FormingWorld
Sheet Forming Simulation NEWS

Issue: 001
Jan 2019

The Forming News Blog Driven by AutoForm! *Visit: FormingWorld.com*

The Printed Edition for AutoForm Customers.

Dear AutoForm Customers,

As part of our incentive to provide the latest information available anywhere concerning sheet metal forming simulation we now offer a printed circulation of our top blog posts for the month, just for our customers. Visit FormingWorld.com to see other informative posts, delivering the latest news research and forming tips on sheet metal forming.

This issue contains two blog posts.

Plenty of Sheet Metal Forming Opportunity Says Andrew Halonen, Mayflower Consulting LLC!

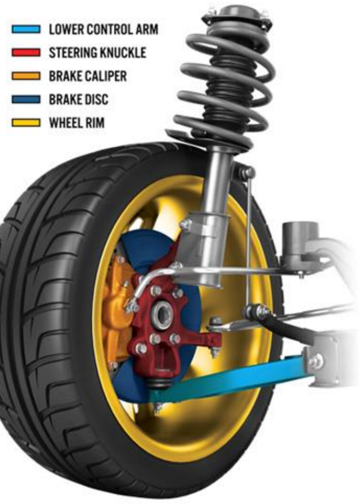
In this blog post, Andrew Halonen, President of Mayflower Consulting, LLC, presents a valuable study on the lightweighting of critical safety components manufactured for wheel-end and suspensions. Suspension arms are made from many materials & processes to meet the same specification, yet an OEM reports that those produced from sheet metal stampings deliver substantially better economics. The parts in the study comprise 20% of the vehicle weight, showing a perfect opportunity for economical lightweighting with stampings.

With the increasing CAFÉ 2025 fuel economy targets, automobile manufacturers are using a number of methods to improve fuel economy. Engine downsizing, turbo systems, electrification, aerodynamics and lightweighting are among the most effective methods. In 2017, there was considerable news on electrification; will it gain market acceptance and if so, how will it affect the material selection? Logically, range-limited vehicles will benefit most from lightweight materials, yet because they are adding expensive batteries and related operating systems; they need to carefully manage costs.

Let's look at the safety critical components in the wheel-end and suspensions -- what materials are used? What processes are used? Well, we wanted to find out, so we crawled underneath 89 vehicles to see for ourselves. These components comprise of roughly 20% of the total vehicle weight, yet they get little attention in the automotive press, and across the material consortiums promoting their respective materials and process innovations. These components include wheels, brake calipers, brake discs, steering knuckles and suspension arms and links.

Before embarking on this study, I had the impression that most suspension arms were solid – cast or forged, aluminum or iron. Boy, was I wrong!

The trade study of 89 vehicles over 16 brands is organized by market segments that it includes 5 performance cars, 24 cars, 38 cross-overs/SUVs, 15 pickups, 4 minivans and 3 work vans. Let's take a deep dive into the car data from the following vehicles that were found on dealership lots in the summer of 2017.



Safety Components in Trade Study

The safety critical components in the wheel-end and suspension systems include the following:

- Wheels
- Brake discs
- Brake caliper
- Steering knuckle
- Suspension arms

Wheels, Brake Discs, Brake Calipers, Steering Knuckles

These components are not made by sheet products. Aluminum castings dominate automotive wheel manufacturing. Steering knuckles are a mix between aluminum castings and iron castings, yet some are aluminum forgings especially when an OEM is seeking double-digit elongation. Brake calipers are predominantly gray iron despite the 2.3kg weight savings delivered by cast aluminum on the overweight front axles. Brake discs are mostly gray iron, yet a few premium vehicles integrate aluminum or steel "hat" in the center to reduce the weight by 15-20%.

Suspension Arms

Look no further than the suspension, specifically the lower control arms (LCA) on cars, for another multi-material story. Did you know that there are six different ways to produce a lower control arm on a small sedan? And, we found seven different ways to produce the rear upper control arms (UCA)!

