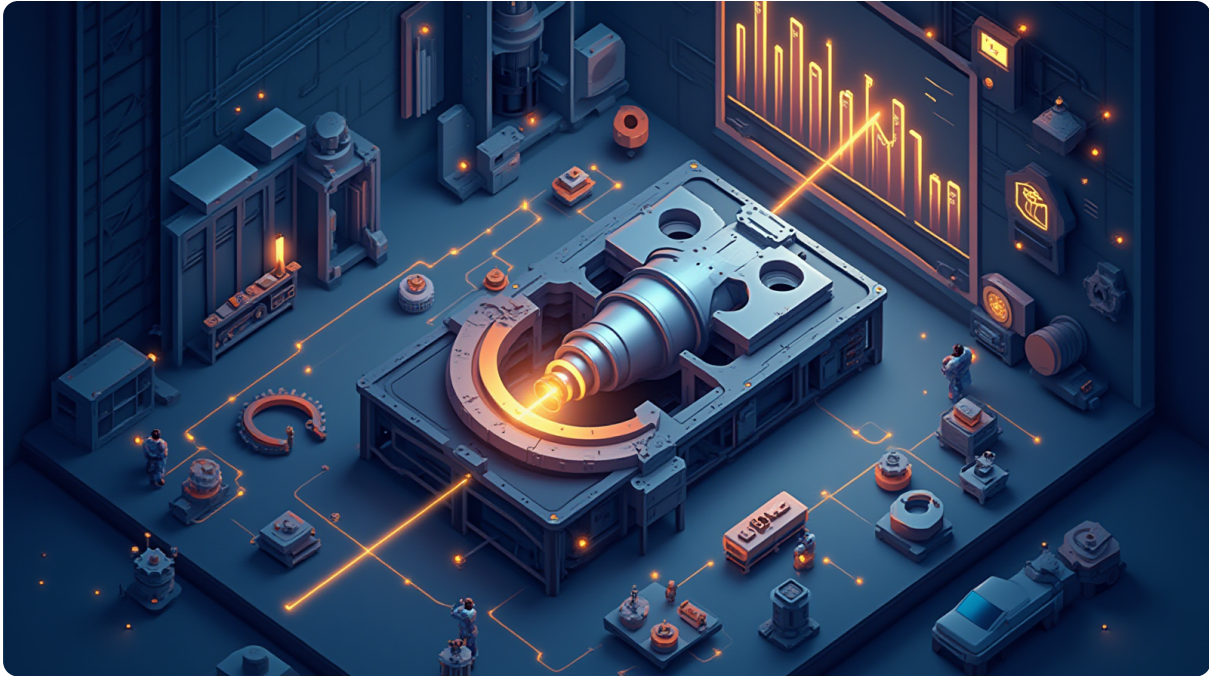


Making Engine Blades: The Reality of Additive Parts in Aerospace

How advanced metal printing changes the rules for mission-critical components.

Additive Manufacturing · Aerospace Quality · Supply Chain Risk · High Reliability

The newsletter for operations leaders who prefer technical reality over vendor hype.



The Challenge: Why the F135 Engine Is Hard to Make

When you are manufacturing components for something like the F135 engine, there is no room for “close enough.” In many industries, a minor variance might mean a slightly slower cycle time or a bit of wasted scrap. In aerospace, a microscopic defect in an engine blade isn't just a quality issue; it's a catastrophic failure at high altitude and high velocity.

I have spent years watching how manufacturing teams approach these "zero-fail" components. The difficulty doesn't just come from the metallurgy or the extreme temperatures the parts must endure—it comes from the fact that every single step of the process must be locked down to a degree that feels almost obsessive to those outside the industry. You aren't just making a part; you are building a pedigree for that part. Every heat treatment, every forge cycle, and every machining pass has to be documented, verified, and repeatable. If you can't prove exactly how it was made, it doesn't exist in the eyes of the regulators or the safety engineers.

The F135 isn't just a piece of hardware; it is a testament to what happens when manufacturing processes are pushed to their absolute limits. When we talk about these components, we aren't talking about "moving parts" in the sense of a machine that might need maintenance. We are talking about flight-critical components where the margin for error is zero. That reality dictates every choice made on the floor—from the purity of the raw alloy to the precision of the final inspection.

How Additive Manufacturing Changes the Rules (LMD-W)

For decades, we've relied on traditional methods: casting and machining. In those worlds, you start with a bulk piece of material and subtract what you don't want, or you melt it into a mold to create a shape. It is a well-understood path. But when we move into Laser Metal Deposition (LMD-W), the rules of the game change fundamentally.

In additive manufacturing, we aren't subtracting; we are building. We are melting metal powder and "printing" it layer by layer using high-powered lasers. This shifts the point of control from the final machining stage to the very beginning of the build. In a traditional shop, if a part is slightly off at the end, you might be able to grind it down or rework it. In additive manufacturing, once that powder is fused and layered, there is no "fixing" it later in the process.

