DEVELOPMENT OF RADIATION CURING TECHNOLOGY OF POLYMER MATRIX COMPOSITES BY JAPANESE NATIONAL PROJECT ON ADVANCED MATERIALS AND PROCESS DEVELOPMENT FOR NEXT GENERATION AIRCRAFT STRUCTURES

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Abstract

The research and development project on advanced composite materials & process development for next generation aircraft structures has been performed since FY2003 as a 5-year Ministry of Economy, Trade and Industry (METI) program in Japan. This project aims to develop innovative lightweight materials & process technologies for civil aircraft structures and consists of 3 technical areas, radiation-curing technology of polymer matrix composites (PMC) structures, structural health monitoring (SHM) technology of PMC structures, and advanced magnesium alloy technology.
In radiation-curing technology, matrix resin system, fabrication process and structure member production technology are being developed about electron beam (EB) curing, ultraviolet (UV) curing and visible light curing.

In this paper, we introduce briefly the activities and typical results up to FY2005 on radiation-curing technology of polymer matrix composites (PMC) to be used as structural materials

1. Introduction

The project has performed since FY2003 as a 5-year METI program in Japan. This project aims to develop innovative lightweight materials & process technologies for civil aircraft structures and consists of 3 technical areas, radiation-curing technology of polymer matrix composites (PMC) structures,
structural health monitoring (SHM) technology of PMC structures, and advanced magnesium alloy technology.

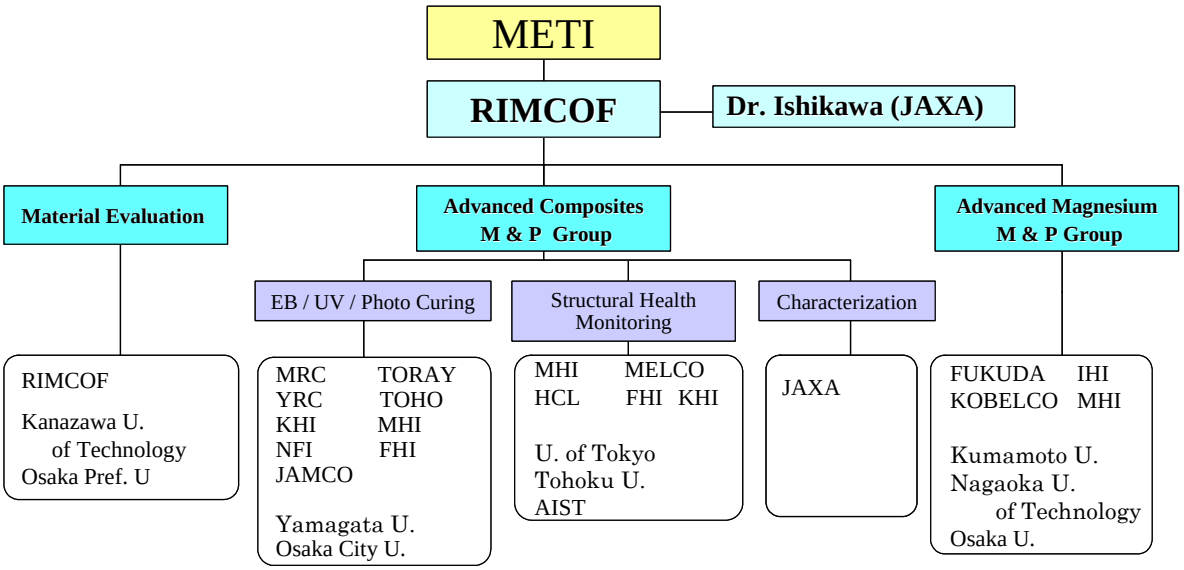

Table 1.Project Schedule

	2003	2004	2005	2006	2007
(1) General Research・Data Base	← General Research・Data Base →				
(2) Advanced Composites M & P Dev.					
① EB / UV / Photo Curing Process	← M & P →			← Components →	
② Structural Health Monitoring	← Sensors →			← Systems →	
③ Characterization	← Materials →			← Components →	
(3) Advanced Mg Alloy M & P Dev.	← M & P →			← Components →	

Fig.1 shows the functional organization of the project in which research activities are conducted with close cooperation among industries, universities and governmental institutes. Table1 shows the schedule of the 5-years project.

2. Development of radiation curing technology of PMC structures

This work aims to reduce the fabrication cost of PMC by applying innovative radiation curing processes instead of autoclave curing. The radiation curing process is superior to autoclave curing in curing time, cost of fabrication jigs etc. They have also advantages in size and dimensional accuracy of cured structures.

