## 1 INTRODUCTION

Civil building 3D printing machine is a machine that processes geopolymer mortar under computer control to create three-dimensional objects, with materials added together (geopolymer concrete, sand, and water combined). Objects can be either shapes or geometries and are typically generated using digital model data from 3D models derived from Additive Manufacturing Files (AMF). 3D printing builds a three-dimensional object from a computer-aided CAD model or AMF file, by adding layers of material layer by layer in a row.

This civil building 3D printing machine requires a device or devices designed to control the shape or characteristics of the material flow (specially to regulate the number of geopolymers) when exiting (or entering) a hopper called a nozzle. Oleh therefore, in this case the author focuses on "Proses Manufacture of Geopolymer Mortar Nozzle Construction On 3D Printing Machines of Civil Buildings

## 2 PURPOSE

The purpose of making this tool is as follows:

1. Knowing the construction of the geopolymer mortar nozzle on the 3D printing machine of civil buildings.
2. Knowing the work of the geopolymer mortar nozzle on the 3D printing machine of civil buildings.
3. Knowing the manufacturing process of geopolymer mortar nozzle construction on a civil building 3D printing machine.
4. Knowing the estimated time required to make the construction of the geopolymer mortar nozzle on the civil building 3D printing machine.
5. Knowing the estimated cost needed to make the construction of a geopolymer mortar nozzle on a civil building 3D printing machine.



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# 3 MANUFACTURING PROCESS

## 3.1 Manufacturing Process Flow

The process of making the construction of a geopolymer mortar nozzle consists of several stages, these stages can be described in general on the following flow chart:

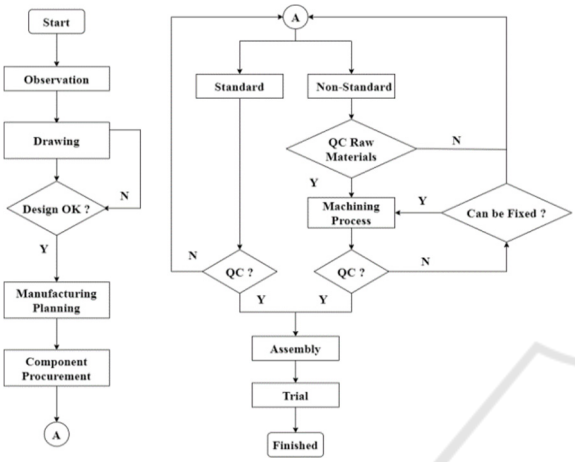



Diagram 1: Flow Chart of The Construction Process of Geopolymer Mortar Nozzle Construction.

## 3.2 Construction Nozzle Mortar Geopolymers

Below is a picture of the construction of the geopolymer mortar nozzle:

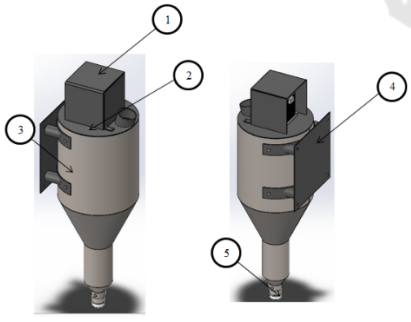



Figure 1: Construction of the Geopolymer Mortar Nozzle.

| No. | Part | Material |
|---|---|---|
| 1 | Motor Cover | ST37 |
| 2 | Hopper Cover | ST37 |
| 3 | Nozzle Hopper | SS304 |
| 4 | Nozzle Holder | ST37 |
| 5 | Nozzle Head | ST37 and PTFE |

Figure 2: List of Parts Names and Materials for Construction of Geopolymer Mortar Nozzles.

Material is the raw material for the manufacturing process both directly from natural and artificial which will be processed into a product. The main materials used in the manufacturing process of geopolymer mortar nozzle construction in civil crane 3D printing machines are ST37, SS304 and PTFE.

## 3.3 Working Principle

The working principle of this tool is mortar geopolymers accommodated inside hopper nozzle will move down due to the force of gravity and the large amount of expenditure mortar geopolymers are governed by Extruder driven by the motor Stepper. Here is an explanatory table of the working principles of construction mortar nozzle geopolymer on the machine 3D printing civil buildings.

