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Struktur analysis and material selection in reactor and condensers for liquid smoke maker

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Abstract. Liquid smoke can be obtained by condensing or condensing biomass from the pyrolysis process . To make a liquid smoke device, an appropriate material is needed because the resulting liquid smoke will function as food preservation, especially for milkfish preservation. Therefore we need a suitable material so as not to affect the results of the liquid smoke. On the other hand, structural analysis is also needed to determine the strength of the material in this liquid smoke maker. The first method used is a qualitative method. This method is a computational method using *software* that has been developed by Ashby named CES Edupack. The second method is used for selecting the next material, quantitative method is a systematic method used to narrow the choice of material with themethod approach *digital logic.* In the research results, the selected material is Stainless Steel 304 with specifications Thermal Conductivity: 16.2 (W / mK) Maximal Service Temperature: 750 (^oC) Density: 8 (g / cc) Yield Strength: 215 (Mpa). With the analysis of the structure, namely the condenser maximum stress is $2x10^4$ N / m^2, for the *Strain the* value is $6.08x10^{-9}$. for Displacement, it can be 3 x 10^{-5} mm. The safety factoris 1 x 10^6. obtainedFor the tangential stress obtained is 11.05 N / m^2. At the maximum strain reactor is 321 MPa, the *strain* resultingis $8x10^{-6}$. For the *displacement* , the result is 0.09 mm. and the last is the *safety factor* , the result is 65. For the longitudinal stress that is produced is 1.65 N / m^2

Keywords. Liquid Smoke, Material selection, Stainless Steel, Reactor, Condensers

1. Introdsuction

Liquid smoke can be obtained by condensing or condensing biomass from the pyrolysis process. Liquid smoke has various functional properties. Its main function is to give the desired flavor and color to the smoked product, which is played by acetic acid and carbonyl compounds. Another function is acid which acts as antibacterial and antioxidant [1-5].

To make a liquid smoke device, an appropriate material is needed because the resulting liquid smoke will function as food preservation, especially for milkfish preservation. Therefore we need a suitable material so as not to affect the results of the liquid smoke. On the other hand, structural analysis is also needed to determine the strength of the material in this liquid smoke maker [6-7].

2. Method.

Other In 2015 MF Ashby and D. Cebon explained that in some circumstances the material can be selected according to individual satisfaction. Many people are still looking for materials that are in accordance with what they want, but many do not understand about materials that are suitable in their fields. In determining the material, not only the type of material is taken into consideration, but also the shape of the material must also be considered.

Methods The first method used is a qualitative method. Where this method is a computational method using *software* that has been developed by Ashby named CES Edupack. In *software* thisprovides the wearer ease of browsing, searching, and choose thethat is in the *software* CES Edupack.

Digital logic itself is a systematic tool as a means of support. Steps for material selection of liquid smoke tools by selecting and comparing material properties according to material performance objectives. To determine theimportance *relative* of each of the required properties and how to present them with a table.

In comparing the two characteristics of the performance goals, the most important goal is assigned a number (1) and the least important is assigned a number of zero (0), the number of decisions being, Then to want (N) is N=$\frac{n(n-1)}{2}$. calculating the weight factor expressed by (α) α = $\frac{m}{N}$. The next step is to find the performance index of the material that has been selected, the goal is to find out the working value of the selected material, and the highest value to be taken. Before determining the value of the performance index, first looking for the scale of the properties of the selected candidate material for these properties is an objective that needs to be needed / desired. The formula for calculating the properties of the scale and is presented in the form of a table.

$$\text{Scale Properties : } \frac{\text{Number of Value Properties x 100}}{\text{maximum value value properties}}$$

To find out the scale value of theproperties, *density* use the formula below.

$$\text{Scale Properties : } \frac{\text{Minimum value of properties x100}}{\text{minimum value properties}}$$

And to find *the material performance index,*

$$\gamma = \sum_{i}^{n} = 1.\beta.i.\alpha.i$$

Where :

β = scale properties
α = Weight Factor
I,n = sum of all related n

Then next is to calculate the value *figure of merite* (FOM), namely:

$$M= \frac{\gamma}{C}$$

Where :
γ = performance *index*
C = cost of strength

Then after getting the selected material, it is a structural simulation using *Solidworks 2018 software.*

3. Result and discusion

3.1 Determining the Liquid Smoke Material

The selection stage starts from thestage *translation* which will be used by the liquid smoke tool is as follows.

