

# Developing a transfer function based firmware for a gripper sensor

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**Abstract.** Sensors a system whose sole purpose is to sense and give the output. It maybe of anything from normal measuring of speed, temperature to the in-depth sensing of motions or strains. One such type of sensor is being fabricated to measure the value of stress using strain gauges. Strain gauge is a sensor which has change in values when external force is applied. Previously stress is found on a beam near the point of maximum bending but in here the stress are known from an object so as it helps in gripping of the object. The main purpose is to implement in the robot grippers. Considering it as a sensor the size is in centimeter range. From the design aspect it is of two parts namely base and struts. The struts are arranged in a regular array on the base plate. The major consideration would be the base as a fixed part and the pressure is applied on the strut top side. Simulation of design are done in ANSYS with consideration. It is done to determine the material used to fabricate. The fabrication will be done and the stress and strain data will be taken.

## 1. INTRODUCTION

A sensor is an essential component in robot. The elementary purpose of a sensor is to measure some parameters. Some of the commonly known and used sensors are temperature, proximity, light, humidity and etc. All these senses some value and gives it to the controller. Sensor are classified into different ways such as,

Active sensors are those in which the output depends on the power source provided by the external source. Passive sensors are ones which doesn't depend on external source and the output is by the signal measured within it. Analog sensors are ones which gives continues output. The output is mostly voltage relative to the input measured. Digital sensors are those which provide output either high or low which is either 1 or 0. For the output from analog sensor it requires amplifier to amplify the output to required level. There is greater resolution and higher accuracy for digital sensor compared to analog. Proprioceptive sensors are ones which is used to measure values internally and the exteroceptive are ones which is for measuring external values. Basically, there are some criteria by which the sensor is selected they are,

- Accuracy  
The difference in actual value and indicated value of the sensor
- Environmental condition
- Range  
This gives the measurement limit of the sensor.
- Calibration

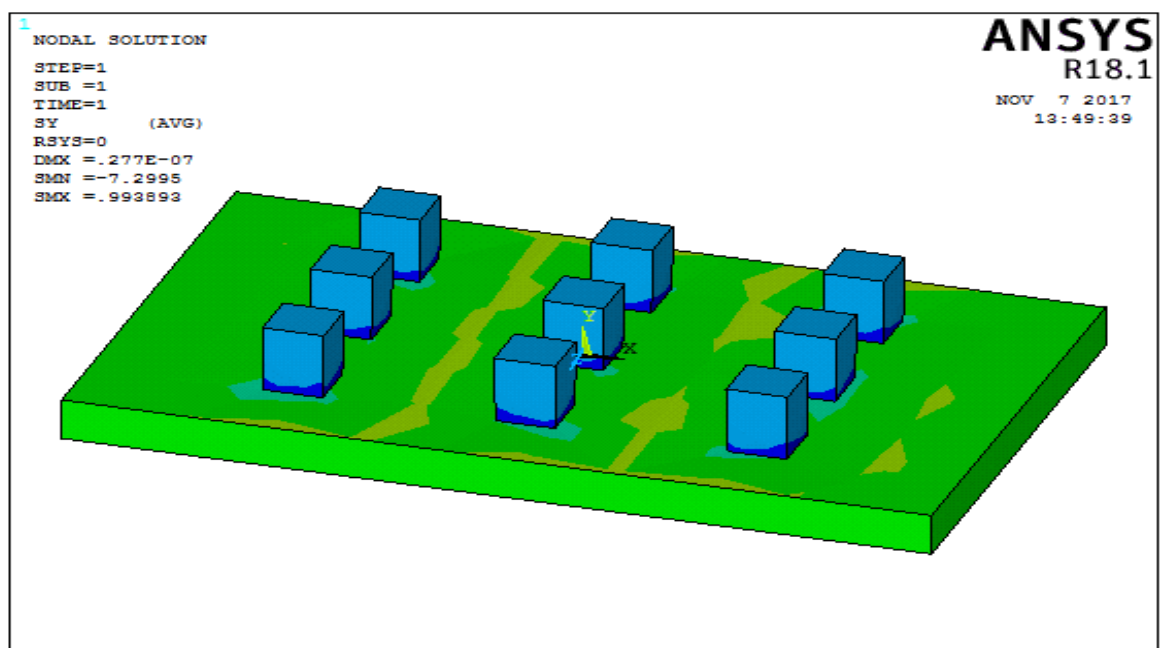


- Cost

Robots are termed intelligent because of the work it does without any need of help from humans. To perform with such efficiency the sensors play a key role. It helps in positioning the robot, moving the joints, working of gripper and holding of objects. All the works can be performed with the sensors and the controller working together. When it comes to holding an object the usual problem of slip and damage to the object exists. This new type of sensor which is being built helps in reducing or eliminating the problem. Grippers are ones which are present at the end effector of a robot. There are four types of robotic grippers namely,

- Pneumatic grippers
- Hydraulic grippers
- Vacuum grippers
- Servo-electric grippers

For material selection a software named ANSYS is used to perform analysis. Ansys is an analysis software for engineering purpose. Some of the elements provided are finite element analysis, structural analysis, computational fluid dynamics, implicit and explicit method and heat transfer. The simulation result gives the deformed result of the model with all the values of stress, strain and displacements. One good thing is that after the simulation the process can be generated as report in which it contains all the values of the parameter we need.

