Università degli studi di Genova

Mechanical Design Methods in Robotics

Solar Robot project

WalkerBot

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1 Introduction

The purpose of the project is the physical realization of a little toy robot, found as one of many models provided inside a kit.
The work done can be divided in four main phases:

- Modelling phase
- Assembly and Analysis
- Printing phase
- Building phase

2 Measuring & Modelling phase

The first step addressed was to measure a finite number of parts, in which the robot is divided, and draw them on a CAD (CREO Parametric). All the parts that compose the robot were divided for the number of students' groups in the course, in the way that each of them had at least three pieces to reproduce. All the parts were shared between each group in order to let everyone access to all the necessary pieces useful to build a chosen robot. In our specific case we had to build the WalkerBot model, described more in depth later.

Each part has been measured with the caliber with an approximation on the first decimal value. For each measured part, a geometric table was drawn and used as a guide to build the model on the virtual environment.

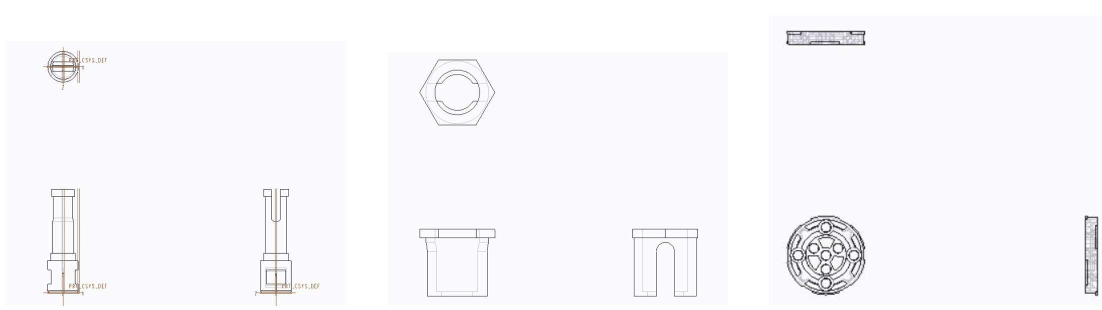

Figure 1: table of E5 E7 and wheel

2.1 Modelling with the CAD

The software used is Creo Parametric 3.0 which is useful to build, test and improve the correct functionality of the whole assembly, that will be seen in the next chapters. For our group, we had to build and model E5, E7 and the main wheel pieces. Below and above are shown the table and the realization of the three pieces. As reference unit measures, mm - N & s were used to suit the actual properties of the already provided models.

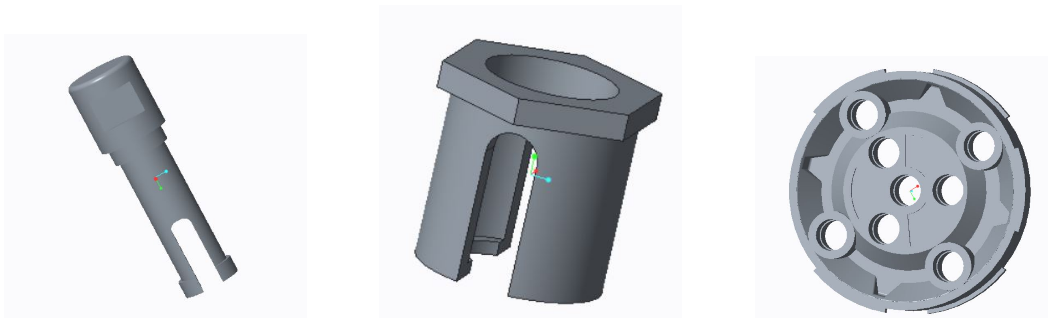

Figure 2: model of E5 E7 and the wheel

A crucial part in the end of the modelling phase was to coordinate with the other groups in order to adjust each piece, to make them fit all of the models chosen.

3 Assembly and Analysis

3.1 Assembly

The assembly was done following the instructions provided inside the kit. The Walkerbot robot has in total 31 pieces and numerous connections. The entire assembly was composed not taking in account the head piece of the robot, not modeled during the project period.

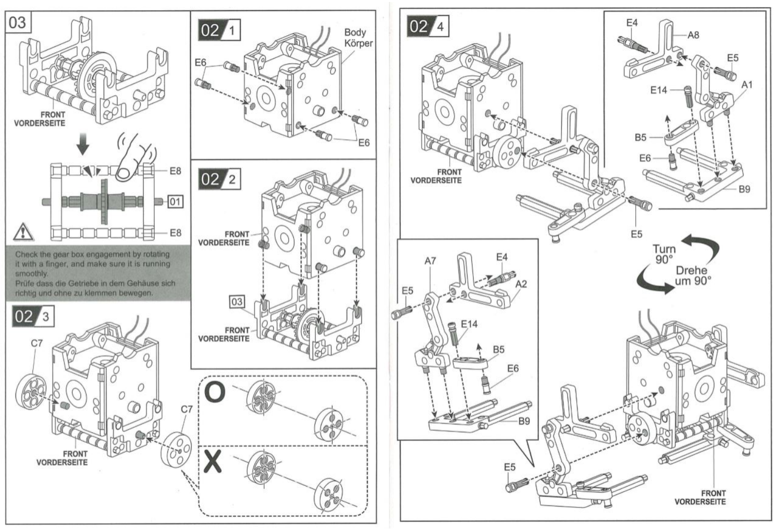

Figure 3: instructions for the assembly

The assembly was divided mainly in three sub-assemblies:

