National Aeronautics and Space Administration

Innovative Manufacturing of Launch Vehicle Structures - Integrally Stiffened Cylinder Process -

NASAfacts

Reducing launch costs is essential to ensuring the success of NASA's visions for planetary exploration and earth science, economical support of the International Space Station, and competitiveness of the U.S. commercial launch industry. Reducing launch vehicle manufacturing cost supports NASA's budget and technology development priorities.

Manufacturing of the Shuttle external cryogenic propellant tank relied on multi-piece machined and welded construction using technology developed in the 1950's. It was expensive, time consuming, and environmentally unfriendly. Welding increased tank weight and risk. This manufacturing technology remains the baseline for NASA's Space Launch System and commercial launch system cryotanks.

Slotted mandrel for forming 10-foot diameter integrally stiffened cylinder in 2017.

NASA Langley Research Center (LaRC) is developing innovative spin/flow forming technology that could revolutionize cryogenic tank fabrication by producing a net shape tank with internal stiffeners in one forming operation. This eliminates the need for expensive machining and longitudinal welding of the cryogenic tank barrel sections. The integrally stiffened cylinder (ISC) advanced manufacturing technology will replace conventional multi-piece construction, realizing up to 50% reduction in the cost to manufacture launch vehicle cryogenic tanks with an associated 10% reduction in vehicle mass.[1] While targeted for cryogenic tanks, ISC technology will also benefit manufacture of launch vehicle intertank and dry bay structures, sounding rockets, and missile bodies.

Integrally stiffened cylinder successfully flown on sounding rocket in 2015.

Ongoing work aims to optimize and scale up the ISC process to fabricate aerospace quality aluminum alloy cryogenic tanks at commercial launch vehicle sizes. The goal is to form large, net shape cryogenic tank walls (skin) and stiffeners in one forming operation. NASA is teaming with the European Space Agency (ESA) and U.S. and international industry partners to manufacture 10-foot diameter prototype stiffened cryogenic tank barrel segments using the ISC process. Successful demonstration will pave the way for infusion of ISC technology into the U.S. and European launch vehicle industries.

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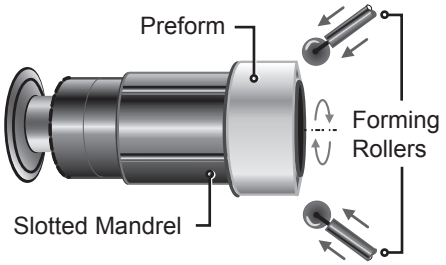
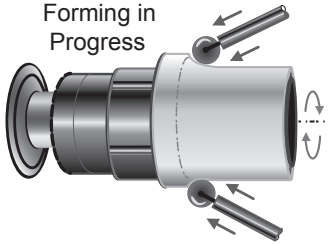
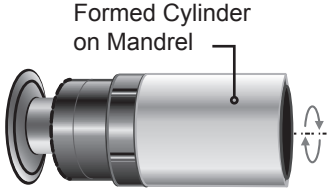
[1] "Cost-Benefit Analysis for the Advanced Near Net Shape Technology (ANNST) Method for Fabricating Stiffened Cylinders." *NASA TM-2016-219192*

Integrally Stiffened Cylinder Process



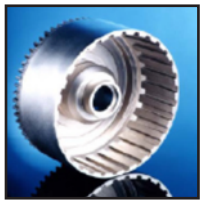




Formed Integrally Stiffened Cylinder

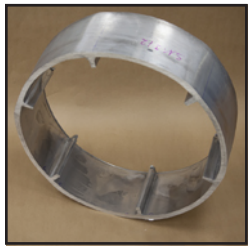
In the ISC process, a rotating ring shaped preform is formed over a cylindrical mandrel which has slots that correspond to the stiffener shape. Metal flows into the slots to form the stiffeners on the inside as the cylinder takes shape.

Integrally Stiffened Cylinder Process Development - Lab to Launch in Four Years -



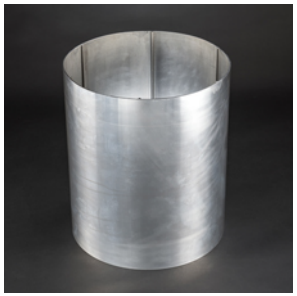
Automotive Steel Clutch Housing (8 in. dia.)

Transition to Aerospace



Aluminum Cylinder with 1 Inch Tall Stiffeners (17 in. dia.)

Sounding Rocket Flight Qualification



Sounding Rocket Segment (17 in. dia.; 20 in. long)

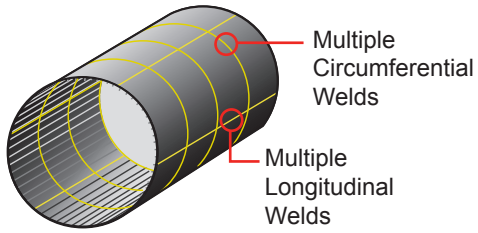
Successful Flight Demonstration

Sounding Rocket Launch October 2015

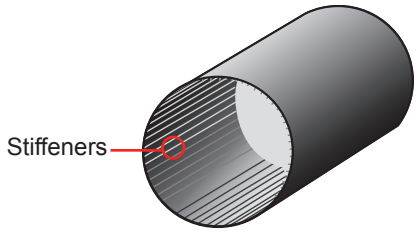
The ISC process is an adaptation of an automotive manufacturing method to make steel clutch housings. NASA LaRC optimized this technology to form aerospace aluminum alloys and demonstrated stiffener sizes and shapes required for cryogenic tanks. Initial process scale up resulted in successful manufacture and flight of an integrally stiffened sounding rocket payload segment.

Comparison of Manufacturing Technologies

Conventional Fabrication
- Multi-Piece, Welded Construction -



Integrally Stiffened Cylinder Process
- Single-Piece, Net Shape Construction -



The ISC process eliminates all longitudinal welds and reduces the number of circumferential welds required to assemble a cryogenic tank barrel.

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FS-2017-03-278-LaRC.

NASA Facts