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Development of roller tank prototypes for moving goods with a capacity of 5 tons

Heri Wibowo*, Ardhias Mahendra P., Aldho Jaya P., Aldyth Gunanto P., Bima Lantip B.
Department of Mechanical Engineering Education, Yogyakarta State University, Yogyakarta, 55281, Indonesia
*Corresponding author: heri_wb@uny.ac.id

Abstract

Transporting products is a common practice in many industries. To increase the effectiveness and efficiency of the transfer, assisting devices are utilized. The available goods movement equipment on the market is bulky and less adaptable for moving goods in confined spaces. The primary purpose of roller tanks is to aid and facilitate human labor in the process of moving products from one location to another in order to increase the effectiveness and efficiency of human labor. A roller tank facilitates the transportation of containers, industrial machinery, and other heavy equipment. The purpose of this roller tank's design is to discover: (1) the roller tank's design, (2) the manufacturing process for roller tanks, and (3) the performance test results for roller tanks. Requirements analysis, problem analysis and specifications, design, technical analysis, component fabrication, assembly, and tool testing are the methods used to construct this roller tank. The outcome of this roller tank design is a design with a functional drawing of a roller tank with dimensions of 280 mm in length, 150 mm in width, and 83 mm in height. The roller tank prototype is composed of ST 37 steel plate and low alloy carbon steel. The tank's drive wheel is made of nylon, and its two shaft bearings consist of a ball bearing 6804 ZZ and a roller thrust bearing 55105.

Keywords:
Prototype, moving goods, roller tank.

1 Introduction

Currently, the education and business sectors must be able to continue developing innovative instruments. With the development of apparatus in a variety of industries, tools are required to aid in the distribution or relocation of a component or machine. Market-available tools for moving goods are large and less adaptable for moving goods in confined spaces; therefore, innovation is required to create tools for moving goods that are small in size but capable of moving hefty goods [1]. A roller tank is an alternative instrument that is suitable for application. This roller tank is a tool designed as a means of transporting a heavy load that is compact, flexible in a confined space, and saves time when transporting products from one area to another.

In the process of moving containers, industrial machinery, and other heavy equipment, rollers are an effective instrument [2]. The form of machine mover that is manufactured through machining and fabrication includes a roller. This instrument comprises of two parts: the primary component and the driving component. The principal component is the body unit, while the propelling component is the wheel unit [3]. In the application of the process of transporting goods/machines, four roller tanks are typically required. A capacity set of roller tanks can transport products weighing up to 5 tons. The majority of the used materials are composed of ST37 steel plates, low alloy carbon steel, and polymer-based nylon for the roller containers' drive wheels. This roller tank undergoes a process of machining and fabrication [4]. The machining process consists of turning, milling, drilling, and polishing, whereas the fabrication process entails body assembly by welding plates.

With these roller tanks, warehouse distribution will become simpler and more efficient [5]. Compared to hand pallets, roller containers are more cost-effective. This can be used as a basis for selecting affordable transportation equipment that is functionally equivalent to existing transportation equipment.

Shameem [6] has modeled the stability of the roll motion to make it user-friendly and safe. Using an active stabilizer system with fins on the sides of the roller or a passive system such as an anti-roll tank can minimize roll movement. This method is highly effective at regulating roll movement.

Modelling with roll stability is considered in the design of this roller tank as part of the safety and comfort of using the tool. In this prototype, a stable compact roller tank for a load of 5 tons was developed using carbon steel which is easy to find on the market.

2 Research Method

2.1 Manufacturing Process of Roller Tanks

The roller tank manufacturing process is carried out by following the flow chart stages shown in Fig. 1. Identification of the problem is done by looking at the problems and needs of the conveyance equipment in the workshop so that the specifications of the equipment according to the use of moving goods in the workshop can be known.