Looking at a subset of six cars with curb weights ranging from 2,246 pounds to 3,969 pounds (1018-1800 kg), the study found forged steel, welded steel, stamped steel, forged aluminum, cast aluminum, and a unique product on a rear LCA, extruded aluminum with a cover. One of the six cars is a plug-in hybrid electric vehicle (PHEV); it has steel suspension arms, a mix of aluminum and iron on the brake calipers & steering knuckles, and it has a cast aluminum subframe.

Ford Fiesta, Stamped Steel, Front

Chevy Impala, Welded Steel, Front

Ford Focus, Forged Aluminum, Front

Chevy Impala, Extruded Aluminum, Rear

Dodge Dart, Cast Aluminum, Front

Ford Taurus, Forged Steel, Front

Source: Mayflower Consulting, LLC

Most of these cars fall beneath a gross vehicle weight of 4,700 pounds (2,132 kg), which is about the maximum weight for a front suspension using MacPherson strut (no upper control arm); heavier vehicles with independent suspension use a double wishbone (upper & lower control arms).

On the upper control arms, we found seven different material & process combinations with the addition of ductile iron, which was not found on the lower control arms. See the summary of materials & processes on the 24 car models below.

Suspension Material & Process Selection of Upper Control Arms (UCA) and Lower Control Arms (LCA) on 24 Cars

	FRONT		REAR	
MATERIAL, PROCESS	LCA	UCA	LCA	UCA
Forged Aluminum	9	1	0	3
Cast Aluminum	2		7	2
Extruded Aluminum	0		2	2
Forged Steel	2		0	1
Stamped Steel	3	1	1	2
Welded Steel	8	2	13	6
Ductile Iron			0	3
N/A		20	1	5

*N/A pertains to suspensions without listed component.

What does the future hold for suspension arms?

The suspension arms represent a myriad of materials and technologies spanning the cost versus weight trade-offs. I think the future is bright for stamped and/or welded sheet product control arms for these reasons:

- When this data was presented at the Lightweighting World Expo in Novi MI in October, I asked an OEM manager if he was surprised to see so many steel clamshell suspension components? He said, “No. The weight is close to aluminum forgings at about one-third the price.”
- The market is gearing up for electrification, yet the battery system is extremely expensive. Autonomy is expensive. These market demands put more cost pressure on other components, and clamshell steel is low cost.
- The Tesla S sedan is mostly aluminum, yet the front upper control arm is clamshell steel. If it makes sense on a premium EV, it really ought to be the material of choice on an affordable EV.
- The Chevy Camaro rear linkages were simple steel stampings. With the high strength “Gen3” steels coming, will we see more wheel-ends like this Camaro?

