AI-Driven Precision

AI for Quality Control at Each Stage of Manufacturing Lifecycle

Quality Control | Artificial Intelligence | Jewellery Manufacturing

1. The Problem: Why Human Eyes Are Not Enough

For hundreds of years, the final word on whether a piece of jewellery was good enough came from one place — the experienced eye of a master craftsperson. If it looked right to them, it passed. If it didn't, it went back for fixing.

That approach worked well when workshops were small and output was low. But today, jewellery factories produce thousands of pieces a week, and a single mistake — a tiny crack, a stone that is slightly the wrong colour — can cost thousands of dollars in wasted material and labour.

The Core Problem with Human Inspection

The human eye is remarkable, but it gets tired. Research shows that after just two hours of closely examining jewellery, a person's ability to spot defects drops by 15 to 25 percent. Think of it like trying to proofread the same page over and over — you start missing things you would have caught at the beginning.

Beyond tiredness, there is also the issue of subjectivity. Two trained inspectors looking at the same gemstone might grade it differently. One might say a small inclusion (a tiny imperfection inside the stone) is 'minor'. The other might say it is 'significant'. These disagreements lead to inconsistency — and in a luxury product, inconsistency is costly.

The Real Cost of Missed Defects

- If a flaw is caught early (at the raw material stage), fixing it might cost almost nothing.
- If the same flaw is only spotted after the piece has been fully assembled and polished, the cost can be 10 to 20 times higher — because all that labour and material has already been spent.
- Factories that rely entirely on human inspection typically see 2–8% of their production scrapped, and up to 15% sent back for costly reworking.

15–25%	2–8%	15%	10x
Drop in human inspection accuracy after 2 hours	Typical scrap rate from late defect discovery	Production value lost to rework costs	Higher fix cost when defects caught late

2. Step One: Teaching Machines to Test Gemstones

The first and most important question a jeweller must answer about any stone is: is it real? The market is increasingly flooded with lab-grown diamonds — stones that are chemically identical to natural ones but formed in a factory rather than deep in the earth. They are not fake, but they are worth significantly less than natural diamonds, and misrepresenting them is fraud.

How AI Detects Lab-Grown Diamonds

Specially built machines now use a technique called Time-Resolved Photoluminescence — which sounds complex, but the idea is simple. When you shine a certain kind of light on a diamond, it glows (fluoresces) and then fades. The speed and pattern of that fading is like a fingerprint — completely different for natural and lab-grown stones. The machine reads this pattern in milliseconds, with zero errors.

One such system, made by De Beers (the world's largest diamond company), can test 85 rings at the same time, or large batches of loose stones, automating a process that would take a human hours.

AI Grading: Replacing Guesswork with Data

Once authenticity is confirmed, stones need to be graded — sorted by quality. Traditionally, a grader would compare a stone to a set of physical 'master stones' and make a judgement call. This is both slow and inconsistent.

AI grading systems — including one developed jointly by GIA (the world's leading gem grading authority) and IBM — use cameras and deep learning (a type of AI that learns from millions of examples) to map every inclusion inside a stone, compare it against known standards, and assign a grade automatically. This has reduced grading disagreements between machines and human experts by 30–40%.

Tool / System	What It Does	Key Result
De Beers Synth Detect	Shines specialised light and reads the glow pattern to tell natural from lab-grown diamonds	Zero false positives — never mistakes a synthetic for a real stone
Yehuda Sherlock AI	Uses UV light to screen multiple stones at once	Flags stones below an 80% confidence threshold for human review
Sarine Clarity-II	Deep learning system that scans and grades clarity automatically	Sorts stones from near-perfect (VVS) to heavily included (I3)
Auto DIASSORTER	Uses a sphere of light and twin cameras to grade colour and clarity together	Automates physical sorting — no human sorter needed

3. Step Two: Using AI to Cut Gemstones More Precisely

Cutting a rough gemstone into a finished, faceted stone is both an art and an engineering challenge. The goal is to get the maximum value out of every rough stone — maximising size while also achieving the best shape, symmetry, and light performance.

How AI Plans the Cut

Systems like Sarine's Galaxy use 3D scanning technology to map every millimetre of a rough stone's surface and interior — including where the natural imperfections sit inside it. The AI then runs thousands of simulations to find the cutting plan that gives the best outcome: highest carat weight, best clarity, most attractive shape.

