UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

POSCO CO. LTD.,
Petitioner,

v.

ARCELORMITTAL,
Patent Owner.

Case No. IPR2024-01377
U.S. Patent No. 11,326,227

DECLARATION OF DIERK RAABE, PROFESSOR DR.-ING.
IN SUPPORT OF PATENT OWNER'S RESPONSE

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TABLE OF ABBREVIATIONS

Abbreviation	Description
’227	U.S. Patent No. 11,326,227
’602	U.S. Patent No. 10,961,602
Cornette	Cornette et al., “High Strength Steels for Automotive Safety Parts,” SAE Technical Paper Series 2001-01-0078 (2001)
Engels	Engels et al., “Controlling and monitoring of the Hot-Stamping Process of Boron-Alloyed Heat-Treated Steels” (2006)
GMW14400	GMW14400 Material Specification
Hein	Hein et al., “Hot Stamping of USIBOR 1500 P: Part and Process Analysis Based on Numerical Simulation” (2006)
Laurent	U.S. Patent No. 6,296,805
Nishibata	U.S. Patent Publication No. 2006/0185774
POSITA	Person of ordinary skill in the art
Takagi	U.S. Patent Application Publication No. 2004/0009366

I. INTRODUCTION

1. I have been retained by Patent Owner ArcelorMittal as an expert in this *inter partes* review proceeding involving U.S. Patent No. 11,326,227. I have been asked to provide my opinions relating to the patentability of the claims of the ’227 Patent, including providing opinions related to the state of the art and responding to the opinions of Dr. Miles.

2. I make the following statements based on my own personal knowledge or belief based on my expertise in the field. Below are my opinions and their underlying bases.

A. Qualifications

3. I am qualified by education and experience to testify as an expert in the fields of metallurgical science and engineering. Below, I summarize my education, qualifications, and experience, which are also summarized in my *curriculum vitae* (CV), attached as Exhibit 2014.

4. Since 2010, I have been the chief executive officer of the Max Planck Institute for Sustainable Materials (“MPIE”), formerly known as the Max Planck Institute for Iron Research, and the director of one of MPIE’s four departments: the Department of Microstructure Physics and Alloy Design. MPIE is the world’s largest and most highly cited and reputed research organization dedicated to the basic study of steels. I have been a scientific member of the Max Planck Society,

an association of German non-profit research institutes, since 1999. Prior to that, I was a scholarship-funded scientist with the Department of Materials Science and Engineering at Carnegie Mellon University and a visiting researcher at the US National High Magnetic Field Laboratory in Tallahassee, Florida.

5. I completed my education at RWTH Aachen University, from which I received my diploma (the equivalent of a Master's degree) with the highest possible distinction *summa cum laude* in 1990, doctorate with the highest possible distinction *summa cum laude* in 1992, and habilitation (the highest academic degree in Germany, equivalent to an Associate Professorship) in 1997. While completing my habilitation, I was a scientist and group leader RWTH Aachen.

6. I work in the fields of materials simulation, microstructures, and the resulting mechanical properties of metallic alloys. I work on thermodynamics and kinetics of metals as well as in alloy design, coatings, heat treatment, and metal forming. My research includes extensive investigation into the interplay between microstructural phenomena and mechanical performance of metallic systems, particularly in steels, intermetallics, multiphase alloys, and metal-matrix systems. A focus of my research approach is the combination of thermomechanical material processing, simulation, and characterization down to the atomic level.

7. With nearly four decades of experience in the field, I have expertise in, among other areas, steel-aluminium joining, interdiffusion mechanisms, and the

role of alloying elements, including in martensitic and press-hardened steels, coatings, welding, and steel design. My experience in, for example, merging phase-field simulation, thermodynamic databases, and nanoscale characterization lends to my expertise in developing predictive understandings and frameworks for reactive diffusion systems, such as those described in the patents at issue in this case (including expertise in predicting and controlling interfacial reactions between Fe and Al, and resulting diffusion kinetics, intermetallic phase transformation, and microstructural development).

8. In all, I have authored more than 700 peer-reviewed publications and seven books on materials science and engineering. My papers have been published in a number of prestigious journals, including *Nature, Science, Nature Materials, Nature Materials Reviews, Nature Communications,* and *Acta Materialia*. My work has been publicly cited over 100,000 times. According to Google Scholar, and my research currently maintains an h-index rating of 182.

9. I have received three best paper awards from respected international journals for the following articles: "A Novel Roll-Bonding Methodology for the Cross-Scale Analysis of Phase Properties and Interactions in Multiphase Structural Materials," 1-6 International Journal of Materials Research 3-14 (2015); "Autonomous Filling of Grain-Boundary Cavities during Creep Loading in Fe-Mo Alloys," 47 Metallurgical and Materials Transactions 4831 (2016); and

"Investigation of the Orientation Dependence of Recovery in Low-Carbon Steel by Use of Single Orientation Determination" 66 Steel Research 222-29 (1995).

10. I have received a number of awards over the course of my career. In 2004, I received the Leibniz Prize, which is generally considered the most important research award in Germany. Twice, in 2012 and 2022, I have received a European Research Council (ERC) Advanced Grant, the largest single-researcher grant in Europe. In 2022 I received an honorary doctorate from the Norwegian University of Science and Technology. I was the recipient of the 2022 gold medal from *Acta Materialia*, a premier journal in the field of materials science. I have also been routinely invited to give lectures at universities and research institutes around the world, including the University of Cambridge, the Chinese Academy of Sciences, the University of British Columbia, the Korean Advanced Institute of Science and Technology, Imperial College London, and Tel Aviv University.

11. Since 2011, I have been twice a member of the German Council of Science and Humanities, the main board to advice the German federal government in all fields of science and academic education, selected by the German president. I am also a member of the German National Science Academy Leopoldina, member of the US National Academy of Engineering, member of the German National Engineering Academy Acatec, member of the Northrhine-Westfalian Academy of Sciences, and Honorary Professor at the Katholieke Universiteit

Leuven in Belgium. I have been a professor at RWTH Aachen as well. I have supervised more than 55 Ph.D. students and a similar number of postdocs, many of whom now are associated and full professors at universities around the world, such as at MIT, KU Leuven and RWTH Aachen.

12. My research has given me fundamental insight into the metallurgical challenges of joining steel and aluminium coating (including in achieving specific microstructural designs and controlling phase transformation). I have made foundational contributions to understanding aluminium-steel interactions, specifically in the context of hot-dip aluminizing and joining dissimilar metals. For example, I co-authored a landmark study in *Acta Materialia* (2011) investigating intermetallic layer formation during diffusion between low-carbon steel and both pure aluminium and Al–Si alloys.[1] The research identified Al_5Fe_2 (θ-phase) as the dominant intermetallic and revealed orientation-dependent growth kinetics governed by parabolic diffusion. Crucially, the addition of Si, which was expected to retard growth based on melt experiments, instead *accelerated* reaction layer formation in solid/semi-solid regimes—contradicting conventional thermodynamic predictions and revealing the high complexity of this topic. This

[1] Ex. 2015 (Springer, H., Kostka, A., Payton, E. J., Raabe, D., Kaysser-Pyzalla, A., & Eggeler, G. (2011). On the formation and growth of intermetallic phases during interdiffusion between low-carbon steel and aluminum alloys. *Acta Materialia*, 59(4), 1586–1600).

pioneering study illustrates my research focus on correlating thermodynamics and interdiffusion to explain phase stability and kinetics. It also provided critical insights for industrial applications such as automotive body-in-white assembly, where galvannealed and aluminized coatings must use diffusion control to balance adhesion and corrosion resistance.

13. By way of another example, in a related study on laser welding of aluminium to steel, I observed the evolution of intermetallics such as Al_5Fe_2 and $Al_{13}Fe_4$ at the interface, demonstrating that morphology and layer thickness correlate more strongly with peak thermal cycles than with dwell time.[2] These results have direct implications for designing manufacturing processes such as for resistance spot welding and hybrid bonding in vehicle lightweighting strategies (for example, in manufacturing aluminium-alloy coated hot-stamped vehicle reinforcement parts such as those relevant to the patents at issue in this case).

14. Furthermore, my research has addressed a variety of related topics in that context such as general intermetallic phase formation kinetics, solid/solid, solid/liquid, and solid/semi-solid interdiffusion effects between steel and aluminium alloys (pure Al and Al-5wt.%Si). My research has included, for

[2] Ex-2016 (Lemmens, B., Springer, H., Duarte, M. J., de Graeve, I., de Strycker, J., Raabe, D., & Verbeken, K. (2016). Atom probe tomography of intermetallic phases and interfaces formed in dissimilar joining between Al alloys and steel. *Materials Characterization*, 120, 268–272).

example, demonstrating that η-phase (Al_5Fe_2) dominates reaction layers depending on temperature and heating rate, and grows with parabolic kinetics, indicating diffusion-controlled growth.[3] My research has also addressed how to identify ternary phases (τ_6, τ_5, τ_1) in Fe-Al-Si systems, revealing complex interfacial chemistry.[4] My research has also extended to Kirkendall porosity and mechanical degradation, linking Kirkendall porosity at Al/η-phase interfaces to embrittlement in welded steel-Al joints.[5]

15. In sum, I have deep experience in the issues and underlying science behind the patents at issue here.

B. Compensation

16. For time spent in connection with study and analysis in this matter, I am being compensated at my standard consulting rate. My compensation does not

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[3] Ex-2017 (Lemmens, B., Springer, H., de Graeve, I., de Strycker, J., Raabe, D., & Verbeken, K. (2017). Effect of silicon on the microstructure andg rowth kinetics of intermetallic phases formed during hot-dip aluminizing of ferritic steel. *Surface & Coatings Technology*, 319, 104–109).

[4] Ex-2018 (Lemmens, B., Springer, H., Peeters, M., de Graeve, I., de Strycker, J., Raabe, D., & Verbeken, K. (2018). Deformation induced degradation of hot-dip aluminized steel. *Materials Science and Engineering: A*, 710 (July 2017), 385–391).

[5] Ex-2019 (Springer, H., Kostka, A., dos Santos, J. F., & Raabe, D. (2011). Influence of intermetallic phases and Kirkendall-porosity on the mechanical properties of joints between steel and aluminium alloys. *Materials Science and Engineering: A*, 528(13–14), 4630–4642. https://doi.org/10.1016/j.msea.2011.02.057).

depend on my opinions or the outcome of this proceeding.

C. Materials Considered

17. I have considered all documents cited in my Report and the Miles Declaration and all documents cited therein or attached thereto.

II. LEGAL STANDARDS

18. I am not an attorney. I have been informed of and understand the following legal standards, which I understand apply in this Investigation.

A. Claim Construction

19. I understand that claim construction is a matter of law and that claim terms are interpreted from the perspective of a hypothetical person of ordinary skill in the art (a "POSITA") would understand them at the time of the invention, according to their ordinary and customary meaning in view of the patent and evidence related thereto.

20. Here, I understand that, for the purposes of this proceeding, Petitioners and Patent Owner do not dispute the plain and ordinary meaning of claim terms. For example, a POSITA would understand that the plain and ordinary meaning of "superficial layer" is surface layer. This is consistent with Dr. Miles's view, who equated "superficial layer" and surface. Ex-1003 ¶ 49. Similarly, in the '683 Patent IPR, Petitioner proposed that a POSITA "would have understood 'Superficial layer' to mean 'a surface layer.'" Ex-1031, 22-24, 32; Pet., 19. I therefore adopt that meaning here in my analysis.

B. Prior Art

21. I understand that a person shall not be entitled to a patent if the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public in the United States before the effective filing date of the claimed invention.

22. I understand prior art cannot anticipate or render obvious a patent clam if the alleged disclosures cited as prior art are not enabled. I understand that an enabling disclosure is a disclosure that provides sufficient to detail to enable a person having ordinary skill in the art to make the claimed invention. I also understand that mere naming or description of subject matter is insufficient, if it cannot be produced without undue experimentation.

C. Anticipation

23. I understand that a prior art reference anticipates a patent claim if the reference discloses or includes every element of the patent claim, arranged as described in the claim in a manner that would enable person having ordinary skill in the art to practice the claimed invention. If even a single element is missing, the prior art reference does not anticipate the patent claim.

24. An element is inherently disclosed in a prior art reference only if the missing matter is necessarily present in the thing described in the reference and would be so recognized by persons of ordinary skill. The mere fact that a certain

thing may result from a given set of circumstances is not sufficient.

D. Obviousness

25. A patent claim is invalid for obviousness if the claimed invention would have been obvious at the time the invention was made to a person having ordinary skill in the art. See 35 U.S.C. § 103. To assess obviousness, the following factors are considered: (1) the scope and content of the prior art; (2) the differences between the art and the claims at issue; (3) the level of ordinary skill in the art at the time the invention of the asserted patent was made; and (4) objective evidence of non-obviousness. To determine whether claim elements are found in the prior art, it is necessary to compare the properly construed claim language of the patent with the teachings of the prior art.

26. To combine prior art references to show obviousness, a person of ordinary skill in the art, without knowledge of the claimed invention, or without the use of hindsight, must have been motivated to combine the prior art by, for example, some suggestion or teaching in the prior art, the knowledge of one of skill in the art, or the nature of the problem to be solved. Such a person must have had a reasonable expectation of success in doing so. It is appropriate to look to a variety of factors when evaluating reasons to combine references in an obviousness analysis. It is important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the alleged prior art elements in the

manner claimed. A patent composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art.

27. I understand that the motivation to combine must be more than a conclusory statement. That requires an adequate evidentiary basis and articulation of a reason why a person of ordinary skill in the art would combine the prior art references. That requires more than merely rejecting arguments for why a person of skill in the art would not be motivated to combine, but instead a reasoned explanation of why one of skill in the art would be motivated to combine. Common sense or common knowledge cannot be used as a substitute for reasoned analysis and evidentiary support. And relying solely on common knowledge or common sense is improper.

28. Motivation to combine requires a showing that one of skill in the art would be motivated, at the time of the invention, to have combined all references in a combination together. It is not sufficient to say that one of skill in the art could combine all references in a combination, but rather, one must show that one of skill in the art would have combined all references in the combination.

