Mechanical Analysis of Ice-Composite and Fibber Strength by Daily Tools

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Abstract. The analysis on mechanical properties of ice-composite focus on three aspects. The first is the novelty of the material. As an ice composite, the selection and placement of different fibres will have a crucial impact on the material and properties of the composite. Regarding the type of fibre, 10 groups of controlled experiments are designed totally with materials commonly used in daily life, with three samples in each group and 33 samples in total. The fillers include cloth of socks, polyester fibre plastic bags (hard, soft, garbage sorting bags), pulp, hemp ropes, nylon ropes, non-woven fabrics, bamboo fibre, and the mask material applied in preventing COVID-19 specially. Considering that in most cases, the mask is a one-off, it is also creatively thought of using disinfected waste masks as reinforcement material for the ice-composite to reduce the waste of recyclable materials. Considering that disposable masks commonly used in this scheme usually consist of an inner and outer layer, as shown in the figure. The applicability of these two fibres was investigated by adding these materials prepared by the inner and outer layers of masks into the Ice-composite. In order to systematically study the influence of different variables on ice composites, different control groups in four directions are set: fibre type, fibre content, fibre length, and fibre orientation. For each control group, more than 2 types of materials were tested and relevant parameters were analysed according to the results. In addition, as a result of the experiment environment to room temperature, and in the process of operation, hands and other body parts contact could accelerate the melting of the ice, leading to the change of the sample properties. To conquer this problem, a blank control group which contains only ice at room temperature is set to make a comparison and provide a standard for determining the improvement of fibre added ice-composite. (The parameters measured in this sample will be used as correction factors in the experiment so that the real properties of the resulting ice composite can be measured.) Considering the influence of fibre orientation on material properties, an extra control group for the same kind of materials is set: one group is stirred evenly with the matrix, and the other group is placed vertically along the direction of the box. In terms of testing, the mechanical properties of the products are mainly tested, including Stiffness Properties, Elastic property. Three related physical properties, the elastic modulus $E$, the shear modulus $G$, and the Poisson's ratio $V$, are measured to evaluate. Tensile and compressive strength in $X$, $Y$, and $Z$ directions are also considered. In particular, different evaluation systems are established for uniform and multilayer unidirectional composite (longitudinal). In addition, a series of properties, such as bend strength, impact strength, and fracture toughness are measured.
Considering the limits of daily measuring instruments, the melting of ice in the operation process affects the measurement of normal strain and the fact that the strain of ice composite material is relatively small, it is creatively thought to use a laser pointer and cosmetic mirror which are common in the multimedia classroom of the university campus to magnify the tiny deformation to facilitate measurement. In terms of the result presentation, it is tried to use broken line charts to show the correlation between various variables and material properties. Finally, the error sources existing in the experiment has been summarized and some improvement plans are proposed according to the existing problems of this experiment.

1. Instruction
The methods of strengthening ice-composite are not only applied in the past but will also be developed in the future to be further applicable to the construction of special structures in the cold regions.

From the development history of ice composite, it is not difficult to find that the manufacturing methods of ice-composite can be generally divided into two categories, called microscopic and macroscopic reinforcement methods (shown in fig.1). Different manufacturing methods meet different requirements for ice-composite.

![Figure 1. The methods of ice-composite reinforcement](image)

For microscopic reinforcement, the ice-composite is created by mixing the ice homogeneously with the material to prevent the formation and propagation of cracks [11]. At present, a large number of materials have been tried for micro-reinforcement, including various water-soluble polymers, disperse and fibrous materials.

If the ice-composite is composed of two or more continuous phases, it is macroscopic reinforcement. These ice-composite reinforced by macroscopic reinforcement methods are known as sandwich or laminar flow type composites [12]. The study suggested the use of macroscopic reinforcement materials such as branches, logs, and geotechnical fabrics.

In this experiment, we mostly used macroscopic reinforcement methods and a few microscopic reinforcement methods such as homogenous mixing of paper pulp and water to fabricate ice composites. The reinforcing effect of different materials on ice-composite and the influence of fibre orientation on the strength of ice-composite were investigated. The mechanical properties, such as elastic modulus E, shear modulus G and Poisson's ratio V, are tested and compared to finally get the conclusion of the experiment.