The key insight is that a single decision — such as cutting the stone 1mm to the left rather than the right — can mean the difference between a stone worth USD 5,000 and one worth USD 12,000. AI makes these decisions objectively, based purely on data.

Robotic Cutting with Water-Cooled Lasers

Once the plan is set, robotic laser systems carry out the cutting. One sophisticated system, called the Da Vinci, uses a laser guided by a thin stream of water. This matters because lasers generate heat, and heat can crack a stone. The water acts as a cooling jacket around the laser beam, keeping the stone safe while still achieving incredibly precise cuts — down to a fraction of a millimetre.

At the same time, AI vision systems watch the cutting process in real time, comparing each facet as it is formed against the original plan. If anything drifts even slightly off target, the system corrects immediately.

Why Precision Cutting Matters

- A diamond cut even slightly out of proportion can lose 10–20% of its potential market value.
- AI planning systems help manufacturers consistently achieve near-perfect proportions, maximising the value of every stone they process.
- YOLO-based AI vision models (a type of real-time image recognition) deployed on metal-cutting machines have reduced inspection time by 90% while detecting over 99% of defects.

4. Step Three: Checking the Metal — X-Ray Vision for Casting

After gemstones are ready, the metal setting — the ring, necklace, or bracelet — needs to be made. Most fine jewellery is made through a process called casting: liquid metal is poured into a mould and left to solidify. It sounds simple, but it is one of the most failure-prone stages of jewellery manufacturing.

The Hidden Problem Inside Metal

As liquid metal cools and solidifies, tiny bubbles and gaps can form inside it — invisible from the outside, but potentially catastrophic. A ring with a microscopic hollow inside a prong (the claw that holds a gemstone) might look perfect on the day it is made. But under the stress of everyday wear, that weakness can cause the prong to snap — and the stone to fall out.

Traditional quality control used to involve slicing a piece of metal open to look inside — which obviously destroys the piece. Even then, a 2D cross-section can be misleading because a

pocket of weakness that looks small in one slice might be part of a much larger connected network of weakness running through the metal.

3D X-Ray Scanning with AI Analysis

Modern factories now use industrial X-ray CT scanning — the same principle as the CT scans used in hospitals, but applied to a ring or a pendant. This creates a full 3D model of the interior of the metal piece, revealing every bubble, gap, and weakness without touching or damaging it.

An AI system then analyses this 3D model, distinguishing between harmless tiny gas bubbles (which occur naturally and do not weaken the piece) and dangerous interconnected shrinkage networks — which do. Without AI, these distinctions are extremely difficult to make reliably by eye.

Type of Defect	What Causes It	How AI Fixes It
Blowholes (large bubbles)	Gas gets trapped during casting if the mould is not properly burned out or if heating is too fast	AI monitors the heating process step by step and controls pressure automatically
Shrinkage porosity (connected weakness networks)	Metal does not fill the mould fully as it cools, leaving a network of gaps	3D X-ray + AI maps the exact shape and extent of the weakness and flags pieces for rejection or re-casting
Surface pores (tiny holes on the outside)	Metal poured at too high a temperature	AI monitors and adjusts casting temperature in real time

5. Step Four: Checking the Assembly — Spotting the Invisible

The most delicate stage of jewellery making is setting the stones — placing each gemstone into its metal mount and securing it with tiny prongs (claws) or a surrounding rim of metal. This is called micro-assembly, and it requires extraordinary precision.

Even a stone that sits at a tilt of less than one degree can look noticeably off to a trained eye — and will almost certainly be returned by a customer. A prong that is bent even slightly incorrectly may not grip the stone securely, making it a loss risk.

The Lighting Problem

Taking a photograph of jewellery for inspection sounds easy — but it is actually very difficult. Polished metal and faceted gemstones reflect and scatter light in all directions. A standard camera under ordinary light will miss hairline scratches, microscopic chips on stone edges, or a prong that is not quite closed because the glare and reflections hide them.

AI-assisted vision systems for jewellery use a combination of specialised lighting types to solve this:

- Diffuse lighting (light from all directions at once) eliminates glare from the metal surface, making the shape and geometry of the piece easy to read.