29. It is impermissible to use the claimed invention itself as a blueprint for piecing together elements in the art. In other words, it is impermissible to use hindsight reconstruction to pick and choose among disclosures in the prior art to

reconstruct the claimed invention.

E. Secondary Considerations of Non-Obviousness

30. In evaluating whether patent claims are invalid as obvious, objective indicia of nonobviousness can be considered. Such objective indicia can include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; and (h) teaching away from the invention in the prior art. I also understand that these objective indications are only relevant to obviousness if there is a connection, or nexus, between them and the invention covered by the patent claims.

31. I understand that a patentee is entitled to a rebuttable presumption of nexus between the asserted evidence of objective indicia and a patent claim if the patentee shows that the asserted objective evidence is tied to a specific product and that the product is the invention disclosed and claimed. In other words, presuming nexus is appropriate when the patentee shows that the asserted objective evidence is tied to a specific product and that product embodies the claimed features, and is coextensive with them. If on the other hand, the patented invention is only a

component of a commercially successful machine or process, the patentee is not entitled to a presumption of nexus.

F. Enablement of Prior Art

32. I also understand that the disclosure in asserted prior art must be adequate to enable possession of the desired subject matter. That is, the reference must teach a skilled artisan to make or carry out what it discloses in relation to the claimed invention. Thus, to render a claim obvious, the prior art, taken as a whole, must enable a skilled artisan to make and use the claimed invention. I understand that it is insufficient to name or describe the desired subject matter, if it cannot be produced without undue experimentation. I understand that the enablement inquiry takes into account what is known to a person of ordinary skill in the art. Thus, I understand that a disclosure need not include that which is already known to and available to one of ordinary skill in the art.

33. I understand that, to determine whether a prior art disclosure is enabling with reasonable (and not undue) experimentation, one may consider, among other factors, the relative skill of those in the art, the amount of direction or guidance presented in the prior art, the quantity of experimentation necessary, the amount of direction or guidance presented, the presence or absence of working examples, the state of the prior art, the relative skill of those in the art, and the predictability or unpredictability of the art. Thus, for example, I understand that

undue experimentation may be implicated and the enabling requirement not met when a disclosure provides a mere roadmap, starting point, or invitation to research without more.

III. PERSON OF ORDINARY SKILL IN THE ART (POSITA)

34. For purposes of this proceeding, I will use Dr. Miles's description that a POSITA "would have had at least an undergraduate degree in materials science, manufacturing engineering, mechanical engineering, or equivalent knowledge, training, or experience, with at least two years of experience working in metallurgy." Ex. 1003 ¶ 15.

35. Although I surpass Dr. Miles definition of a POSITA now and at the priority date of the Asserted Patents. Through my research and teaching, I am familiar with the knowledge and understanding of a POSITA as of the priority date[6] of the Challenged Claims, state of the art at the time, and alleged prior art cited by Dr. Miles. I have taught students with the requisite experience, and also interacted with people of skill in my consulting, project, and conference travel. I can opine on, for example, how a POSITA would have understood the disclosure and claims of the '227 Patent, the disclosures of the prior art and whether they

[6] I understand the parties do not agree on the invention date of the Challenged Claims. I understand Dr. Miles has not opined on an invention date for the Challenged Claims. In this report, if I do not specify a date, it means my opinion would be the same regardless of whether the Asserted Clams have an invention date of no later than December 2005 or October 30, 2006.

enabled persons of skill at the time to practice or reproduce their disclosures, the state of the art and underlying science at the time, the motivation of POSITAs to combine the prior art and their likelihood of success in doing so, and what combinations would have been obvious to a POSITA.

IV. OVERVIEW OF THE STATE OF THE ART

A. Background on Hot Stamping

36. Hot stamping is a process used in sheet metal forming. As I explain below, "hot stamping" is used to describe the overall process (e.g., from a coil to a final part) *and* also to describe a specific step within the process (i.e., when the part is hot stamped or formed and cooled into the final part shaped). As a result, context matters when determining the meaning of the phrase "hot stamping."

37. I understand that ArcelorMittal and VinFast jointly described the technology related to the '227 Patent as follows:

> The manufacturing process begins with the manufacturing of steel sheets. The steel sheets are then hot dipped into an aluminum or aluminum-alloy bath, which results in aluminum or aluminum-alloy coated steel, which is produced and shipped in coils.
>
> The coils are next "hot stamped," a process in which the steel from the coils is heated and press-hardened through die quenching. Specifically, the aluminum or aluminum-alloy coated steel coil is fed into a press and die where a blank in the desired shape is punched out from the large metal sheet. The blank is then loaded into an oven or furnace to be heated. Next, the heated blank is transferred to a hot stamping press which presses and cools the piece. Finally, the hot-stamped part is unloaded from the press for finishing.

These hot-stamped parts may form various components of an automobile, such as the frame, which includes, for example, door rings, front and rear bumper beams, door reinforcements, windscreen pillar reinforcements, A- and B-pillars, roof rails, and dash panel crossmembers. These hot-stamped parts are then assembled into automobiles.

Ex. 2020 (Joint Technology Stipulation) at 2.

38. The ’227 Patent also provides a background of the state of the art:

In recent years the use of pre-coated steels in hot-stamping processes for the shaping of parts has become important, especially in the automotive industry. Fabrication of such parts may include the following main steps:

Pre-coating of a steel sheets, by hot dipping;

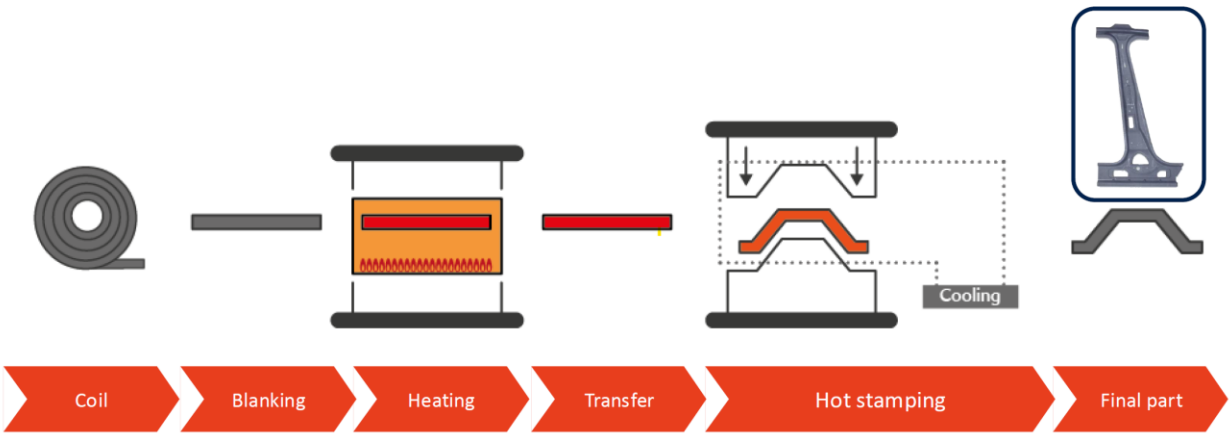
Trimming or cutting for obtaining blanks;

Heating the blanks in order to obtain alloying of the steel substrate with the pre-coating, as well as the austenitizing of the steel; and

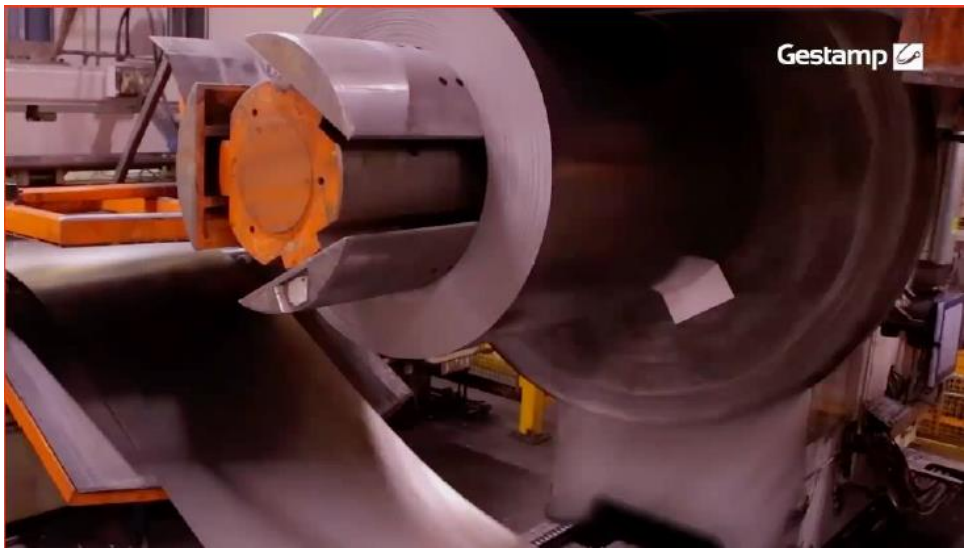
Hot forming followed by rapid cooling of the part in order to obtain predominantly martensitic structures, See for Example U.S. Pat. No. 6,296,805, incorporated herein by reference.

Ex. 1001 (’227 Patent) at 1:41-53.

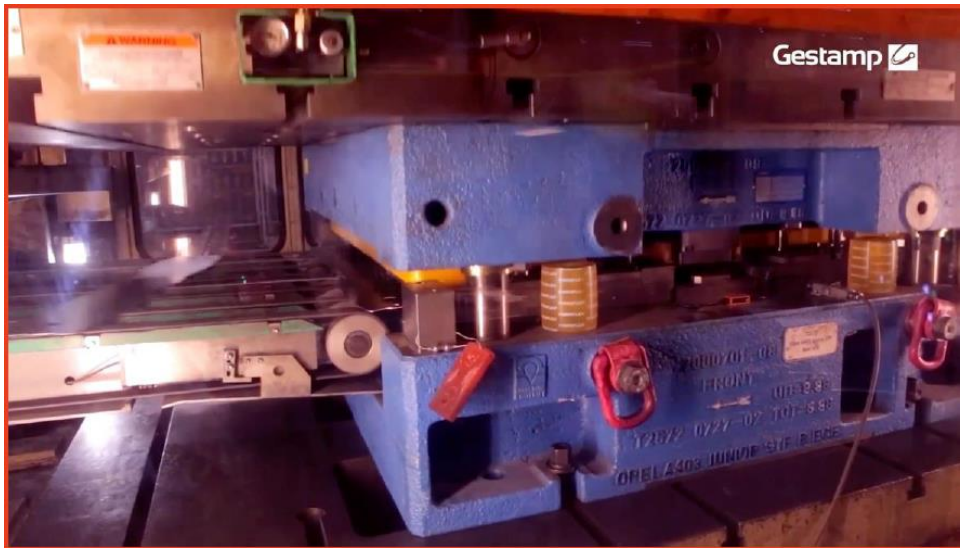
39. A picture of the hot stamping process is depicted below:



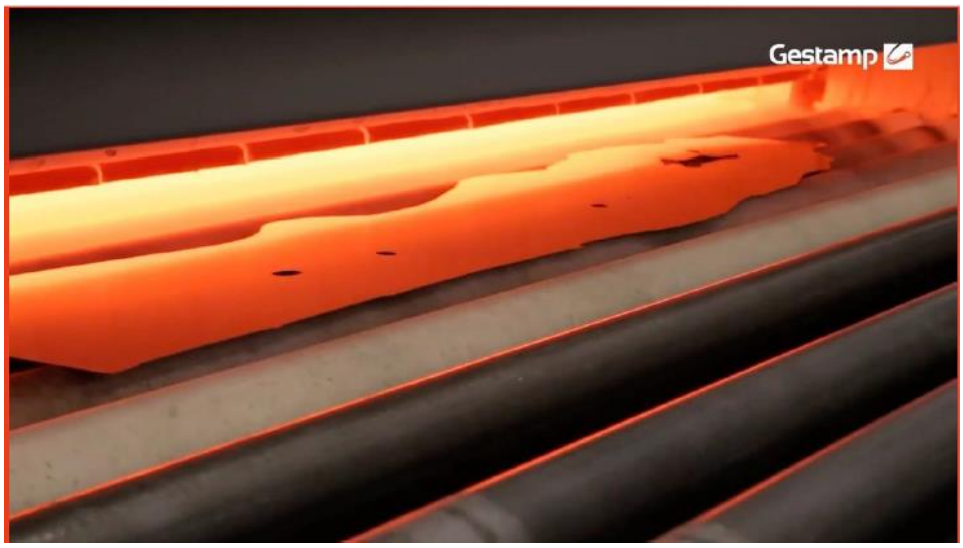
40. Coil: The process typically starts with a steel coil. The coil will have a certain composition, thickness, and other features. The coil can also be uncoated or pre-coated, where the coating will also have a certain composition, thickness, homogeneity and so on. All these features can be changed or varied. Below is a picture of a coil at a factory.



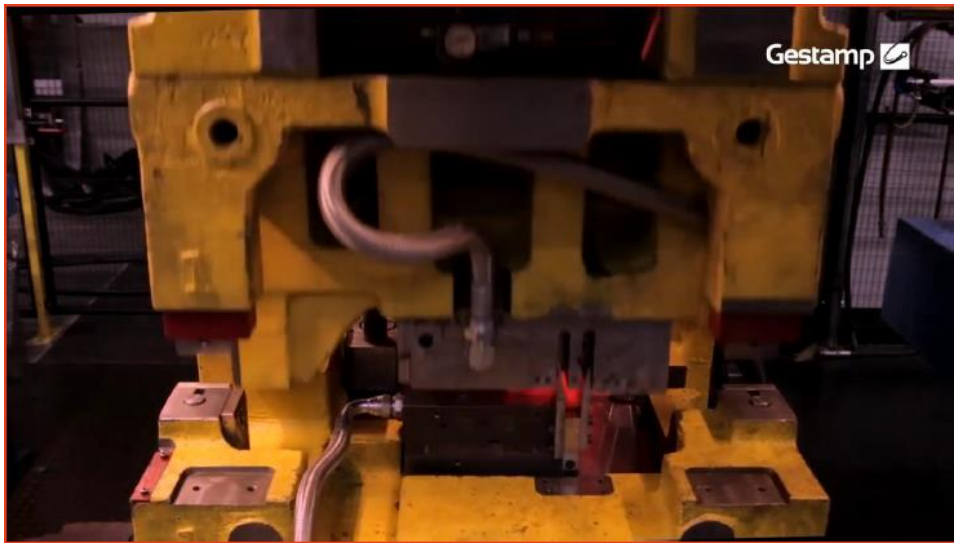
41. Blanking: In the blanking step, the coil is cut so its shape is closer to the final desired shape. Below is a picture of machinery cutting the coil into blanks.



