Utilization of PCM technology with various applications of commercial production vehicle

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Advantage of PCM

Rapid cure prepreg
Cures in 3-5 minutes
Suitable for compression molding

Excellent Surface Quality
Paint ready Class A surface
Exposed carbon weave

Automation Ready Molding Process
Preforming by press forming
Efficient compression molding

Prepreg / SMC Hybrid
3D complex shape with excellent mechanical property
Material for PCM Technology

- **Rapid cure prepreg**
  - 3 - 5 minutes cure at 140 °C

- **Resin optimized for compression molding**
  - High viscosity at molding temperature
  - Tg higher than tool temperature

*Viscosity at elevated temperature*

*DMA*

- Conventional prepreg
- PCM prepreg

*The Kaiteki Company* Mitsubishi Chemical Holdings Group
Engine Hood Model Part

- PCM prepreg gives excellent surface quality
  - UD prepreg gives smooth pinhole free Class A surface
  - Weave prepreg is good for aesthetic applications

  **Body color painted part**
  - #360 UD Prepreg
  - Cross ply (0/90/0/90/0) 1.1mm thick
  - Paint: Primer/Base/Clear Top
    - Total 100 micrometer thick
    - Three bake at 120°C for 30 minutes

  **Clear coat painted carbon fabric look part**
  - #360 2X2 twill prepreg
  - Twill + Cross ply total 1.3mm thick
  - Paint: Clear Primer/Clear Top
    - Total 70 micrometer thick
    - One bake at 120°C for 30 minutes

MITSUBISHI RAYON CO., LTD.
SMC / PCM Hybrid Molding

PCM
UD and/or Fabric
Prepreg

Hybrid Molding
UD and/or Fabric
Prepreg + SMC

100% mold coverage, preform recommended

Charge
Press
De-mold

Molds complex shape with SMC

SMC
Structural Model Parts Development

- Structural floor demonstration by PCM/SMC hybrid
  - Prepreg achieved high strength and consistency
  - CF-SMC molded complex shape

**Structural floor model**
Size: 500X500mm

Ribs and boss were molded with CF-SMC. A metal insert was molded-in

CF-SMC was charged on the preform, where 3D shape to be formed on the part
Nissan R35 GT-R CFRP Deck Lid

- CFRP deck lid was developed by PCM technology.
  - Outer panel; UD prepreg
    - 5 plies (Cross ply) 1.1mm thick
    - Body color paint for Class A surface
  - Inner panel; 3K plain weave fabric prepreg
    - 3 plies 0.6mm thick
    - Clear coat for exposed carbon fiber
  - Bonded with epoxy adhesive
  - CFRP deck lid is 40% lighter than Al deck lid.
    - Aluminum; 4.1kg, CFRP; 2.4kg
High cycle preforming process
- Cycle time shall match compression molding
  - Equipment
  - Process parameters
- Optimization of part design for press forming
  - Good drapability
  - Structural requirement

Compression molding
- High cycle molding process
  - Automation-ready procedures
  - Tool design, Molding parameters

Bonding
- Epoxy adhesive
  - Applied by robot
Darapability Analysis of Inner Panel

- Prototype part was designed based on the original aluminum part
  - Mechanical properties met requirement
  - Drapability for press forming was insufficient
    - Design modification of inner panel was necessary

Preliminary design based on original Aluminum part

Drapability analysis by FiberSim

Red color indicates where large shear will occur to fit prepreg to the geometry
Cause of Wrinkles

- The length of red colored line was shorter than that of blue colored line.
  ⇒ Prepreg on the red colored line remained in excessive amount.
  ⇒ Some wrinkles formed in red portion.
- Design was changed to extend length and prevent wrinkles.
Design of inner panel was modified by FiberSim analysis so it could be molded by press molding.
Design of CFRP Deck Lid

- Design of CFRP deck lid was verified by static FEM analysis to confirm if it has equal properties to original aluminum deck lid
  - Prepreg lay up design
  - Bonding design of outer and inner panel
  - Fixture installation

- Deck lid design was also evaluated by dynamic FEM analysis to make sure it exhibits appropriate failure mode

- Parts design was validated by series of actual parts test, including crash test
Example of FEM Analysis

Design of CFRP deck lid was verified by FEM analysis to confirm if it has equal properties to original aluminum deck lid
(Prepreg lay up, Bonding of outer and inner panels, Fixture installation)