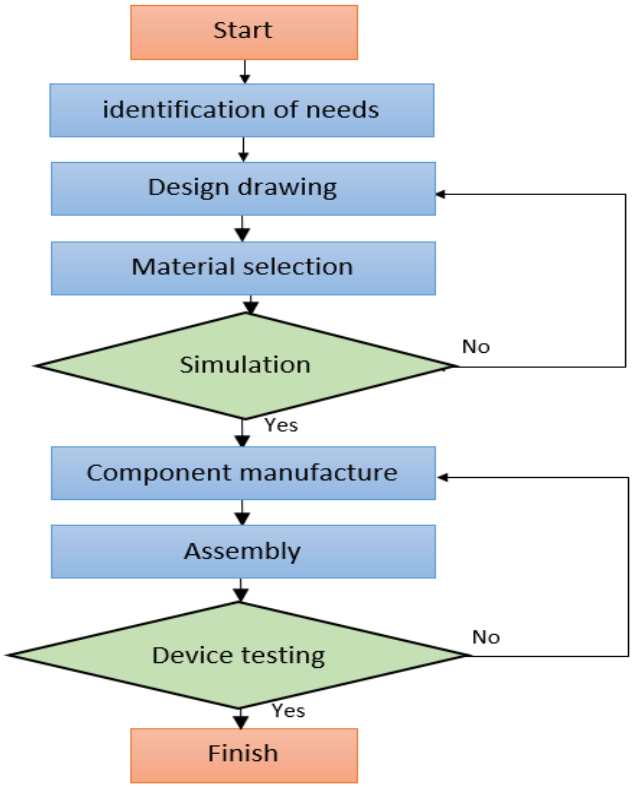

Fig. 1. Manufacturing process flowchart roller tanks.

2.2 Design of Roller Tanks

Tool design is accomplished by drawing a design with the Inventor 2020 software [7] in consideration of the material's strength to support a maximum burden of five tons supported by four roller tanks. The design of the roller tank is depicted in Fig. 2. Fig. 3 depicts a comprehensive image of the roller tank exploded into 14 major components.

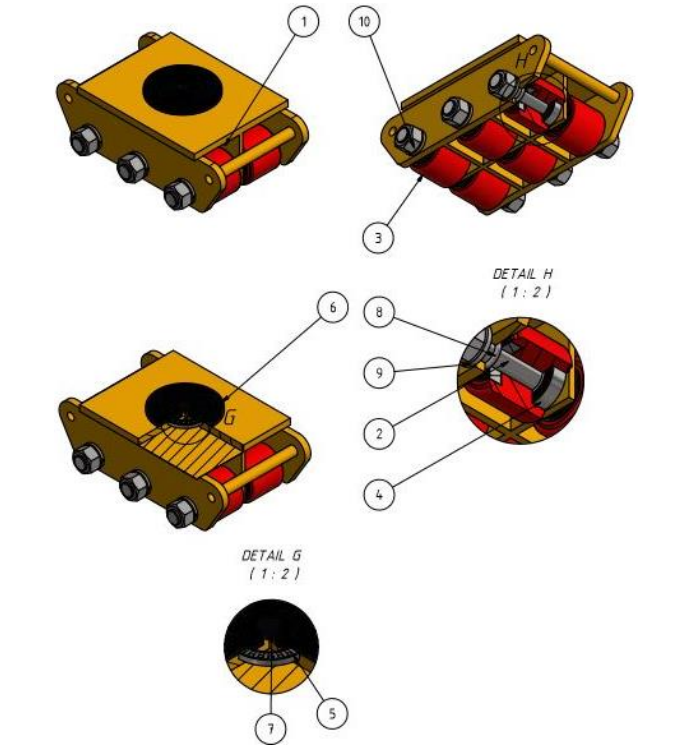

Fig. 2. Design roller tanks.

