

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FORD MOTOR CO.,
Petitioner,

v.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
Patent Owner.

IPR2019-01401
Patent 9,255,519 B2

Before KEN B. BARRETT, LYNNE H. BROWNE, and
JAMES J. MAYBERRY, *Administrative Patent Judges*.

MAYBERRY, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)
ORDER
Dismissing Patent Owner's Motion to Exclude
37 C.F.R. § 42.64

I. INTRODUCTION

A. *Background and Summary*

Petitioner, Ford Motor Company, filed a Petition (“Pet.”) requesting *inter partes* review of claims 1–6 and 9–22 (the “Challenged Claims”) of U.S. Patent No. 9,255,519 B2 (Ex. 1001, the “’519 patent”). Paper 2. We instituted trial on all Challenged Claims and grounds. Paper 10.

Patent Owner filed a Patent Owner Response. Paper 18 (“PO Resp.”). Petitioner filed a Reply to the Patent Owner Response. Paper 22 (“Reply”). Patent Owner filed a Sur-reply to the Reply. Paper 27 (Sur-reply”).

We conducted a consolidated oral hearing on November 19, 2020, for this proceeding, IPR2019-01399, and IPR2019-01402 and the record includes a copy of the transcript of that hearing. Paper 35 (“Tr.”).

Patent Owner moves to exclude certain evidence. Paper 28. Petitioner opposes that motion (Paper 29) and Patent Owner replies to the opposition (Paper 32).

The Board has jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons that follow, we conclude that Petitioner demonstrates, by a preponderance of the evidence, that the Challenged Claims are unpatentable.

B. *Real Parties in Interest*

Petitioner identifies itself as the sole real party-in-interest. Pet. 69. Patent Owner identifies itself and Ethanol Boosting Systems, LLC, the exclusive licensee of the ’519 patent, as real parties-in-interest. Paper 5, 2.

C. *Related Matters*

Petitioner and Patent Owner indicate that the ’519 patent is the subject of litigation in the U.S. District Court for the District of Delaware in a case styled *Ethanol Boosting Systems, LLC v. Ford Motor Company, LLC*, No.

1:19-cv-00196-CFC (D. Del.). Pet. 69; Paper 5, 2. Patent Owner appealed the claim constructions in this litigation to the Federal Circuit. PO Resp. 30–31; *see also* Ex. 1041 (providing the District Court’s claim construction order). The Federal Circuit affirmed the constructions. Ex. 1052 (providing the Federal Circuit’s Rule 36 affirmance).

Patent Owner indicates that litigation in the U.S. District Court for the District of Delaware in a case styled *Ethanol Boosting Systems, LLC v. Ford Motor Company, LLC*, No. 1:20-cv-00706-CFC (D. Del.) relates to the ’519 patent. Paper 23, 2.

Petitioner also filed, concurrent with the filing of the Petition, petitions for *inter partes* review of three related patents, in cases numbered IPR2019-01399 (challenging US 9,810,166), IPR2019-01400 (challenging US 8,069,839), and IPR2019-01402 (challenging US 10,138,826). Pet. 70; Paper 5, 2.

The parties indicate that the ’519 patent is related to the following additional patents and pending patent applications: US 10,344,689; US 10,221,783; US 9,708,965; US 9,695,784; US 8,857,410; US 8,733,321; US 8,707,913; US 8,522,746; US 8,468,983; US 8,353,269; US 8,302,580; US 8,276,565; US 8,171,915; US 8,146,568; US 8,069,839; US 7,971,572; US 7,841,325; US 7,762,233; US 7,740,004; US 7,640,915; US 7,444,987; US 7,314,033; US 7,225,787; US App. 16/251,658; US App. 16/424,471. Pet. 70–71; Paper 5, 2–5.

D. The ’519 Patent

The ’519 patent, titled “Fuel Management System for Variable Ethanol Octane Enhancement of Gasoline Engines,” issued February 9, 2016, from an application filed September 5, 2014, and ultimately claims priority to an application filed November 18, 2004. Ex. 1001, codes (54),

(45), (22), (63). The '519 patent is directed “to spark ignition gasoline engines utilizing an antiknock agent which is a liquid fuel with a higher octane number than gasoline such as ethanol to improve engine efficiency.” *Id.* at 1:31–34. We reproduce Figure 1 from the '519 patent below.