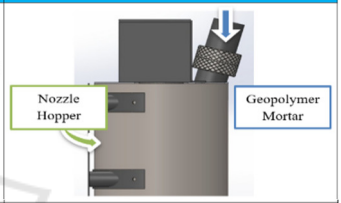
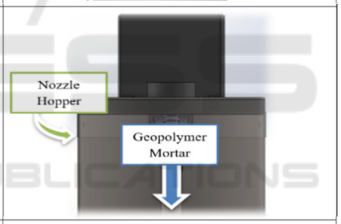
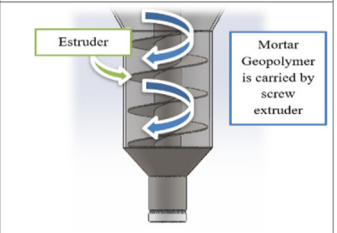
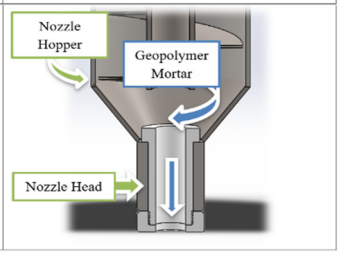
| No. | Description | Picture |
|---|---|---|
| 1 | The geopolymer mortar from the mixer is drained and accommodated into the nozzle hopper |   |
| 2 | The geopolymer mortar will automatically move down due to the presence of gravitational force |   |
| 3 | The discharge rate of the geopolymer mortar will be regulated by an extruder driven by a stepper motor |   |
| 4 | Mortar geopolymer out through nozzle head |   |

Figure 3: Table of Working Principle of Geopolymer Mortar Nozzle.

## 3.4 Mass Nozzle Mortar Geopolymer

The nozzle mass of the geopolymer mortar is the summation of the construction mass of the nozzle, extruder, stepper motor, standard components, and mass of the geopolymer mortar.

### 3.4.1 Calculation of the Mass of Geopolymer Mortar on the Hopper Nozzle

The calculation of the mass of the geopolymer mortar on the nozzle hopper is carried out by calculating the volume of tube 1, tube 2, reducer 1, reducer 2 and connecting nozzle head. The sizes of the hopper nozzle are as follows:

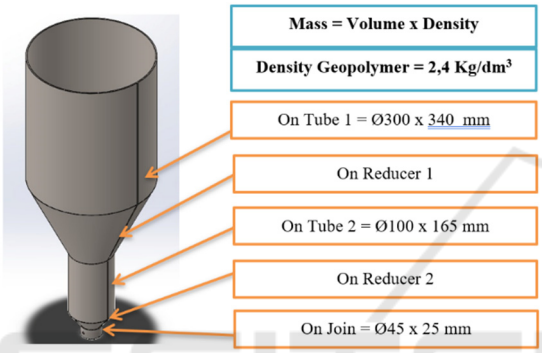



Figure 4: Nozzle Hopper.

a) Geoolimer Mass on Tube 1

- Volume at T1 $= \pi \times r^2 \times t$ (1)
  $= 3.14 \times 150^2 \times 340$
  $= 2.4033 \times 10^7\ mm^3$
  $= 24{,}033 dm^3$
- Mass at T1 $= 24{,}033 \times 2.4$
  $= 57.68$ Kg

b) Geolymer Mass on Tube 2

- Volume at T2 $= 3.14 \times 50^2 \times 165$
  $= 1.2952 \times 10^6\ mm^3$
  $= 1.2952\ dm^3$
- Mass at T2 $= 1.2952 \times 2.4$
  $= 3.1$ Kg

c) Geolymer Mass on The Join

- Volume at Join $= 3.14 \times 22.5^2 \times 25$
  $= 3.9740 \times 10^4\ mm^3$
  $= 0.0397\ dm^3$
- Mass at Join $= 0.0397 \times 2.4$
  $= 0.1$ Kg

d) Gepolimer mass on Reducer 1

- Volume on Reducer 1
  $= 1/3 \times \pi \times t \times (R^2 + R \times r + r^2)$ (2)
  $= 1/3 \times 3.14 \times 205 \times (150^2 + 150 \times 50 + 50^2)$
  $= 6.9734 \times 10^6\ mm^3$
  $= 6.9734\ dm^3$