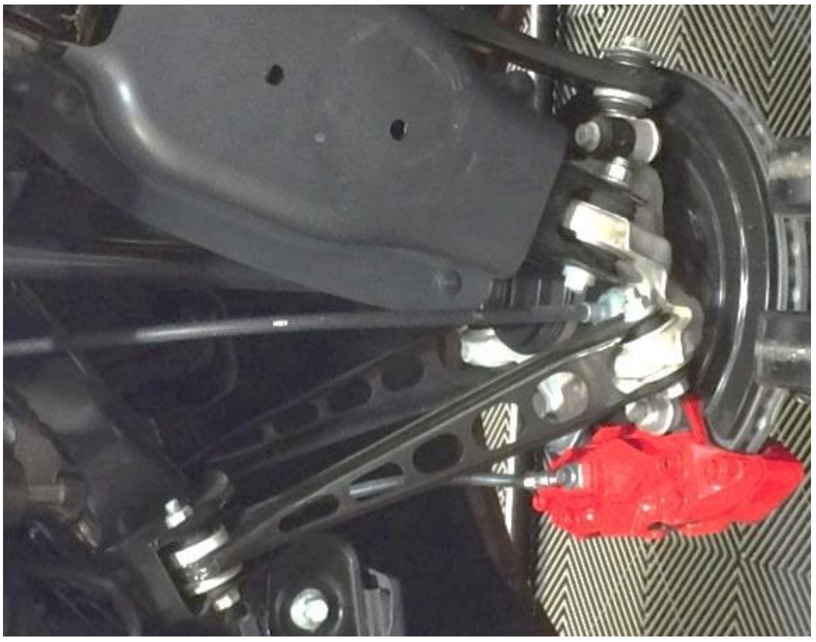


Image: Chevy Camaro Rear Suspension Links

ABOUT THE AUTHOR

Andrew Halonen is President of Mayflower Consulting, LLC, a lightweighting consultancy that provides strategic marketing, market research and business development for high tech clients in automotive, defense and commercial trucking. Andrew works with castings, composites, additive manufacturing and new material development programs.

Mayflower Consulting LLC produced a self-funded trade study on the materials and design of suspension and wheel-end components on 89 vehicle spanning six market segments.

Tryout Loops REDUCED: FARA Stampi S.r.l Progressive Die Application with AutoForm

Customer Says AutoForm is a Permanent Part of Their Company - an Over the Shoulder Look at How They Simulate Progressive Die Stamping

"AutoForm solutions applied to progressive die design has allowed us to evolve from handcrafted processes to an industrialized method." Elio Falco, CEO at FARA Stampi S.rl.

FARA Stampi S.r.l. (FARA hereafter) specializes in transfer and progressive dies, along with part assembly in the sheet metal forming industry. Founded in 2008 as an offshoot from a then forty year old company (Falco S.r.l) they produce and maintain all those dies along with producing new parts for the automotive industry, including bodywork and chassis elements, battery trays and piping supports to name just a few. They supply to international OEMs such as FCA, PSA and Magna, as a well-known supplier in the automotive industry.

Like many sheet metal forming operators FARA has adopted AutoForm products as their software solution in process simulation. During a recent visit at their plant we wanted to overview their engineering and tryout process for progressive dies, top to bottom. As a thorough introduction we went through their entire process chain for two particular parts, a tank filler hole-support and a radiator piping-support. The exploration started at the bidding phase, and supported the design of the process and closely followed actual tryout.

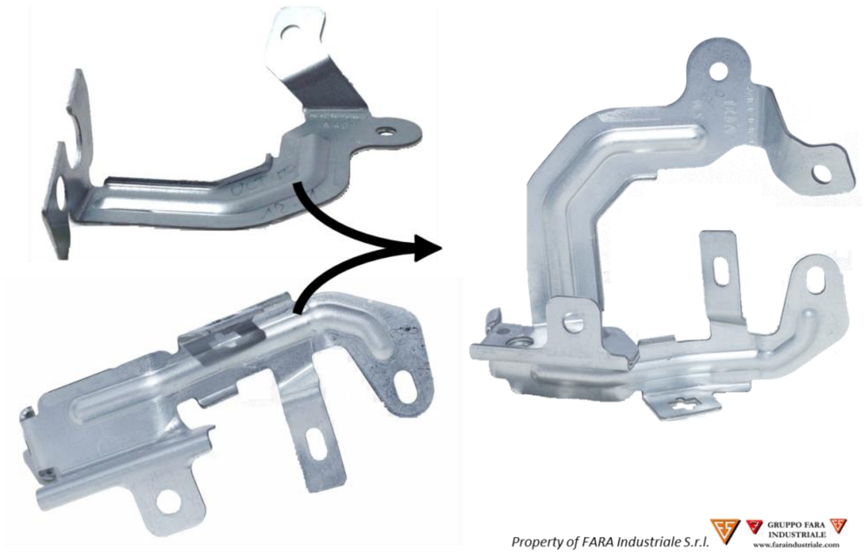


Figure 1 – Tank-filler hole support – double-part on a strip

Once FARA receives the part geometry that first thing they do is running a feasibility analysis