2. Material of experiment

2.1. Material selection
As sources of ice-composites are all in-home (or neighbour), the fibres and particles are not allowed to be processed or grinded or mixed exactly, expecting samples in a lab. In other words, the raw materials have to be selected around the office or dormitory and processed by scissors tapes.
2.1.1. Adopted materials. For the basic of ice composites, water is one of the essential raw materials, because of the ice phase. Owing to the fact that tap water is quite easy to collect and distilled water is hard to obtain without instruments in the lab, ice phase is made by tap water.

In the history of ice-composites, paper is one of the most familiar raw materials thanks to its cheap, easy to operate and gain features. There’s no denying that, there are several types of paper in life such as cardboard boxes, A4paper, toilet paper and facial tissue for different plant fibres and various additives. [14]

![Figure 2. (a~i) Adopted materials. a) thick cotton ropes, b) nylon ropes, c) cardboard box, d) facial tissue, e) knitting thread, f) plastic bags, g) high-fibre non-woven fabric and melt-blown fabric strips, h) cotton sock strips, i) thin ropes](image)

As the pandemic in recent years, a disposable mask is common in life and is considered in raw material. Generally, a three-layer mask consists of two layers of high-fibre non-woven fabric (polyester like polypropylene resin) outside and one layer of melt-blown fabric (main material including polypropylene). [15] The key characters of high-fibre non-woven fabric are hydrophobicity and high strength, which means the strength is non-directional and both vertical and horizontal strength are similar. [15] Compared with non-woven fabric, the melt-blown fabric is made into a porous and fluffy structure, result in lower strength and better water absorption.

Besides, nylon ropes and plastic bags can be found and used normally in daily life. Commonly, nylon rope is made by nylon also called polyamida. And two types of edible plastic both consist of polyethylene film involved plasticizers or colorants in the experiment.

Additionally, cotton ropes from sweaters, knitting thread and socks are also within the consideration of the experiment. Cellulose is the main material in cotton ropes except for colorants and other additives, which are hydrophobic and of high strength.

2.1.2. Discarded materials. In brainstorming of the experiment, other common materials in life including coke, branches and leaves, have also been considered but these are discarded finally. Owing to fact that hundreds of air bubbles and impurity are going to exist in coke, the eventual ice-composite structure is hard to be confirmed. Although both branched and leaves are much easy to collect in the garden and operate, the complex structure and features lead to abandonments.

2.2. Experimental tools for pre-operation and testing
Weighing scales, rope, hammer, drop weight, scissors, ruler, tape measure, rubber band, chopsticks
2.3. Material preparation

According to the fact that distinguishing structures probably generate distinguishing properties, it is necessary that set up different operations for raw materials. Tap water is frozen as a blank experiment.

Table 1. The preparation of discarded material

| Materials           | Distribution                  | Homogeneous mixture | Vertical and multi-layer arrangement | Vertical arrangement with entanglement |
|---------------------|-------------------------------|---------------------|--------------------------------------|---------------------------------------|
| Paper fibre         | Different paper fibre components | ✓                    |                                      |                                       |
| Disposable mask     | High-fibre non-woven fabric   | ✓                   |                                      |                                       |
|                     | Melt-blown fabric             | ✓                   |                                      |                                       |
| Nylon ropes          | Red                           | ✓ (more chaotic)    |                                      |                                       |
| Plastic bags         |                               | ✓                   |                                      |                                       |
|                      | Blue                          | ✓                   |                                      |                                       |
|                      | Thick ropes                   | ✓                   |                                      |                                       |
| Cotton               | Thin ropes                    | ✓                   |                                      |                                       |
|                      | Knitting thread              | ✓                   |                                      |                                       |
|                      | Sock strips                   | ✓                   |                                      |                                       |

Considering that several kinds of paper provide different types of fibres and paper fibre is easy to design controlled experiments, groups of paper-fibre sample are set to explore how the content of changing paper fibre components in ice composites affects the performance of final products. After processing, all ice composites with paper fibre are able to be a homogeneous mixture under ideal conditions, similar to an isotropic mixture, resulting in that the fibres are entangled in the composite. Additionally, cardboard boxes and A4 paper own higher strength fibre and more additives, and facial tissue obtain longer length fibre.

Thanks to distinguishing main compounds and characters for high-fibre non-woven fabric and melt-blown fabric, the controlled groups are set for exploring how different materials affect the performance of ice composite. One of the prerequisite processes is that the masks strips are arranged along the boxes.