42. Heating: The next step in the process is heating the blank in an oven. During this step, the steel will undergo austenitic transformation. This is a complex step with many different parameters that can impact the structural properties of the coating and material of the final part. This includes the size of the oven, the type of the oven, the heating times, ranges, and rates at each heating stage, the dew point, temperature, and temperature distribution. The heating curve is important control step in the processing: if it is done too fast, the aluminum has insufficient diffusion time to react with the base steel. This means that the melting point of the unreacted aluminum (which is only 660°C) could be reached before necessary diffusion, resulting in liquid aluminum and fouling. Below is a picture of a blank being heated on rollers in a tunnel oven.

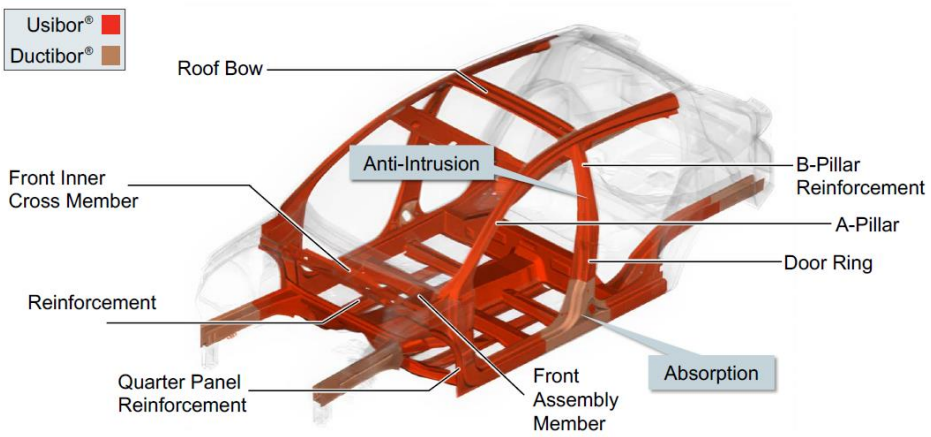


43. Transfer and Hot stamping: During these steps, the blank is transferred to the stamping part of the process and hot stamped. As I mentioned above, "hot stamping" not only can refer to the overall process but can also refer to this specific step within the overall process. The part is quenched, rapidly cooled down in temperature, and adjusted into the shape of the final desired part—all at the same time. There are many parameters that can be adjusted during these steps including transfer time, cooling time, and exit temperature. During this step, martensitic transformation also occurs. Below is a picture of a blank being quenched.



B. Problems with Conventional Hot Stamping

44. In the early 2000's, hot stamping was not widely used in the automotive industry. It was used in limited applications such as bumper beams, which could be bolted onto a car. It, however, was not widely used, for example, to make parts for the passenger cage or body-in-white ("BIW") portion of the vehicle (the components of the vehicle shown in color below). These parts needed to be both spot welded together and must have a corrosion resistant coating, as well as must display a high degree of formability and paintability. Hot stamping parts that had these attributes posed several problems.



45. For example, the ’227 Patent describes problems associated with conventional hot stamping during the manufacturing process, specifically with the hot stamping of parts for the BIW with corrosion resistant coatings (i.e., based on aluminium alloy).

> Problems however are experienced with the furnace operation: the rollers may become fouled by metallic deposits which come from the pre-coating of the blanks. If these deposits are excessive, maintenance of the rollers has to be performed and productivity is decreased.

Ex. 1001 (’227 Patent) at 2:2-6.

46. Dr. Drillet, one of the named inventors of the ’227 Patent, further described the problem with fouling:

> So concerning the hot-stamper, as the coating has to be transformed inside the oven at a very high temperature, we have this risk to deposit a lot of liquid, and this was aluminum, mainly the aluminum coating will melt during austenization. We have to be careful not to put an excessive deposition of liquid to the surface of the rolls of the hot-stamper

Ex. 2009 (ITC Tr.) at 110:19-25.

47. Another issue, as mentioned above, is that automotive manufacturers

needed parts that displayed high weldability, paintability, and were corrosion resistant. Ex. 2009 (ITC Tr.) at 108:3-109:3. For example, A-pillars and B-pillars are mounted using a spot-welding process, which means hot stamped parts needed to have the appropriate microstructure to be weldable in a "sufficiently wide operating range." Ex. 1001 ('227 Patent) at 2:6-27; Ex. 2009 (ITC Tr.) at 108:25-109:3.

48. The '227 Patent addressed these issues and more.

V. THE '227 PATENT

A. Introduction to the '227 Patent

49. The '227 Patent is titled "Coated steel strips, coated stamped products and methods." Ex. 1001 ('227 Patent) at Title. The named inventors of the '227 Patent are Pascal Drillet, Dominique Spehner, and Ronald Kefferstein.

50. The '227 Patent issued on March 30, 2021 from application number 16/413,799, which was filed on May 16, 2019. It is a continuation of application number 15/606,770, which was filed on May 16, 2017, which is a continuation of application number 13/621,015, which was filed on September 15, 2012, and issued as U.S. Patent No. 9,708,683, which is a division of application number 12/447,777, which was filed as application number PCT/IB2006/004019 on October 30, 2006, and issued as U.S. Patent No. 8,307,680.

51. The Abstract of the '227 Patent states:

> A pre-coated steel strip is provided. The steel strip includes a strip of base steel having a length, a width, a first side, and a second side. The length of the strip is at least 100 m and the width is at least 600 mm. An aluminum or an aluminum alloy pre-coating is on at least part of at least one of the first or second sides of the strip of base steel. A thickness t_p of the pre-coating is from 20 to 33 micrometers at every location on at least one of the first or second sides. Processes, coated stamped products and land motor vehicles are also provided.

Ex. 1001 ('227 Patent) at Abstract.

52. The specification of the '227 Patent states:

> The inventors have also discovered that particularly good weldability of aluminized and hot stamped parts is associated with a special succession of coating layers on the parts, proceeding from steel substrate outwards.

Ex. 1001 ('227 Patent) at 2:64-67.

53. Figure 1 of the '227 Patent is an embodiment of the claimed invention and shows the microstructure of a hot stamped part, including the successive coating layers:

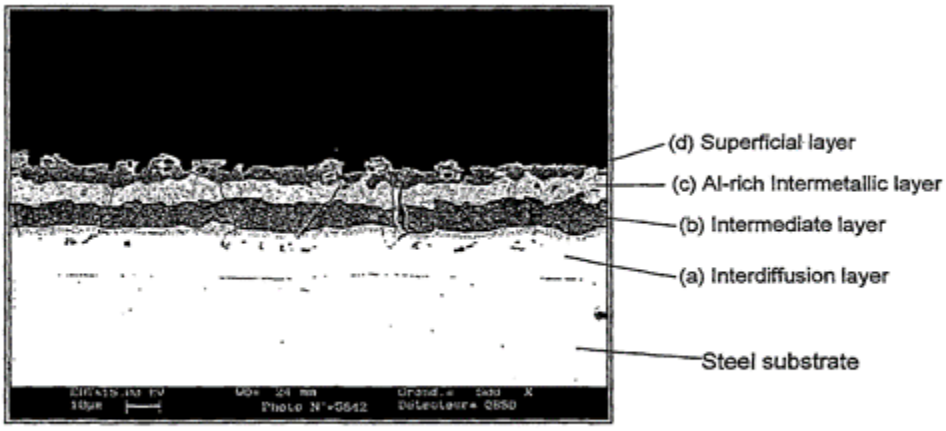


Fig. 1 10μm

Ex. 1001 ('227 Patent) at Figure 1. These layers are the Interdiffusion layer, Intermediate layer, Intermetallic layer, and Superficial layer. Ex. 1001 ('227 Patent) at 3:54-59.

54. The '227 Patent explains that the inventors discovered benefits to hot stamped parts with the specific claimed microstructure:

- "This arrangement is particularly favorable for the further welding of the part." Ex. 1001 ('227 Patent) at 3:58-59.
- "The inventors have also discovered that good welding results are achieved if the coating obtained on parts made out of blanks having undergone intermetallic alloying, austenitizing and hot stamping, displays distinctive features. It must be pointed out that this coating is different from the initial pre-coating, since the thermal treatment causes an alloying reaction with the steel substrate which modifies both the physico-chemical nature and the geometry of the pre-coating: in this regard, the inventors have discovered that particularly good weldability of aluminized and hot stamped parts is associated with the following succession of coating layers on the parts[.]" Ex. 1001 ('227 Patent) at 6:12-23.
- "Without being bound by a theory, it is thought that this particular layer disposal, in particular layer (a) and, layers (c) and (d) influence the resistivity of the coating both by their intrinsic characteristics and by the effect of roughness. Thus, current flow, heat generation at the surfaces, and nugget formation in the initial stage of spot welding are affected by this particular arrangement." Ex. 1001 ('227 Patent) at 6:57-64.
- "The steel is particularly suited to the production of structural and anti-intrusion parts." Ex. 1001 ('227 Patent) at 11:30-31.

55. Accordingly, the '227 Patent discloses, enables, and claims a beneficial coating microstructure that is obtained in a repeatable, consistent, and robust manner. The '227 Patent discloses process parameters that will achieve a beneficial or ideal coating microstructure in a repeatable consistent, and robust

matter. *See generally* ’227 Patent; *see also* 4:44-64; 5:12-67; 6:1-52; 6:53-7:3; 7:5-8:4; 8:5-9:20; 9:21-11:42; 11:46-14:56; 14:58-16:60; and Figures.

VI. BACKGROUND ON THE SCIENCE OF HOT STAMPING

56. As described above, the hot stamping process is a complex process with many different parameters that impact the properties of the final part. Ex. 2021 (“The hot stamping of Boron steel is a complex process which involves the prior plastic deformation followed by a continuous cooling transformation. The phase transformation during press hardening is affected by many factors, including material content, tool/blank interfacial contact, tool design, etc.”).

57. The relationship among all the different parameters on the microstructure of a final part is still being studied by researchers in the field. Ex. 2022 at 10902 (“The purpose of this research is to determine the effects of heat treatment temperatures, cooling conditions, and and mechanical properties of 22MnB5 steel in detail to improve quality hot stamping parts.”).

58. In 2006, it was recognized that this process was complex.

> However, the multi-phase microstructure, which is at the base of the strengthening mechanisms in most of these steels, leads to unacceptably high stresses during forming and significant spring-back phenomena, thus making traditional sheet metal forming technologies unsuitable. The possibility to perform stamping operations at elevated temperatures represents a solution of these problems, allowing lower loads on tools and higher accuracy of formed components. Compared with conventional sheet metal forming, the proper design of hot stamping process chain requires the deep knowledge of both interface phenomena and material behaviour at high temperatures in order to

> obtain the desired properties of final products in terms of microstructure and strength characteristics.

Ex. 2023 at 396.

59. In 2006, it was also recognized how little was known about the relationship among the different parameters on the microstructure of a final part. For example, a 2006 paper in the Journal of Materials Processing Technology succinctly described the state of the art:

> In the automotive industry, the hot forming of high strength steels offers the possibility to obtain significant reduction of weight without affecting the structural performances of final products. The main reason of its restricted application in the industry lies however in the ***lack of basic knowledge about mechanical and microstructural characteristics*** of sheets at elevated temperature, boundary conditions (i.e. friction and heat transfer), sensitivity of the formed component geometrical and mechanical characteristics to all the process parameters.

Ex. 2023 at Abstract (emphases added).

60. There are many examples in the literature recognizing the complexity and lack of knowledge about the hot stamping process.

- "Despite its advantages, hot stamping is a complex manufacturing process where the properties and quality of the final part are strongly affected by the material and the numerous parameters in the thermo-mechanical cycle, such as strain- and strain rate-paths, temperature and microstructure evolution that mutually interact during the forming and the cooling stages." Ex. 2024 at 265.
- "The mechanism of formation of the layered structure is not fully evident." Ex. 1016 (Takagi) ¶ 0019.
- "Despite these numerous studies of the coating, the findings of the resulting phase composition, coating/substrate interface, and void distribution in the coating are inconsistent . . . As such, this work is focused on the TEM-SAED

analysis of the coating/substrate interface, and the description of phases through the coating, as well as an analysis of the top surface layer by means of XPS and roughness measurements to increase the general knowledge of Al-Si coatings." Ex. 2025 at 3.

61. At the ITC Investigation, VinFast's expert acknowledged that how the different parameters in the hot stamping process impact the microstructure of a part is not clear:

> [ArcelorMittal Attorney]. In your view, the heating rate, the heating time, holding time, and quenching rate during hot-stamping are all process conditions that affect the result of the hot-stamped, aluminum alloy-coated steel; correct?
>
> [VinFast's Expert]. Well, the difficulty I have with the question is that we know that Dr. Drillet has said that those parameters are important. I think in my deposition, I stated that I think it's not clear that how each one of those parameters affect the formation of the coating, because there hasn't been a good description in any document I've seen, other than to say that it has an influence, how that influence imposes itself, how those process conditions impose themselves in terms of forming a microstructure in the coating.
>
> Because we've seen that it's possible to form coatings which don't have that microstructure.
>
> And I think that there is according to the literature that I've seen, not a clear consensus in terms of precisely what set of conditions are required to produce that specific microstructure because we see that sometimes it occurs and sometimes it doesn't.

Ex. 2009 (ITC Tr.) at 961:4-24.

> [ArcelorMittal Attorney]. In your deposition, I asked, "So, in your view, you cannot determine whether one or more of the claimed layers in the patents is present unless you know the processing conditions for the part; correct?" And you answered, "Correct." That was your testimony, right, sir, yes or no?
>
> [VinFast's Expert]. It is.

Ex. 2009 (ITC Tr.) at 962:16-22.

