Evaluation of Recyclability through Pyrolysis of Composite Lashing bar

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INTRODUCTION

Lashing bar

- A lashing bar is a device used to fix containers on a container ship, and is fixed through tension applied to the lashing bar
- The lashing bar is made of metal and used, but due to its heavy weight during use, great damage occurs in the event of a safety accident
- In order to suppress accidents, we are researching the manufacturing of lacing bars using composite materials with light weight and high mechanical properties

<Lashing bar>

- **Comparison**

	Steel	Composites
Tensile Strength	100 MPa	200 MPa
Specific Gravity	7.8	2.0
Corrosion	10 Years	50 Years
Weight	20 kg	10 kg

Recycling of CFRP

- Recycling of CFRP is being studied in various ways dueto the high price of CF
- Common recycling methods can be divided into three categories
  : mechanical recycling, chemical process, pyrolysis
- Mechanical grinding or milling is not suitable for high-priced carbon fiber because it causes a lot of damage, and research through pyrolysis and chemical methods is being actively conducted
- Pyrolysis was carried out to confirm the thermal stability of the composite lashing bar and to evaluate its recyclability after use

- **Pros and cons**

Adventages	Disadvantages
- Existing commercial equipment	- Resin residue on the fiber surface
- Energy recovery from resin	- Large process variation depending on fiber type
- Excellent adhesion between rCF and epoxy	- Requires gas processing device

- Realization of pyrolysis using an electric furnace
- This equipment can raise the temperature to about 1100 ℃

EXPERIMENT

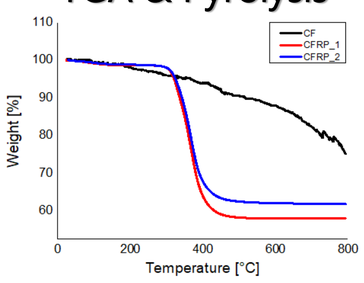
- **TGA Condition**
  - Dynamic ramp type
  - Heating rate
    : 10 ℃ / min
  - Check weight loss

- **Pyrolysis Condition**
  - Decision based on TGA results
    : 300, 400 ℃, 8 ℃ / min
  - Faild evaluation 300 ℃
  - Proceed at 400 ℃ to complete

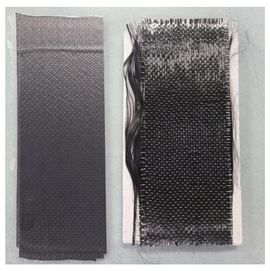
- **SEM-EDS Condition**
  - Working condition
    : 23 ℃, 53 % RH
  - Check surface condition by SEM
  - Surafce composition analysis using EDS

RESULT

- **TGA & Pyrolysis**



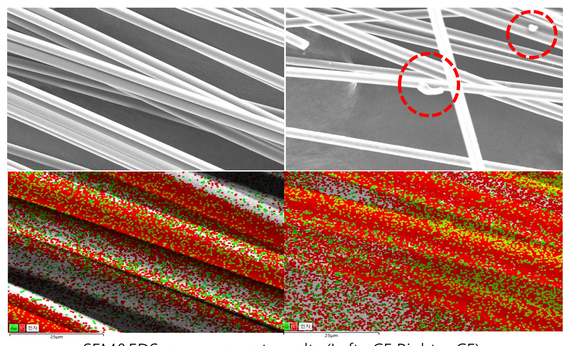
<TGA measurement results>



<Pyrolysis results(400 ℃, 3 hr)>

- 300 ℃ : Resin decomposition occurs
- pyrolysis was carried out at 300 ℃, but the resin was not completely decomposed, so the test was completed by pyrolysis at 400 ℃

- **SEM-EDS**



<SEM&EDS measurement results (Left : CF Right : rCF)>

- SEM-EDS CF Result

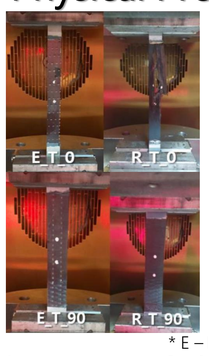
Element	Line type	Weight %	Weight % σ	atom %
C	K series	92.61	-	92.61
Au	K series	7.39	-	7.39

- SEM-EDS rCF Result

Element	Line type	Weight %	Weight % σ	atom %
C	K series	83.36	0.36	88.81
O	K series	13.63	0.35	10.90

- Looking at the SEM results, resin remains on the surface compared to the initial fiber
- Other than that, there is no significant difference when looking at the surface
- EDS results show that a lot of O is generated on the surface during the pyrolysis process
- It can be seen that oxidation has occurred in the fiber

- **Physical Properties**



		E_T_0	E_T_90	E_I_0	E_I_90
Max Load	[kN]	35.89	1.64	9.29	1.47
Max Str.	[Mpa]	1608.45	42.20	60.42	9.51
		R_T_0	R_T_90	R_I_0	R_I_90
Max Load	[kN]	39.94	1.03	5.52	0.79
Max Str.	[Mpa]	1000.15	27.98	39.53	5.85

* E – Pyrolysis X / R- Pyrolysis O / T - Tensile / I - ILSS

- Changes in failure patterns before and after pyrolysis
- Max strength value decreases overall after pyrolysis

CONCLUSION

- ✓ As a result of the TGA measurement, a weight loss is shown at around 320 ° C. The weight loss section appearing after 600 ° C is considered to be the decomposition of carbon fiber
- ✓ As a result of the SEM measurement, it was confirmed that the resin was completely removed from the fiber surface during the pyrolysis process, and as a result of the EDS result, a lot of O was generated on the surface, indicating that the fiber itself had been oxidized
- ✓ The pyrolysis test on CFRP is expected to be used as a material for recycling synthetic lashing bars in the future
- ✓ Decomposition temperature and time must be controlled to minimize surface oxidation and property degradation
- ✓ Based on this, we plan to carry out a recovery study on CFRP that is not usable in ther future

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