- Coaxial lighting (light pointing straight down at the piece) picks up surface defects on flat areas.
- Dark-field lighting (light from the sides only, with no light from above) makes tiny cracks and chips on gemstone edges light up like a beacon — they glow against a dark background and become instantly visible.
- Structured light (a projected grid pattern) allows the system to build a precise 3D map of the piece — measuring stone height, tilt angle, and prong position in three dimensions.

What the System Checks

The Assembly Verification Checklist

- Are the prongs fully bent over the stone's edge? Even 0.1mm of gap can allow a stone to loosen.
- Is the stone sitting level? Structured light maps the exact tilt — any angle beyond a tiny tolerance triggers a rejection.
- Are there any chips on the stone's edge caused by the setting tool? Dark-field light reveals these instantly.
- Are all stones in a multi-stone piece (like a pavé ring) at exactly the same height, and perfectly aligned with each other?

6. Step Five: Protecting Against Fakes and Returns

The final stage of AI quality control goes beyond the factory floor. It addresses a problem that costs the jewellery industry billions annually: fraud.

The two most common forms are counterfeit returns (a customer buys a genuine piece, swaps it for a fake or lower-quality piece, and returns the fake for a full refund) and supply chain substitution (a genuine piece is replaced with a lesser one somewhere between the factory and the shop).

Physical Fingerprinting — Every Piece Is Unique

Just like a human fingerprint, every piece of jewellery has a unique physical identity at the microscopic level. The grain structure of the metal, the tiny lines left by polishing, the microscopic variations in how solder has flowed — these are impossible to replicate exactly, even in a factory trying to make an identical copy.

AI-powered authentication systems scan these microscopic surface features — up to 20,000 reference points on a single piece — and create a unique digital record called a Digital Product Passport. This is linked cryptographically (using the same type of secure encoding used in online banking) to a database. When a piece is returned or reaches a new point in the supply chain, it can be re-scanned and its identity verified in seconds.

20,000	99.86%	100%	Seconds
	Authentication accuracy		

Microscopic reference points per piece	Tamper-evident — cannot be forged	Time to verify a piece at any point in the chain

7. What Does All This Deliver? The Business Case in Plain Numbers

Putting AI quality control in place is an investment. But the returns are measurable, rapid, and substantial. Here is what factories that adopt this integrated approach typically see:

What Changes	The Old Way	With AI	What It Means for the Business
How long inspection takes	Slow, manual, and dependent on how tired the inspector is	50–80% faster	More pieces checked per day; faster shipment to customers
How much gets scrapped or reworked	2–8% scrapped; 15% reworked	20–50% less waste	Direct cost saving — less gold, silver, and gemstone material thrown away
Accuracy of gemstone grading	Varies inspector to inspector	30–40% more consistent	Fewer disputes with customers; stronger brand reputation
Protection against counterfeits	Barcodes and engravings — easily faked	99.86% accurate fingerprinting	Near-elimination of return fraud and supply chain theft

To put this in concrete terms: a mid-size jewellery factory turning over USD 5 million a year in production might currently lose USD 200,000–400,000 annually to scrap, rework, and fraud. Implementing AI quality control across the five stages described in this report could recover 40–60% of that loss within the first two years — while also opening doors to higher-value buyers who require certified quality processes.

In Summary

This is what the full AI quality control system does, from start to finish:

Stage	The Simple Version
1. Gemstone Testing	Machines instantly tell real diamonds from lab-grown ones — with zero errors
2. Gemstone Grading	AI reads and grades the quality of every stone, consistently and without fatigue

3. Cutting Planning	AI designs the most valuable cut for each rough stone; robots execute it precisely
4. Casting Inspection	3D X-ray + AI finds hidden weaknesses in metal before they can cause a problem
5. Assembly Verification	Smart cameras with specialist lighting check every prong, every stone, every angle
6. Authentication	A microscopic fingerprint permanently links each piece to its verified digital identity

The bottom line is straightforward: AI does not replace the skill and artistry of jewellery making. It gives those skills a foundation of certainty — ensuring that every piece that leaves a factory is exactly what it is supposed to be, and can be proven to be so at any point in its lifetime.

The One-Sentence Version

- AI quality control in jewellery manufacturing means: catching problems earlier, wasting less material, grading more consistently, and guaranteeing the authenticity of every single piece — saving money, building trust, and protecting the brand.

Great jewellery has always been about precision. AI just makes that precision measurable, repeatable, and provable.