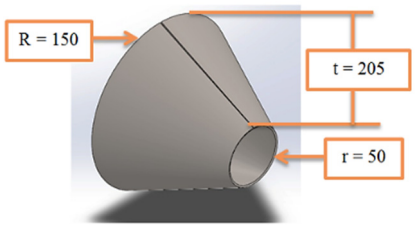



Figure 5: Reducer 1.

- Mass on Reducer 1
  $= 6.9734\ dm^3 \times 2.4$ Kg/ $dm^3$
  $= 16.74$ Kg

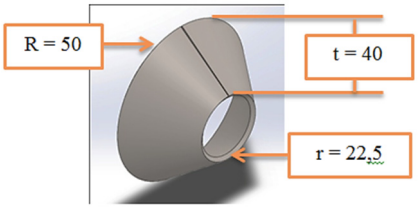



Figure 6 Reducer 2.

a) Mass Reducer 2

- Volume Reducer 2
  $= 1/3 \times 3.14 \times 40 \times (50^2 + 50 \times 22.5 + 22.5^2)$
  $= 1.7296 \times 10^5\ mm^3$
  $= 0.1729\ dm^3$
- Mass Reducer 2
  $= 0.1729\ dm^3 \times 2.4$ Kg/ $dm^3$
  $= 0.41$ Kg

So the total mass of the geopolymer mortar is the summation of the mass of tube 1, tube 2, reducer 1, reducer 2 and connecting nozzle head which is **78.03 Kg**.

### 3.4.2 Mass Calculation Nozzle Mortar Geopolymers

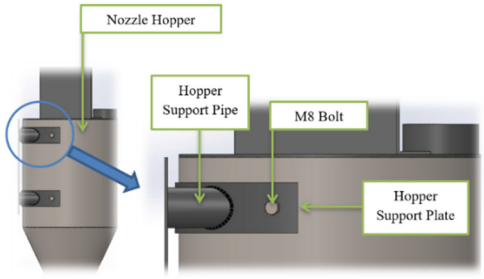
| No. | Part Name | Spesification | Qty | Mass (Kg) |
|---|---|---|---|---|
| 1 | Nozzle Construction | - | 1 | 21,42 |
| 2 | Extruder | - | 1 | 1,57 |
| 3 | Stepper Motor | Nema 42 110 x 110 mm | 1 | 6,8 |
| 4 | Nuts and Bolt | M8 x 20 | 4 | 0,08 |
| 5 | Nuts and Bolt | M6 x 15 | 4 | 0,04 |
| 6 | Ring Plate | M8 | 4 | 0,004 |
| 7 | Ring Plate | M6 | 4 | 0,004 |
| 8 | Mixer Connection | - | 1 | 0,4 |
| Total Mass | | | | 30,318 |

Figure 7: Table of Mass of Geopolymer Mortar Nozzle Parts.

The mass of the nozzle of the geopolymer mortar
$= 30{,}318$ Kg $+ 78.03$ Kg
$=$ **108,348 Kg**

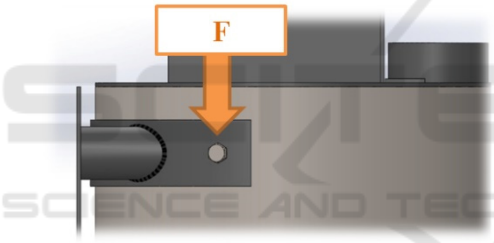
## 3.5 Calculation of Voltage Occurring in BoltEd Joints

In the manufacturing process of the geopolymer mortar nozzle construction, the connection on the hopper support plate must be considered, because this plate will hold the nozzle of the geopolymer mortar. This plate relates to the hopper nozzle using the method of splicing nuts and bolts M8.




Figures 8: Bolt joints on the Hopper support plate.