<u>*Function:*</u>
Produces liquid smoke for preserving milkfish.
<u>Objective:</u>
- Minimizing material weight

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<u>Constraints:</u>
- Radius dimensions are determined
- Can be corrosion resistant
- Material remains strong in withstandinggas pressure *<u>Free Variable:</u>*
- Material selection - Material <u>thickness</u>

3.2 Determining the material based on chemical Aspect

Aspects In designing materials in terms of thermal and chemical aspects there are several factors, namely:

- Material has a maximum working temperature of 400°C
- Has good corrosion-resistant ability.

After knowing the factors above, the next step is theprocess *screening* using the *software* CES Edupack. In this study, the authors used 2013 version of CES Edupack.

Figure 1. Software CES Edupack 2013

In this graph there are various kinds of selected metal materials with a very wide maximum working temperature as shown in Figure 4.5. Then aprocess is carried out *screening,* which will select the desired material, namely the material for the liquid smoke device.

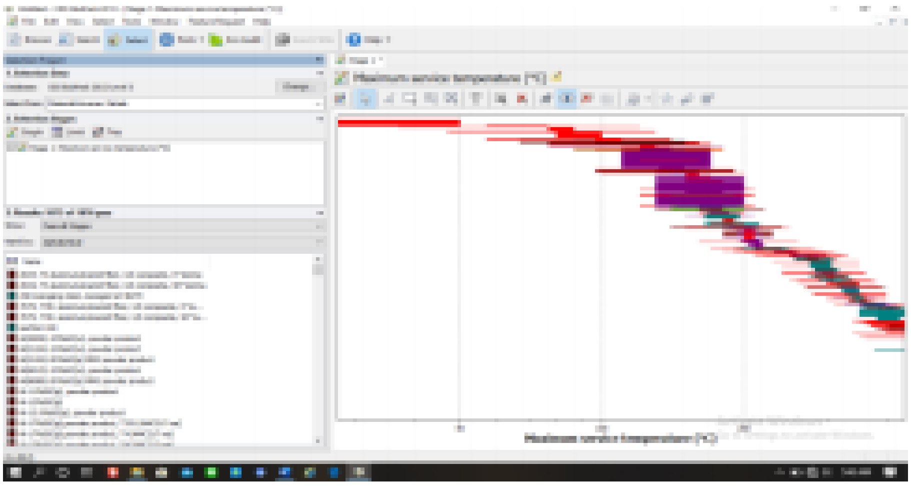

Figure 2. *Screening Process*

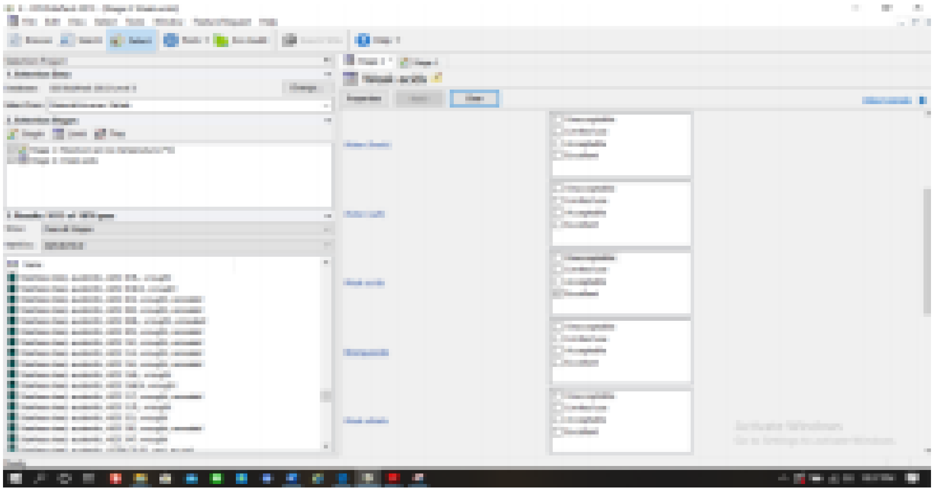

Figure 3. Limit Stage

Process So 4 types of material are selected which will later be used in this liquid smoke device. Some of these materials include:

1. Stainless Steel AISI 304
2. Stainless Steel AISI 301
3. Stainless Steel AISI 316
4. Stainless Steel AISI 310

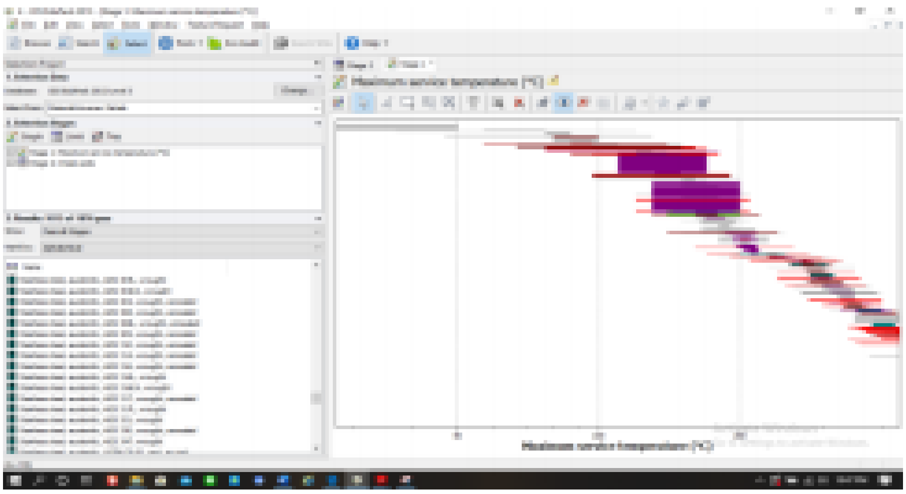

Figure 4. Screening Results

3.3 Determining by quantitative methods

The initial method used is CUP (*Cost Per Unit Property*), this method looks at the cost of the properties that work, by comparing the properties of the selected material and at a relatively low cost, which is declared good to be applied.

Furthermore, to determine the stated weight factor (α) which is obtained from the value of each number of goals (m), divided by the value of the number of decisions desired (N).

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Table 1. Candidate Material Price

Material	Price In Dollars/Uni Weight	Relative Cost	Rank
Stainless Steel AISI 304	3.73	1.226973684	3
Stainless Steel AISI 1301	3.04	1	2
Stainless Steel AISI 316	4.93	1.621710526	4
Stainless Steel AISI 310	6.76	2.223684211	1

Table 2. Required Requirments

Traids Required	Number Of Properties Required									
	1	2	3	4	5	6	7	8	9	10
Thermal Conductivity	1		0			1		0		
Maximum Service Temperature		1			0		0		1	0
Yield Strength				1		0			0	
Density	0		1				1			
corrosion resistant		0		0	1			1		1

Based on this table, it can be determined the weight factor (α) of the reactor tube which is shown in table 3. Table 3 Weight Factors

Table 3. Weight Factors

Traids Required	Number Of Decision	Weight Factors
Thermal Conductivity	2	0.2
Maximum Service Temperature	2	0.3
Yield Strength	1	0.1
Density	2	0.2
corrosion resistant	3	0.3
Total	10	1

For the case in this study we need the cost of unit strength. Then the formula we use is as follows: *cost of unit strength* = $=\frac{C\rho}{S}$ (Moh Faraq), can be seen in table 4. Cost per unit for candidate material for liquid smoke equipment:
Where: C : *Relative Cost* , ρ = *Density* , S = *Strenght*

Table 4. Cost of unit strength

Material	Price In Dollars/Uni Weight	Relative Cost	Yield Strength	Density	Cost Of Unit Strength
Stainless Steel AISI 304	3.73	1.226	215	8	0.047654835
Stainless Steel AISI 301	3.04	1	205	8.03	0.039170732
Stainless Steel AISI 316	4.93	1.621	290	8	0.044736842
Stainless Steel AISI 310	6.76	2.223	310	8	0.057385399

Next is table 5. Which contains material data properties of each liquid smoke device material. For the next, get the value of the performance index material. To get the value, first know the value of the nature.