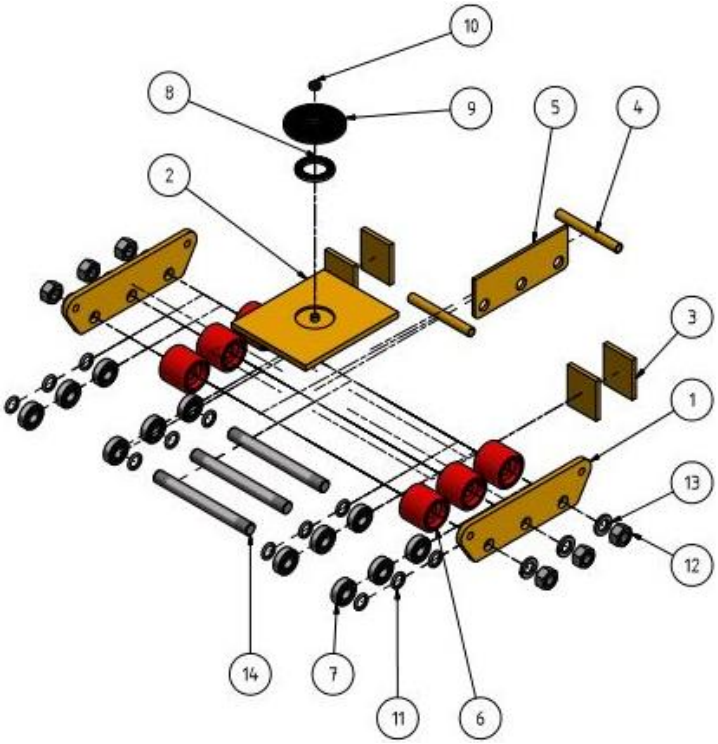

Fig. 3. Explode drawings roller tanks.

Detailed material specifications that composed this tools are shown in Table 1.

Table 1. Component list roller tanks

Item	Qty	Part number	Material
1	2	BASE1	Carbon steel
2	1	BASE2	Carbon steel
3	4	BASE3	Carbon steel
4	2	BASE4	Carbon steel
5	1	BASE5	Carbon steel
6	6	Wheel/roller	Polystyrene, high impact
7	12	Bearing	Low alloy carbon steel, high strength
8	1	Roller thrust bearing	Low alloy carbon steel, high strength
9	1	Support base	Low alloy carbon steel, high strength
10	1	Magnet	UHMW, black
11	12	Washer	Low alloy carbon steel, high strength
12	6	Hexagonal nuts	Stainless steel
13	6	Fastener coil	Low alloy carbon steel, high strength
14	3	Wheel axle	Medium carbon steel

3 Results and Discussion

3.1 Roller Tank Analysis

Roller tank analysis aims to determine the strength of the frame when it is loaded, to produce a safe value for use after the simulation, the results are shown in Table 2.

3.1.1 Displacements

Displacement is the change in distance of a moving element from its initial location as a result of the application of a force [8][9]. In this instance, the curve is denoted by a chart color whose indicator value differs. Simulation is performed using inventor on an image of a roller tank that has a vertical burden applied to its center [10]. Fig. 4 depicts the displacement distribution, and Table 3 provides a description of the color indicators.

With a curvature value between 0 and 0.00753 mm, dark blue and light blue are categorized as having the lowest curvature. With a value between 0.01506 mm and 0.02259 mm, the areas in dark green and light green are classified as moderately curved. With a value of 0.03012 mm, the yellow area is classified as a substantial deformation level area. The region colored red has the highest degree of curvature, with a maximal value of 0.03765 mm.

Table 2. Analysis results roller tanks

Mass : 11.8939 kg
Acceleration of gravity : 10 m/s2
Max load : 49033,250 Nor 5 tons