### 3.5.1 Load/Voltage on M8 Bolts




Figures 9: The direction of force occurring on the M8 bolts.

Known:

| Technical Information | Value | Information |
|---|---|---|
| Geopolymer Mortar Nozzle Mass | 110 Kg | 110 Kg for safety |
| Yield strength ST37 | 250 MPa | Standard |
| Bolt cross-sectional area M8 | 32.84 mm² | Standard |

Figure 10: M8 bolt information table.

find:

a) Permissible voltage
b) Maximum load of bolts
c) Voltage on the bolts

Answer:

1) Determining the Clearance Voltage

$\sigma$ permissions $= Re/Sf$ (3)
$= 250 / 1.5$
$= 167\ N/mm^2$

$\tau$ permissions $= 0.7 \times \sigma$ permissions
$= 0.7 \times 167\ N/mm^2$
$= 117\ N/mm^2$

Information:

$\sigma izin$= Tensile voltage/normal clearance ( $N/mm^2$ )
$\tau izin$= Clearance shear stress ( $N/mm^2$ )
Re= Resistant extension ( $N/mm^2$ )
Sf= Safety factor

Safety Factor for static loading = 1.2 – 2

2) Maximum load bolts M8

$\tau = F / A$ (4)
$F = \tau \times A$ (5)
$= 117 \times 32.84$
$= 3842\ N$

Description:

$\tau$= Shear stress ( $N/mm^2$ )
A= Cross-sectional area ( $mm^2$ )

The force of the geopolymer mortar nozzle is 1100 N, it can be determined that 1 bolt M8 is able to withstand the load of the geopolymer mortar nozzle. However, due to several considerations, namely extreme weather factors and natural disasters such as earthquakes, 4 M8 bolts were used.

3) Determining the shear stress that the bolt receives

F = 1 100 N
F = 1 nz100 N / 4 = 275 N (Loading divided on 4 bolts)

$\tau = F / A$ (6)
$= 275\ N / 32.84\ mm^2$
$= 8.4\ N/mm^2$

## 3.6 Material Use

The procurement of materials for the construction of geopolymer mortar nozzles is divided into 2, namely standard parts and raw materials.

### 3.6.1 Standart Parts

This Standard Part is obtained by buying standard parts/components without the need to do the machining process again, for example standard components, namely baut and nuts. For the next process these standard components go directly into the assembly process.

### 3.6.2 Non-Standart Parts/Raw Material

This Raw Material is obtained by purchasing raw materials, then the machining process is carried out to get the desired shape and function according to the working drawing.

## 3.7 Machining Process

The machining process discusses the work of raw materials and sub assembly parts, this machining process includes the stages of the work process, operation plan and quality control process. The following is an explanation of each stage of the machining process.

### 3.7.1 Stages of Raw Material Work Process

The stages of the work process are the sequence of processes for making raw material components. The following are the stages of work on the raw material components of the construction of the geopolymer mortar nozzle.

| No. | Part Name | Quantity (pcs) | Stages of the Work Process | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 1.1 | Motor Cover Plate | 2 | HG | BND | QC | |
| 1.2 | Motor Cover Bracket | 2 | CB | HG | DR | QC |
| 2.1 | Hopper Cover Plate | 1 | HG | DR | QC | |
| 2.2 | Mortar Directional Plate | 1 | HG | RL | QC | |
| 2.3 | Hopper Cover Quarterly Plate | 1 | HG | RL | QC | |
| 3.1 | Tube 1 | 1 | HG | RL | DR | QC |
| 3.2 | Tube 2 | 1 | HG | RL | QC | |
| 3.3 | Tube Connecting Head Nozzle | 1 | HG | RL | DR | QC |
| 3.4 | Reducer 1 | 1 | HG | RL | QC | |
| 3.5 | Reducer 2 | 1 | HG | SMF | QC | |
| 4.1 | Slider Mount Plate | 1 | HG | DR | QC | |
| 4.2 | Pipe Support Hopper | 4 | CB | HG | QC | |
| 4.3 | Hopper Support Plate | 2 | HG | SMF | DR | QC |
| 5.1 | Outering Nozzle Head 1 | 1 | LT | DR | WB | QC |
| 5.2 | Outering Nozzle Head 2 | 1 | LT | DR | WB | QC |
| 5.3 | Innering Nozzle Nozzle | 1 | LT | DR | WB | QC |

Figure 11: Stages of the raw material work process.