Mr. Falco said- "In running the feasibility check first thing we look at is the so called - development on the plan – for the entire part. This step is crucial because we can look for critical areas and determine trim lines. Based on this information, we can already start to 'see' the full strip: define the plan, lifters and holders' position (inside, outside) etc. AutoForm speeds us towards this goal, because 99% of the time we do not only deal with linear flanges (for which we could use our CAD product) but with stretch flanges, and most the time we do not develop those flanges (and determine trim lines) on a plan but rather on a drawn or tilted area. In this case, without AutoForm we could not easily get the right shape of the flattened part in a short amount of time and consequently determine the most appropriate pitch and the most efficient nesting: without this information we could not determine the material consumption either and therefore evaluate the final cost." Mr. Falco added: "if we realize that the part is not feasible, and trust me it happens more often than many imagine, we have to then ask for a part modification. Whenever critical areas can't be fixed and a part can't be produced according to how it has been designed, we have to talk to the customer and to justify the request for changes, and here it's particularly important that we can back it up with feasibility study produced by AutoForm as evidence towards an alternative. Another crucial aspect: time is always a factor. The sooner we have that study the better, especially when bidding in an auction. AutoForm helps us a lot in achieving this goal and saves us from having any trouble later on down the line".

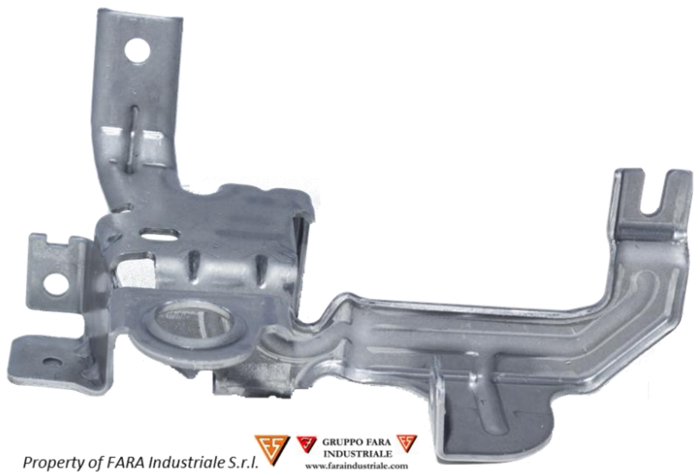


Figure 2 - Radiator piping support – Single part production

This attests to the importance of undertaking the right avenue of study from the very beginning. The planning aims to avoid under/overestimation; which either could result in losing a bid or costing too high. Imagine losing an auction (overprice the product due to the non-correct estimation of the costs and the consequent limitation of the possible discount you can offer to the customer).

'Truth be told, thanks to AutoForm, we expanded the variety of parts we produce today, and thus extended our market. The software supported and still supports us in making decision when working on particular parts where we had very limited or even no experience at all on. **In a few words we now produce parts we could never have produced without AutoForm simulation in such a short amount of time'** Mr. Falco continues.

At this point the drawing of all the tools directly in CAD environment commences: "The possibility of importing and quickly replacing tool geometries at any time in AutoForm^{plus} allows us to generate the tools of each station/operation one after the other. To validate the process we can start simulating only a few stations for instance, meaning that there is no need to draw all tools to simulate the entire process and then realize that something is wrong and make changes. With a limited amount of time spent on CAD we start validating the tools' geometry, and we know that it won't take too long to apply any kind of modification we might need" Mr. Sergio Siragusa Senior Designer says.