- The body with the gears
- Two legs
- Shaft Mechanism

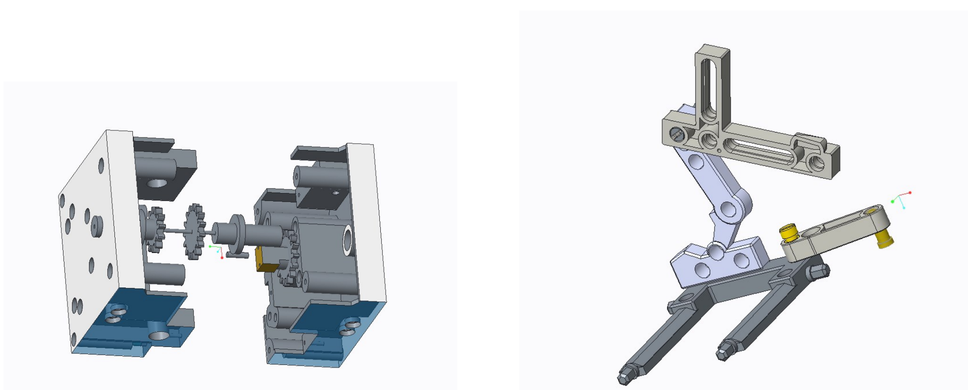

Figure 4: sub-assemblies

All the sub-assemblies are merged together in order to build the robot and the final result is shown in the figures below:

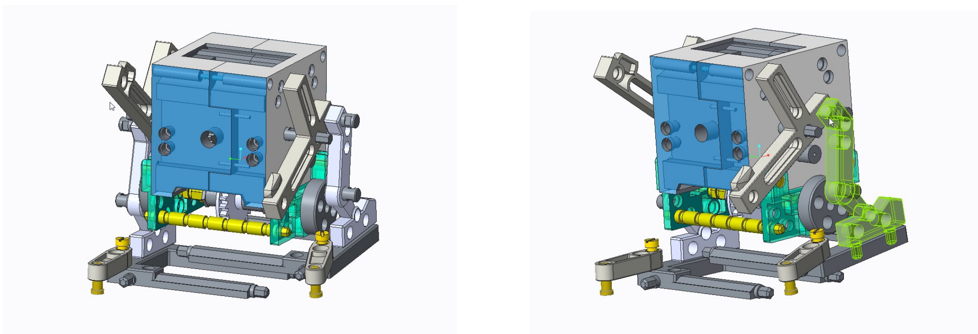

Figure 5: resultant assembly

As a first step, the properties of every single model were prepared, choosing to set the material of the whole with plastic ABS. This is useful for the program to understand the mass and inertia of the construction, helping the user to simulate correctly the mechanism behaviours and the material properties especially in stress situations.

3.1.1 Mechanism realization

The mechanism is then realized taking into account the gears inside the entire body and on the main shaft assembly, which is a fundamental part of the motion transmission.
To build the gearbox it's been considered what are the primitives measurements of each gear that compose the mechanism in order to tell the program the speed ratios between them. The CAD program lets you do it easily, guiding the process without efforts. In our case, the ratio values corresponded to a value of 24 for the bigger gear and 12 for the smaller one (for the transmission between the gearbox and the shaft). This has been realized using the Creo Mechanism section, where the Gears option allows to create the coupling between two toothed wheels, selecting the pins of the wheels involved and inserting the measure of their primary circumference or ratio. By dragging the components it is possible to evaluate the correctness of the coupling.

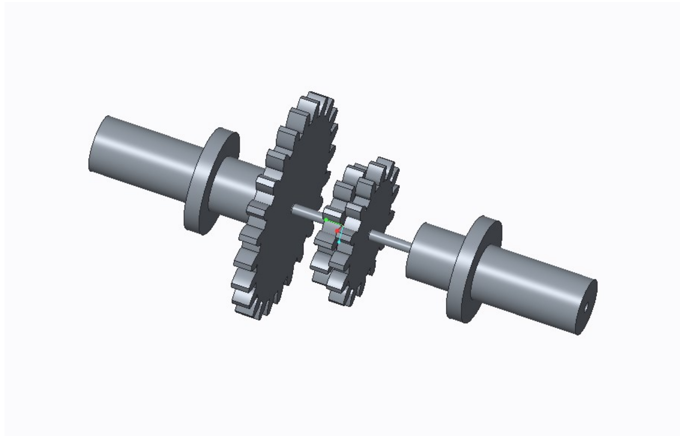

Figure 6: gearbox

3.2 Analysis

For the part of Analysis, Creo provides all the tools needed to test any kind of piece or assembly in all the situations possible from conductivity simulation to heat maps creation or, in our case, a full dynamic analysis of the assembly.