Information:

**HG:** Hand Grinding
**CB:** Cut Burrs
**DR:** Drill
**LT:** Lathe
**QC:** Quality Control
**RL:** Rolling
**BND:** Bending
**SMF:** Sheet Metal Forming
**WD:** Welding
**KB:** Work Bench

### 3.7.2 Stages of the Process of Working on sub Assembly Parts

The following are the stages of the process of working on the components of the sub assembly part sub assembly construction of the geopolymer mortar nozzle.

| No. | Part Name | Quantity (pcs) | Stages of the Work Process | | |
|---|---|---|---|---|---|
| | | | 1 | 2 | 3 |
| 1 | Motor Cover | 1 | WD | HG | QC |
| 2 | Hopper Cover | 1 | WD | HG | QC |
| 3 | Nozzle Hopper | 1 | WD | HG | QC |
| 4 | Nozzle Mount | 1 | WD | HG | QC |
| 5 | Nozzle Head | 1 | FT+TH | QC | |

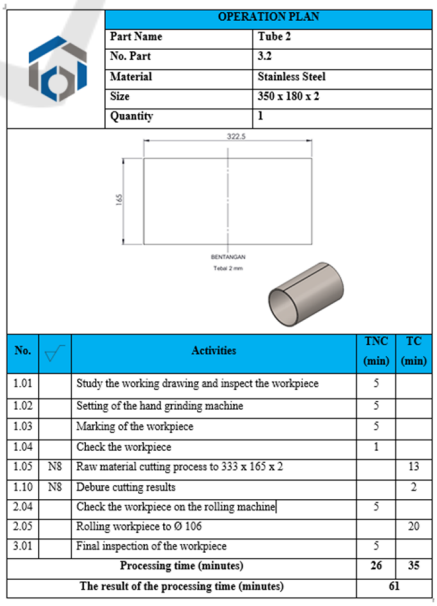
Figure 12: Stages of the process of working on sub assembly parts.

Information:

**HG:** Hand Grinding
**WD:** Welding
**FT+TH:** Fit+Thread
**QC:** Quality Control

## 3.8 Operation Plan

Work planning is made to regulate the workprocess to avoid mistakes and as a source of information to calculate the estimated processing time. The following is one of the operation plans for the construction of the geopolymer mortar nozzle.



| OPERATION PLAN | |
|---|---|
| Part Name | Tube 2 |
| No. Part | 3.2 |
| Material | Stainless Steel |
| Size | 350 x 180 x 2 |
| Quantity | 1 |

| No. | ✓ | Activities | TNC (min) | TC (min) |
|---|---|---|---|---|
| 1.01 | | Study the working drawing and inspect the workpiece | 5 | |
| 1.02 | | Setting of the hand grinding machine | 5 | |
| 1.03 | | Marking of the workpiece | 5 | |
| 1.04 | | Check the workpiece | 1 | |
| 1.05 | N8 | Raw material cutting process to 333 x 165 x 2 | | 13 |
| 1.10 | N8 | Debure cutting results | | 2 |
| 2.04 | | Check the workpiece on the rolling machine | 5 | |
| 2.05 | | Rolling workpiece to Ø 106 | | 20 |
| 3.01 | | Final inspection of the workpiece | 5 | |
| Processing time (minutes) | | | 26 | 35 |
| The result of the processing time (minutes) | | | 61 | |

Figure 13: Operation Plan (OP).

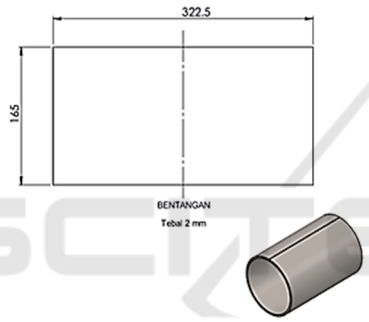
## 3.9 Quality Control (QC)

After carrying out the planning of the process and the machining process. Thework that has been completed in the process will pass the Quality Control (QC) stage.