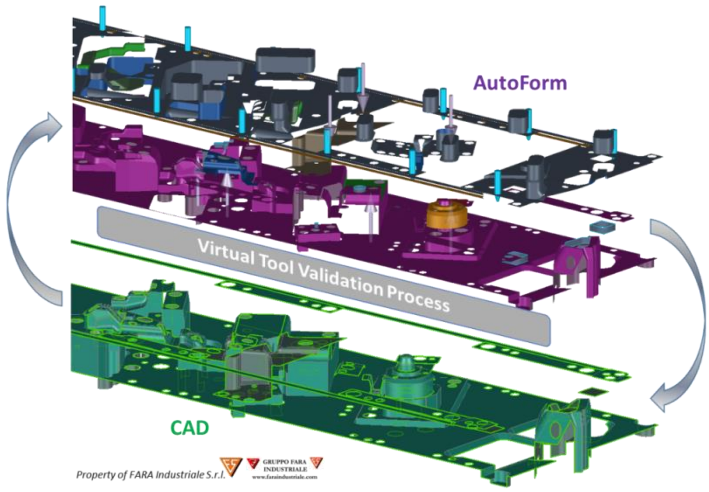


Figure 3 – Virtual Tool Validation Process

Process engineering and process design proceed nearly parallel, and this allows users to evaluate different solutions in a short timeframe and ensure that at the end the process works; a few adjustments (limited re-cuts) that do not require any additional virtual validation can be directly applied during the tryout loops.

"Simulating a process with an incremental solver also means accurately simulating the movement of the tools and detecting possible interferences. For example, during the simulation of the single part die we realized that one of the forming tools was hitting the web before actually forming the part (figure below, left). To maintain the plan as it was already defined, we introduced a tool to the previous station that actually flanged the web so that the forming tool at the next station could work correctly."

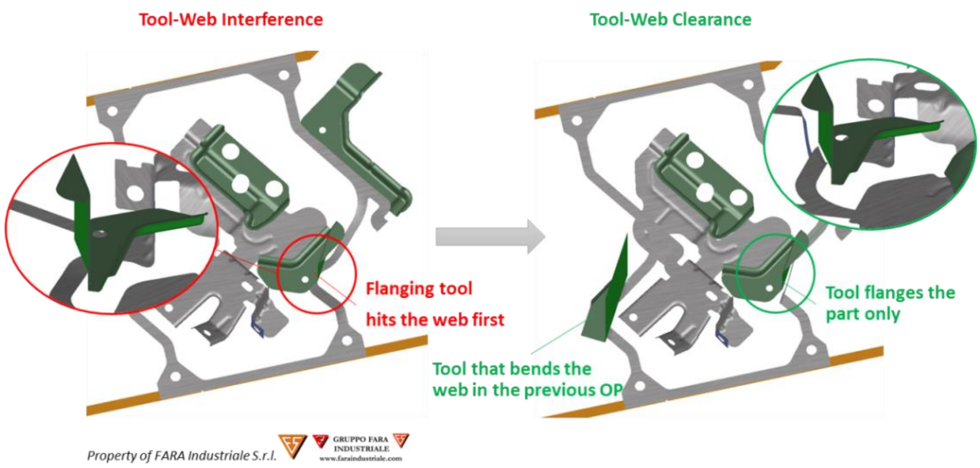


Figure 4 – Example: tool-web interference issue detection and solution

“Without this simple but accurate check, we would have realized the problem only upon arriving to tryout; it goes without saying the kinds of problems we’d face.”

Figure 5 – Solution: web flanging visible on the ‘real’ strip

Next the tool geometries are released for milling: “We mill the tools exactly as validated by AutoForm, we keep 100% to the results we get from simulation and we cut the tools accordingly, and **that’s what really pays off at the end, this is where we save time and reduce costs**” Mr. Falco says.

‘Since introducing AutoForm in our engineering process for all parts (before doing that we used to outsource engineering of the most complicated parts) we have seen the total working hours (from the day we get the part to delivering the die) drop by 30% in average, and tryout loops have dropped by 50%! Where we needed five to six adjustment loops in the past, now we spend two, maximum three loops, making small adjustments, which are always made by re-cutting the tool through CNC - never by hand, and after that the die is ready.’

The figure below summarizes the process (figure 6). The ‘Virtual Tool Validation’ process (loops) drastically reduces the chances of having severe issues in tryout, which would otherwise lead to a redesigning of the entire strip and a re-cutting of all tools. Yet we end up with just a few loops for small localized adjustments, which at FARA are always applied through CNC machines, meaning that changes are first applied in CAD and then transferred to the milling machine through CAM.