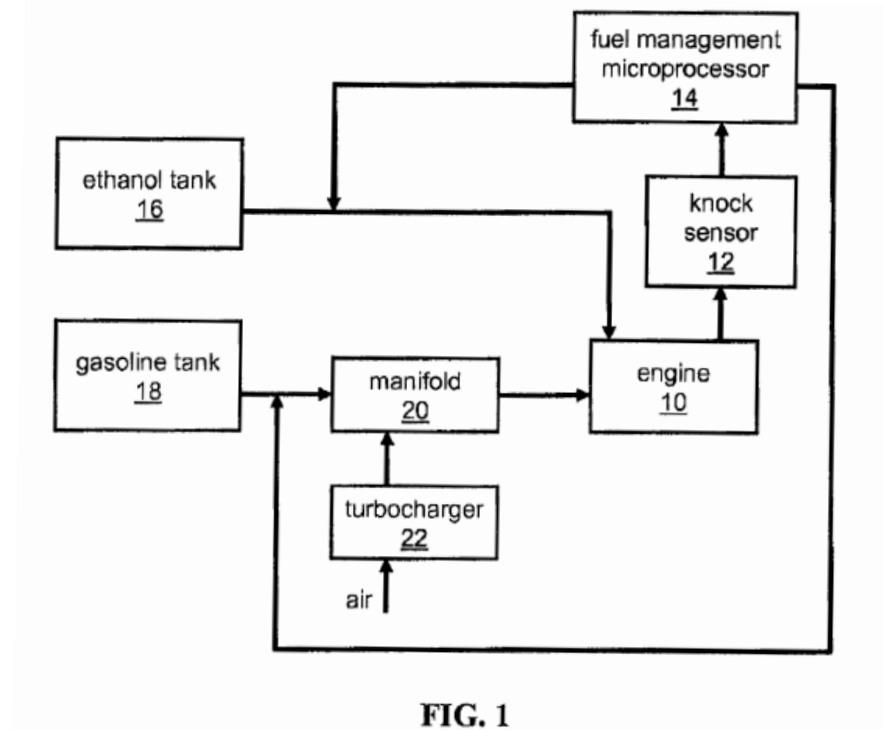


Figure 1 depicts “a block diagram of one embodiment of the invention disclosed” in the '519 patent. Ex. 1001, 2:63–64. Spark ignition gasoline engine 10 includes knock sensor 12, fuel management microprocessor system 14, engine manifold 20, and turbocharger 22. *Id.* at 3:13–21. Ethanol tank 16 contains an anti-knock agent, such as ethanol, and gasoline tank 18 contains the primary fuel, such as gasoline. *Id.* at 3:15–20. Fuel management microprocessor system 14 controls the direct injection of the anti-knock agent into engine 10 and the injection of gasoline into engine manifold 20. *Id.* “The amount of ethanol injection is dictated either by a predetermined correlation between octane number enhancement and fraction

of fuel that is provided by ethanol in an open loop system or by a closed loop control system that uses a signal from the knock sensor 12 as an input to the fuel management microprocessor 14.” *Id.* at 3:21–27. The fuel management system minimizes the amount of ethanol directly injected into the cylinder while still preventing engine knock. *Id.* at 3:27–29.

“Direct injection [into the cylinder] substantially increases the benefits of ethanol addition and decreases the required amount of ethanol. . . . Because ethanol has a high heat of vaporization there will be substantial cooling when it is directly injected into the engine 10,” which “further increases knock resistance.” Ex. 1001, 3:33–41. The amount of octane enhancement needed from the ethanol to prevent knocking is a function of the torque level. *Id.* at 5:61–6:5. “[P]ort fuel injection of the gasoline in which the gasoline is injected into the manifold rather than directly injected into the cylinder is preferred because it is advantageous in obtaining good air/fuel mixing and combustion stability that are difficult to obtain with direct injection.” *Id.* at 3:42–46.

E. Illustrative Claims

Of the Challenged Claims, claims 1, 13, and 19 are independent. Claim 1, reproduced below, is representative.

1. A fuel management system for a turbocharged or supercharged spark ignition engine
where the fuel management system controls fueling from a first fueling system that directly injects fuel into at least one cylinder as a liquid and increases knock suppression by vaporization cooling and from a second fueling system that injects fuel into a region outside of the cylinder; and
where there is a range of torque where both fueling systems are used at the same value of torque; and
where the fraction of fuel in the cylinder that is introduced by the first fueling system decreases with decreasing torque and

the fuel management system controls the change in the fraction of fuel introduced by the first fueling system using closed loop control that utilizes a sensor that detects knock; and

where the fuel management system also employs spark retard so as to reduce the amount of fuel that is introduced into the cylinder by the first fueling system.