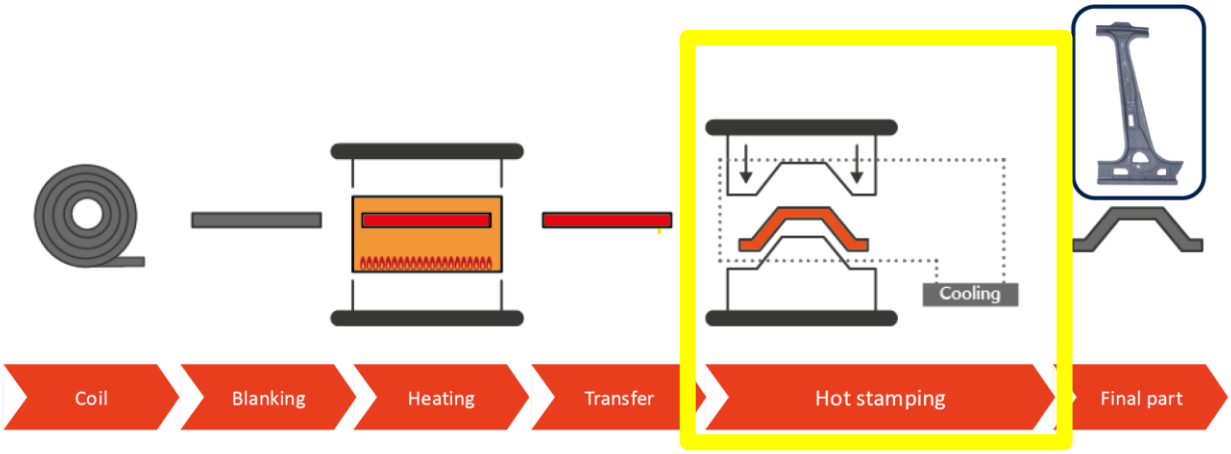
62. During the hot stamping process, diffusion occurs between the steel and aluminum coating. These diffusion kinetics are incredibly complex. For example, there are complex and non-linear interactions between Fe, Al, and Si. A change in the amount of any one of these elements will impact the thermodynamic and diffusional process. This is a multi-dimensional problem, where all chemical elements and all processing parameters need to be considered, rendering the intricate and often unpredictable relationships between layer composition, heating rate, oven dwell time, layer thickness, Kirkendall porosity, mechanical properties of layers, and base sheet steel etcetera extremely hard to control and design for. Adding to this already complex process, the parameters in the hot stamping process will also have an effect on the thermodynamic and diffusional process. A seemingly minor change to any variable or parameter will create complex microstructural interactions that will impact the formation of intermetallics, layer formation (or degradation), and lamellar structure and spacing.

VII. OVERVIEW OF THE ASSERTED ART

A. Engels

63. Engels is titled "Controlling and Monitoring of the Hot-Stamping Process of Boron-Alloyed Heat-Treated Steels." Ex. 1005 (Engels) at 1. Its authors are H. Engels, O. Schalmin, and C. Muller-Bollenhagen. Ex. 1005 (Engels) at 1.

64. Engels is predominantly focused on the specific step of hot stamping within the hot stamping process.



65. Using the diagram from above, I highlighted that step as shown.

66. I excerpted the Abstract of Engels below:

Abstract

Due to steadily rising crash requirements to be met by modern automotive structures, the application of ultra-high strength materials has increased. Hot-stamping is an approach to produce these structural parts. High material strengths may lead to wear problems during the trimming operations following the hot-stamping process. Depending on part geometries, the trimming operation can be integrated into the hot-stamping process. The desired mechanical and surface properties call for an analysis of the effects of process parameters on the above-mentioned part requirements. Accordingly, the feasibility analysis during prototyping has to be distinguished from the analysis of heat treatment and from the analysis of the quenching behavior inside the die. Besides standard destructive testing methods, the magnetic inductive approach seems to be apt for testing the mechanical and technological properties of the parts.

Ex. 1005 (Engels) at 1.

67. Engels has four sections:

- The first section is titled "Introduction." Ex. 1005 (Engels) at 1-2.
- The second section is titled "Hot-Stamping of Boron Alloyed Steels." Ex. 1005 (Engels) at 2-6. This section has three subsections:

- "2.1 Direct Process." Ex. 1005 (Engels) at 3.
- "2.2 Indirect Process." Ex. 1005 (Engels) at 4.
- "2.3 Combined Hot-Stamping and Cutting." Ex. 1005 (Engels) at 4-6.

- The third section is titled "Part-Specific Process Parameters." Ex. 1005 (Engels) at 6-12. This section has two subsections:
  - "3.1 Heat Treatment." Ex. 1005 (Engels) at 8-9.
  - "3.2 Simulation of the Cooling Behavior During the Hot-Stamping Process." Ex. 1005 (Engels) at 4-6.
- The fourth section is titled "Magnetic Inductive Testing of Mechanical Properties of Hot Stamped Structural Parts." Ex. 1005 (Engels) at 12-16. This section has three subsections:
  - "4.1 The Operating Principle of Magnetic Inductive Testing." Ex. 1005 (Engels) at 12-14.
  - "4.2 Hysteresis and Material Properties." Ex. 1005 (Engels) at 14-15.
  - "4.3 Testing the Applicability of the Process." Ex. 1005 (Engels) at 15-16.

68. **Introduction:** The introduction of Engels shows that Engels is focused on the hot stamping step of the hot stamping process. Engels mentions that hot stamping can allow for parts with "tensile strengths R_m of up to 1600 MPa." Ex. 1005 (Engels) at 1. The strength of a steel part depends on the extent of the martensitic transformation that occurs in a steel part. In the hot stamping process, martinsitic transformation occurs during the hot stamping step.

69. In the introduction, Engels also states that it will provide a "brief"

overview of the hot stamping process in Chapter 2. Ex. 1005 (Engels) at 2. And that Chapter 3 will cover process parameters "with regard to mechanical part properties" and that "optimum mechanical properties can be obtained if the cooling conditions inside the die are modelled according to the TTT diagram." Ex. 1005 (Engels) at 2. Engels states that a theoretical approach to analyzing the cooling behavior will also be outlined. This again shows that Engels is focused on the specific step of hot stamping because mechanical properties related to the cooling conditions inside the die and an analysis of cooling behavior are related to the strength of the steel. In fact, Dr. Miles agrees that mechanical structural changes are related to the specific hot stamping step. Ex. 1003 (Miles Decl.) ¶ 33 ("In view of this continuous, unified process that includes immediate transfer to a die for stamping, a POSITA would have understood Engels FIG. 5 to illustrate a part that has undergone the entirety of that process, including stamping: to depict a part that has undergone only a portion of the process (e.g., furnace treatment without forming in a die) would have been viewed as much less illustrative and relevant. This is particularly true in view of the immediate context of Engels FIG. 5, which includes a discussion of how the forming and quenching process causes 'structural change' in the part."). Finally, Engels describes Chapter 4 as showing that the control and validation of process parameters related to tensile strength and hardness may be better done through a non-destructive magnetic inductive

processes. Ex. 1005 (Engels) at 2, 12.

70. **Section 2:** Section 2 of Engels provides a very generic and basic text-book overview of hot the hot stamping process. For example, its description is not specific to precoated steels. Ex. 1005 (Engels) at 2 (discussing "using uncoated 22MnB5"). While Engels states that blanks or parts can be austenitized at temperatures between 900 and 950 degrees Celsius, Engels does not state that particular range is tied to any specific microstructure beyond that fact that austenization can occur.

71. **Section 3:** Section 3 of Engels describes the various process parameters that impact the hot stamping process. The majority of section 3 is directed to analyzing parameters that impact the mechanical properties of a part. Ex. 1005 (Engels) at 6-7, 9-12. Indeed, all of section 3.2 is solely about simulating the cooling behavior of a part during the specific step of hot stamping.

72. The only parts of section 3 relating to the heating step of the hot stamping process is two rows of Table 1 and section 3.1. Ex. 1005 (Engels) at 7-9. I have excerpted these portions of Engels below.

	Part characteristics		
		Surface properties	
	Mechanical properties	22MnB5+AS diffusion layer	22MnB5, oxidation, surface decarburization
Heat treatment			
Temperature profile	X	X	
Protective atmosphere			X
Stamping and tempering			
Transfer time t_T between furnace and die	X		X
Cooling realized according to TTT diagram	X		

Table 1. Part-specific process parameters

3.1 Heat Treatment

The heat treatment of uncoated boron steel is carried out under a protective atmosphere in order to avoid oxidation and surface decarburization. Besides so-called endo- and exo-gases, a nitrogen atmosphere with natural gas added at a 95:5 ratio is being used. This is a non-explosive mixture providing light carburization effects.

When using hot-dip aluminum coated boron steels, it is crucial to look for a correctly shaped diffusion layer with regard to layer thickness, porosity and roughness, as this layer will decisively impact the corrosion and welding properties of the hot stamped parts. The diffusion process is affected by the preset temperature profile of the heating facility.

Thus, these are the parameters which have to be taken into account when setting the temperature profile:

- the heating rate,
- the total processing time,
- the maximum austenitizing temperature and
- the material thickness.

Figure 5 shows a cross-section polish of the diffusion layer of a hot-dip aluminum coated boron steel. Five phases which differ in their layer thickness and chemical composition can easily be distinguished.

phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
		Volume-%				
1	5 – 9	7,2	89,2	1,9	0,3	1,4
2	< 1µm	unmeasurable				
3	11 – 18	51,4	45,9	1,9	0,1	0,7
4	3 – 8	33,9	54,3	10,6	0,3	0,9
5	5 - 11	53,2	44,1	1,9	0,2	0,6

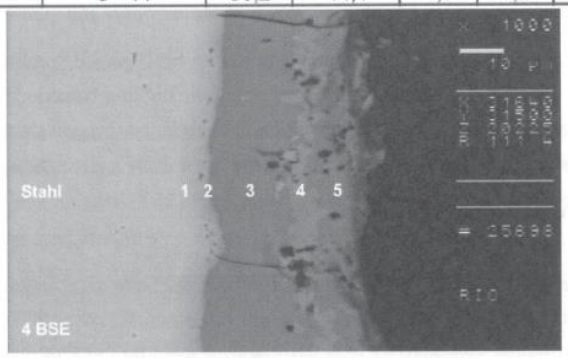


Figure 5. SEM micrograph of a cross-section polish of the diffusion layer

73. Engels states the following about the heating process:

- The surface properties has some type of relationship to the temperature profile. Ex. 1005 (Engels) at Table 1. The diffusion process is affected by the temperature profile. Ex. 1005 (Engels) at 8.

- The shape of the diffusion layer "with regard to layer thickness, porosity and roughness" will impact corrosion and welding properties of the hot stamped part. Ex. 1005 (Engels) at 8.

- The parameters that need to be taken into account are "the heating rate, the total processing time, the maximum austenitizing temperature and the material thickness." Ex. 1005 (Engels) at 8.

- Engels shows Figure 5, which is a figure showing a cross-section polish of a diffusion layer of a hot-dip aluminium coated boron steel. Ex. 1005 (Engels) at 8-9.

- According to Engels, five phases that have different layer thicknesses and chemical compositions can "easily" be distinguished in Figure 5. Ex. 1005 (Engels) at 9. Engels provides the layer thickness for those five easily distinguished phase numbers and the measurements of Al, Fe, Si, Cr, and Mn for those phase numbers. Ex. 1005 (Engels) at 9.

74. Engels does not provide any information about the following as it

relates to Figure 5:

- The base steel composition beyond stating that it is a "boron steel"
- The base steel thickness
- The precoating composition beyond stating that it is an "aluminium" coating
- The precoating thickness
- The precoating homogeneity
- The oven size
- The oven type
- The heating times (at xi heating stage)
- The heating rates (at xi heating stage)
- The heating ranges (at xi heating stage)
- The dew point
- How Engels delineated phases or layers beyond the qualitative description of "easily distinguished"
- How the measurements of Al, Fe, Si, Cr, and Mn for those phase numbers were generated

75. In the ITC Investigation, VinFast's expert agreed that Engels did not disclose the heating rate or heating curve:

> [ArcelorMittal Attorney]. So if we go one more slide ahead to slide 50, we don't know in Engels what heating rate or heating curve or heating time was used to obtain the steel that is imaged in this SEM; correct?
>
> [VinFast's Expert]. I agree.

Ex. 2009 (ITC Tr.) at 964:9-13.

76. **<u>Section 4:</u>** Section 4 of Engels relates only to the specific step of hot stamping. Ex. 1005 (Engels) at 12-16. It describes a way to test the strength and hardness of a part using a magnetic inductive process. Ex. 1005 (Engels) at 12-16.

B. Cornette

77. Cornette is titled "High Strength Steels for Automotive Safety Parts" and its authors are D. Cornette, T. Hourman, O. Hudin, J.P. Laurent, and A. Reynaert of Usinor Research. Ex. 1014 (Cornette) at 1. Usinor is a predecessor to ArcelorMittal.

78. The abstract of Cornette provides:

ABSTRACT

Energy savings are among the most important goals of steel users. Usinor proposes a wide range of very high strength steels (HSLA, DP, TRIP, etc.) for weight reduction and impact resistance. This text deals with the mechanical testing and different design solutions associated with these steel grades. Tensile and formability properties are presented first by means of basic tests (drawing, stretching, bending, etc.) in order to classify the different steels. A specific part of the text deals with a ultra high tensile strength pre-coated boron steel for hot forming. In addition to this, the crash resistance is investigated by using a dynamic axial compression test and a dynamic three point bending test on structural components with closed and open cross sections. For each steel grade, the estimated weight saving potential is compared with respect to parts manufactured in high drawability steel. Finally, two different designs are presented with steel solutions for safety parts. The first one shows the advantage of the use of TRIP steel and a hydroforming technique for a crash box instead of using a conventional forming technique. The second one deals with the design of a cross frontal sill with a complex cross section, formed using a profile rolling technique.

Ex. 1014 (Cornette) at 3.

