POSTPROCESS
Automated. Intelligent. Comprehensive.

CASE STUDY

Ingersoll Rand
Inspiring Progress™

THE SITUATION

Efficiency is everything at Ingersoll Rand. The $14 billion global industrial manufacturing giant has been a leader in compressed air technologies for 145+ years largely because of its relentless focus on creating comfortable, sustainable, and efficient environments. When you're that good, the bar to get better is high.

THE OPPORTUNITY

The engineers at Ingersoll Rand recognized a key efficiency opportunity to move beyond standard open impeller designs to a shrouded impeller design. Open impeller designs require clearance between the impeller and stationary inlet. The challenge is that compression gas recirculates in that clearance space creating a slip loss. This results in reduced efficiency and performance. Shrouded impellers eliminate these slip losses, thereby improving the overall performance of the total compressor package.

But shrouded impellers are inherently difficult to manufacture. With impellers rotating at 60,000 RPM, the design has very tight tolerances to meet aerodynamic testing and the welding process required for the shrouded impellers restricts the aerodynamic design of the blades. The blades further require excellent surface finishing to optimize aerodynamic performance. More troubling, issues with welding and surface finish impacting performance often reveal themselves during quality control (QA), creating significant rework. It can take months to successfully build a shrouded impeller using traditional manufacturing techniques.

"We have chosen the DECI Duo because of its repeatability, minimal setup, processing times, and cost of ownership"

Ioannis Hatziprokopiou
Mechanical Engineer
New Product Development
Ingersoll Rand Compression Technologies and Services

Additive Manufactured Shrouded Impeller

The Ingersoll engineering team was tasked with commercializing a shrouded impeller design using Additive Manufacturing (AM). AM offered a compelling solution - complete design freedom and the ability to build a shrouded impeller as a monolithic part, eliminating the problematic welding.

THE PROBLEM

AM brings its own challenges. Aerodynamic performance fundamentally depends on the level and consistency of surface finish. Computational Fluid Dynamic (CFD) calculations for boundary layer formation and other flow requirements use surface finish values, and surface roughness and inconsistencies invisible to the eye will compromise results. Outstanding **surface finishes are essential to meet performance thresholds**.

At Ingersoll, the shrouded impellers are made from titanium and nickel alloy and arrive off the 3D printer at an R_a (roughness average) value that does not meet the specifications from the engineering team. The problem is compounded within the long internal channels that measure less than 0.5-inch (12.7 mm) width and 5-7 inches (127-177.8 mm) length. The Ingersoll engineering team has employed multiple surface enhancement methods including manual sanding, grinding tools, chemical etching, and combinations thereof. The results distantly lacked the quality and consistency required to meet Ingersoll's exacting standards. These are inconsistent, non-repeatable processes that are unable to consistently produce end parts within the specifications required.

What Ingersoll needed was a replicable way to achieve exacting surface finish requirements on the complex geometry of its shrouded impeller to drive a measurable increase in efficiency for its advanced air compressors.

THE POSTPROCESS SOLUTION

Ingersoll brought its dilemma to PostProcess. The requirement was to deliver excellent surface finish standards and repeatable results to an exacting requirement, while working with complex metal part geometries including internal channels and organic shapes.

PostProcess' automated Hybrid DECI Duo was the ideal choice for this challenge. The DECI Duo uses PostProcess' proprietary AUTOMAT3D™ software to optimize a combination of energy and exclusive chemistry including detergents and suspended solids, which ensures the geometries have the desired surface finish while preserving fine-feature details.

Using benchmark parts to establish operating settings that met Ingersoll's exacting standards, the PostProcess solution was able to consistently finish parts that passed aerodynamic testing with flying colors. The DECI Duo produced an average of **70-80% reduction in R_a for parts run for 20 minutes or less**.

While Ingersoll's high quality and consistency requirements led them to PostProcess, the ease of operations and cost savings are seen as significant additional advantages.

"We have chosen the DECI Duo because of its repeatability, minimal setup, processing times, and cost of ownership. Photochemical machining, extrude honing, and micro polishing or micro machining all yield very good results when applied correctly, however extensive tooling and equipment costs, setup times, and required DOE's prior to applying the surface finishing method to obtain a repeatable process have made the DECI Duo a better option.

In addition, some of aforementioned finishing techniques unevenly remove material inside the flow path of the impeller, whereas the DECI Duo uniformly treats the entire surface of the flow path. The final geometry of the flow path must remain as unaltered as possible after post-processing of any kind"

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Mechanical Engineer
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Additive Manufactured shrouded impellers were implemented on the last three stages of this six stage 6R3MSGEP+4/30 engineered air booster machine seen below. This single process multi-stage geared centrifugal compressor has a final discharge pressure of approximately 1100 psig.

Exacting Surface Finishing of Complex 3D Printed Metal Geometries

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