Fixing the attention on operating nylon ropes and plastic bags, the critical solution is different distribution in ice composites. To research the impact of between distribution and features, plastic strips are designed in a vertical arrangement with entanglement and along with boxes. However, the distinction is that nylon ropes are only used for comparison between others by arrangement along with the boxes.

In order to research the influence of different structure plant fibres on the performance of ice composites, four groups of controlled experiments are designed including thick ropes, thin ropes, knitting thread and sock strips. The significant distinguish are different diameter and distribution, and even the sock strips enrich fibre network by multiple layers.

2.4. Material processing

2.4.1. Processing procedure. From the whole experiment framework, the experiment is divided into two parts. The one (experiment A) aims to explore and summarize the effect of fibre content on ice composite performance by setting up samples with a series of paper fibre content. While the other one (experiment B) lists controlled variable experiments with the purpose of comparison and research that how different types of material influence the ice-composite characters.

Experiment A

Firstly, what this part has to be ensured is the ratio of a mixture (cardboard box, A4paper and facial tissue). To measure the more accurate data, the quality of A4 paper, tissue paper and cardboard is normally calculated by the quotient of total mass and quantity. The weight of A4 paper is to measure the total mass of 10 pieces of paper, and then calculate 1/3 of the area to get the quality of paper scraps. Similarly, the weight of tissue paper strips is calculated by 2/65 pieces, and the weight of cardboard scraps is calculated by 1/4 of the whole. (Symmetrical paper scraps and strips are gained by scissors)

After calculating and processing, the paper scraps, strips with water are weighed and soaked in a mineral water bottle for 60 minutes. With chopsticks stirring, paper scraps and strips are mixed in the
water bottle gently and thoroughly until the colour is uniform and no obvious layers appear. Eventually, label the group number for samples with content in table 2.

Experiment B

For comparing several types of fibre, each raw material is supposed to own its processing procedure. High-fibre non-woven fabric and melt-blown fabric are cut into uniform strips by scissors and evenly distributed in the mould as vertical and multilayer arrangement, with the label of groups 1 and 2. Nylon ropes is distributed orderly along with the box (group 3). As the same as the disposable mask, plastic strips samples are groups 4 and 5. In addition, depending on different thickness (diameter) of fibre in table 4, label the group 6 to 8 as the experiment group where the distribution following the table 3. Besides, the sock strips, as the widest fibre, are labelled as group 9 to compared another cotton-ice composite.

2.4.2. Processing data

**Table 2. Paper fibre composition in experiment A**

| Cardboard box, A4paper and facial tissue ratio | 5 : 3.72 : 1.47 |
| Paper fibre composition | 5.92% |

| Group number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Sample weight/ g | 139.8 | 155.4 | 125.5 | 141.2 | 128.6 | 139.4 | 100 | 95.6 | 118.1 |
| Weight (fibre)/ g | 0.5 | 1.07 | 1.32 | 0.96 | 0.34 | 3.82 | 3.00 | 4.70 | 0.64 |
| Weight (water)/ g | 139.3 | 154.3 | 124.2 | 140.2 | 128.3 | 135.6 | 97.0 | 90.9 | 117.5 |
| Cross-sectional area/ cm$^2$ | 6.12 | 13.38 | 12.88 | 8.09 | 11.27 | 12.15 | 8.05 | 14.18 | 5.25 |

**Table 3. The initial data of the sample in experiment B**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Disposable mask | High-fibre non-woven fabric | 2.8 | 14.2 |
| | Melt-blown fabric | 3.4 | 14.2 |
| Nylon ropes | 1.8 | 14.8 |
| Plastic bags | Rad | 5 | 13.5 |
| | Blue | 6 | 14.3 |
| Cotton | Thick ropes | 2.7 | 15.3 |
| | Thin ropes | 0.7 | 13.6 |
| | Knitting thread | 0.2 | 14.6 |
| | Sock strips | 11 | 10.8 |

3. Test

Testing:

Tip: Our group approximates the sample as unidirectional cuboids which have three orthogonal directions 1,2,3 (figure 3). Considering that the difference between isotropy and anisotropy of materials will have a great influence on the experimental results, for isotropic materials, including pulp-ice composites, ice composites with sock fragments, and ice composites with PVC plastic bag fragments, we tested G and E, and get Poisson's ratio with formula 1 below to estimate the influence of fibre content and fibre length, to get relevance between fibre content, fibre length and mechanical properties.
\[ G = \frac{E}{2(1+v)} \]  

(1)

For unidirectional fibre-reinforced ice-composite, which are prepared by setting thin and slender strips of mask materials (inner material and outer material are set separately as 2 samples), a nylon cord twisted together and dispersed into many thin strands separately as well as cotton cord twisted into a single strand and dispersed into many thin strands, we test the impact of fibre type and fibre orientation on impact strength and bending strength.