79. On pages nine to 11, Cornette has a section titled "Pre-Coated Boron Steel." Ex. 1014 (Cornette) at 9-11. In this section, Cornette describes USINOR's

development of "USIBOR" and it explains the benefits of using a pre-coated boron steel versus uncoated boron steels. Ex. 1014 (Cornette) at 9-11. For example, Cornette displays the general process for hot stamping, but other than Figure 21, does not provide any other process parameters:

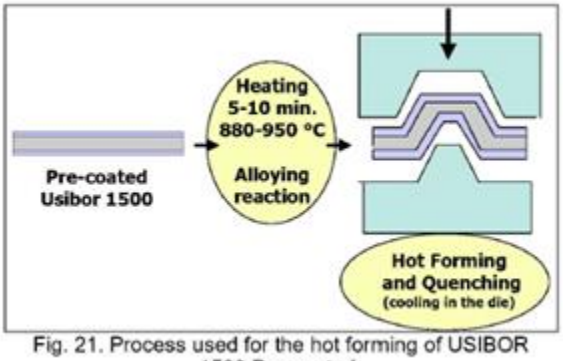


Fig. 21. Process used for the hot forming of USIBOR 1500 Pre-coated.

Ex. 1014 (Cornette) at 9.

80. Cornette also shows the chemical composition of the precoated boron steel.

Table III. Chemical composition of pre-coated boron steel in thousandths of percent

	C	Mn	Si	S	Cr	Al	B	Ti
Min.	200	1100	150		150	20	2	20
Max.	250	1350	350	8	300	60	4	50

Ex. 1014 (Cornette) at 9.

81. Cornette then provides a "Description of the Coating."

DESCRIPTION OF THE COATING

The coating, made of aluminum and silicon, is applied with a hot dipped process.
The average layer thickness showing the best compromise between corrosion protection and weldability is 25 µm.
Heating the pre-coated boron steel (generally 900°C, 5 minutes) creates an alloying reaction between substrate (iron) and the coating (aluminum - silicon) which leads to a hard multiphase alloy layer.
Fe-Al-Si layer is typically about 40 µm at the steel surface. The following photo shows a section view of the coating after heat treatment:

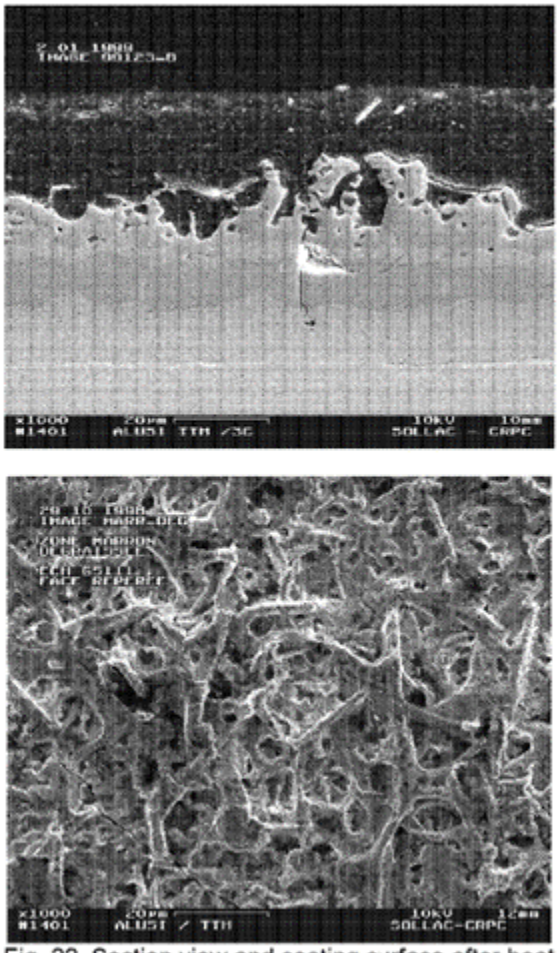


Fig. 22. Section view and coating surface after heat treatment.

Ex. 1014 (Cornette) at 9-10.

82. Cornette does not provide any further analysis or description of these pictures. For example, Cornette does not indicate the composition of the coating

contained in Figure 22, the thickness of the base steel used to generate Figure 22, or the heating rate. Cornette then briefly describes "Mechanical Characteristics" but notes that "[m]echanical properties after hot forming process are not gauarant[e]ed by USINOR." Ex. 1014 (Cornette) at 9-11.

83. Cornette also briefly describes "Spot Weldability," "Surface Treatment," "Corrosion Resistance," and "Painted parts." Ex. 1014 (Cornette) at 10-11.

84. Finally, Cornette concludes this section with some advantages of using a pre-coated boron steel instead of an uncoated boron steel. Ex. 1014 (Cornette) at 11.

C. Laurent

85. Laurent is U.S. Patent No. 6,296,805 and is titled "Coated hot- and cold-rolled steel sheet comprising a very high resistance after thermal treatment." The named co-inventors are Jean-Pierre Laurent, Jean-Paul Hennechart, Dominique Spehner, and Jacques Devroc. It describes a steel sheet with various compositions.

86. For example, the abstract of Laurent provides:

(57) **ABSTRACT**

Hot-rolled steel sheet which then can be cold-rolled, coated, the steel in the sheet having the following composition by weight:

0.15%<carbon<0.5%

0.5%<manganese<3%

0.1%<silicon<0.5%

0.01%<chromium<1%

titanium<0.2%

aluminum<0.1%

phosphorus<0.1%

sulfur<0.05%

0.0005%<boron<0.08%, the remainder being iron and impurities inherent in processing, the sheet ensuring a very high mechanical resistance after thermal treatment and the aluminum-based coating ensuring a high resistance to corrosion.

Ex. 1023 (Laurent) at Abstract.

D. Nishibata

87. Nishibata is titled "Method For Hot Forming And Hot-Formed Members." Ex. 1050 (Nishibata) at 1. The named applicants are Toshinobu Nishibata, Masahiro Nakata, Shuntaro Suda, Akira Obayashi, and Masanobu Ichikawa. Ex. 1050 (Nishibata) at 1.

88. The abstract of Nishibata provides:

(57) Abstract: A method for hot forming, wherein in the cooling step of hot pressing, a formed product is first cooled at a rate of a critical cooling rate or higher down to the Ms point thereof and then cooled at a rate of 25 to 150°C/s from the Ms point to 200°C; and a hot pressed member which has been formed by the method and has a Vickers hardness of less than (the maximum quench hardness - 10) and (the maximum quench hardness - 100) or more. The hot pressed member is manufactured from a high strength steel sheet by means of hot pressing and exhibits a stable strength and toughness in combination.

Ex. 1050 (Nishibata) at 1.

E. Takagi

89. Takagi is U.S. Patent Pub. No. 2004/0009366 and is titled "Aluminum-coated structural member and production method." Ex. 1016 (Takagi) at 1. The named applicants are Kiyoshi Takagi, Eizaburo Nakanishi, and

Tomoyuki Yoshida. Ex. 1016 (Takagi) at 1.

90. The abstract of Takagi provides:

(57) **ABSTRACT**

An aluminum-coated structural member includes an Al—Si—Fe alloy layer formed on a steel substrate layer. The alloy layer includes a softer region having a hardness smaller than or equal to a hardness of the steel substrate layer, extends from the surface of the steel substrate layer toward a surface of the alloy layer, over a depth range greater than or equal to 50% of a thickness of the alloy layer. The Al—Si—Fe alloy layer has an oxide weight smaller than or equal to 500 mg/dm^2.

Ex. 1016 (Takagi) at Abstract.

91. Takagi provides examples of aluminium-coated steel sheets. In its examples, however, the coating layer has a thickness of 10 to 20 µm. Ex. 1016 (Takagi) at [0035].

92. Takagi also explains that "[t]he mechanism of formation of the layered structure is not fully evident." Ex. 1016 (Takagi) at [0019].

F. Hein

93. Numerical Simulation," and its authors are P. Hein, R. Kefferstein, and Y. Dahan. Ex. 1019 (Hein) at 1. R. Kefferstein is one of the co-inventors on the Asserted Patents.

94. The abstract of Hein provides:

Abstract

The amount of ultra high strength hot-stamped boron steel is rapidly increasing in automotive bodies-in-white. Indeed, this material and the related hot stamping technology allow reaching strength levels (1500 MPa) which are far above those of best-in-class cold stamping steels. Moreover, the traditional balance between high strength, low formability and high springback is outruled by hot stamping.

General market trends of hot stamping are discussed and an overview of the main parameters defining the process window of hot stamping is given. A test device has been set up to determine the formability limits of USIBOR 1500 P in hot stamping. The methodology for FE-analysis of hot stamping is presented and the flow chart of a typical feasibility study, as realised by Arcelor for its customers, is described.

Ex. 1019 (Hein) at Abstract.

95. Hein discusses the differences between using uncoated and coated boron steel. Ex. 1019 (Hein) at 2-3. Hein also discusses market trends. Ex. 1019 (Hein) at 3-5.

96. Hein also notes that the process parameters can "significantly impact the cost effectiveness of the process":

2 Main Influencing Process Parameters

When designing a hot stamping process, and choosing the corresponding machine technology, particular attention has to be paid to factors directly influencing the part quality, the cycle time and the process stability. All three factors significantly impact the cost effectiveness of the process.

Ex. 1019 (Hein) at 5.

G. GMW14400

97. GMW14400 is titled "Low Carbon, Heat-Treatable Boron Steel – Uncoated or Aluminized Pre-Coated." Ex. 1026 (GMW14400) at 1. It is a material specification from GM Worldwide Engineering Standards. Ex. 1026

(GMW14400) at 1.

98. The scope of GMW14400 provides:

> **1 Scope**
>
> This specification covers the requirements for low carbon, heat-treatable boron steel used in the manufacture of structural parts requiring heat treatments to achieve high strength. Press-hardened steel can be pre-formed and subsequently hot-stamped and die quenched, but post-forming should not be the scope for this type of steel. Typical applications include door impact beams, bumper impact beams, and reinforcements for impact structures.

Ex. 1026 (GMW14400) at 1.

99. GMW14400 provides requirements for parts, but does not provide any process parameters for obtaining those requirements. For example, GMW14400 provides the following requirements:

Table 6: Al-Si Coating Requirements[Note 1]

Condition	Coating Mass (g/m^2)	Coating Thickness (μm) [Note 2]
Prior to hot-stamping	60 to 100	20 to 33
Following hot-stamping	N/A	>35

Note 1: Additional demands can be specified by the local business units.
Note 2: Prior to hot-stamping, suitable evaluation instruments to measure coating thickness on the as-received sheet include eddy current, ferromagnetic, or microscopy. Magnetic inductive measurements are not recommended following the hot-stamping operation without proper calibration.

Ex. 1026 (GMW14400) at 7. However, as noted, GMW14400 also notes that local business units could provide additional demands on coating mass and thickness. Ex. 1026 (GMW14400) at 7.

VIII. PETITIONER'S ENGEL'S BASED GROUNDS DO NOT RENDER THE CLAIMS OF THE '227 PATENT UNPATENTABLE

A. Engels Is Not Enabled

100. In my opinion, Engels would not have enabled a POSITA to practice the Challenged Claims without undue and excessive experimentation requiring modulation and design of multi-dimensional and complex chemical, microstructural, processing parameters.

101. As I explained above, a POSITA is defined as someone who "would have had at least an undergraduate degree in materials science, manufacturing engineering, mechanical engineering, or equivalent knowledge, training, or experience, with at least two years of experience working in metallurgy." Ex-1003 ¶ 15.

102. As defined, a POSITA would have been analogous to an experienced technician working in metallurgy. A POSITA would not have been a specialist in, or even experienced with, the microstructural science of aluminium-alloy coated hot-stamped steel. As a result, a POSITA would not have been able to design manufacturing processes to create the claimed microstructural layers recited in the Challenged Claims or to arrive at the microstructure shown in Engels without at a minimum undue and excessive experimentation.

103. I also attended the ITC evidentiary hearing where VinFast's technical expert, Dr. Brown used the same definition of a POSITA that is being used in this

case. Ex. 2009 (ITC Trial) 940:2-17. As Dr. Brown stated, this definition of a POSITA is not confined to any specific type of metallurgical experience. Ex. 2009 (ITC Trial) at 940:18-22. As a result, Dr. Brown testified that an individual working at a steel plant melting and forming steel slabs would qualify as a POSITA.

> [ArcelorMittal Attorney]. For example, if a steel worker at a plant had an undergraduate degree in mechanical engineering and two years of experience working the line where they're melting and forming steel slabs, they would qualify as a person of skill in the art, in your view, with respect to the asserted patents; correct?
>
> [VinFast's Expert]. Yes.

Ex. 2009 (ITC Tr.) at 940:23-941:3.

104. Dr. Brown's testimony is consistent with my opinion regarding the level of skill in this case.

105. The level of skill is insufficient to arrive at the Challenged Claims or the microstructure in Engels based on the state of the art and disclosures in Engels without undue experimentation. I have taught students with the requisite experience and also interacted with people of skill in my consulting, project, and conference travel that meet the definition of a POSITA for more than 35 years on several continents. And I have, likewise, interacted with many people who surpass the definition of a POSITA. The level of skill that would have been needed to design manufacturing processes exceeds the definition of a POSITA in this case,

and would have required graduate level coursework, advanced degrees, and/or significantly more experience in the field. An undergraduate degree in the recited fields and two years of experience working metallurgy would not provide someone the skill to arrive at the Challenged Claims based on Engels's disclosures without massive, complex undue experimentation. In other words, given the advanced skill needed, it would not have been possible for a POSITA someone to recreate the Challenged Claims or the microstructure in Engels based on the disclosure contained in Engels and the state of the art.

106. As I explained above, hot stamping is a complex process with many parameters. Here, for example, a POSITA would have needed to design the heating, holding, cooling conditions, that would, during hot stamping, yield the specific phase transformation, lamellar structure, and intermetallic layering in an aluminium alloy coating as called for in the Challenged Claims. This would have been far beyond the skill of a POSITA. A POSITA would not have been able to just look at an SEM image of an intermetallic phase layered microstructure in an aluminum alloy coating that is a handful of microns thick and be able to make it without excessive and undue experimentation. Indeed, as I explained above, hot stamping is a complex field, and even today, researchers are studying the relationship among all the different parameters on the microstructure of a final part. As a result, Engels would need to provide substantial guidance for making

the claimed invention, but, as explained below, it does not.