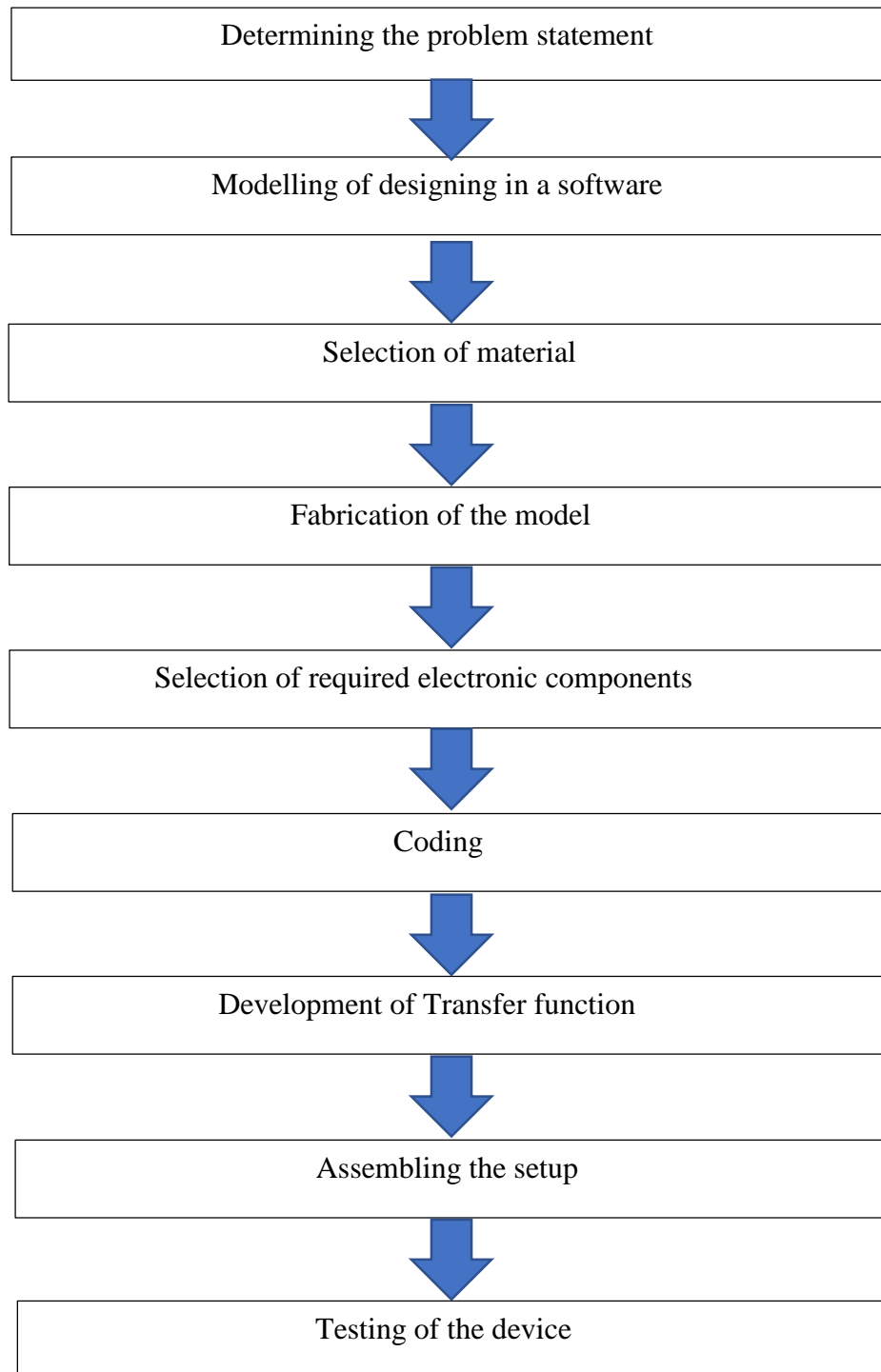


**Figure 1.** Overview of ANSYS workbench

The figure 1 shows the workbench in ANSYS as seen all the steps to do the simulation is present of the left box names ANSYS main menu. The model present in the workbench is either created in ANSYS or a designed file is imported. The dialogue box shows the output data that can be seen. It has stress along individual direction. Strain along the required direction.