3.1. Isotropy

3.1.1. Principle. The fillers inside the sample are orientation or uniformly distribution. So, in order to explore if the orientation of filler may affect the properties of the sample, all experiments need to be carried out in three orthogonal directions (direction1,2,3 as shown on the figure below)

3.1.2. Experimental device. Each property testing has a different device.

3.1.3. Operational process

![Figure 3. Three orthogonal directions of sample](image)

In order to find out whether the ice composite sample is isotropy or not, all testing processes need to test at least in three directions (direction1,2,3 as shown on the figure below). But, because of the limited time and experimental condition, this property may not be realized.

3.1.4. Our Solutions. For E, we just calculate E along 1 direction as shown in fig 3. For G, we just discuss G in Plane 23, G23.

3.2. Tensile strength and Compressive strength

3.2.1. Principle [16]. The basic equation:

\[ \sigma = \frac{F}{s} \]  

(2)

F is the max force applied at two opposite surfaces of the ice composite.

S is the intersection surface which is perpendicular to the force. To measure the tensile/compressive strength of the sample in one direction, you need to increase the applied force on two opposite surfaces until the sample rupture. Normally, in the case of isotropy sample, the tensile strength and compressive strength are the same. However, because the fiber inside has orientation, we need to explore the tensile/compressive strength in the fibre orientated direction and transverse direction.

![Figure 4. Basic principle of tensile](image)
3.2.2. Experimental device

![Experimental device image]

**Figure 5.** Comparison of laboratory experiment [17] and daily tools of testing compressive strength

The principle of tensile/compressive strength is the same in our experiment and laboratory device, but we simplify the device so we can realize with normal staff. Our group uses a heavy to compress or pull the sample and we measure the strain of the sample.

3.2.3. Operational process

![Operational process image]

**Figure 6.** Operational process of compressive strength with weighted plastic bottle

3.3. Shear strength

3.3.1. Principle [18]. The basic equation:

\[ G = \frac{F_s}{A} \]  

(3)

G: The shear strength of sample, Fs: Shear stress, A: Shear-Bearing area
3.3.2. Experimental device

![Experimental device diagram]

**Figure 7.** Laboratory experimental device and shear modulus on Plane 23

In our experiment, we explore the shear strength on the plane 23. We use a bottle of water to be the weight which hang at the one end of the sample. Another side with the support force given by the table, the simple shear strength experiment can be realized.

3.3.3. Operational process. Hang a bottle of water at one end side of sample with rubber bands. Then adding water until the sample rupture. Record and measure the rupture area. Measure the weight of the bottle of water.

The laser pointer is attached to the sample. With weight increasing, the specular reflection of the laser point is going to be offset by the same angle as the sample. The displacement of the laser point is recorded and the bending angle of the sample can be obtained by using similar triangles and inverse trigonometric function. Calculate the shear strength with the formula.

![Operational process images]

**Figure 8.** Operational process of shear strength

3.4. Bending strength

3.4.1. Principle [19]

\[
\sigma = \varepsilon \frac{E}{2} = \frac{3WL}{bh^2}
\]  

(4)

σ: bending strength  
W: weight of the weight  
L: effective length of the sample  
b: width of the sample  
h: thickness of the sample
Hang the weights at one side of the sample, another side use heavy to fix, then increase the weight of weights until the sample rupture.

3.4.2. **Experimental device**

![Figure 9. The principle of bending strength](image)

We found it difficult to measure the bending angle of the sample is hard to measure because the bending is too small, so we use a method to simplify the angle measuring(fig). Firstly, we tied the laser on the sample and signed the laser incident position (point A) on a paper. After hanging the heavy on the sample, the incident light will change the position to point B. The laser light source point O, original incident position point A, incident position point B will form a triangle OAB. So, after measuring the length of OA, OB, AB, the bending angle AOB can be solved by mathematical method.

