3-D PRINTING MATERIAL USING AUTO AI PROJECT

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1) INDRODUCTION :

1.1 OVERVIEW

Artificial Intelligence (AI) is the leading field of science nowadays. Machines can learn and complete tasks independently. 3D printing is much more than the production of plastic prototypes. Additive manufacturing is the most prospective and highly evaluated technological field in the modern world. 3D printing technologies take an origin from the Stereolithography printing technique which has been invented in 1984. Additive manufacturing is used to create objects with complex shapes which are not possible to manufacture with traditional techniques.

AM develops evolution of science with rapid prototyping and digital manufacturing. Various polymer, metal and bio materials are used in engineering applications mainly to create prototypes and finished products with unique shapes, multifunctional compositions, reliability and high quality. Digital manufacturing era just started, 9 ideas can be transported to the 3D models and then send directly to 3D printing machine that can start work and finish without human supervision.

1.2 PURPOSE

To identify the type of material required after a 3D model is designed is a complicated task.The aim of the study is to determine the best material which will be perfect for the given use case. Where there are eleven setting parameters and one output parameters. Based on these input parameters we will predict the best material for model. This model will predict whether to use PLA or ABS. Hence, the selection of right material is important to get accurate 3D model.

2)LITERATURE SURVEY:

2.1 EXISTING PROBLEM & SOLUTION

1. Output/quality problems while 3D printing

In some ways, this is the most basic thing, but there are many quality-related problems with 3D printing today:

- Fragile, delaminated FDM (fused deposition modeling) parts
- Low-resolution output
- Materials

The materials are defined by what can be extruded, squirted, or melted, but this is not based on their application or final use. And even though there are some examples of multimaterials, it’s typically only two at a time. So we’re constraining ourselves.

2. The Process Is Unreliable. Too Much 3D Printer Troubleshooting

The complexity of just getting the process to work is often daunting, and it involves too much fiddling with formats, parameters, and mechanical adjustments.

3. The Target: It’s Wrong.

The fourth lamentation is that people have been aiming at the wrong target with their 3D-printing efforts.

They’ve been happy creating prototypes, replacement parts, and trinkets; but what they should be focused on are final parts and creating novel solutions to higher-level problems.

In order to reach this new target, it’s important to look at 3D printing holistically, through four facets of additive manufacturing: parts, system, materials, and process.

4. The Market: It’s Prematurely Mature.

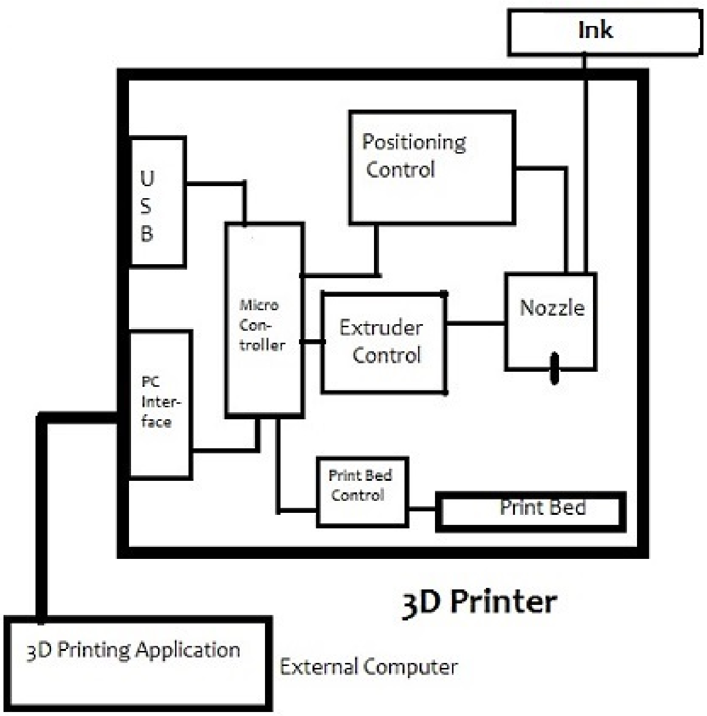
Manufacturers are unfortunately mistaking that smaller, earlier chasm for the bigger one ahead. Customers are the enthusiasts, not the majority. Yet manufacturers are using business models meant to optimize later phases as if there were already a printer in every home.