Name	Minimum	Maximum
Volume	2070300 mm^3	
Mass	11.8939 kg	
Von mises stress	0.218752 MPa	344.166 MPa
1st principal stress	-102.726 MPa	356.502 MPa
3rd principal stress	-424.431 MPa	73.0437 MPa
Displacement	0 mm	0.0376477 mm
Safety factor	0.801357 ul	15 ul
Stress XX	-172.316 MPa	112.104 MPa
Stress XY	-152.892 MPa	169.51 MPa
Stress XZ	-75.4843 MPa	97.2685 MPa
Stress YY	-314.287 MPa	241.154 MPa
Stress YZ	-95.622 MPa	125.304 MPa
Stress ZZ	-328.977 MPa	264.778 MPa
X displacement	0 mm	0.0376477 mm
Y displacement	-0.00423481 mm	0.00411517 mm
Z displacement	-0.00605254 mm	0.00600511 mm
Equivalent strain	0.0000000899002 ul	0.00238248 ul
1st principal strain	-0.0000547963 ul	0.00273019 ul
3rd principal strain	-0.00262882 ul	0.0000156534 ul
Strain XX	-0.00259284 ul	0.00261768 ul
Strain XY	-0.00158123 ul	0.00159478 ul
Strain XZ	-0.00125323 ul	0.00127748 ul
Strain YY	-0.00116989 ul	0.00101467 ul
Strain YZ	-0.000781996 ul	0.000808871 ul
Strain ZZ	-0.0013118 ul	0.0011841 ul
Contact pressure	0 MPa	325.481 MPa
Contact pressure X	-284.517 MPa	120.594 MPa
Contact pressure Y	-191.598 MPa	170.512 MPa
Contact pressure Z	-176.483 MPa	196.561 MPa

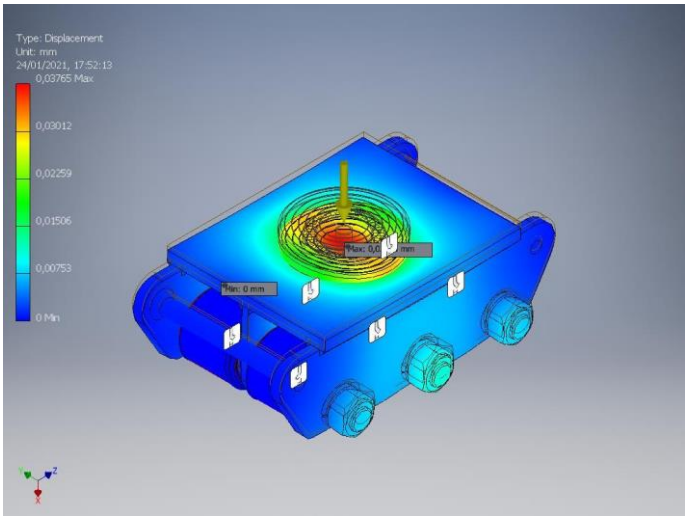

Fig. 4. Result displacements.

Table 3. Color indicator displacements

Color indicator	Value	Information
Red	0.03765	Highest displacement level
Yellow	0.03012	Highest displacement level
Light green	0.02259	Medium displacement level
Dark green	0.01506	Medium displacement level
Light blue	0.00753	Low displacement level
Dark blue	0	Lowest displacement level

The crimson area is the most curved portion of this axis because the yield point occurs at the fastest rate [11]. In the test, it is supposed that the force exerted at the center of the runway of the test object is 1.25 tons. The maximal displacement of the specimen was 0.037655 millimeters.

3.1.2 Safety Factor

Safety factor is the ratio of safety factor designed theoretically to attain the allowable stress. The allowable stress of a construction material is determined by the way of loading, the nature and quality of the materials, the work methods and forms of construction, and the expertise of the planner, the quality control of materials, and the planning materials [12].

Fig. 5 illustrates the safety factor simulation outcomes for a roller tank with a vertical load in the center. The color degradation of the safety factor due to loading is depicted in Table 4. On the basis of the graph, it is clear that the safety rating is very high, as shown by the pale blue color (large safety ratio) in multiple areas of roller tank construction.

The results of the analysis are depicted in the figure as a color change in the roller tank area, which indicates that the test object has a safety factor value of 12 that is the safest.