3.4.3. **Operational process**

![Figure 11. Experimental processes (1-4)](image)

3.4.4. **Principle [21].** The basic equation:

$$A = \frac{W}{HB} \quad (5)$$
A: Impact strength
W: Energy lost by impact
H: Remaining width of notch
D: Spline thickness
Impact strength is the ratio of the energy absorbed by the sample in the process of impact failure to the original cross-sectional area.

3.4.5. Experimental device

![Figure 12](image).

\[ W = MgH \]  \hspace{1cm} (6)

M: the weight of the weight
G: acceleration of gravity
H: the height of the weight

In our experiment, firstly, we use a nylon wire to hang up 10kg of weight so we can control the height of the weight. When we let go the weight, it will free fall to impact the sample we put right under the weight. Then we increase the height of free fall motion of weight until the sample exists rupture. Record the height then measure the intersection surface area.

With the mass and the height of the weight, we can calculate the energy that breaks the sample.

3.4.6. Operational process:

![Figure 13](image).

Figure 13. a) 20cm b) 30cm c) 40cm height of the impact strength
The energy destroys the sample can be measured as the gravitational potential energy of the heavy which weight is known. So, when we keep increasing the height of the heavy the impact energy is higher enough to destroy the sample. Then we measure the area of the cross section to obtain the impact strength.

4. Results and a Discussion
Fibre type and Fibre orientation as variables, both impact of which is shown by measuring impact strength and bending strength.

Table 5. The result of impact strength

| Material | Cotton cloth | Thick nylon | Fine nylon | Face mask (Blue) | Face mask (white) |
|----------|--------------|-------------|------------|------------------|-------------------|
| Highly(mm) |             |             |            |                  |                   |
| Test1    | 110          | 150         | 150        | 170              | 170               |
| Test2    | 215          | 220         | 220        | 240              | 240               |
| Test3    | 310          | 350         | 350        | 350              | 350               |
| Test4    | 380          | 430         | 430        | 460              | 458               |
| Test5    | —            | 580         | —          | —                | 520               |
| Calculated impact strength | 7.283KJ/m² | 11.116KJ/m² | 8.241KJ/m² | 8.816KJ/m² | 9.966KJ/m² |

(Note: At the measured place, the acceleration of gravity in Xi’an is 9.7944 meters per quadratic second and the hammer we use to cause impact strength is 10kg. Average cross section area measuring impact strength is 51.1 cm². And average cross section area in bending case is.)
4.1. Fibre type
According to the table, it can be seen that fibres made from different materials and also with similar structure will still lead to relatively obvious difference in mechanical properties. Compared the inner-side material with external-side material from mask, the impact strength as well as the bend strength of inner-side material is higher, which is mainly resulted from different fiber structure. For external material, the PP melt-blown fabric has higher density and tighter structure while the PP non-woven fiber light and breathable which reinforced not so well.

4.2. Fiber Orientation
The impact of fiber orientation can be discussed in accordance with the comparison between thick nylon group and dispersed nylon group (which are marked in blue in Table.5).

According to data measured, it has been revealed that as a reinforcing fibre, twisted strands of nylon perform better than those separated into smaller strands when they are added into ice composite separately. The reason behind this is that the matrix reinforced by twisted fibers will transfer loading more effectively while dispersed fibers also increase the surface area of interface, which further reduces the transfer efficiency of matrix to fiber and when the load is applied, the dispersed fibers will fail at lower stress showing lower impact strength and bend strength. Fibre type and Fibre orientation as variables, both impact of which is shown by measuring impact strength and bending strength.

| Material Content (%) | Pulp-ice composites, | Composites with sock fragments, | Ice composites with PVC | Ice composites plastic bag fragments, |
|----------------------|---------------------|---------------------------------|------------------------|-------------------------------------|
| 1                    | 70%                 | 56%                             | 30%                    | 30%                                 |
| 2                    | 75%                 | 75%                             | 40%                    | 40%                                 |
| 3                    | 80%                 | 79%                             | 50%                    | 50%                                 |
| 4                    | 85%                 | 82%                             | 60%                    | 60%                                 |

4.3. Fibre contents
Fibre content are controlled by adding different wight rate of fibres and water during preparation before freezing.