But that's crazy, because this is still the first phase, where open innovation should still be predominant. Instead, you see manufacturers put ID chips in material cartridges, so they can't be refilled or sourced elsewhere.

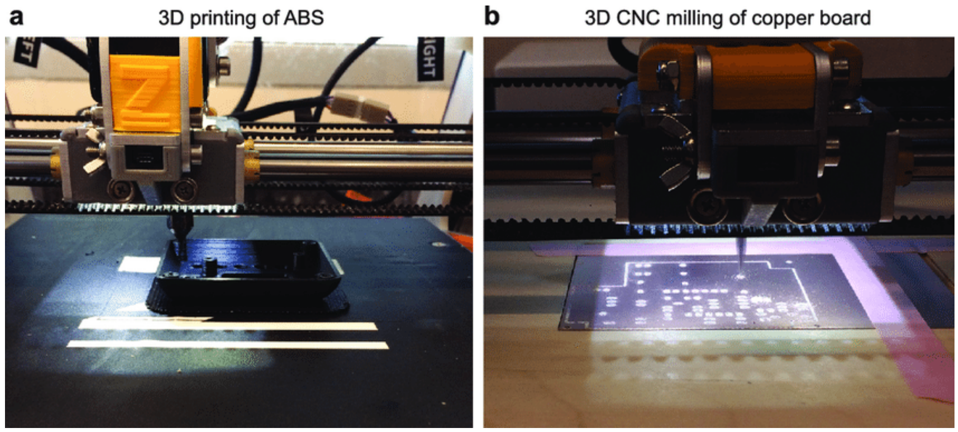
Doing that gets you fascinated with material sales, and then you start doing dumb things like overprinting support materials, as opposed to addressing the real customer need, which is that they don't want support materials at all.

3) THEORITICAL ANALYSIS:

3.1 BLOCK DIAGRAM



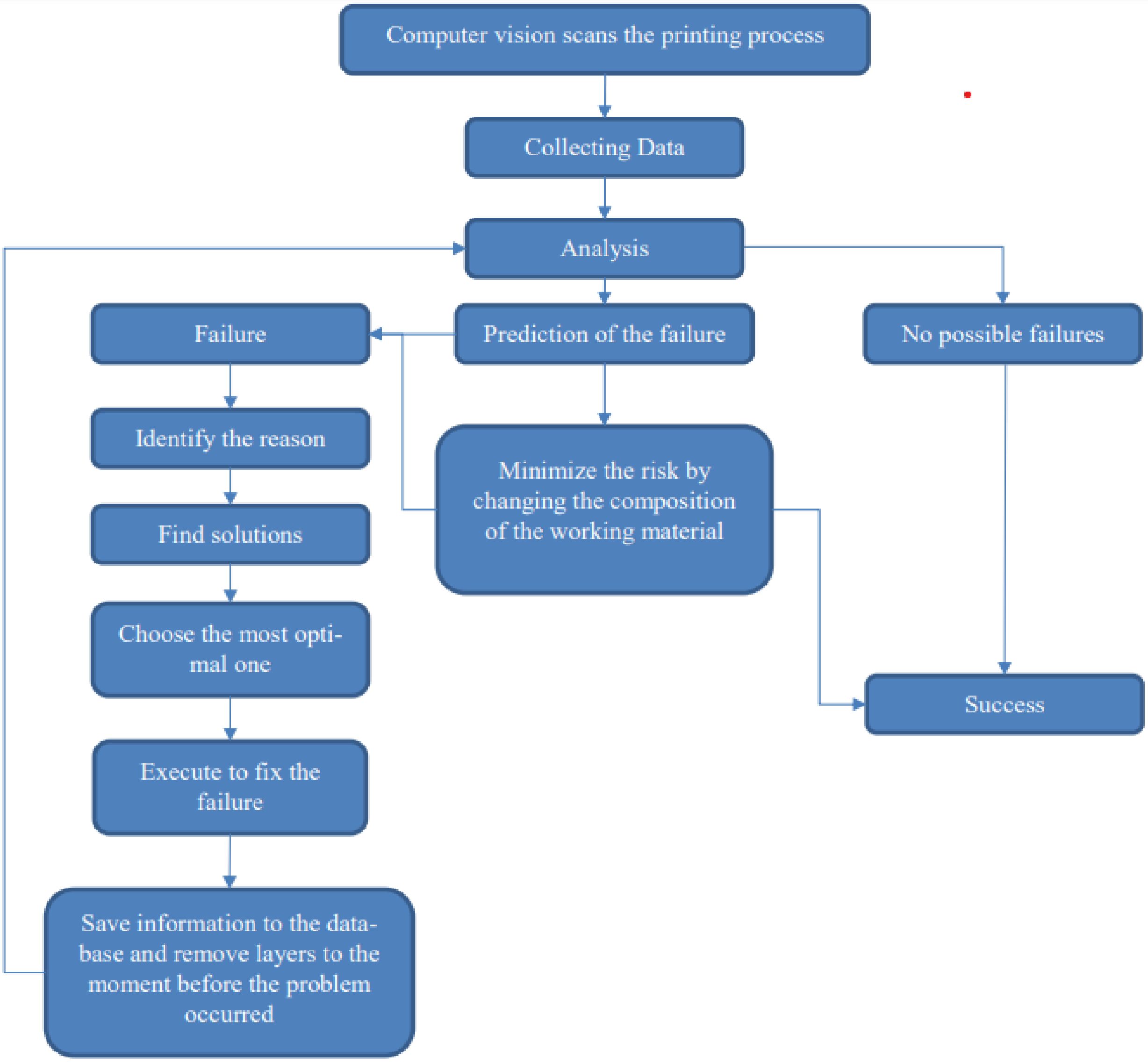
3.2 HARDWARE DESIGN



4) EXPERIMENTAL INVESTIGATIONS

High-performance polymers are plastics that have better thermal and mechanical properties than other engineering plastics. In general, polymers are relatively light materials when compared to metals. Currently, research era is focused on developing high-performance plastic such as PEEK (polyetheretherketone) for applications in drones, aircrafts, rockets and formula 1. This is due to its durability comparable to metal parts, its significant lightness and its capacity able to withstand operating temperatures of above 150 °C. However, these materials are well established and fabricated using conventional production method, which limits the freedom to achieve high-complexity structures. 3D printing or additive manufacturing techniques allow for complex shapes to be easily produced together with a degree of control over the process parameters. Though fused deposition modelling was attempted earlier with these polymers, more promising approaches such as robot-based extrusion method attained very little attention. In particular, 3D printing mould structures using high-performance materials for automated fibre placement (AFP) process need sufficient attention. This paper attempts experimental investigations with PEEK, using the robotic extrusion method. Thus, the thermal, mechanism of material consolidation, the effects of significant process parameters on critical responses and thermomechanical properties are determined with respect to its application for moulds for AFP process.

5) FLOWCHART



6) RESULT

The new field of artificial intelligence has been studied to develop ideas about the improvement of the additive manufacturing process. Different SLA 3D printing problems have been identified during the visit to the Ajatec factory. General concept of the AI science was introduced with examples and solutions for the real-time 3D printing control. Plan for machine learning implementation was suggested. Concept of layer thickness control for the failure compensation was developed. AI system for the real-time printing control was created and explained with algorithms, required human and technical resources. Control over the quality and quantity concept was introduced. Sweeper self-control system was developed to avoid warping. Design support system concept was suggested for the future development. Theory of the photopolymers and photopolymerization reaction was represented with possible solutions of modifying laser setting and material properties. The necessary information to create solutions for the real-time 3D printing control was found, studied and produced in this research. The concepts were developed to solve each presented problem with different algorithms for machine learning and AI system.