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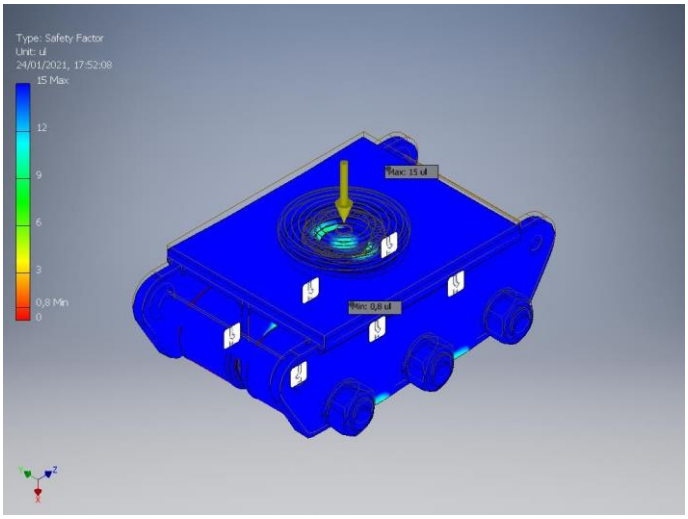

Fig. 5. Results safety factor.

Table 4. Results safety factor

Color indicator	Value	Information
Red	0.8	Lowest safety ratio
Yellow	3	Low safety ratio
Light green	6	Medium safety ratio
Dark green	9	Medium safety ratio
Light blue	12	High safety ratio
Dark blue	15	Highest safety ratio

3.2 Manufacturing Process of Roller Tank Components

Process the manufacture of this roller tank body goes through various machining processes. Namely through the process of milling and surface grinding.

3.2.1 Manufacturing of RH and LH Plate Brackets

RH and LH plate brackets using an esser plate material with type ST 37 steel with a thickness of 10 mm with dimensions and sizes according to Fig. 6. The total number of plates made was 8.

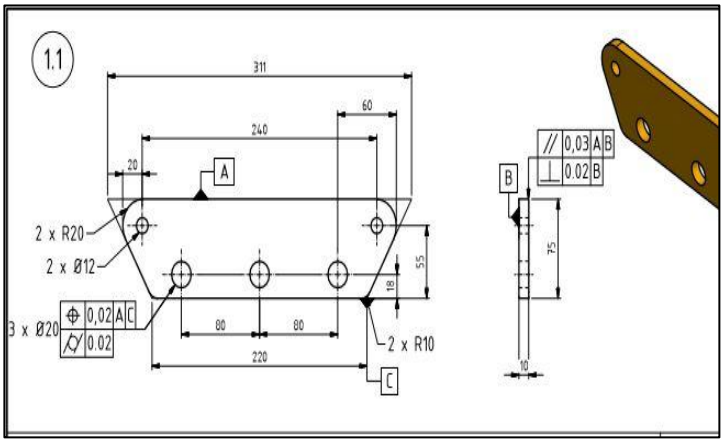

Fig. 6. Bracket plate RH and LH.

Machines and equipment used: 1) milling machine, 2) surface grinding machine, 3) end mill ø12, 4) drill bits ø8, ø12, ø20 and center drills. Work steps: perform milling until the plate conforms to the dimensions of the working drawing. The drilling process is gradual with a milling machine starting from using a center drill to a ø20 drill bit. Perform the finishing process on the base surface using a surface grinding machine.

3.2.2 Making Main Base Plate

Play base this plate uses an esser plate with ST 37 steel type [13] using a plate thickness of 10 mm and the dimensions according to Fig. 7. The total number of bases is 4 pieces.