In first 3 years, the materials (resin systems, prepregs) for radiation curing and radiation curing processes including electron beam (EB) curing, ultraviolet (UV) curing and visible light curing are being developed. In latter 2 years, the trial manufacturing and the evaluation for model parts will be performed.

The primary target of this work is to achieve 40% cost saving compared with conventional autoclave curing.

2.1 EB curing process for aircraft structure

Advanced pultrusion (ADP) is one of the non-autoclave processes for long beams such as stringers and floor beams. It reduces fabrication cost, but fabrication time cannot be reduced as long as thermal curing is applied. EB cure is a key process to shorten the cure time of composites parts.
By using high power EB, curing is completed within a few seconds and high-speed low cost fabrication can be achieved. In this work, EB curable resin system and EB curing (EBC) process suitable for ADP has been developed. Fig.2 shows the concept of ADP by EBcuring process.

EB cured laminates showed higher than 80% of mechanical properties compared with thermal cured laminates except in-plane shear strength.

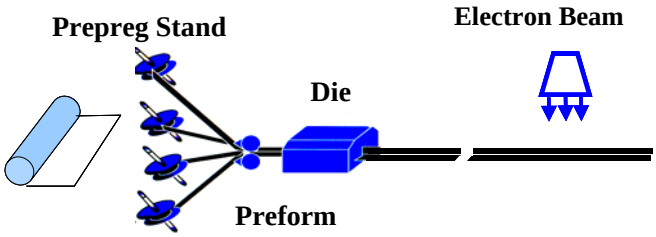

Fig.2.Concept of ADP by EB curing process

2.2 UV curing process for aircraft structure

There is no UV curing resin system/prepreg that is applicable for PMC due to the fact that UV light doesn't transmit carbon fiber.

In this work, resin system/prepreg suitable for UV-curing process has been developed. UV-curing process has also been developed with two composite fabricating technologies, Resin Transfer Molding (RTM) and Filament Winding (FW).

Fig.3 shows a schematic image of RTM/chain-curing fabrication process[1]. After the chain-curable resin is injected into carbon
fabric, only a few minutes of UV irradiation at one side of the mold is enough to achieve the complete cure of the part. At first, UV cure of the resin occurs at the irradiated point, then the self-generated heat of polymerization leads to the continuous thermal cure.

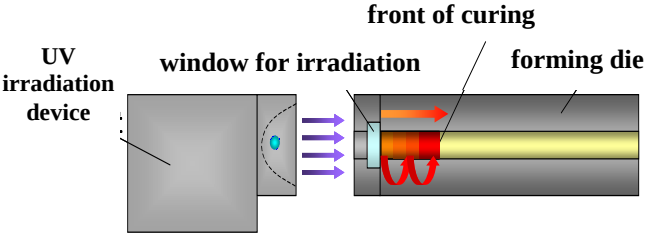

Fig.3. Schematic image of RTM/chain-curing fabrication process

Using this technique, a Z-section composite frame member shown in Fig.4 was experimentally produced. 1000 mm long composite with 50% fiber volume fraction was chain-cured in about 10 minutes.

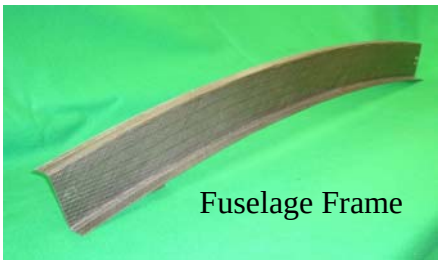

Fig.4. Trial composite parts fabricated by RTM/chain-curing process

Fig.5.shows the trial composite parts by FW and UV curing process. The diameter is 800mm and the thickness is 3mm.

Fig.5. Trial composite parts fabricated by FW/UV-curing process

2.3 Visible light curing process for aircraft structure

Though visible light curing process has a possibility to realize cost reduction due to high safety compared with above 2 processes, the development of resin system is very important due to a disadvantage of low energy. In this work, visible light curing process is being developed.

It is expected that this process can be applied to the repair of composite structures as well as the fabrication of thin structures such as empennage.

3. Conclusion

The radiation curing technology of PMC being carried out as a national project on development of advanced composite materials & process for next generation aircraft structure was overviewed. It is expected that the high performance and high reliable aircraft composite structure can be provided with low fabrication cost by the technologies developed in this project.

Acknowledgement

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References

[1] K.Hasegawa et al, “Development on Aircraft Composite Structures by UV-curing Process Technologies”, *Proceeding of the Ninth Japan International SAMPE Symposium,Tokyo, (2005)*