By following this process the total working hours needed to deliver a die, to mass production, is drastically shorter, as opposed to not following the simulation. The chart below pictures the ‘breakeven’ points between the two processes. The data is clear; a greater number of hours spent in simulating the process will save time, from the milling phase onwards. The milling hours include time spent on re-cutting tools during tryout.

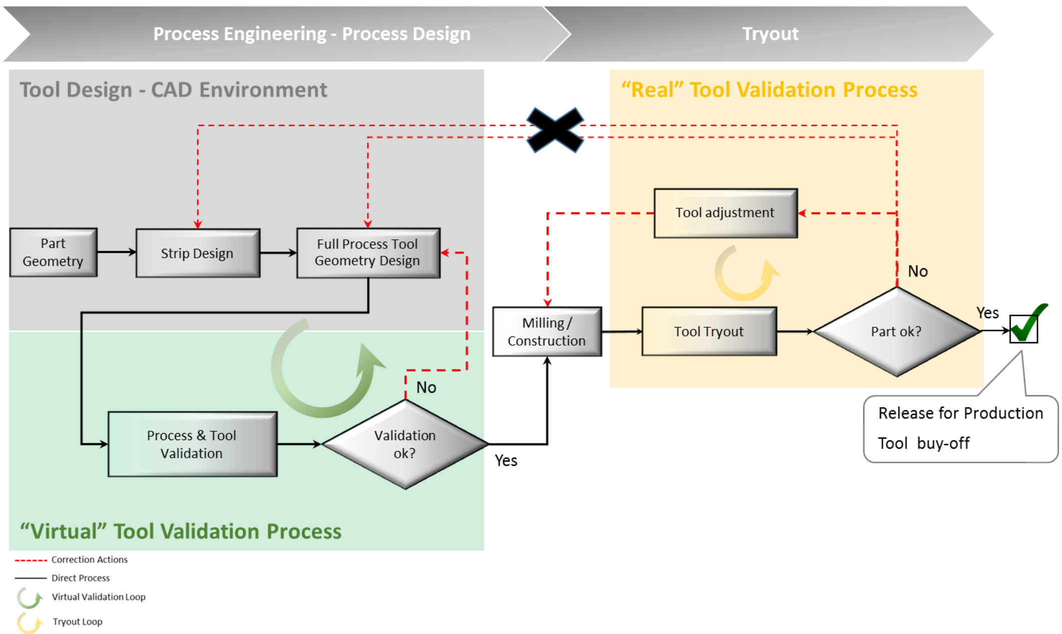


Figure 6 – ProgDie Full Design Process

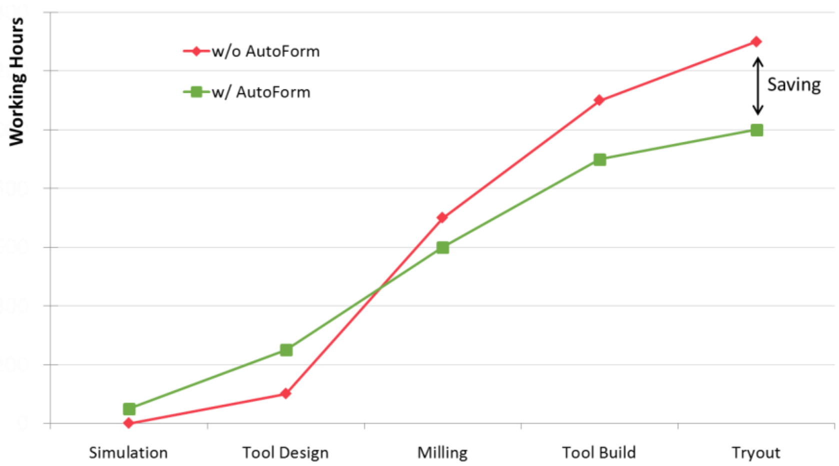


Figure 7 - Qualitative Comparison of Process Timing

The reduction of tryout loops is depends on the accuracy of simulation results; so the question is – how close to reality are the results provide by AutoForm? Mr. Falco explains: "As already mentioned, we are really close. We know that we cannot have a 100% match for different reasons. Firstly the input in the software does not exactly match what we have in reality: for example, let's talk about material properties. To comply with our requirements we ask our suppliers to deliver the material having characteristics within a certain range, and we test the material for acceptance. In simulation we always try to consider the worst case scenario from a springback point view (higher yield stress); yet, it may happen that the real material is actually closer to the lower value of the range, and because of the combined effect between material and