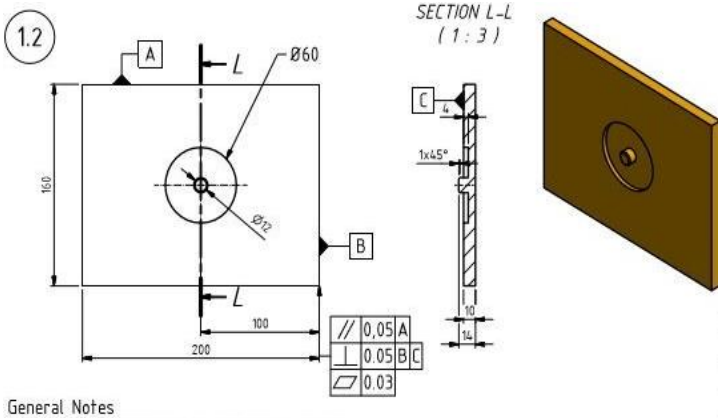

Fig.7. Main base plate.

Machines and equipment used: 1) milling machine, 2) surface grinding machine, and 3) end mill ø12. Work steps: perform milling until the plate conforms to the dimensions on the working drawings. Perform the finishing process on the surface of the base using a surface grinding machine.

3.2.3 Making Bracket Plate Support

Bracket plate supportit functions as a shaft rod holder which uses an esser plate material with ST 37. The plate uses a thickness of 6 mm and the dimensions are in accordance with Fig. 8. The total number of lower bases is 4 pieces.

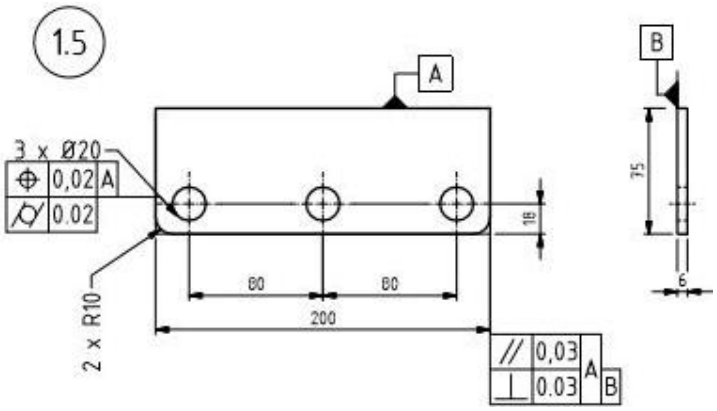

Fig. 8. Bracket plate support.

Machines and equipment used: 1) milling machine, 2) surface grinding machine, 3) end mill ø12, 4) drill bits ø8, ø12, ø20 and center drills. Work steps: perform milling work on the plate according to the dimensions on the working drawings. Carry out the drilling process in stages starting from using a center drill to a ø20 drill bit. Perform the finishing process on the base surface using a surface grinding machine.

3.2.4 Shaft Rod Manufacturing Process

Making the shaft rod using a lathe machining process. The material of the shaft rod used is mild steel ST 60 [6] with a size of ø20 mm and a length of 200 mm and on both sides there are threads according to Fig. 9.

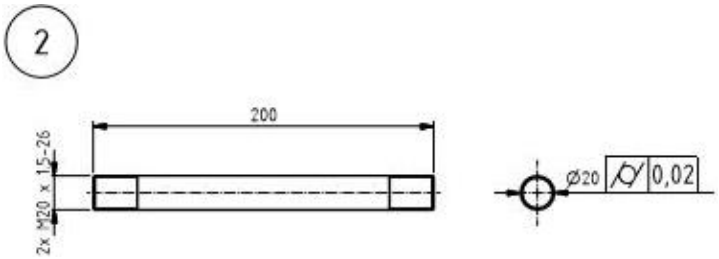

Fig. 9. Shaft rod.

Machines and equipment used: 1) lathe, 2) right align chisel, and 3) screw chisel. Work steps: do the facing process on one side, then do the cross-cutting process as far as the chisel can cut until the object is ø20 mm in size. Turn the workpiece over, and make cuts up to ø20 mm in size. Do the facing until the length has a length of 200 mm.

3.2.5 Wheel Manufacturing Process

Manufacture of these wheels using a lathe machining process. The material for the wheels is nylon with a size of ø60 mm and a length of 54, shown in Fig. 10.