7)ADVANTAGES & DISADVANTAGES

ADVANTAGES

__1. Flexible Design

3D printing allows for the design and print of more complex designs than traditional manufacturing processes. More traditional processes have design restrictions which no longer apply with the use of 3D printing.

2. Rapid Prototyping

3D printing can manufacture parts within hours, which speeds up the prototyping process. This allows for each stage to complete faster. When compared to machining prototypes, 3D printing is inexpensive and quicker at creating parts as the part can be finished in hours, allowing for each design modification to be completed at a much more efficient rate.

3. Print on Demand

Print on demand is another advantage as it doesn't need a lot of space to stock inventory, unlike traditional manufacturing processes. This saves space and costs as there is no need to print in bulk unless required.

The 3D design files are all stored in a virtual library as they are printed using a 3D model as either a CAD or STL file, this means they can be located and printed when needed. Edits to designs can be made at very low costs by editing individual files without wastage of out of date inventory and investing in tools.

4. Strong and Lightweight Parts

The main 3D printing material used is plastic, although some metals can also be used for 3D printing. However, plastics offer advantages as they are lighter than their metal equivalents. This is particularly important in industries such as automotive and aerospace where light-weighting is an issue and can deliver greater fuel efficiency.

Also, parts can be created from tailored materials to provide specific properties such as heat resistance, higher strength or water repellency.

5. Fast Design and Production

Depending on a part's design and complexity, 3D printing can print objects within hours, which is much faster than moulded or machined parts. It is not only the manufacture of the part that can offer time savings through 3D printing but also the design process can be very quick by creating STL or CAD files ready to be printed.

6. Minimising Waste

The production of parts only requires the materials needed for the part itself, with little or no wastage as compared to alternative methods which are cut from large chunks of non-recyclable materials. Not only does the process save on resources but it also reduces the cost of the materials being used.

7. Cost Effective
As a single step manufacturing process, 3D printing saves time and therefore costs associated with using different machines for manufacture. 3D printers can also be set up and left to get on with the job, meaning that there is no need for operators to be present the entire time. As mentioned above, this manufacturing process can also reduce costs on materials as it only uses the amount of material required for the part itself, with little or no wastage. While 3D printing equipment can be expensive to buy, you can even avoid this cost by outsourcing your project to a 3D printing service company.

8. Ease of Access
3D printers are becoming more and more accessible with more local service providers offering outsourcing services for manufacturing work. This saves time and doesn't require expensive transport costs compared to more traditional manufacturing processes produced abroad in countries such as China.

9. Environmentally Friendly
As this technology reduces the amount of material wastage used this process is inherently environmentally friendly. However, the environmental benefits are extended when you consider factors such as improved fuel efficiency from using lightweight 3D printed parts.

10. Advanced Healthcare

3D printing is being used in the medical sector to help save lives by printing organs for the human body such as livers, kidneys and hearts. Further advances and uses are being developed in the healthcare sector providing some of the biggest advances from using the technology.

DISADVANTAGES

1. Limited Materials

While 3D Printing can create items in a selection of plastics and metals the available selection of raw materials is not exhaustive. This is due to the fact that not all metals or plastics can be temperature controlled enough to allow 3D printing. In addition, many of these printable materials cannot be recycled and very few are food safe.

2. Restricted Build Size

3D printers currently have small print chambers which restrict the size of parts that can be printed. Anything bigger will need to be printed in separate parts and joined together after production. This can increase costs and time for larger parts due to the printer needing to print more parts before manual labour is used to join the parts together.