- Torsional Rigidity
  Deformation when one corner of deck lid is lifted

- Stiffness type A
  Deformation when heavy baggage is put on the deck lid

- Stiffness type B
  Dent resistance against local load such as by human elbow

- Stiffness type C
  Deformation by load from wing spoiler
Result of FEM Analysis

- **Torsional rigidity**
  - Deformation when one corner of deck lid is lifted
    - CFRP: Max. Displacement: 13.6mm
    - Aluminum: Max. Displacement: 13.9mm

- **Stiffness type A**
  - Deformation when heavy baggage is put on the deck lid
    - CFRP: Max. Displacement: 0.61mm
    - Aluminum: Max. Displacement: 2.59mm

Fixed Load 125N

Load; 196N
Area; 300mm × 400mm
Result of FEM Analysis

- **Stiffness type B**
  - Dent resistance against local load such as by human elbow
    - CFRP: Max. Displacement: 12.4mm
    - Aluminum: Max. Displacement: 14.6mm

- **Stiffness type C**
  - Deformation by load from wing spoiler
    - CFRP: Max. Displacement: 4.83mm
    - Aluminum: Max. Displacement: 12.1mm

Load: 686N
Area: 50mm²
Load: 25kg
Area: 0.02mm²
Load: 50kg
Area: 0.04m²
Crush Test for Collision Safety

- Deck lid didn’t detach after compressing it up to required stroke.
  - Fastened structure assures safety of deck lid after collision.
Deck Lid for 2014 GT-R

- PCM deck lid was adopted to two high performance models

GT-R 2014 (Factory option) | GT-R NISMO
In order to enhance driving performance, large spoiler is attached on GT-R NISMO.

- Large load from spoiler leads to large deformation of the deck lid
- Fixed structure is required to better endure large load.

Max. Displacement: 1.3mm
Verification of Fatigue Resistance

- **Deck lid**
  - Max. Displacement: 1.3mm
  - Verify by using specimens with the same structure as actual part.

- **Specimens**
  - Load span: 120mm
  - Outer 1.1mm
  - Inner 0.6mm
  - Adhesive
  - Reinforcement

Fatigue property (Load-Number curve)

Load-Displacement curve

Load at actual Max. deformation

Confirm whether deck lid breaks or not in terms of fatigue property
Load-Displacement Curve

Maximum displacement: 7.3mm (maximum load: 1448N)
Maximum load is 275N when displacement is 1.3mm
The value of fatigue load is much higher than that of load which is simulated from actual deformation.

- Deck lid did not break after fatigue.
Production of GT-R Deck Lid by PCM

- **Preforming by press forming**
  - Automation ready, 5 minute cycle time
- **Compression molding by 1000 ton press**
  - Automation ready process
  - Steel tool; 140°C, Pressure; 8MPa, 5 minutes cure
- **Bonding**
  - Robot applies adhesive in a few minutes
  - Epoxy adhesive; 100°C, 30 minutes cure

By Courtesy of **Challence**
Production of GT-R Deck Lid by PCM

PCM Technology
Production of NISSAN GT-R Trunk Lid
GT-R Interior Parts

- Decorative covers for air conditioner and audio control
  - Used for all GT-R models since 2011
    - Net shape molding by PCM technology, 5 minutes cure
    - 2 plies of 3K 2X2 twill weave prepreg, 0.45 mm thick
    - Exposed carbon parts with clear coat
Porsche 918 PCM applications

- Porsche 918 uses CFRP under floor consist of 5 parts
  - Used for all GT-R models since 2011
    - Net shape molding by PCM technology, 5 minutes cure
Porsche 918 PCM hydraulic cover

- Hydraulic Cover; Molded by PCM process
  - Size: 650mm x 300mm, Weight: 0.5 kg, Rapid cure UD prepreg
  - Automated preforming process followed by Compression molding
Porsche 918 PCM under floor

- Under floor; Molded by PCM process
  - Size: 1800mm x 1800mm, Weight: 6.5 kg, Rapid cure UD prepreg
  - Light weight sandwich core structure
To a world standard.

Mitsubishi Rayon is one of the world’s leading suppliers of carbon fibre. Our driving force is our integrated production system – raw material to finished product – which enables us to respond quickly to changing market needs. Our new range of P330 carbon fibres is an example of this response in action with a fibre that offers high strength and resilience plus volume production. The standards set by Mitsubishi are endorsed by customers throughout the world.