part shape we can experience cracks or splits in reality. But these are rare cases, as we typically do not face this kind of problem. Another important aspect is the trim lines - the final part might not be within acceptable tolerances but we are always really close."

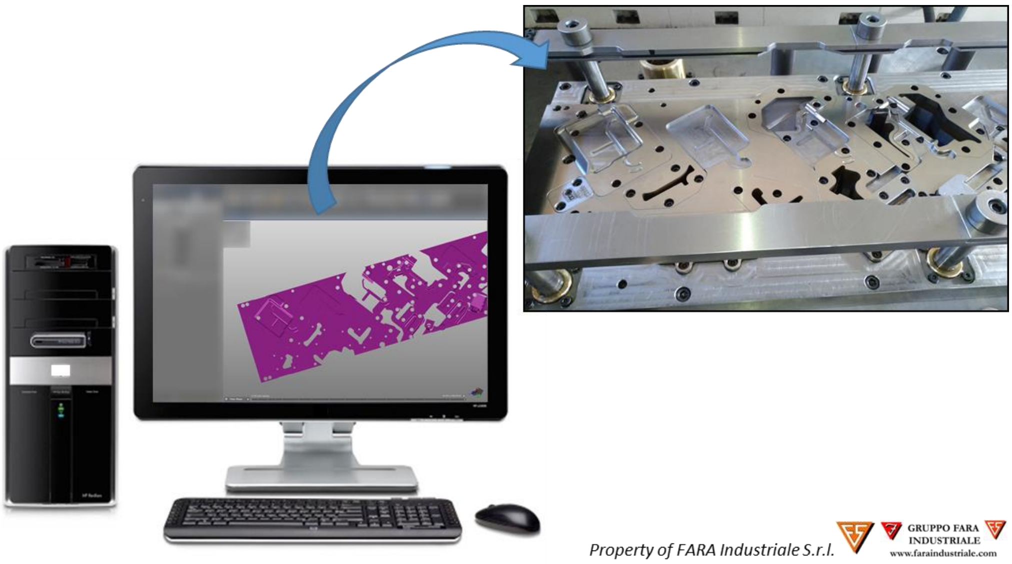


Figure 8 - From Simulation to Reality

FARA and AutoForm have a great relationship, demonstrated through a decade of proficient projects and implementation, so what next? Mr. Falco ended saying, “Naturally we work hard at trying to increase our business which of course is strictly related to the automotive industry, and the more our business increases the more AutoForm becomes important. No matter what happens I can definitely say that AutoForm is an integral part of the DNA of this company, and will always be part of it, as long as this company is in business.”

P.S the actual blog posts viewed online contains a video of Fara’s tool shop.

See more blog post at FormingWorld.com for all the latest articles!

Other recent titles of interest at our site:

- **Who is “the Metal Whisperer?” Interview with Christian Beschorner on the Acceptance of FEA Solutions Over the Last Twenty Years**

- **Reducing Tool Recuts with Virtual Tryout vs. Tryout Reality - Where to Invest Your Time to Reduce Tool Recuts: an Interview**

- **Mazda Tool Maker Keylex Corp: 80% Reduction of Task-Hours for Part Validation – a Japanese Success Story with AutoForm**