3. Post Processing

Although large parts require post-processing, as mentioned above, most 3D printed parts need some form of cleaning up to remove support material from the build and to smooth the surface to achieve the required finish. Post processing methods used include waterjetting, sanding, a chemical soak and rinse, air or heat drying, assembly and others. The amount of post processing required depends on factors including the size of the part being produced, the intended application and the type of 3D printing technology used for production. So, while 3D printing allows for the fast production of parts, the speed of manufacture can be slowed by post processing.

4. Large Volumes

3D printing is a static cost unlike more conventional techniques like injection moulding, where large volumes may be more cost effective to produce. While the initial investment for 3D printing may be lower than other manufacturing methods, once scaled up to produce large volumes for mass production, the cost per unit does not reduce as it would with injection moulding.

5. Reduction in Manufacturing Jobs

Another of the disadvantages of 3D technology is the potential reduction in human labour, since most of the production is automated and done by printers. However, many third world countries rely on low skill jobs to keep their economies running, and this technology could put these manufacturing jobs at risk by cutting out the need for production abroad.

6. Design Inaccuracies

Another potential problem with 3D printing is directly related to the type of machine or process used, with some printers having lower tolerances, meaning that final parts may differ from the original design. This can be fixed in post processing, but it must be considered that this will further increase the time and cost of production.

7. Copyright Issues

As 3D printing is becoming more popular and accessible there is a greater possibility for people to create fake and counterfeit products and it will almost be impossible to tell the difference. This has evident issues around copyright as well as for quality control.

8)APPLICATIONS

-Aerospace and defence: for functional prototype
-Industrial goods: modeling for on the spot demand
-Medical & Dental: 3D printing can be used to provide patient-specific solutions, such as implants and dental appliances.

9)CONCLUSION

_The main perspective way of artificial intelligence implementation in the world of additive manufacturing technologies is based on the 3D printing process development and bringing the design process to the new level. AI working system concept has been explained. Control over 3D printing properties has been introduced with created algorithms. Required human resources have been described. Necessary equipment has been introduced. AI science has been used to solve the problems of analysis process before the printing procedure to reduce risks of failure. Another interesting part is the further development of the digitalization process allowing user to solve the failures in the printing process with an AI system without asking for service support. This feature simplifies the supply chain and the production process. Machine learning improvesthe printing quality reducing risks of failure and manufacturing waste. The recycling in the field of additive manufacturing should be minimized with zero waste production. Also, there are a lot of possible ways which can be developed to protect the printing data and digital security system due to AI technologies.

10) FUTURE SCOPE

The nearest future of the interaction between the artificial intelligence and additive manufacturing depends on the machine learning development. Elements of mechanisms and tools should be 3D printed and transported to substitute failed parts that will lead to the 76 reduction of spare parts costs and transportation expenses, and improved customer experience . The importance of this study is valuable for the future development of AM technologies, especially SLA 3D printing. This thesis covers all parts of possible cooperation of AM and AI system with detailed instructions. The AI system with computer vision can be easily developed based on the presented solutions.

11) BIBILOGRAPHY

https://www.twi-global.com/technical-knowledge/faqs/what-is-3d-printing/pros-and-cons

https://www.theseus.fi/bitstream/handle/10024/155967/Iuganson_Thesis.pdf?sequence=1

Autoshift.com -> redshift

12) APPENDIX

A.SOUCE CODE

```
import pandas as pd
data = pd.read_csv("data.csv", sep = ";")
```

In [3]:

```
data.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 50 entries, 0 to 49
Data columns (total 12 columns):
layer_height         50 non-null float64
wall_thickness       50 non-null int64
infill_density       50 non-null int64
infill_pattern       50 non-null object
nozzle_temperature   50 non-null int64
bed_temperature      50 non-null int64
print_speed          50 non-null int64
material             50 non-null object
fan_speed            50 non-null int64
```

roughness 50 non-null int64
tension_strenght 50 non-null int64
elongation 50 non-null float64
dtypes: float64(2), int64(8), object(2)
memory usage: 4.8+ KB

Let's multiply these columns by 100 to make them more understandable.

