Greene Tweed

STRUCTURAL COMPONENTS

Xycomp® Composite Impeller

High-speed centrifugal compression for hydrogen and light gas

New Industry Benchmark for Hydrogen

As the global hydrogen economy expands, industry faces a critical infrastructure bottleneck. Standard reciprocating and diaphragm compressors struggle to achieve the high mass-flow rates necessary for industrial-scale adoption. While centrifugal compressors offer the continuous flow and high throughput needed for utility-scale networks, hydrogen's exceptionally low molecular weight presents a physical challenge. To reach meaningful pressure ratios, hydrogen compressors must push impeller velocities to the extreme, surpassing 600 m/s, which is nearly double the speed required for natural gas. At these speeds, the density of traditional metal impellers generates destructive centrifugal forces, making them unsuitable for pure hydrogen service.

Greene Tweed engineers developed the Xycomp® Composite Impeller to overcome these physics-based limitations. Crafted from our proprietary Xycomp® thermoplastic composites, this impeller combines a PEEK matrix with continuous carbon fiber to achieve a superior strength-to-weight ratio. This advanced lightweight design allows the impeller to operate safely at extreme rotational speeds, generating the necessary pressure rise without succumbing to the mechanical stresses that cause metallic impeller failure. On its third design iteration, the impeller achieved a record-breaking tip speed of 688 m/s (47,800 RPM, Ø275mm), setting a new standard for performance and reliability in hydrogen compression applications.

With only three iterations, Greene Tweed demonstrated that impellers made from C/PEEK composites combined with the right design and optimized processing parameters, can spin fast enough to compress pure hydrogen in a multistage centrifugal compressor. We are currently developing more complex geometries in collaboration with several compressor OEMs to bring this technology to real-world applications.

Features and Benefits

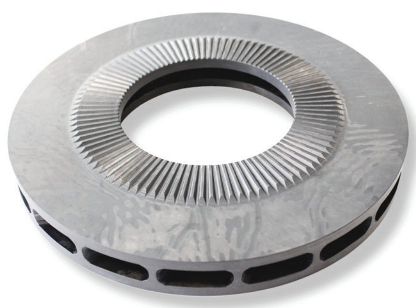
- **High-Speed Capability**
  Proven to reach a record-breaking tip speed of 688 m/s, nearly double that of traditional metallic impellers.
- **Significantly Reduced Weight**
  Up to five times lighter than conventional metallic impellers, reducing rotational mass and inertia.
- **Superior Strength-to-Weight Ratio**
  Xycomp® composites offer three times the strength-to-weight ratio of metal designs.
- **Optimized Material Composition**
  Utilizes Xycomp® thermoplastic composites with a PEEK matrix and continuous carbon fiber for maximum reliability and hydrogen compatibility.
- **Scalable Efficiency**
  Enables the use of centrifugal compressors for utility-scale infrastructure, removing bottlenecks associated with positive displacement designs.

Applications

- Centrifugal Hydrogen Compressors
- Utility-Scale Pipeline Networks
- Light gas compression applications

1st Impeller Design
(Failed at 500 m/s)

2nd Impeller Design
(Failed at 534 m/s)



3rd Impeller Design
(Failed at 688 m/s)

By replacing metallic components with advanced composites, Xycomp® technology unlocks the potential of centrifugal compressors for the hydrogen sector. This innovation enables operators to build efficient, scalable, and safe transport systems, supporting global decarbonization goals by making high-volume hydrogen infrastructure a practical reality.

Xycomp® Materials

The impeller is made from GT's Xycomp® thermoplastic composite product line. Continuous carbon fiber and a PEEK matrix were selected. From a fiber perspective, the current impeller design utilizes a combination of carbon fiber orientations and types. Both unidirectional and quasi-isotropic lay-ups are present, allowing designers to optimize directional strength where needed. Considerable focus was placed on testing and down-selecting an optimized z-strength (ILT) material.

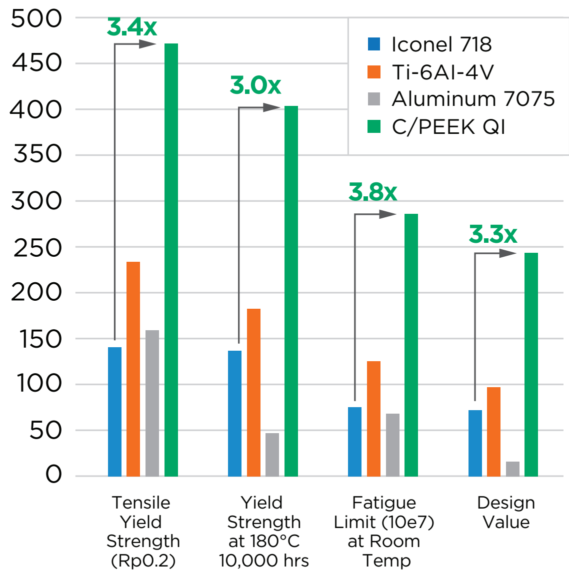
Processing occurs at GT's Switzerland facility, via a modified compression molding approach. Individual components are molded separately and then remolded into a single solidified composite impeller. Processing trials via coupon shear testing were conducted to find the optimal molding process.

COMPARATIVE PROPERTIES OF C/PEEK TO HIGH END METALS

	Iconel 718	Titanium Ti-6Al-4V	Aluminum 7075-T6	C/PEEK QI
Density, g/cm^3	8.20	4.43	2.80	1.59
Modulus, GPa	206	115	72	53
Tensile Yield Strength (Rp0.2), MPa	1140	1040	470	750
Yield Strength at 180°C, after 10,000 hrs Exposure, MPa	1100	800	125	637
Fatigue Limit S-N (10e7), MPa	621	552	195	450
Design Value (Assuming Fatigue, HT and Creep are Cumulative), MPa	600	424	52	382
Charpy V-Notch, J	33	22	8.5	9.3
SPECIFIC PROPERTIES				
Modulus, $GPa/(g.cm^3)$	25	26	26	32
Tensile Yield Strength (Rp0.2), $MPa/(g.cm^3)$	139	235	168	475
Fatigue Limit (10e7) at Room Temp	134	181	45	403
Fatigue Limit S-N (10e7), $MPa/(g.cm^3)$	76	125	70	285
Design Value (Assuming Fatigue, HT and Creep are Cumulative)	73	96	19	242

C/PEEK composite with a QI lay-up $[(0/45/90/-45)_n]_s$ has over 3x higher specific strength, fatigue limit, and design value than Iconel 718

Specific Properties (1/Density)



API Standard 617 — Chapter 1

2.2.1.9 Materials that have a yield strength in excess of 827 MPa (120,000 psi) or hardness in excess of Rockwell C 34 are prohibited for use in hydrogen gas service where the partial pressure of hydrogen exceeds 689 kPa (100 psi gauge) or the hydrogen concentration exceeds 90 molar percent at any pressure.

Greene Tweed

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