107. A POSITA's lack of meaningful knowledge is further compounded by the fact that Engels does not provide guidance on how to arrive its disclosed microstructure or at the Challenged Claims. As I explained above, Engels is focused on "wear problems" that occur "during the trimming operations" of the hot stamping process. As to the specific heating step, Engels provides barely any disclosure beyond what could be learned from a basic undergraduate textbook on hot stamping (e.g., a simplified schematic of the hot stamping process and some of the parameters that are involved with the hot stamping process). *See supra* VII.A.

108. Engels does not provide any meaningful guidance as to how to create the depicted microstructure. Engels does not provide values, ranges, or describe the relationship among the parameters that impact the heating step of the hot stamping process. For example, Engels provides no disclosure whatsoever as to the heating curves needed to obtain the specific microstructure shown in Engels, which a POSITA could not simply intuit or create based on the SEM picture. Indeed, at the ITC evidentiary hearing, Dr. Brown agreed that Engels did not disclose this information.

> [ArcelorMittal Attorney]. So if we go one more slide ahead to slide 50, we don't know in Engels what heating rate or heating curve or heating time was used to obtain the steel that is imaged in this SEM; correct?
>
> [VinFast's Expert]. I agree.

Ex. 2009 (ITC Tr.) at 964:9-13.

109. To create the microstructure depicted in Engels or practice the Challenged Claim, a POSITA would need to determine these parameters, such as base steel composition, base steel thickness, precoating composition, precoating thickness, precoating homogeneity, oven size, oven type, heating curve (heating times, rates, and ranges for each heating stage), and the dew point. Engels recognizes that many of these parameters need to be determined, but it does not actually say anything about how these parameters collectively relate to one another and impact the formation, relative sizing, or composition of microstructural interdiffusion phase layers.

3.1 Heat Treatment

The heat treatment of uncoated boron steel is carried out under a protective atmosphere in order to avoid oxidation and surface decarburization. Besides so-called endo- and exo-gases, a nitrogen atmosphere with natural gas added at a 95:5 ratio is being used. This is a non-explosive mixture providing light carburization effects.

When using hot-dip aluminum coated boron steels, it is crucial to look for a correctly shaped diffusion layer with regard to layer thickness, porosity and roughness, as this layer will decisively impact the corrosion and welding properties of the hot stamped parts. The diffusion process is affected by the preset temperature profile of the heating facility.

Thus, these are the parameters which have to be taken into account when setting the temperature profile:

- the heating rate,
- the total processing time,
- the maximum austenitizing temperature and
- the material thickness.

Figure 5 shows a cross-section polish of the diffusion layer of a hot-dip aluminum coated boron steel. Five phases which differ in their layer thickness and chemical composition can easily be distinguished.

Ex. 1005 (Engels) at 8.

110. Other state of the art references also recognize that parameters play a

critical role and impact the formation, relative sizing, or composition of microstructural interdiffusion phase layers.

> **2 Main Influencing Process Parameters**
>
> When designing a hot stamping process, and choosing the corresponding machine technology, particular attention has to be paid to factors directly influencing the part quality, the cycle time and the process stability. All three factors significantly impact the cost effectiveness of the process.

Ex. 1010 (Hein) at 12; *see also supra* VI.

111. Since Engels does not provide any guidance, a POSITA would have been on their own to determine how to design and determine these parameters. However, as explained above, a POSITA would not have had sufficient knowledge to do so and would not succeed without undue and excessive experimentation.

112. The state of the art in combination with Engels also would not have helped a POSITA practice the Challenged Claims or create the microstructure disclosed in Engels.

113. During the ITC Investigation, VinFast's expert reviewed the state of the art, including all the references asserted in this IPR. Dr. Brown stated that the art did not show a relationship among the parameters and how they impact the development of attributes in the microstructural layers.

> [ArcelorMittal Attorney]. In your view, the heating rate, the heating time, holding time, and quenching rate during hot-stamping are all process conditions that affect the result of the hot-stamped, aluminum alloy-coated steel; correct?
>
> [VinFast's Expert]. Well, the difficulty I have with the question is that we know that Dr. Drillet has said that those parameters are important. I think in my deposition, I stated that I think it's not clear

> that how each one of those parameters affect the formation of the coating, because there hasn't been a good description in any document I've seen, other than to say that it has an influence, how that influence imposes itself, how those process conditions impose themselves in terms of forming a microstructure in the coating.
>
> Because we've seen that it's possible to form coatings which don't have that microstructure.
>
> And I think that there is according to the literature that I've seen, not a clear consensus in terms of precisely what set of conditions are required to produce that specific microstructure because we see that sometimes it occurs and sometimes it doesn't.

Ex. 2009 (ITC Tr.) at 961:4-24.

114. As I explained above, the state of the art shows that hot stamping process is a complex process with many different parameters that impact the properties of the final part. *See supra* VI. The chemistry and diffusion kinetics are extremely complex and unpredictable. And even today, the relationship among all the different parameters on the microstructure of a final part is still being studied by researchers in the field. *See supra* VI.

115. The (lack of meaningful) knowledge of a POSITA, the lack of knowledge in the art, the complex nature and unpredictability of the art, the (lack of meaningful) disclosure in Engels all mean that an undue and excessive amount of experimentation in an area requiring multi-dimensional and non-linear parameters would be required to practice the Challenged Claims or create the microstructure depicted in Engels. For example, a POSITA would need to design the various required parameters and understand how those parameters impact the

microstructural properties and phase transformations in an aluminium alloy that undergoes interdiffusion with steel during hot stamping. However, this is beyond the skill-level of a POSITA in this case. As a result, it would have taken an excessive and undue amount of experimentation to practice the Challenged Claims or even to recreate the microstructure in Engels. In my opinion Engels lacks enablement.

B. Engels Does Not Disclose The Claimed Superficial Layer

116. In my opinion, Engels does not disclose the following limitations of the Challenged Claims:

- Claim 1: "(d) a Superficial layer,

  wherein layers (a), (b), (c), and (d) each have a different mean composition from one another,"

117. **"Superficial layer"**: In my opinion, the plain and ordinary meaning of "superficial layer" is "surface layer." I understand this is consistent with Petitioner's interpretation of "superficial layer" in the *inter partes* review proceeding involving U.S. Patent No. 9,708,683. In the '683 proceeding, Petitioner stated:

> **4. "Superficial layer" (Claim 1)**
>
> While the '683 patent fails to define the term "superficial," it has a plain and ordinary meaning. *See* Ex. 1026 at 1828 (defining "superficial" as "lying on or pertaining to the superficies or surface").
>
> As such, a PHOSITA would have understood "Superficial layer" to mean "a surface layer." Ex. 1003 at ¶ 63.

Ex. 1031 ('683 Petition) at 24.

118. In this proceeding, I understand that Petitioner has not formally requested any claim construction. At the same time, Petitioner has asserted that the plain and ordinary meaning, consistent with my interpretation, is a "surface layer." Petition at 18-19 ("The '227 Patent does not describe that the names of the layers (i.e., 'interdiffusion,' 'intermediate,' 'intermetallic,' and 'superficial') denote any particular characteristics of the layers. However, phases 1 (or 1+2), 3, 4, and 5 satisfy the meanings of each of those terms as proposed by Petitioner during IPR proceedings for the '683 Patent."). Likewise, here, Dr. Miles also refers to the interpretation of "superficial layer" in the '683 proceeding. Ex. 1003 (Dr. Miles) at ¶ 49. ("However, phases 1 or 1+2, 3, 4, and 5 satisfy the meanings of each of those terms as proposed by Petitioner during IPR proceedings for the '683 Patent . . . . Phase 5 is superficial in that it is arranged at the surface of the coating.").

119. As a result, I agree with Petitioner and Dr. Miles that the plain and ordinary meaning of "superficial layer" is a "surface layer."

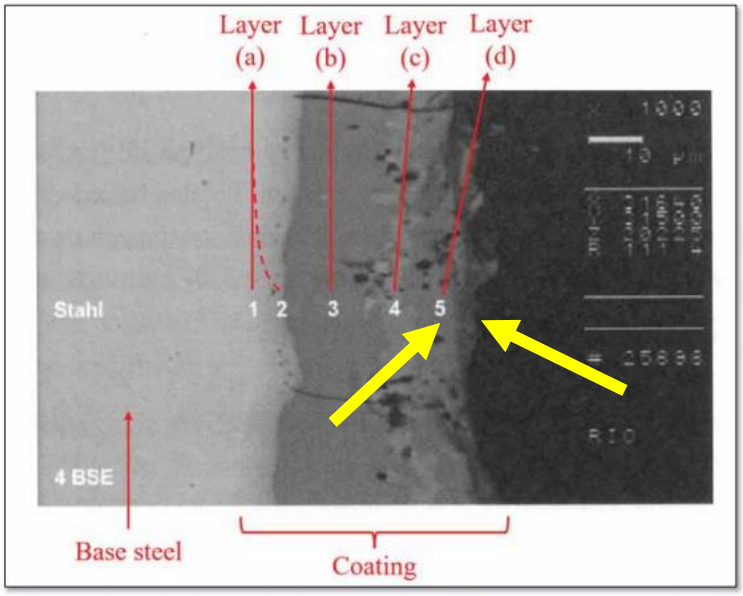
120. **Engels's Phase 5 is not a "superficial layer."** The Petition states that Engels's phase 5 is the claimed superficial layer. I disagree. In Engels, phase 5 is *not* the claimed surface layer.

121. As Dr. Miles recognizes, Figure 5 of Engels is a backscattered scanning electron microscopy image. Ex. 1003 (Dr. Miles) at ¶ 38. And as Dr.

Miles also recognizes, "shading (light/dark) is reflective of the composition of the imaged material." Ex. 1003 (Dr. Miles) at ¶ 38. Dr. Miles uses this contrast in shading as an indication of a layer. Ex. 1003 (Dr. Miles) at ¶ 57 ("In the case of FIG. 5, I measured the coating thickness based on the phase shadings, which, as I discussed above, are representative of different compositions."); Petition at 21 n.3 ("Dr. Miles explains that the measurement was conducted based on the shadings in FIG. 5, which, based on Engels' disclosure and his familiarity with imaging using backscattered electrons (BSE) in scanning electron microscopy (SEM), correspond to the different phases of the coating.").

122. To be more precise, a different shading reflects that a layer has a different overall composition, but the difference in shading does not indicate how a specific element in a layer compares to that same element in a different layer.

123. In Figure 5 of Engels, phase 5 is not at the surface. There is another layer, indicating by a different shading, above Engel's phase 5. I added yellow arrows to Dr. Miles's annotated version of Figure 5. The arrow on the left points to phase 5; the arrow on the right points the presence of another layer above phase 5 that has a different shading.



Annotated Engels FIG. 5

Ex. 1003 (Dr. Miles) at ¶ 48 (adding additional annotations).

124. Figure 5 clearly shows that there is a layer above phase 5, such that phase 5 cannot be the claimed "superficial layer."

125. But Engels provides even more evidence that there is another layer above phase 5. Engels provides a table with measurements of the thickness of the layers. And Figure 5 has a scale. So one can easily measure the thickness of what Engels intends as phase 5.

126. Indeed, as Dr. Miles recognizes, the scale in an SEM image can be relied upon for precise measurements. Ex. 1003 (Dr. Miles) at ¶ 29 ("As I know from personal experience, these scale bars are common in electron microscopy output and can be relied upon for precise measurements of in-focus materials such as the imaged coating."). In fact, Dr. Miles used the scale to measure the thickness

of layers in Figure 5. Ex. 1003 (Dr. Miles) at ¶ 56 ("For example, I have performed a direct measurement in Engels FIG. 5 (shown below) based on the included 10 μm scale. This and other measurements herein (for example, measurements of layers in Hein and Cornette) were conducted by using an on-screen pixel ruler and the included scale to determine a conversion between pixels and μm, and then applying the conversion to pixel measurements of the layers/coatings. In all cases, the images used do not appear distorted, such that the dimensions can be measured with a high degree of accuracy.").

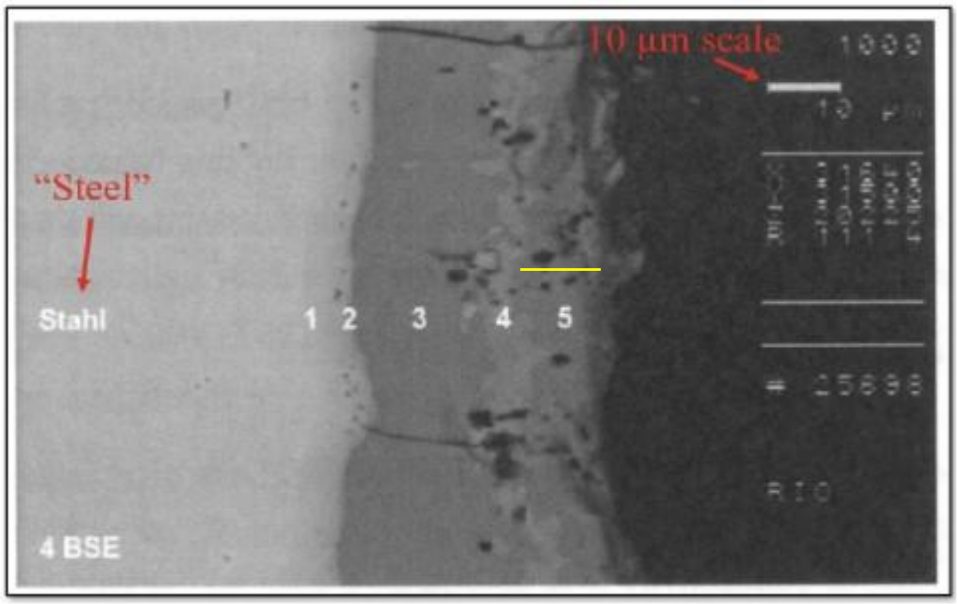
127. Engels's table is shown below:

phase number	layer thickness, μm	Al	Fe	Si	Cr	Mn
		Volume-%				
1	5 – 9	7,2	89,2	1,9	0,3	1,4
2	< 1μm	unmeasurable				
3	11 – 18	51,4	45,9	1,9	0,1	0,7
4	3 – 8	33,9	54,3	10,6	0,3	0,9
5	5 - 11	53,2	44,1	1,9	0,2	0,6

Engels' Table

Ex. 1003 (Dr. Miles) at ¶ 28.