In [4]:

```
data.layer_height = data.layer_height*100
data.elongation = data.elongation*100
```

In [5]:

```
data.head()
```

Out[5]:

	layer_height	wall_thickness	infill_density	infill_pattern	nozzle_temperature	bed_temperature	print_speed	material	fan_speed	roughness	tension_strenght	elongation
0	2.0	8	90	grid	220	60	40	abs	0	25	18	120.0
1	2.0	7	90	honeycomb	225	65	40	abs	25	32	16	140.0
2	2.0	1	80	grid	230	70	40	abs	50	40	8	80.0
3	2.0	4	70	honeycomb	240	75	40	abs	75	68	10	50.0
4	2.0	6	90	grid	250	80	40	abs	100	92	5	70.0

In this data set, ABS and PLA assigned 0 and 1 values for materials.

In [6]:

```
data.material = [0 if each == "abs" else 1 for each in data.material]
# abs = 0, pla = 1

data.infill_pattern = [0 if each == "grid" else 1 for each in data.infill_pattern]
# grid = 0, honeycomb = 1
```

In [7]:

```
data.head()
```

Out[7]:

	layer_height	wall_thickness	infill_density	infill_pattern	nozzle_temperature	bed_temperature	print_speed	material	fan_speed	roughness	tension_strength	elongation
0	2.0	8	90	0	220	60	40	0	0	25	18	120.0
1	2.0	7	90	1	225	65	40	0	25	32	16	140.0
2	2.0	1	80	0	230	70	40	0	50	40	8	80.0
3	2.0	4	70	1	240	75	40	0	75	68	10	50.0
4	2.0	6	90	0	250	80	40	0	100	92	5	70.0

Seperate Input parameters and Prediction Materials.

In [18]:

```
y_data = data.material.values
x_data = data.drop(["material"],axis=1)
```

In [19]:

```
absm = data[data.material == 0]
pla = data[data.material == 1]
```

In [20]:

```
absm.head()
```

Out[20]:

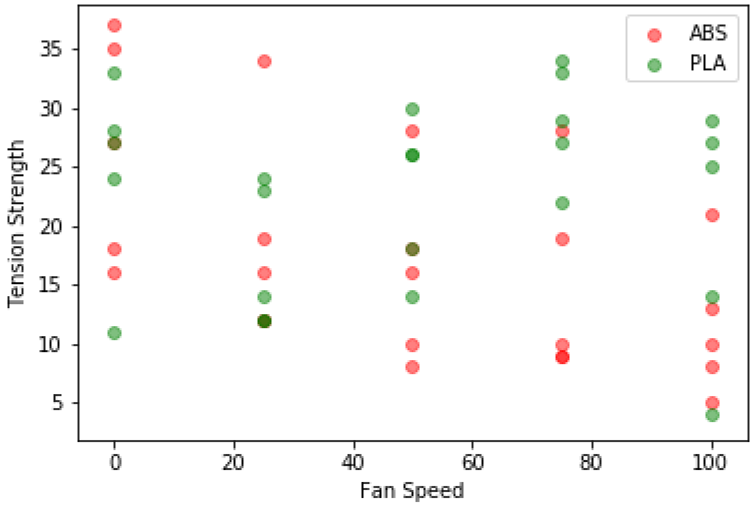
	layer_height	wall_thickness	infill_density	infill_pattern	nozzle_temperature	bed_temperature	print_speed	material	fan_speed	roughness	tension_strength	elongation
0	2.0	8	90	0	220	60	40	0	0	25	18	120.0
1	2.0	7	90	1	225	65	40	0	25	32	16	140.0
2	2.0	1	80	0	230	70	40	0	50	40	8	80.0
3	2.0	4	70	1	240	75	40	0	75	68	10	50.0
4	2.0	6	90	0	250	80	40	0	100	92	5	70.0