Table 5. Characteristics of Candidate Materials

Material	Thermal Conductivity (W/mK)	Maximum Service Temperature (^oC)	Yield Strength (Mpa)	Density (g/cc)	corrosion resistant
Stainless Steel AISI 304	16.2	750	215	8	4
Stainless Steel AISI 301	16.3	357	205	8.03	4
Stainless Steel AISI 316	16.3	870	290	8	4
Stainless Steel AISI 310	14.2	1035	310	8	5

*Information 1: Poor, 2: Fair, 3: Good, 4: Very Good, 5: Excellent

Table 6. Scale Properties

Material	Thermal Conductivity (W/mK)	Maximum Service Temperature (^oC)	Yield Strength (Mpa)	Density (g/cc)	corrosion resistant
Stainless Steel AISI 304	99.4	72.5	215	8	4
Stainless Steel AISI 301	100	34.5	205	8.03	4
Stainless Steel AISI 316	100	82	290	8	4
Stainless Steel AISI 310	87.11	100	310	8	5

Table 7 contains a figure of merit with regard to the cost of each candidate material by dividing the performance index by the cost of strength.

Table 7. Figure of Merit

Material	Thermal Conductivity (W/mK)	Maximum Service Temperature (^oC)	Yield Strength (Mpa)	Density (g/cc)	corrosion resistant
Stainless Steel AISI 304	99.4	72.5	215	8	4
Stainless Steel AISI 301	100	34.5	205	8.03	4
Stainless Steel AISI 316	100	82	290	8	4
Stainless Steel AISI 310	87.11	100	310	8	5

At this calculation stage, the final result of the selected material is Stainless Steel AISI 304. 3.4 Structural Analysis. After obtaining the selected material, the nextanalyze the structure of the reactor and condenser.

V condenser tube: Given: r: 150 mm, t: 850 mm

Then $V : \pi r^2 t$

$: 3{,}14 \times 150^2 \times 850$

$: 600525000 \text{ mm}^3$

$: 600.5 \text{ cm}^3$

V Condenser Pipe: Given : r: 6.35 mm, t : 1800 mm

Then $V : \pi r^2 t$

$: 3{,}14 \times 6.35^2 \times 1800$

$: 227902{,}77 \text{ mm}^3$

$: 0.277 \text{ cm}^3$

V of water supply space: If : r: 6.35 mm, h: 2mm

then $V : 2 (\pi r^2 t)$

$: 2 (3.14 \times 6.35^2 \times 2)$

$: 506.45 \text{mm}^3$

$: 0.0005 \text{ cm}^3$

Condenser volume: V condenser tube – V Condenser pipe – V water supply room

$: 6005 \text{ cm}^3 – 0.277 \text{ cm}^3 – 0.0005 \text{ cm}^3$

: 598 cm^3
: 0.00598 m^3

find the mass of water:

m: ρxv
: 1000 Kg / m^3 x 0.00598 m^3
: 5.9 Kg

Determine Force

F: mxg: 5.9 Kg x 10 m / s^2: 59 N

find the pressure first, namely by the formula:

$$p = \frac{F}{A} = \frac{F}{2\pi r(r+t)} = \frac{59\ \mathrm{N}}{2\pi 150\ \mathrm{mm}(150+850)} = \frac{59\ N}{0.94\ m2} = 62{,}63\ \mathrm{N/m^2}$$

then look for tangential stress by calculating

$$\sigma t = \frac{pD}{2t} = \frac{62{,}63\frac{\mathrm{N}}{\mathrm{m2}}\,x300\ mm}{2x2\ mm} = 4697{,}25\ \mathrm{N/m^2}$$

Based on the simulation, the maximum voltage is $2x10^4$ N / m^2. For the *strain* or strain the value is $6.08x10^{-9}$. for Displacement or deflection, it can be 3 x 10^{-5} mm. And finally, the safety factor that is obtained is 1 x 10^{6} . Based on the simulation, the maximum voltage is $2x10^4$ N / m^2. For the *strain* or strain the value is $6.08x10^{-9}$. for Displacement or deflection, it can be 3 x 10^{-5} mm. And finally, the safety factor that is obtained is 1 x 10^{6} .