Ex. 1001, 7:25–42.

F. Prior Art and Asserted Grounds

Petitioner asserts that the Challenged Claims are unpatentable on the following grounds:

Claims Challenged	35 U.S.C. §	References/Basis
19–22	103(a) ¹	Kobayashi, ² Yuushiro ³
1–6, 9–22	103(a)	Rubbert, ⁴ Yuushiro, Bosch ⁵
1–6, 9–22	103(a)	Kinjiro, ⁶ Bosch

¹ The Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103, effective March 16, 2013. Because the application from which the ’519 patent ultimately claims benefit was filed before this date, and Petitioner does not provide persuasive arguments or evidence to support a later filing date, the pre-AIA version of § 103 applies. *See* Ex. 1001, code (63), 1:5–27; Pet. 3 (disputing the priority date but offering no evidence or analysis to support the contention).

² Kobayashi, US 7,188,607 B2, issued Mar. 13, 2007, from an application filed June 27, 2003 (Ex. 1005).

³ Yuushiro, JP Unexamined Pat. App. Pub. H10-252512, published Sept. 22, 1998 (Ex. 1006). Exhibit 1006 includes a Japanese version of the reference, an English translation of the reference, and a certification of the translation.

⁴ Rubbert, DE 198 53 799 A1, published May 25, 2000 (Ex. 1007). Exhibit 1007 includes a German version of the reference, an English translation of the reference, and a certification of the translation.

⁵ Bosch, *Automotive Handbook* (3d ed. 1993) (Ex. 1031). Ex. 1031 includes excerpts from the handbook.

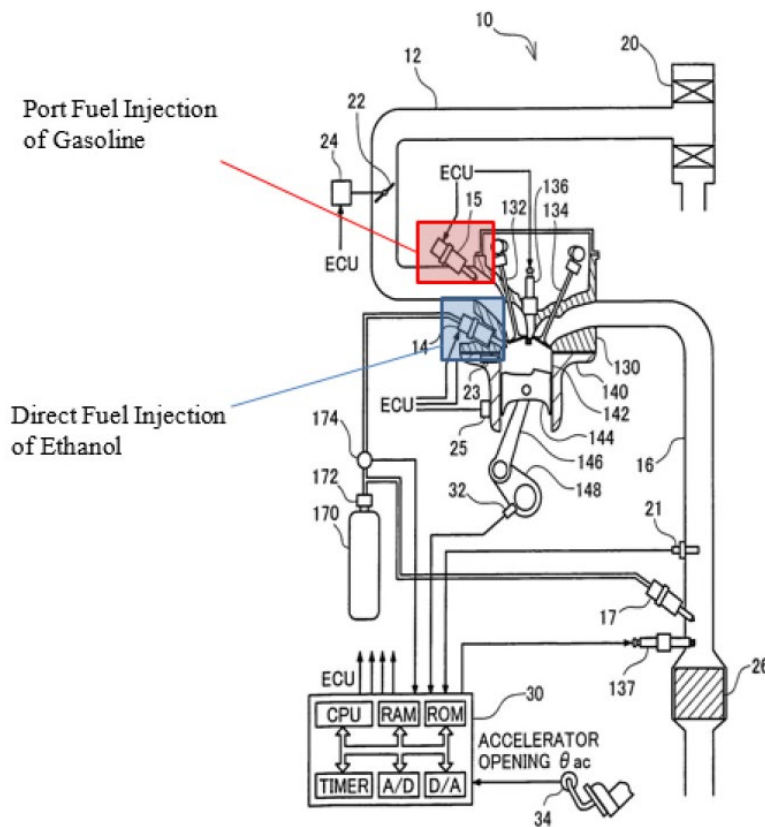
⁶ Kinjiro, JP Unexamined Pat. App. Pub. 2002-227697, published Aug. 14, 2002 (Ex. 1008). Exhibit 1008 includes a Japanese version of the reference, an English translation of the reference, and a certification of the translation.

The following subsections provide a brief description of the asserted prior art references.

1. *Kobayashi*

Kobayashi, titled “Internal Combustion Engine of Compressing and Auto-Ignition Air-Fuel Mixture and Method of Controlling Such Internal Combustion Engine,” issued March 13, 2007, from an application filed June 27, 2003. Ex. 1005, codes (54), (45), (22). Kobayashi “pertains to a technique of controlling auto ignition of the air-fuel mixture to take out power with a high efficiency, while effectively reducing emission of air pollutants through combustion.” *Id.* at 1:13–16. We reproduce Petitioner’s annotated version of Kobayashi’s Figure 1, below.