In [21]:

```
import matplotlib.pyplot as plt
```

In [22]:

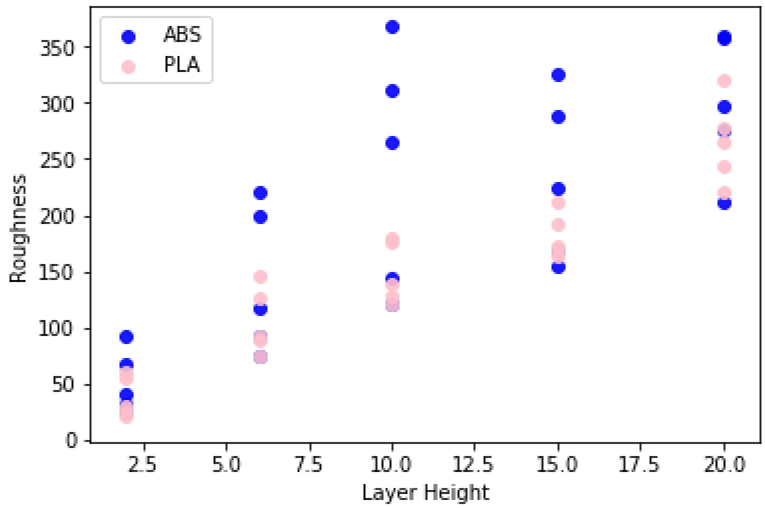
```
plt.scatter(absm.fan_speed,absm.tension_strenght,color="red",label="ABS",alpha= 0.5)
plt.scatter(pla.fan_speed,pla.tension_strenght,color="green",label="PLA",alpha= 0.5)
plt.xlabel("Fan Speed")
plt.ylabel("Tension Strength")
plt.legend()
plt.show()
```



As you see, the air circulation not good for ABS

In [23]:

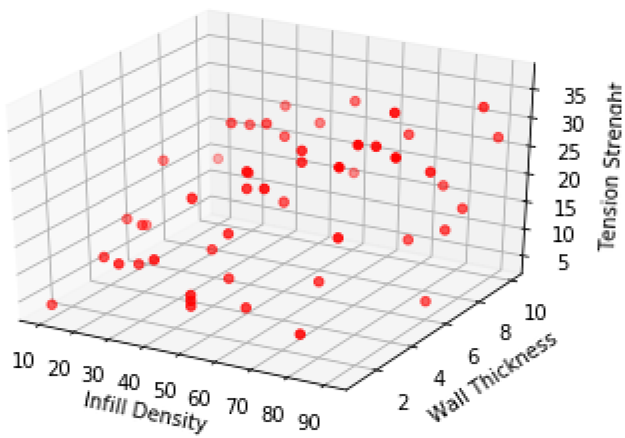
```
plt.scatter(absm.layer_height,absm.roughness,color="blue",label="ABS",alpha= 0.9)
plt.scatter(pla.layer_height,pla.roughness,color="pink",label="PLA",alpha= 0.9)
plt.xlabel("Layer Height")
plt.ylabel("Roughness")
plt.legend()
plt.show()
```



You can see as the layer height increases, the tensile strength increases. But PLA smoother than ABS

In [24]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt

fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')

x = data.infill_density
y = data.wall_thickness
z = data.tension_strenght

ax.scatter(x, y, z, c='r', marker='o')

ax.set_xlabel('Infill Density')
ax.set_ylabel('Wall Thickness')
ax.set_zlabel('Tension Strenght')