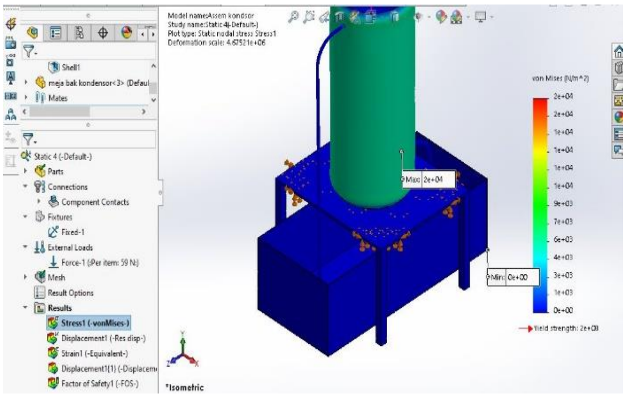

Figure 5. Stress Kondensor

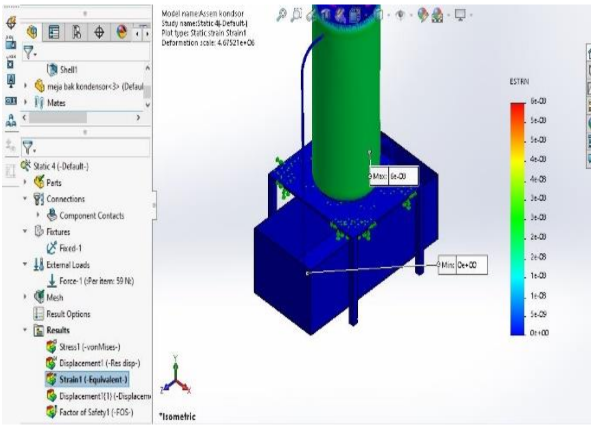

Figure 6. Strain Kondensor

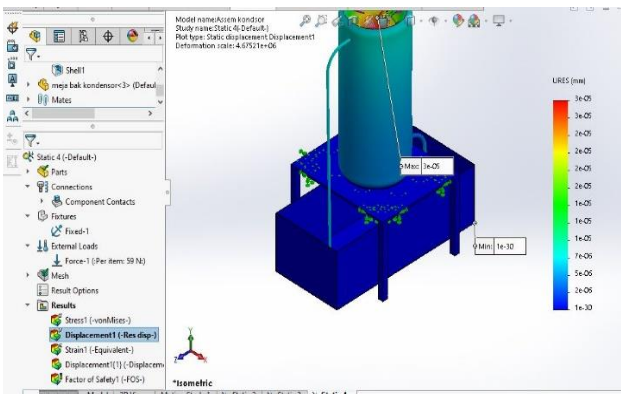

Figure. 7 Displacement kondensor

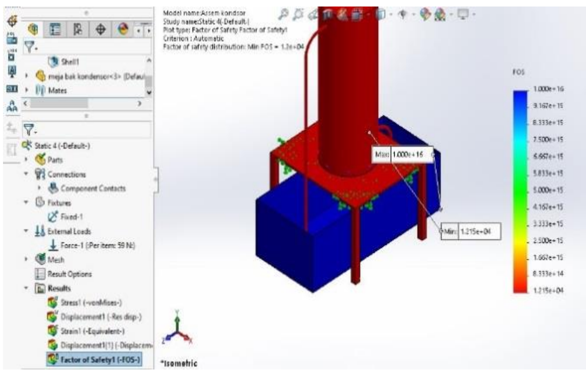

Figure 8 Factor of Safety kondensor

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Condenser On the part of the biomass reactor used is coconut shell with the mass of the coconut shell is 10 Kg. The magnitude of the force from the biomass load is:

F : m x g

F : 10 Kg x 10 m/s^2 : 10 N

Through the process of manual calculation that we first seek first pressure is the formula :

$$p = \frac{F}{A} = \frac{F}{2\pi r(r+t)} = \frac{10\ N}{2\pi 200mm(200+600)} = \frac{10\ N}{1.0048\ m2} = 9{,}95\ N/m^2$$

After getting the pressure, then looking for tangential stress, namely by calculating

$$\sigma l = \frac{pD}{4t} = \frac{9{,}95\frac{N}{m2}\ x400\ mm}{4x2\ mm} = 497{,}5\ N/m^2$$

The results of the simulation after a given force of 10 N is the *stress* can result in a maximum voltage that is equal to 321 Mpa, at the side of the cross section of biomass. In the strain or strain, the results are 8x10^{-6} . For displacement or deflection, the result is 0.09 mm. and the latter is the safety factor of 65.