Fig.1



Pet. 12. Kobayashi's Figure 1 depicts "the structure of an engine . . . that adopts [Kobayashi's] premix compression ignition combustion system."

Ex. 1005, 7:39–41. Petitioner's annotations label the port fuel injection of gasoline (with the injector in red) and direct fuel injection of ethanol (with the injector in blue). Engine 10 includes two fuel injection valves (valves 14, 15). *Id.* at 9:44–47. Gasoline is injected through valve 15 into intake conduit 12 and hydrogen gas is injected through valve 14 into the combustion chamber. *Id.* at 9:47–50. Kobayashi discloses that, in addition to hydrogen gas, liquid fuels with higher octane values than gasoline, such as methanol and ethanol, may be used. *Id.* at 9:58–63.

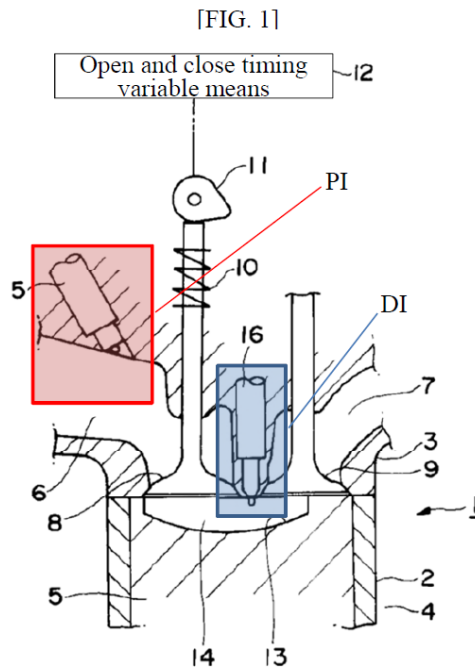
Engine control unit (ECU) 30 controls engine 10, including fuel injection valves 14, 15, and spark plug 136. Ex. 1005, 10:16–17, 27–29. ECU 30 also detects engine knocking using knocking sensor 25. *Id.* at 10:34–36. Under the ECU's control, when the engine is under a high load condition, hydrogen is injected into the cylinder to prevent knocking. *Id.* at 11:58–64, 12:7–12, 13:50–56. The hydrogen is ignited by spark plug 136. *Id.* at 13:50–56. "Ignition of the hydrogen-air mixture with a spark . . . leads to quick combustion of the hydrogen-air mixture to raise the internal pressure of the combustion chamber. The gasoline-air mixture formed in the combustion chamber is accordingly compressed and auto-ignited to start combustion substantially all at once." *Id.* at 16:20–26.

2. Yuushiro

Yuushiro, titled "Compression Ignition Type Internal Combustion Engine," published September 22, 1998. Ex. 1006, codes (54), (43).

Yuushiro "relates to a compression ignition type internal combustion engine that compresses premixed gas at high pressure, and causes compression

ignition.” *Id.* ¶ 1. We reproduce Petitioner’s annotated version of Yuushiro’s Figure 1, below.



Pet. 14. Annotated Figure 1 depicts “a cross-section view . . . of [Yuushiro’s] compression ignition internal combustion engine,” and includes Petitioner’s labels “PI” (port injector,⁷ in red) and “DI” (direct injector, in blue). Ex. 1006, 10 (“Brief Description of the Drawings”); Pet. 14. Engine 1 includes cylinder 4 with cylinder head 3, intake port 6, combustion chamber 14, port injection valve 15, and in-cylinder injection valve 16. Ex. 1006 ¶¶ 21, 22, 25.

⁷ Yuushiro’s Figure 1 includes a reference number “5” for the port injection valve and for the piston. The port injection valve should be reference numeral “15.” See Ex. 1006 ¶¶ 21, 25.

We reproduce Yuushiro's Figure 3 below.