Machines and equipment used: 1) lathe, 2) right align chisel, 3) deep chisel, and 4) center drills, drill bit ø20. Work steps: perform the facing process on one side of the workpiece. Drill using a center drill and ø20 drill bit. Make cross-cuts until the workpiece size is ø60 mm. Do the inner turning process on one side using a chisel according to the size on the working drawing. Perform the facing until the workpiece is 54 mm long.

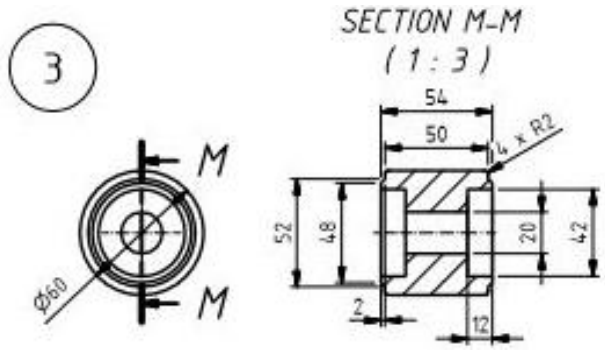

Fig. 10. Wheel.

3.3 Assembly Process

The body assembly process uses a welding process (Fig. 11). Namely by using Shielded Metal Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW) processes [14].

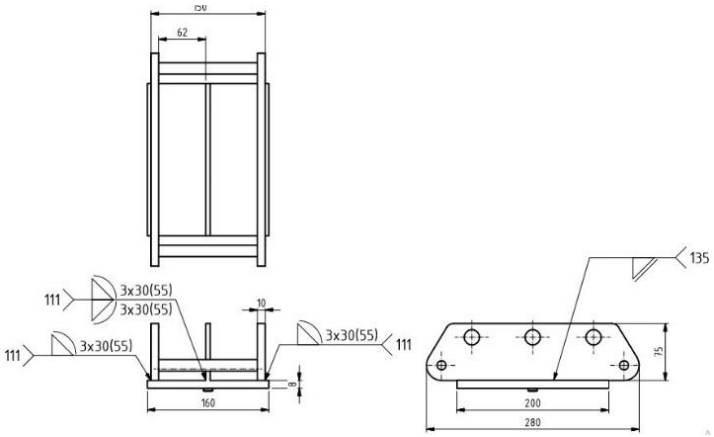

Fig. 11. Welding work pictures.

Machines and equipment used: 1) SMAW welding machine, 2) GMAW welding machine, and 3) Electrode oven. Work steps: perform welding using SMAW welding on the part according to the working drawing. Welding parameters use welding standards according to the size of the electrode used.

3.4 Finishing and Testing

The finishing process on the roller tank is the final stage in making the tool. The surface of the body that has been assembled by the welding process is cleaned using sandpaper, followed by the painting process.

Machines and equipment used: 1) compressor machine and 2) spray guns. Work steps: clean the entire surface of the workpiece with a cloth soaked in thinner. Setting the wind pressure and spreading power on the spray gun for painting. Do basic painting using menni. Do basic painting on all surfaces on the body, and sanded a little to clean the rough fog. Do the color painting according to the desired coloring.

The final result of the roller tank tool is shown in Figure 12. This tool has been tested to transport several machines such as lathes, milling machines, and CNC machines with a weight of more than 2 tons and function properly.

Fig. 12. Roller tanks.

4 Conclusion

Based on the results of the research conducted, it can be concluded that the prototype roller tank is constructed from ST 37 steel plate and low alloy carbon steel. The tank's drive wheel is made of nylon, and its two shaft bearings consist of a ball bearing 6804 ZZ and a roller thrust bearing 55105. The simulation results of the roller tank construction by applying the force exerted at the center of the 1.25 ton test object runway reveal a maximum displacement of 0.03765 mm and a safest safety factor of 12. The roller tank tool product consists of four tools that can be used in tandem to transport items weighing up to five tons.

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