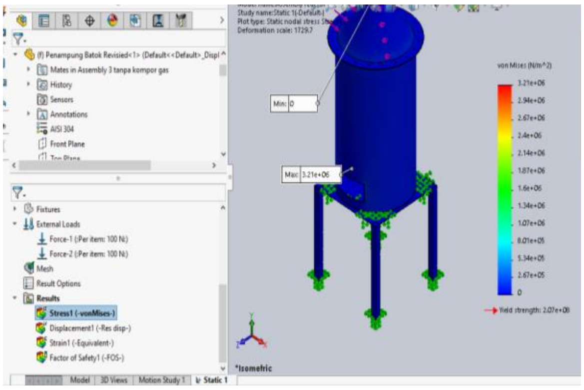

Figure 9. Stress reactor

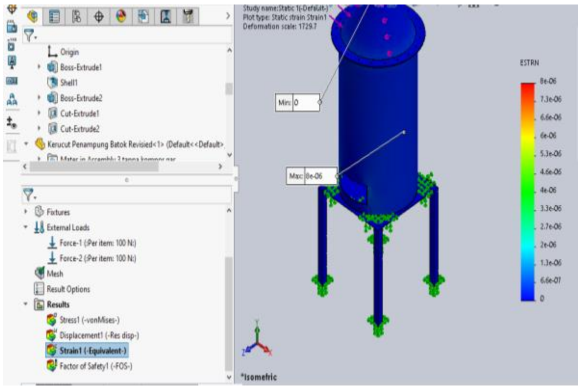

Figure 10. Strain reaktor

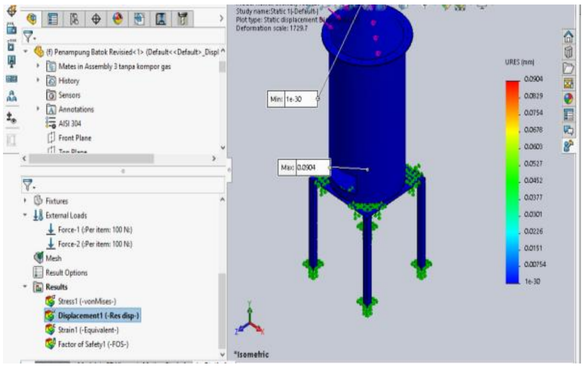

Figure 11. Displacement reactor

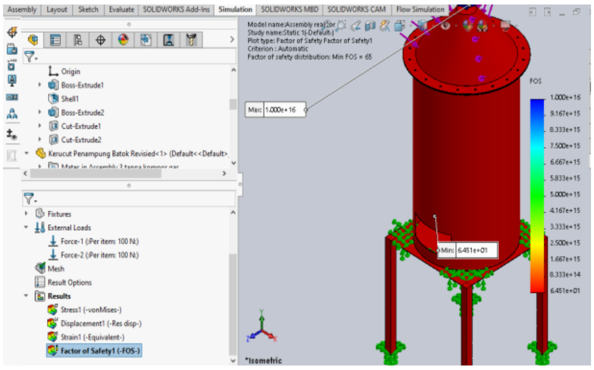

Figure 12. Safety factors reaktor

4. Conclusion

From the simulation results in the condenser get the maximum voltage that is 2x10^4 N / m^{2,} For the *strain* or strain the value is 6.08x10^{-9} . for Displacem.ent or deflection, it can be 3 x 10 $^{-5}$ mm. safety factor in the can that is 1 x 10 ^{6} For tangential stress in getting that 11.05 N / m$^{2\cdot}$In thereactor *stress* , the maximum stress is 321 MPa. The strain is 8x10^{-6} . For displacement or deflection, the result is 0.09 mm. and the last is the safety factor, the result is 65, for the longitudinal stress that is produced is 1.65 N / m^2. In the material selection series, it can be concluded that the suitable material for use in liquid smoke is Stainless Steel AISI 304. Thermal Conductivity: 16.2 (W / mK), Maximal Service Temperature: 750 (^{o}C), Density: 8 (g / cc), Yield Strength: 215 (Mpa).

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