3.2.1 Dynamic analysis

After that a servomotor has been applied to the robot, choosing as the application axis the one of the motor, which is inside the body. In the Profile options, since the physical motor performs 30 RPM, the corresponding 180 deg/s has been insert. At this point the dynamic analysis was made possible in the Creo Mechanism section, through the Mechanism Analysis option. The dynamic type was chosen with an execution time of 10 seconds.
From here we can then try to see what kind of movement each axis did during the simulation, watching its behaviour in relationship with time or other measurements.

3.2.2 Multi-body analysis

By selecting the option "Measures" in the mechanism section, it is possible the analyze the forces and moments of each moving part of the model. The program, after setting up the measuring targets and units, can build graphs of the dynamic evolution of what is observed. In our case, for example, in figure 7 we can see the momentum of the gearbox axis and the external joint position (the one that connects the shaft with the legs) during time.

A further analysis can lead to the discovery of malfunctions in the mechanism, influenced by misplacement, material choice, power supplied ecc.

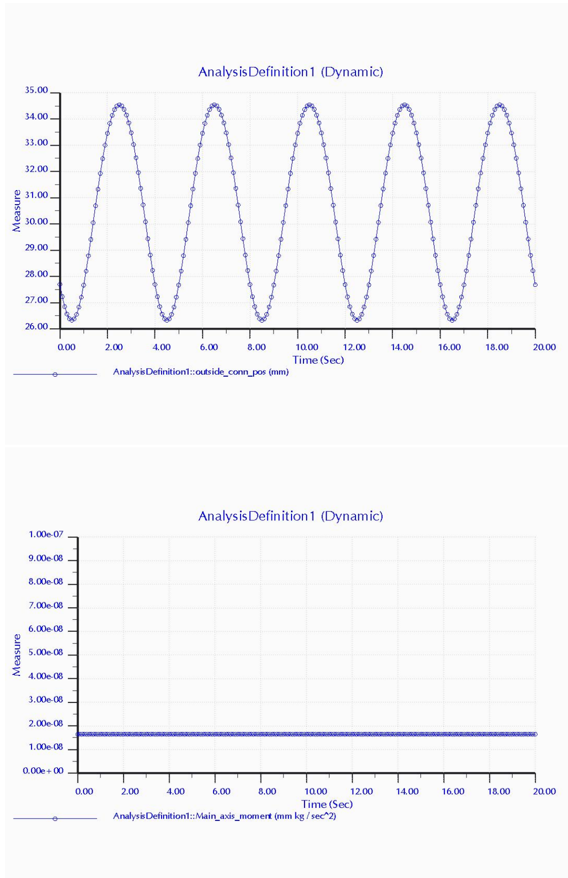

Figure 7: The external joint position and the axis momentum

4 Printing phase

After the assembly and the analysis of the robot all the parts that compose it were printed. The printer used was a WASP industrial 3D printer, located inside the mechanical laboratory of the University of Engineering, in Genoa.

In order to complete the project, firstly we had to double the sizes of each part, using Creo. The pieces were then loaded on the software used to set the properties of the print: this was a crucial and accurate part, since the settings influence a lot the print quality and therefore the time spent on it. The software used to create the GCode (a proto-code used by most of the 3D printers in the market to guide the model realization) was Ultimaker Cura 3.4.0. For this phase is important to consider that the printing temperature leads to deformation and so some parts have been adjusted in order to best fit with the others.

5 Building phase

The last phase of the project was the building phase in which the robot is physically assembled and the circuit for the transmission of the torque is built. For the motion a motor is used actuated with 9Volt potential provided by a battery. At the end the robot has been assembled as in figure 8.

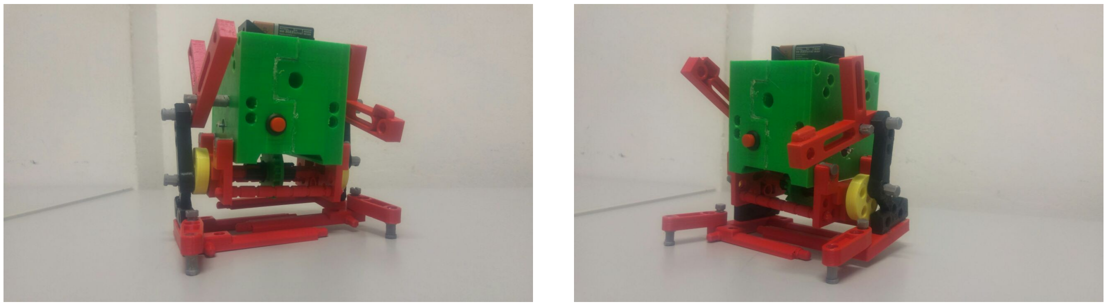

Figure 8: pictures of the assembled robot