This change means that your quality checks have to move forward in time. You can't wait until the part is finished to see if it's good; you have to ensure the environment—the humidity of the room, the purity of the powdered metal, and the calibration of the laser path—is perfect before the first layer hits the bed. It isn't just a new way to make a shape; it's an entirely different manufacturing philosophy where the "process" is the product.

The New Operational Reality: Process Over Product

Here is where many organizations stumble. They see a new machine that can print complex geometries and they think, *"Great, we have a faster way to get parts."* This leads to what I call **The Automation Mirage**. It's the belief that because a high-tech machine is doing the work, the management of that process becomes simpler or "automatic."

It doesn't. In fact, it makes the requirement for rigorous process control much more intense. Because additive manufacturing creates such complex internal geometries, you cannot always inspect the finished part with traditional methods. You have to trust the process that created it. If your team treats the 3D printer like a standard CNC mill—where they just "set it and forget it"—they are inviting **Process Drift**.

When the process drifts, the variance isn't caught at the final inspection; it's baked into the part during the build. You might see a blade that looks perfect on the outside but has internal porosity or un-melted powder pockets inside because the laser intensity fluctuated by 2% over a four-hour run. In this environment, your "quality" isn't just checking the final dimensions; it is the relentless monitoring of the conditions under which those dimensions were created.

What Happens When You Treat AM Like Standard Machining?

There is a significant difference between having a new tool and having a new process. Many managers fall into **The Legacy Lens**—trying to manage a 21st-century manufacturing technology using 20th-century management habits. They treat the additive machine as just another station on the floor, rather than a high-precision laboratory environment that requires specialized oversight.

When you apply old thinking to new methods, the risks become clear:

The Common Mistake	The Underlying Reality
"The machine is calibrated; we don't need to check it every shift."	Small drifts in laser focus or powder flow rates compound over hours of printing.
"We only need to inspect the final dimensions."	Internal defects can be hidden by the geometry, making end-of-line inspection insufficient.
"The material is just metal; it's always the same."	Powder chemistry and moisture content change based on storage, requiring constant verification.

If you treat a 3D printer like a standard mill, you aren't just being "efficient"—you are skipping the very controls that make aerospace-grade parts possible. You are choosing to find out if the process works by waiting for a failure to happen in the field rather than catching it on the floor.

The New Requirements: Verification and Control at Every Step

To move from "experimental" to "operational," you have to replace hope with verification. If you want to bring additive manufacturing into a high-stakes environment like aerospace, your control plan must be as dense as the technology is complex. You need to stop looking for excuses to simplify things and start building systems that account for every variable.

You need three specific layers of defense:

1. **Material Integrity:** Every batch of powder needs a "passport." You need to know exactly where it came from, how many times it has been recycled (if at all), and its chemical makeup before it ever touches the laser.
2. **In-Process Monitoring:** This is the heart of additive manufacturing. Since you can't always see inside the part during construction, you must monitor the "melt pool" in real-time. If the temperature or the melt rate deviates from the established standard, the build should flag itself immediately.
3. **Post-Processing Validation:** Once the part is out of the machine, it enters a gauntlet. This includes Hot Isostatic Pressing (HIP) to close internal pores and specialized non-destructive testing (NDT). You aren't just checking if the blade "looks" right; you are verifying that the process performed exactly as documented.

Practical Takeaways for Your Plant Floor Tomorrow

If you are moving toward additive manufacturing or any other high-complexity, automated production method, don't wait for a non-conformance report to change your behavior. Start implementing these controls now:

1. **Audit the Inputs:** Don't just check the final part; audit the "ingredients." If it's powder, verify the moisture levels and sieve counts today. If it's gas flow, ensure those sensors are calibrated on a strict schedule.
2. **Establish "Hard" Stops:** Define what constitutes an automatic stop in your process. If a laser's power drops by X percent or a temperature fluctuates beyond Y degrees, the machine should stop and alert an operator. Don't leave it to the human at the end of the shift to notice a trend on a graph.
3. **Create "Process Passports":** For any complex build, generate a report that links every part back to its specific build parameters. If you can't tell which batch of powder went into which blade, you don't have a controlled process; you just have a lucky one.
4. **Train for the Difference:** Sit your team down and explain why this isn't "just another machine." Teach them that in additive manufacturing, we aren't checking if they did it right at the end; we are ensuring the system makes it impossible for them to do it wrong in the middle.

The goal is to move from a culture of *correction*—where you find mistakes and fix them—to a culture of *prevention*, where the process is so tightly controlled that a mistake cannot occur in the first place.

Call to Action

What high-stakes component in your operation do you think will be revolutionized by AM next? Share this issue with your engineering team.

Newsletter replies: newsletter@sixsigmakaizen.com · X: [@kaizen_6sigma](https://twitter.com/kaizen_6sigma)

Stay curious, stay improving,

David Rodgers

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References: manufacturingdigital.com/articles/how-gkn-aerospace-rtx-are-3d-printing-f135-engines