## 2. METHODOLOGY

The making of a robot sensor has been fragmented into different types as designing, modelling, fabrication and functioning of the sensor. The Figure.2 portrays the methodology of work. Initial step is to determine the problem statement. Once the statement is clear further studies is carried out to get the different prospect for the concept. With the studies a best possible solution is arrived. Following the study, the idea is made as a three-dimensional model with the help of modelling packages.



**Figure 2.** Methology

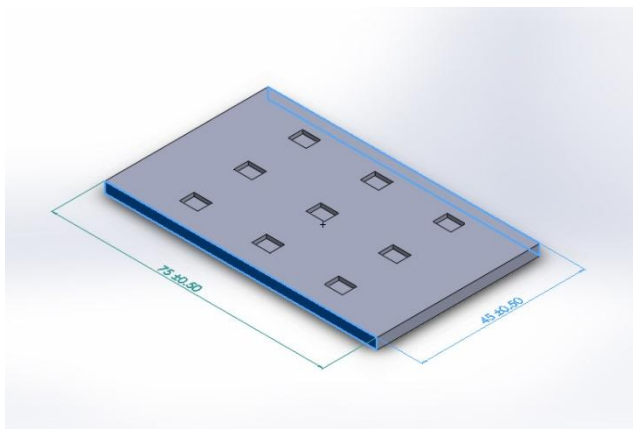
Calculations of maximum and minimum bending stress also the deflection. The next step is the selection of material which is done with the help of analysis by the software. Fabrication of the model is done. Proper electrical system such as strain gauges, microcontroller and the additional elements are chosen. Coding is done as per the task. A transfer function in the control system is created as well.

As a final point the setup is assembled and tested several times for verification.

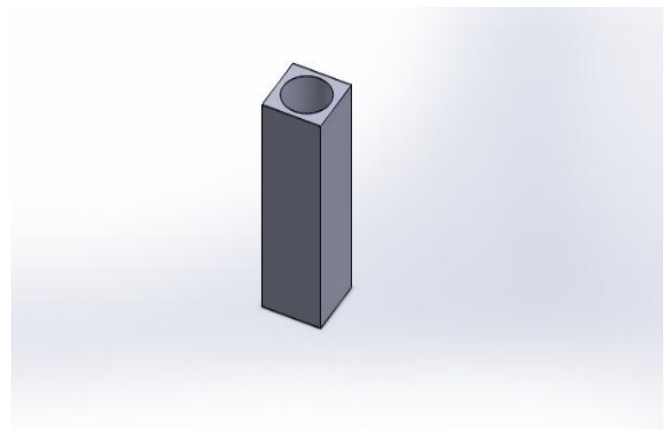
### 3. DESIGN AND MODEL

A sensor is a device which cannot be designed with leniency in dimensions. It has to be compact and should be able to perform the required task. It is one of the essential part as any slight variation in any parameter it is sensed by a sensor. This is said to be implemented as a gripper sensor but at first the product is designed as a normal sensor which can be fixed in a robot and tested. Here the design elements are of two ways namely Base and the Strut. As like most of the models the sensor consists of a base which is of a rectangular form as shown in the following figure 3. It is made in such a way as the sensor of is like that of a tactile sensor. The model is such that base of certain thickness is made and slots are cut for a few millimeters. Slots are made for the fixing up of the struts.

Generally, struts as shown in the figure 4 are for the resisting of longitudinal compression. It is of square in shape and is made hollow of few diameters. Sole purpose of making it hollow is to reduce the area as well as the weight. The modeling is done in SOLIDWORKS by Dassault Systems. The base and the struts are designed separately and then assembled. The figure shows the base plate with slots and as per this sensor it is of 3x3 array which makes it a total of 9 slots in the base. Modelled struts are then assembled in these slots.



**Figure 3.** Base model



**Figure 4.** Strut

### 4. MATERIAL SELECTION

Materials are a critical factor when fabricating a product and it's the same case as well for the sensor. Few things had to be taken into consideration for selection in here. After taking the problems into account it is inferred to make the whole model in one single material of good strength. With that we had so many options in materials. So, to narrow it down software analysis was done by ANSYS. Three upright materials were taken such as steel, cast iron, mild steel which are available in market and can be fabricated from it.