128. Engels's table shows that phase 5 has a maximum thickness of 11 μm. I followed the same process as Dr. Miles, where I used an "an on-screen pixel ruler and the included scale to determine a conversion between pixels and μm." A yellow line that is 11 μm was then placed on Engels's Figure 5. As shown, phase 5 does not extend to the surface.



129. As a result, both a visual examination of Figure 5 and an analysis of Engels's measurements both show that phase 5 does not extend to the surface. Therefore, it cannot be the claimed superficial layer because phase 5 is not a surface layer.

130. I understand that this Institution Decision in this proceeding states the following with respect to Figure 5:

> Figure 5 of Engels indicates 5 phases. *See supra* Section III(E)(2) (reproducing Engels Fig. 5). Figure 5 indicates that the rightmost phase, phase 5, is the phase at the surface. Figure 5, the accompanying table, and the text of Engels all indicate there is no phase six. Ex. 1005, 8–9 ("Five phases which differ in their layer thickness and chemical composition can easily be distinguished."). This evidence adequately supports, for institution purposes, Petitioner's position that phase 5 is a "superficial layer." *See also* Ex. 1003 ¶¶ 44–46. While Patent Owner's argument may present an issue of fact to be finally resolved at trial (if Patent Owner maintains the argument in a Patent Owner response), the evidence before us is sufficient to support that Petitioner has a reasonable likelihood of establishing, by a preponderance of the evidence, that Engels's Figure 5 phase 5 is a surface layer.

Institution Decision at 25.

131. There are a few issues that I wish to clarify. First, the decision states that "Figure 5 indicates that the right most phase, phase 5, is the phase at the surface." Institution Decision at 25. As a I stated above, Figure 5 shows that phase 5 (what the Institution Decision calls the right most phase) is *not* at the surface as there is a phase above phase 5. While Figure 5 indicates that the rightmost *annotated* phase is phase 5, that is not the same as the rightmost face being Figure 5.

132. Indeed, Engels never purports to identify all phases in Figure 5. Instead, Engels explains that "[f]ive phases which differ in their layer thickness and chemical composition can easily be distinguished." Ex-1005, at 8-9. In other words, Engels has limited its identification of phases to those that "can easily be distinguished." If Engels was purporting to identify all phases, there would be no need for the qualifier of "can easily be distinguished."

133. I am also not surprised that Engels self-identified five layers, and did not focus on the surface layer. As I explained above, Engels described non-destructive ways to test the strength and hardness of a hot-stamped part. In other words, the primary focus on Engels was about the strength and hardness of a part. The strength and hardness of a part is primarily derived from the properties of the base steel beneath the coating (and thus most impacted by the layers below the

surface layer). The surface layer, meanwhile, has a greater impact on corrosion resistance and weldability, an issue different from what Engels was addressing. As such, I am not surprised Engels did not focus on the surface layer or try to take its measurements.

134. The Institution Decision states " Figure 5, the accompanying table, and the text of Engels all indicate there is no phase six." Respectfully, I do not agree with this assessment of Engels:

- Figure 5: As I explained above, a visual examination of Figure 5 shows there is a layer above phase 5. As I explained above, Dr. Miles admitted that different shading indicates a different layer. And clearly, there is a different shading above phase 5.
- Accompanying Table: As I explained above, the accompanying table conclusively shows that there is a layer above phase 5. The table provides the maximum thickness for phase 5. However, as shown above, there is clearly additional layer material above phase 5. That means one of two things is true: either there is another layer above phase 5 or Engels did not provide a full measurement for phase 5 (which as explained below presents a different problem).
- Text of Engels: As I explained above, the text of Engels never states that it is attempting to identify all layers present in the SEM. In fact, it states the contrary, it is identifying layers that "can easily be distinguished." And as I stated above, it is not surprising that Engels was not focused on the surface layer.

135. Thus, in my opinion, Engels's phase 5 cannot be the claimed superficial layer.

136. **"Chemical Composition":** The limitations stated above also require a specific chemical composition among the layers. This is underlined below:

- Claim 1: "(d) a Superficial layer,

  wherein layers (a), (b), (c), and (d) <u>each have a different mean composition</u> from one another,"

137. There is no evidence that microstructure in Figure 5 meets the recited compositional relationships.

138. Petitioner relies on Engels's accompanying table for the values of the composition.

Differing Fe compositions

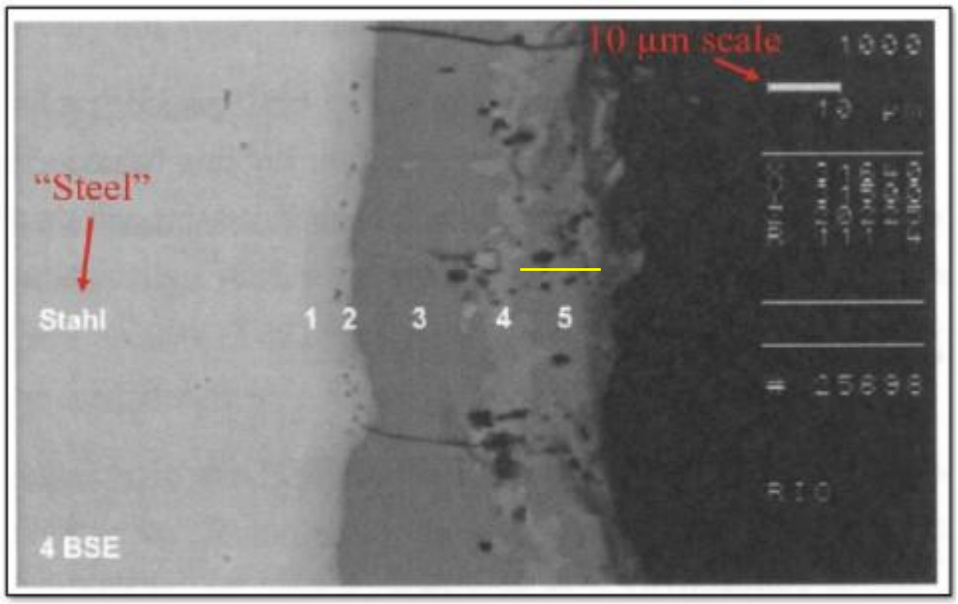
	phase number	layer thickness, µm	Al	Fe	Si	Cr	Mn
			~~Volume-%~~ Mass-%				
Layer (a)	1	5 – 9	7,2	89,2	1,9	0,3	1,4
[Layer (a)]	2	< 1µm	unmeasurable				
Layer (b)	3	11 – 18	51,4	45,9	1,9	0,1	0,7
Layer (c)	4	3 – 8	33,9	54,3	10,6	0,3	0,9
Layer (d)	5	5 - 11	53,2	44,1	1,9	0,2	0,6

Fe% (layer (c)) > Fe% (layer (b))

Annotated Engels' Table

E.g., Petition at 20.

139. However, Engels only provides measurements for the indicated phase and layer thickness as clearly shown in the table. Thus, if there is not a differently numbered layer above layer 5 (and as explained above, there is), then it is clear that layer 5 extends beyond 11 µm. As I showed above, 11µm does not extend to the surface.



140. That means Engels did not measure the compositional element of the full extent of layer 5 (to the extent it is determined that a different layer does not exist above layer 5). Engels only provides compositional and elemental information for the first 11 µm of what would then be phase 5.

141. I understand that Board's Institution Decision stated "Rather, claim 1 only requires a different composition. Engels teaches '[f]ive phases which differ in their layer thickness and chemical composition can easily be distinguished,' and the table accompanying Figure 5 indicates different iron compositions."

142. Engels, however, discloses only the overall composition of what it measured. For example, the layers identified with numbers and provided measurements. Engels's identified layer 5 does not extend to the surface, and as such, Engels could not have provided a measurement for the range of the layer extending to the surface.

143. Instead, Engels only provided a measurement of the composition for the first 11 μm. Without knowing the remaining composition, there is no way to determine if the layer extending to the surface actually differs in composition from other layers as the Challenged Claims require.

IX. THERE IS NO MOTIVATION TO COMBINE TAKAGI, HEIN, AND GMW14400

144. In my opinion, a POSITA would not have been motivated to combine Takagi, Hein, and GMW14400.

145. As I mentioned above, GMW is a material specification from GM Worldwide Engineering Standards. Ex. 1026 (GMW14400) at 1. GMW would not drive a general market demand towards meetings its specification. That is because companies like GMW would obtain their parts from Tier 1 suppliers under contracts with those suppliers. Tier 1 suppliers are companies that hot stamp and produce parts for carmakers based on the designs. Thus, the general market would not have been the audience for GMW but rather individuals at Tier 1 suppliers who design the hot-stamping processes to manufacture those parts.

146. As a result, at best, GMW would have driven a demand for the individuals at Tier 1 suppliers who design the hot-stamping processes to manufacture those parts to attempt to meet its specification. But those individuals are very different than a POSITA in this proceeding. A POSITA in this proceeding would have been an experienced technician working in some aspect of metallurgy.

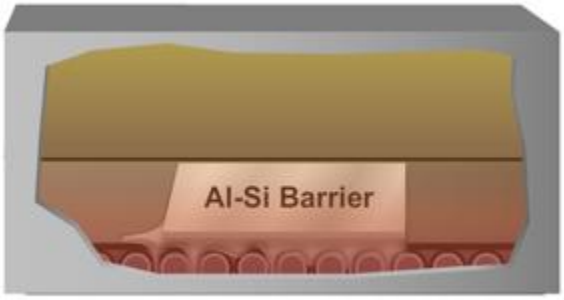
A POSITA would not have been someone who is risen to the highly specialized role of designing hot-stamping processing procedures for aluminum-alloy coated steel (much less specifically for GM). A POSITA would not have been motivated by GMW because GMW was directed to and intended for a very different and very specific audience. Thus, GMW would not have provided a motivation for a POSITA to combine Takagi and Hein.

147. There also many technical reasons why GMW would not have provided a motivation to obtain a post-hot stamping coating thickness of greater than 35 µm.

148. Obtaining a post-stamping coating thickness of greater than 35 µm means that more pre-coating must be used on the base steel at the beginning of the hot stamping process. This would have increased expenses because more pre-coating would mean more cost. Without some added a benefit to a post-stamping coating thickness of greater than 35 µm, and GMW does not describe any benefit to such a thick post-stamping coating thickness, a Tier 1 supplier would not have wanted to absorb increased costs necessary to achieve a greater than 35 µm. At the same time, GMW would not have wanted to pay more for a part merely because more pre-coating had to be used. As a result, without some specific benefit attributable to a post-stamping coating thickness of greater than 35 µm, manufacturing costs would have counselled against trying to obtain such a thick

post-stamping coating thickness.

149. In addition to manufacturing costs, using more pre-coating will create other problems during the manufacturing process. For example pre-coating is applied during a hot-dip process. To obtain a thicker pre-coating, the precoating aluminium immersion bath for the base steel would need to be more exacting. During the heating step, an increase in precoating means that there will a greater transfer of liquid to the production equipment causing fouling in the hot stamping line and related surfaces. For example, the image below is an illustration of a pre-coated steel blank being heated in an oven.



As can be seen, the coating is melting and transferring to the rollers (the piece of equipment that moves the steel blank through the oven). This will cause the liquid to foul the equipment.

150. There are all sorts of consequences from fouling. There will be equipment problems, equipment will degrade faster, and the production lines will need to be stopped so the machinery can be repaired.

151. In addition, when more coating is applied to a base steel, it becomes even more difficult to apply the coating evenly across the steel. If coating is not applied evenly or uniformly, then the diffusion layers will not form properly which will have a detrimental effect on weldability.

152. Furthermore, AlSi coating is a thermal insulator. When AlSi coating increases, then the hot stamping process becomes less efficient. For example, during the heating step, the AlSi coating would increase thermal insulation and require additional adjustments to the heating curve, and result in the use of, among other things, increased temperatures and longer heating times.

153. In addition, if more pre-coating is used, then the interdiffusion phase layer will be thicker and more pronounced. This would have created issues with formability because there is a higher chance that the part's surface coating will crack or have other issues during the forming step.

154. All of these problems have the effect of slowing down production, increasing manufacturing time, increasing waste, increasing costs, and reducing output. As I explained in the above, because GMW did not ascribe any specific benefit to 35 µm, all these problems would have meant that one would not have been driven by GMW to achieve a post-stamping coating thickness of greater than 35 µm.

155. As a result, merely increasing the coating thickness would not have

been commercially desirable. At that time, the state of the art would have counselled against excessive use of pre-coating. Indeed, for example Takagi uses a pre-coating of only 10-20 µm. Takagi did not use more pre-coating because it would not have been desirable to do so. Simply put, more is not always better. It was only after the inventors set forth their specific microstructural design and teachings in the ’227 Patent that a microstructural design for phase layers in aluminum-alloy coating was created and enabled that would facilitate high weldability, high paintability, as well as avoid cracking and formation failure.

156. As I mentioned above, a POSITA would not have been the audience for GMW and would not have been involved with the design of the hot-stamping process or the design of microstructural phase layers in aluminum alloy coatings. However, a POSITA would have been well-aware of the problems caused by using additional pre-coating. A technician or operator would have been well-aware of production problems created by fouling and the other issues I mentioned above. All of these issues would have taught away from trying to achieve a post-stamping thickness of greater than 35 µm.

157. I also note that GMW expressly states that “additional demands” can be specified. Ex-1026, 7 n.2. This means business units and suppliers could seek to revise the requirements of the specification. This is consistent with my opinion that the 35 µm requirement would have caused manufacturing issues.

158. And even if someone was motivated based on GMW, and they would not have been, it would have been an incredibly challenging to create a process to address these problems and even more experience would have been needed. It would take even more skill and the undue and excessive experimentation would be even greater.

159. A POSITA also would not have been motivated by Hein's disclosures. According to the Petitioner, Hein provides benefits consisting of high tensile strength and yield strength, a lack of springback, and a highly adherent coating with good corrosion properties. Petition, 56. But Petitioner has not cited any evidence that Hein's properties are better than Takagi's properties. Without showing that Hein's properties are better than Takagi, there is no motivation to combine.