plt.show()
```

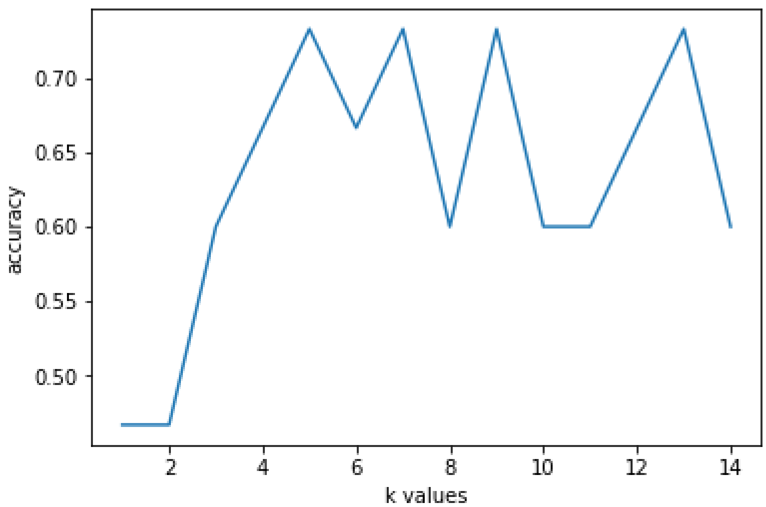


In [27]:

```
# normalization
x_norm = (x_data - np.min(x_data))/(np.max(x_data)-np.min(x_data))

# train test split
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(x_norm,y_data,test_size = 0.3,random_state=1)

from sklearn.neighbors import KNeighborsClassifier
knn = KNeighborsClassifier(n_neighbors = 3) # n_neighbors = k
knn.fit(x_train,y_train)
prediction = knn.predict(x_test)
print(" {} nn score: {} ".format(3,knn.score(x_test,y_test)))

score_list = []
for each in range(1,15):
    knn2 = KNeighborsClassifier(n_neighbors = each)
    knn2.fit(x_train,y_train)
    score_list.append(knn2.score(x_test,y_test))
    print(" {} nn score: {} ".format(each,knn2.score(x_test,y_test)))

plt.plot(range(1,15),score_list)
plt.xlabel("k values")
plt.ylabel("accuracy")
plt.show()
```

```
 3 nn score: 0.6
 1 nn score: 0.4666666666666667
 2 nn score: 0.4666666666666667
 3 nn score: 0.6
 4 nn score: 0.6666666666666666
```

5 nn score: 0.7333333333333333
6 nn score: 0.6666666666666666
7 nn score: 0.7333333333333333
8 nn score: 0.6
9 nn score: 0.7333333333333333
10 nn score: 0.6
11 nn score: 0.6
12 nn score: 0.6666666666666666
13 nn score: 0.7333333333333333
14 nn score: 0.6



In [ ]:

```
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout, Activation
from keras.layers import Input, Dense, Flatten
from keras.optimizers import SGD
from keras.layers.normalization import BatchNormalization

model = Sequential()
model.add(Dense(32,input_dim=11))
model.add(BatchNormalization(axis = -1))
model.add(Activation('relu'))
model.add(Dropout(0.25))
model.add(Dense(64))
model.add(Activation('relu'))
model.add(Dropout(0.25))
model.add(Dense(16))
model.add(Activation('softmax'))
```

```python
model.compile(optimizer='adam', loss = 'sparse_categorical_crossentropy', metrics=['accuracy'])
model.fit(x_data,y, epochs=500, batch_size =32, validation_split= 0.20)
```

In [ ]:

```python
a1 = 4 #layer_height*100
a2 = 5 #wall_thickness
a3 = 60 #infill_density
a4 = 0 #infilkk_pattern
a5 = 232 #nozzle_temperature
a6 = 74 #bed_temperature
a7 = 90 #print_speed
a8 = 100 #fan_speed
a9 = 150 #roughness
a10 = 30 #tension_strenght
a11 = 200 #elangation*100

tahmin = np.array([a1,a2,a3,a4,a5,a6,a7,a8,a9,a10,a11]).reshape(1,11)
print(model.predict_classes(tahmin))

if model.predict_classes(tahmin) == 0:
   print("Material is ABS")
else:
   print("Material is PLA.")
```