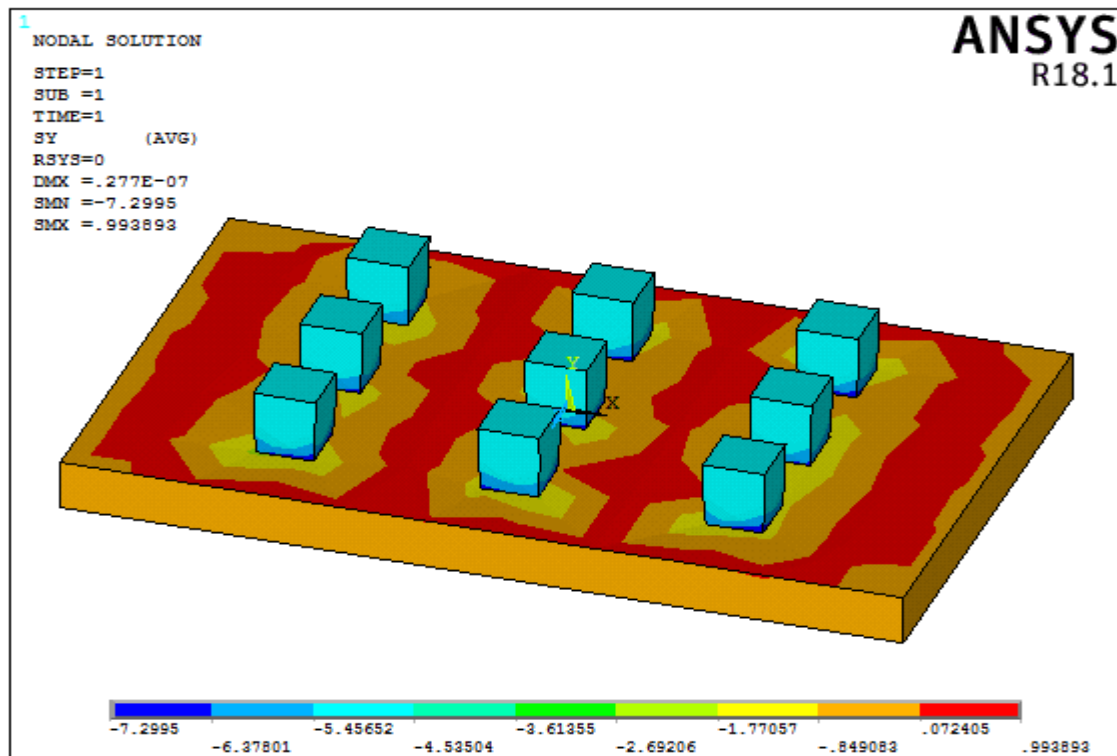
With ANSYS the stress distribution was found for the model with some assumptions. The process in the software is to import the model, apply the material properties. Then select the boundary

condition which ultimately fixes an end or side of choosing. Loads are applied as per requirement in here pressure is applied in load as 50N/m<sup>2</sup> which in the case is assumed value. After all this the model is meshed and the solved. The result gives the deformed model with stress distribution. The same procedure is followed for all three materials.

The first analysis was done by using mild steel, the stress distribution across the nodes were found out and the maximum and minimum values were known. The difference between the values is said to be high. The minimum value obtained was around -1.5 whereas for maximum it was around 0.467. The figure represents the stress distribution on the model for mild steel. A list of stress distributed across the nodes is stored.

Next the analysis was don't with cast iron. Easily speaking it is one of the material with high strength properties. The minimum value obtained is near -1 and the maximum value is around 0.38. The figure gives the stress distribution of the applied material.

Lastly it was tested with steel. The minimum value obtained is -0.9 and the maximum is near by 0.2. Comparing all three results we can conclude that Steel has better result than the other two. It has got better stress distribution and the values are decent in nature. As far as material is concerned, its available easily and can be used for fabrication. The figure 5 following represents the result when analyzed with mild steel which is being selected as the material for fabrication.



**Figure 5.** ANSYS analysis result for Mild Steel material

## 5. DESIGN CALCULATION

Critical buckling load,

$$P_{cr} = \frac{\pi \cdot \pi \cdot E \cdot I}{L \cdot L} \quad (1)$$

With the material as steel and the length of the member being 0.013m we solve the equation.1,

$$P_{cr} = 607 \text{ KN}$$

Critical buckling stress,

$$\sigma_{cr} = \frac{\pi \cdot \pi \cdot E \cdot I \cdot r \cdot r}{K \cdot K \cdot L \cdot L} \quad (2)$$

Applying the vales from the material and the model we solve equation.2 we get,

$$\sigma_{cr} = 6.3 \text{ KN}$$

## 6. CONCLUSION

The mechanical structure is done using a design software. The material selection is done by analysis. The experimental part is carried out next with the help of fixing up strain gauges in the model and getting the output.

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