160. In addition, the strength of a steel part depends on the extent of the martensitic transformation that occurs in a steel part. As explained above, martensitic transformation occurs during the final forming and quenching steps. Thus, even if a POSITA was motivated by the "benefits" in Hein, a POSITA would have looked to the factors that influence these parameters (total cycle time, stamping, and cooling), Ex-1019, 2, and would not have been motivated to use Hein's other processing parameters. These factors would not have impacted the layer formation.

161. Notwithstanding the above, Hein also does not specify the processing parameters for how the "alloyed layer" depicted in Figure 4 was obtained. Thus, a POSITA would not have known what to combine from Hein without excessive and undue experimentation.

162. Even more problematic, it is not possible to take a benefit from microstructure and divorce it from its underlying structure. In other words, "corrosion resistance" is not some independent feature separable from the layered microstructure of the aluminum-alloy coating—corrosion resistance is a feature that results *from* the microstructure. Thus, to the extent Hein's microstructure exhibited superior corrosion resistance, it is a function of that microstructure. If someone then modified that microstructure by combining it with Takagi's microstructure, then the properties would change. A POSITA could not just combine the (undefined) processing parameters that yielded Hein Figure 4 with the properties of Takagi (with a different layered microstructure than Hein Figure 4) and expect to obtain the same corrosion resistant properties.

163. As an analogy, it is not possible to say a military plane has excellent speed and aerodynamics and a cargo plane has excellent capacity so we can just combine the two properties because they both involve planes. The attribute (whether it is speed/aerodynamics or corrosion resistance) depends on the form and cannot be mixed and matched. In other words, to replicate the corrosion resistance

of Hein's Figure 4, one would need to replicate Hein's microstructure. There is no evidence that Takagi's microstructure would have exhibited similar corrosion resistance (and if it would have, there would have been no motivation to combine). There is also no evidence that some Frankenstein-ed microstructure that resulted from some combination of Hein and Takagi would have had the same corrosion resistant properties as Hein's microstructure.

164. To the extent someone would have been motivated by Hein's description of a of a corrosion resistance layer, a POSITA would have been motivated to use the microstructure depicted in Hein's Figure 4 and not some different structure.

165. In my opinion, there also would not have been a reasonable expectation of success in achieving a combination based on Takagi, Hein, and GMW.

166. It would have taken substantial expertise, experience, and extensive and undue experimentation to take the multi-layered microstructure shown in Takagi and replicate it in a thicker coating form—while still maintaining the intermetallic phase layering and structure in Takagi. This would take far more experimentation than routine "trial and error." It would require extensive and undue experimentation.

167. As I explained above, the science behind the hot stamping process is

complex and unpredictable. The relationship among the various parameters is still being studied today. Obtaining specific phase layering and controlled formation and coalescence of intermetallic materials from steel diffusing into aluminum alloy is exceedingly complex and unpredictable. It is not as easy as simply to isolate an attribute and state that it should be changed. To use another analogy, designing and controlling microstructure via diffusion kinetics to form intermetallic phase layers is not like baking a muffin—you don't just add more batter to the pan and get the same muffin, just taller.

168. The fact that hot stamping parameters have been known does not change that the relationship among those parameters is not known. This is not the case of a finite number of possible values where results can be achieved by "trial and error" and "routine experimentation." If that were the case, there would be little need for research in this field. Instead, there is not only an enormous range of options within each variable—e.g., an untold number of options to set heating curves alone—but that the interaction between those variables can be unpredictable. Even Dr. Brown testified to this:

> [ArcelorMittal Attorney]. In your view, the heating rate, the heating time, holding time, and quenching rate during hot-stamping are all process conditions that affect the result of the hot-stamped, aluminum alloy-coated steel; correct?
>
> [VinFast's Expert]. Well, the difficulty I have with the question is that we know that Dr. Drillet has said that those parameters are important. I think in my deposition, I stated that I think it's not clear

> that how each one of those parameters affect the formation of the coating, because there hasn't been a good description in any document I've seen, other than to say that it has an influence, how that influence imposes itself, how those process conditions impose themselves in terms of forming a microstructure in the coating.
>
> Because we've seen that it's possible to form coatings which don't have that microstructure.
>
> And I think that there is according to the literature that I've seen, not a clear consensus in terms of precisely what set of conditions are required to produce that specific microstructure because we see that sometimes it occurs and sometimes it doesn't.

Ex. 2009 (ITC Tr.) at 961:4-24.

169. Thus, the number ways to combine compositional elements, precoating thickness, various heating curve options, holding times, and cooling parameters is exponentially large, and the multidimensional relationship among the relationships was and is still being studied. In my opinion, Petitioner's basis for obviousness is similar to saying that we know all the chemical elements from the periodic table and we know the ways elements bond to one another, and therefore, the discovery of any new pharmaceutical drug is nothing more than "trial and error" and "routine experimentation." Of course that would not be accurate. There is a lot of research that goes into pharmaceutical drugs despite them being all fundamentally based on the periodic table of elements and known ways that elements bond.

170. Designing hot stamping parameters that manipulate diffusion kinetics to yield a particular multi-layered intermetallic microstructure in an aluminum

alloy is neither a one or two-dimensional exercise nor depends entirely on predictable result effective parameters. Dr. Brown's testimony, excerpted above, confirms this.

171. Even Takagi acknowledges that "[t]he mechanism of formation of the layered structure is not fully evident." EX-1016, ¶19; *see also supra* VI.

172. There is not a single variable (e.g., not elemental compositions, thickness, heating curves, temperatures, rates, holding times, quenching parameters) that gives rise to the multi-layered intermetallic microstructure required by the Challenged Claims. Rather, the desired microstructure was the product of the complex interaction of these multiple factors, many of which themselves yield unpredictable results as detailed below. This is why it took the inventors themselves years of extensive research to come to the inventions in the Challenged Claims. And the inventors here were substantially more experienced and skilled in this field of coating and microstructure design than a POSITA.

173. As I explained above, even just the heating curve, can be very complex and variability. For example, heating does not need to be linear or constant. It can be accelerated, decelerated, or held steady for any period throughout the heating stage, resulting in enormous optionality and variation.

174. Heating curves in hot stamping typically are not linear (defined by two points and heating rate), or even a simple curve, but typically constitute a

complex series of variable adjustments over the heating period. And, while such adjustments and variables affect kinetics generally, it was not known how such adjustments affected or could be modulated to create the multi-layered intermetallic microstructure required by the Challenged Claims. *See also supra* VI.

175. The relationship among all the variables is highly complex. For example, the impact the above variables may have on diffusion kinetics will be altered when material thickness is altered. Whatever parameters give rise to, for example, a four-layered intermetallic microstructure yielding a 25 µm coating, will not result in the same microstructure in a thicker or thinner coating.

176. In other words, to achieve a combination, it is not as easy as increasing the thickness of the coating and saying do not change anything else (beyond enlarging things). Instead, the specification designer must redesign the other parameters to again achieve the targeted microstructure under different diffusion kinetics in a different material thickness. As I explained above, at the time of the invention, there was no understanding in the field as to how exactly how these variables could be modulated to achieve that result. Even now, there is still research being conducted into the relationship among these variables.

177. In my opinion, at best, Petitioner's combination is nothing more than an invitation to experiment. This does not show that a POSITA would have had a

reasonable expectation of success in that experiment, absent undue and excessive experimentation (e.g., plugging and chugging through countless variations of parameters in hopes of happening upon the Challenged Claims).

178. There is also the further problem that a POSITA does not have requisite level of skill to designing hot stamping parameters to obtain particular multi-layered intermetallic phases in aluminum alloy via diffusion kinetics. It would take significant adjustments to the process in light of the issues outlined above, such that it would require much more than just trivial adjustments to a hot stamping process (and beyond their experience). For the reasons I have explained above, I do not agree that the proposed adjustments to Takagi were within the skill of a POSITA and would have been achievable with a reasonable expectation of success.

179. I have not seen any evidence that a POSITA would have had reasonable expectation of success in modifying Takagi with Hein or GMW14400, without impacting the other properties of Takagi. In my opinion, for the reasons explained above, there would not have been a reasonable expectation of success. For example, there is no evidence about how a longer formation time required for thicker coatings and layers impacts the elemental composition of these layers (or the correlative formation of intermetallic compounds). Dr. Miles does not address but appears to assume that the elemental composition of each layer and the

relationships of the elemental composition among the layers will stay the same; this is inaccurate as explained above. *See also supra* VI.

180. As another example, as heating time increases, and the layers grow thicker, more diffusion occurs and the elemental composition of each layer changes. The diffusion kinetics affected by changes in the heating curve implicated in attempting a thicker coating can affect the coalescence of, or give rise to the degradation of, the desired phase layers. A POSITA would not have had a reasonable expectation of success in modifying Takagi with GMW14400.

181. I also disagree it would have been obvious to try mixing and matching various parameters to achieve the Challenged Claims. It is not predictable and it is not straightforward to form a specific intermetallic layered microstructure by diffusion kinetics during hot stamping is a complex process and the relationships between and among the various parameters is neither straightforward nor predictable. *See also supra* VI. As a result, there is nothing routine about the experimentation required to obtain the Challenged Claims.

182. In addition, I also disagree that a POSITA "would have expected a thickness increase with heat treatment on the order of about "50%." Petition at 55. As explained above, the post-hot-stamped coating thickness is going to be impacted by many parameters during the heating process prior to hot stamping, including heating temperature, heating time, heating rate, oven size and more. *See*

supra IV and VI. I under Dr. Miles relies on French Patent Publication No. FR2833504 (Ex. 1025) for this alleged relationship. Ex. 1003 ¶¶ 160, 164. However, this publication is very clear that the 50% increase it describes pertain to the specific conditions used in that references. Ex. 1025, 5:1-20 ("The alloying, through interdiffusion, leads to an increased thickness of the layer which, for the treatment specified above, generally corresponds to a 50% increase."). The general notion that more leads to more (e.g., pre-coating material leads to more post-stamping coating) says nothing about how more pre-coating impacts diffusion kinetics and the formation of microstructural layering during the diffusion process. It is also not possible to have generally have a "50%" increase in the post-coating, without impacting the other properties of the final hot stamped coating. *See supra* IV and VI (complex multidimensional relationship).

183. Similarly, the same is true for pre-coating composition (varying the Al% and Si% in the pre-coating) or varying the base steel composition will impact the heating process, the formation of layers, the growth of the layers, the diffusion kinetics, the Kirkendall effect (the formation of voids in microstructural layers), the composition of the layers, and the characteristics of the final coating. Petitioner significantly oversimplifies that complex multidimensional relationship among these parameters in hot stamping. *See supra* IV and VI.

184. I also disagree that the proposed varying constitutes a small

modification. At the micrometer scale involved in hot stamping, changing the pre-coating to a thickness of 25 µm is not a "small modification" compared to the 10-20 µm range disclosed by Takagi. At that scale, a difference of 5-15 µm is significant. Changing the pre-coating thickness from 10 µm to 25 µm would more than double the volume of coating material, giving rise to downchain impacts on diffusion kinetics, microstructural layer formation, and the resulting properties of the hot stamped part. *See supra* IV and VI. As I explained above, and for these reasons, there would not have been a reasonable expectation of success. Indeed, a POSITA would have understood the complexity and unpredictability at issue and would not have thought any of this would have been obvious to try. *See supra* IV and VI.

185. It would also take an undue and excessive amount of experimentation to obtain the Challenged Claims. *See supra* IV and VI. I disagree there would be anything routine about the experimentation required to obtain the Challenged Claims. As I explained above, even today, research is still being done about the complex relationship among the parameters, diffusion kinetics and microstructural layer formation which shows this is much more complex than routine experimentation. *See supra* VI. Because of the complexity, unpredictability, specialized knowledge and experience required, still developing understanding in the field of the underlying kinetics, and generalist level of ordinary skill a POSITA

would have, the alleged combination would not have been obtained by POSITA through mere routine experimentation.

X. OTHER GROUNDS

186. I understand that Petitioner asserts that secondary references in Grounds 1B, 1D, 1F, and Ground 2C provide better improved properties or benefits, such that a POSITA would have been motivated to combine each or a combination of them with the other references recited in those grounds. I reviewed Dr. Miles's declaration and the Petition and have not seen any assertion of how the benefits described in these proposed references are superior to what is disclosed in the base references. If anything, the references teach away from using them. For example, Cornette states mechanical properties are not guaranteed. Ex. 1014 at 10. A POSITA reviewing Cornette would not have been motivated to use a reference that is expressly stating that the properties described are not guaranteed. For all the reasons described above with trying to combine references, a POSITA also would not have had a reasonable expectation of success. And because of the complexity involved, this would not have been a matter of routine optimization and would have taken excessive and undue experimentation. *See* supra IV.A, VI, and IX.

187. In my opinion, there would not have been a motivation to combine Engels and Takagi. Petitioner's premise for a motivation to combine is fundamentally flawed. A POSITA would not expect different microstructures with

similar but different layer formations to have the same properties. *See* supra IV.A, VI, and IX. Two similar layered microstructures can have very different properties based on the specific details of their layer formation and composition. *Id*.

188. In my opinion, there would not have been a motivation to combine Vaissiere with the Petitioner's other references. A POSITA would have known that any change any processing parameters could have a significant impact on kinetics and the resulting microstructure. As a result, a POSITA would not have been motivated to use values from a different reference as those values would have impacted the properties of the microstructure. As a result, there would not have been a motivation to combine.

XI. CONCLUSION

189. The findings and opinions set forth in this declaration are based on my work and examinations to date.

190. I may continue my examinations. I may also receive additional documentation and other factual evidence over the course of this IPR that will allow me to supplement and/or refine my opinions. I reserve the right to add to, alter, or delete my opinions and my declaration upon discovery of any additional information. I reserve the right to make such changes as may be deemed necessary.

191. In signing this declaration, I recognize that the declaration will be

filed as evidence in an IPR before the PTAB. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

192. I hereby declare that all statements made herein of my own knowledge are true and that all statements are made on information and belief are believed to be true; and further these statements were made with the knowledge that willful false statements and the like are punishable by fine, imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

DATE: June 10, 2025