Quality Control aims to check that the parts that have been made are in accordance with their respective work drawings, if the compensatoryis not suitable and exceeds the existing tolerances, then the components must bere-worked or re-procured and cannot be continued to the next process.

| POLITEKNIK MANUFAKTUR BANDUNG | | INSPECTION FORM | | | | | | No. Order | |
|---|---|---|---|---|---|---|---|---|---|
| Buyer : | | Checked date: 29/6/2022 | | | | | | Person in Charge | |
| Part : Tube 2 | | > | 0 | 6 | 30 120 | 400 | 1000 | Examiner | QC |
| No. Part | ≒ 3.1 | ≤ | 6 | 30 | 120 400 | 1000 | 2000 | Fani | Alvian |
| Quantity | ≒ 1 | TOL | ±0,1 | ±0,2 | ±0,3 ±0,5 | ±0,8 | ±1,2 | | |

Decision : Good




| Inspection Standard | Special Tolerances | Inspection Result 1 | 2 | 3 | 4 | 5 | Information |
|---|---|---|---|---|---|---|---|
| 322,5 | ± 0,5 | 323 | 323 | | | | Steel crossbar 0.1 mm accuracy |
| 165 | ± 0,5 | 165 | 165 | | | | Steel crossbar 0.1 mm accuracy |
| Ø106 | ± 0,5 | 106,2 | 106,2 | | | | Calipers 0.02 mm accuracy |

Figure 14: Quality control (QC).

## 3.10 Assembly

Assembly is the activity of combining components or parts that have been made into a unit that has a certain function. The components of machining, cutting and fabrication are assembled in a manner in accordance with the existing working drawings until all these components become unitary and can be used according to their functions.

The following are the stages of assembly of each part of the construction of the geopolymer mortar nozzle:

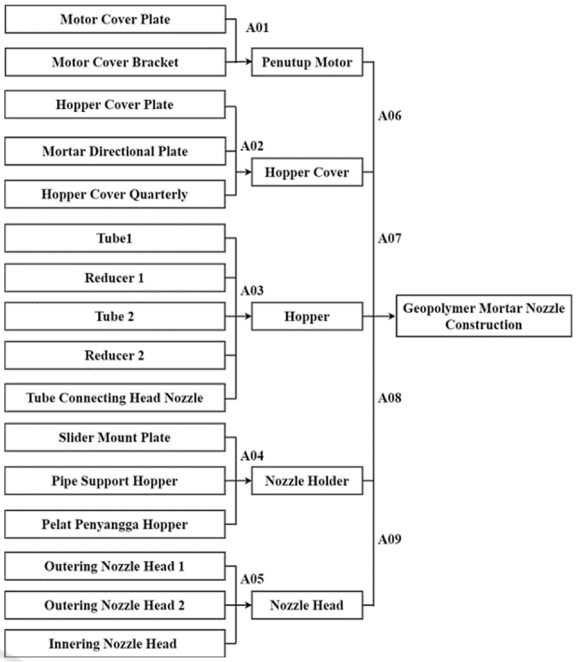



Diagram 2: Geopolymer mortar nozzle construction assembly process.

## 3.11 Trial

After the construction of the geopolymer mortar nozzle is completed, the next step is a trial. The trial stage is carried out to ensure that the construction of the geopolymer mortar nozzle can be used in accordance with its function. At this stage, what must be done is a trial of the production of geopolymer material, starting with inserting a geopolymer mortar into the nozzle hopper as much as 30 liters, then turning the extruder by adjusting the strepper motor at different speeds each time the test is carried out.

This aims to determine the construction ability of the geopolymer mortar nozzle in removing geopolymer material. Itis hoped that after the trial stage, data on the speed of the motror stepper and the ideal fluid discharge will be obtained so as to produce the best production of geopolymer material.