As the calculation of E and G is a little complex, we omit the tedious calculation process and present the results directly in the table below.

| Material Young’s Modulus/ E,GPa | Pulp-ice composites, | Composites with sock fragments, | Ice composites with PVC |
|---------------------------------|----------------------|---------------------------------|------------------------|
| 1                               | 0.524                | 0.513                           | 0.517                  |
| 2                               | 0.527                | 0.521                           | 0.524                  |
| 3                               | 0.528                | 0.526                           | 0.526                  |
| 4                               | 0.535                | 0.528                           | 0.530                  |
Table 8. Corresponding shear modulus of different samples

| Material                  | Pulp-ice composites, G/GPa | Composites with sock fragments, G/GPa | Ice composites with PVC, G/GPa |
|---------------------------|-----------------------------|--------------------------------------|---------------------------------|
| 1                         | 0.533                       | 0.519                                | 0.524                           |
| 2                         | 0.547                       | 0.527                                | 0.531                           |
| 3                         | 0.564                       | 0.529                                | 0.534                           |
| 4                         | 0.569                       | 0.532                                | 0.547                           |

Poisson's ratio was calculated by equation (3.1)

Table 9. Corresponding Poisson's ratio of different samples

| Material                  | Pulp-ice composites, γ     | Composites with sock fragments, γ   | Ice composites with PVC, γ       |
|---------------------------|----------------------------|-------------------------------------|----------------------------------|
| 1                         | 0.508442777                | 0.505780347                         | 0.506679389                      |
| 2                         | 0.518281536                | 0.5056926                           | 0.506591337                      |
| 3                         | 0.531914894                | 0.502835539                         | 0.507490637                      |
| 4                         | 0.529876977                | 0.503759398                         | 0.515539305                      |

Obviously, corresponding with the knowledge we got in lecture, with the increase of fibre content, for all samples: pulp-ice composites, ice composites with sock fragments, ice composites with PVC plastic bag fragments, the elastic modulus and shear modulus will become larger when the content of fibre increase.

4.4. Fibre length

If we ensure enough time for stirring when we prepare pulp, the paper will be crushed enough and the long fibres will break into “tiny” fibres of shorter length, in which case, according to the experimental results, the E as well as G of ice-composite prepared well be the largest if we only take variable time of stirring into consideration.

In this case we cannot give quantified parameters to determined how full our mixture is. However, the experience from long-term experiments tells us that this is true.

5. Error analysis

Because of rudimentary test environment in life, there is no denying that the error appears around each step involved in materials and processing, testing and operating, and measurement error.

5.1. Materials and processing

In the selection of raw materials, it is hard to accurately identify the component of different materials and fibre types (microstructure such as network and interaction). During materials selection, what the types is accordance with are different interaction between ice phase and fibre, and more composite ratio and approaches of arrangement. Due to imprecise and the lack of pre-experiment material selection, the difficulty of measuring material properties’ data increases.

During processing, the main error source is ignoring the buoyancy of fibre in water. The one is the density of fibre is lower than water, for example the density of plastic bag (lower than 0.96g/cm³). Another one is the specific porous structure, which means the air bubble are unavoidably stored in the porous structure like high-fibre non-woven fabric. Both two reasons are going to allow the fibre strips to float on the surface of the water or gather on the upper layer of freezing ice composite.
Moreover, the selection of raw materials and uneven moulds for sample preparation, the non-uniform samples all lead to a larger error for the properties of the fibres.

5.2. Testing and operating

In the testing procedure, the significant shortcoming is ideal experimental design and measurement without professional instruments. Firstly, the irregular sample model causes uneven force to deviate from the axial direction and the complex arrangement system of stress and strain. Furthermore, with measuring time going on, the phase of ice composite turns into liquid in the room temperature. In other words, the size and the structure dynamically change over time. Directly, the width of sample decreases as well as microstructure changed, which definitely led to the error for the properties like stiffness, ultimate strength as a result. Besides, as operating by life set-up, the loading not along the axials makes tolerably errors, for instance, impact test that weight deviated from the longitudinal direction cause the sample to bounce after receiving an impact.

5.3. Measurement error

As the rough testing environment and equipment, low accuracy refers to data measured in this experiment with large distinguish about “true” properties. For the limitation of time and number of samples, it is difficult to confirm the precision by repeating experiment, which is the degree to which repeated measurements under unchanged conditions show the same results. What’s more, human error also makes a difference because all measurements are subject to error, which contributes to the uncertainty of the result.

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