# 4 ESTIMATED TIME AND COST

## 4.1 Estimated Time

Etime estimation is obtained from the summation of TNC (Time non cutting) and TC (Time Cutting) on the operation plan. Here is the calculation of the total

estimated time of the construction process of the geopolymer mortar nozzle construction:

| Part No. | Part Name | Qty | TH | | Processing Time (min) |
|---|---|---|---|---|---|
| | | | TNC | TC | |
| 1.1 | Motor Cover Plate | 2 | 29 | 48,8 | 68 |
| 1.2 | Motor Cover Bracket | 2 | 34 4 | 4.8 | 38.8 |
| 2.1 | Hopper Cover Plate | 1 | 22 | 30 | 52 |
| 2.2 | Mortar Director | 1 | 21 | 22 | 43 |
| 2.3 | Hopper Cover Quartering | 1 | 26 | 25 | 51 |
| 3.1 | Tube 1 | 1 | 28 | 105,2 | 133.2 |
| 3.2 | Tube 2 | 1 | 26 | 35 | 61 |
| 3.3 | Tube Connecting Head Nozzle | 1 | 26 | 23,3 | 49.3 |
| 3.4 | Reducer 1 | 1 | 26 | 90 | 116 |
| 3.5 | Reducer 2 | 1 | 21 | 50 | 71 |
| 4.1 | Slider Mount Plate | 1 | 26 | 25,9 | 51,9 |
| 4.2 | Pipe Support Hopper | 4 | 26 | 3 | 29 |
| 4.3 | Hopper Support Plate | 1 | 31 | 39 | 70 |
| 5.1 | Outering Head Nozzle 1 | 1 | 35 | 1,2 | 36,2 |
| 5.2 | Outering Head Nozzle 2 | 1 | 32 | 12,5 | 44,5 |
| 5.3 | Innering Head Nozzle | 1 | 30 | 1,1 | 31.1 |
| **Total Process** | | | **439** | **516.8** | **955.8** |

Figure 15: Total Estimated Time.

Total machining process time:
= 955.8 minutes : 60 minutes
= 15.93 hours
7 hours = 1 working day
15.93 hours = 2.3 days ≈ **3 working days**

## 4.2 Estimated Cost

Here is the overall cost of the manufacturing process of geopolymer mortar nozzle construction on civil building 3D Printing machine:

- Total Biata Raw Material Rp. 664.500,00,-
- Total Standard Part Cost Rp. 4,500.00,-
- Total Machining Cost Rp. 497.100,00,-
- Total Operator Fee Rp. 257.400,00,- +
- **Total Cost** **Rp. 1.423.500,00,-**
- Overhead Costs (20% x Process Costs) **Rp. 284.700,00,-**

So, the total cost of the basic cost of the geopolymer mortar nozzle construction process on the civil building 3D printing machine is **Rp. 1,708,200.00,- ≈ Rp. 1,708,500.00,-**.

# 5 CONCLUSION

Overall, the results of the manufacturing process of the geopolymer mortar nozzle construction on the civil building 3D printing machine can be concluded as follows:

1. The process of making geopolymer mortar nozzle construction produces designs, work drawings and manufacturing process planning which are used to reference the manufacturing process of Geopolymer Mortar Nozzle Construction on Civil Building 3D Printing Machines.
2. The working principle of this tool is that the geopolymer mortar accommodated in the hopper nozzle will move down due to the force of gravity and the large expenditure of the geopolymer mortar is regulated by the extruder driven by the stepper motor.
3. In the process of making Geopolymer Mortar Nozzle Construction on the Civil Building 3D Printing Machine, this includes observation, manufacturing planning, machining and fabrication ice pros, assembly planning and trial planning. The machining process includes a lathe and a drill. The fabrication process includes cutting grinding, hand grinding, drilling, Sheet Metal forming, bending, rolling, and welding.
4. The total estimated time required in the construction process of the geopolymer mortar nozzle is 15.93 hours and the total estimated cost of the geopolymer mortar nozzle construction process is Rp. 1,700,500.00,-.

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Anonim, Elemen Mesin 1
Anonim, Elemen Mesin 2