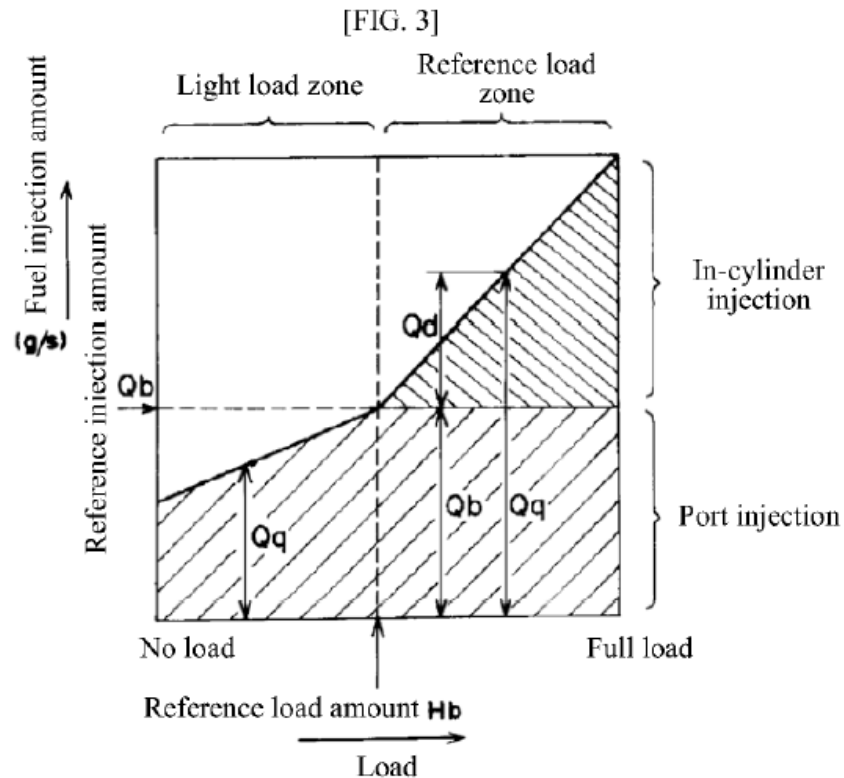


Figure 3 provides an exemplary fuel injection map. *Id. at* 10 (“Brief Description of the Drawings”). Yuushiro discloses that its system identifies a reference load amount (H_b), corresponding to a reference injection amount (Q_b), the maximum amount of fuel injected through port injection for which knocking does not occur. *Id.* ¶¶ 16, 38, 39. Loads that are equal to or less than H_b correspond to a light load zone and loads greater than H_b correspond to a high load zone. *Id.* ¶ 39. For loads in the light load zone, only port injection through valve 15 is used. *Id.* For loads in the high load zone, both port injection and direct injection are used. *Id.* As seen in Figure 3, in the high load zone, the amount of fuel directly injected into the cylinder through valve 16, Q_d , increases with increasing load, as the port injection amount, Q_b , remains the same, that is, at the maximum value for which knocking does not occur. *Id.* ¶ 39, Fig. 3; *see also id.* ¶¶ 41–50

(describing operations in the light load zone), ¶¶ 51–58 (describing operations in the high load zone).

3. *Rubbert*

Rubbert, titled “Method for Mixture Formation in a Mixture-Compressing External-Ignition Internal Combustion Engine with Fuel Injection,” published on May 25, 2000. Ex. 1007, codes (54), (43). Rubbert discloses a combination of induction pipe injection (that is, port injection) and direct injection of fuel. *Id.* at code (57). Rubbert describes that

in the idling and partial load ranges, the greater portion of fuel in the mixture is injected by induction pipe injection than by direct injection. The directly injected fuel in this load range results in an ignitable mixture near the spark plug and allows reliable ignition of the lean mixture in the entire combustion chamber.

In contrast, the fuel portion in the mixture can be mostly or completely injected by direct injection in the full-load range of the internal combustion engine, which means that the advantages of direct injection with respect to cylinder filling and knock limit can be fully utilized.

Id. at 2, col. 1–col. 2.

4. *Bosch*

Bosch, which Petitioner contends was published in 1993, is titled “Automotive Handbook.” Ex. 1031, 1–3⁸; Pet. 9. As seen in its table of contents, the Handbook covers a wide array of subjects directed to automotive engineering. *See* Ex. 1031, 4–5. Exhibit 1031 includes excerpts from the handbook, covering sensors (pp. 6–12), mathematics (pp. 13–16), quality (pp. 17–19), engineering statistics (pp. 20–23), reliability (pg. 24), data processing in motor vehicles (pp. 25–26), control engineering (pp. 27–

⁸ Exhibit pagination.

28), internal-combustion engines (pp. 29–58), engine cooling (pp. 59–60), air filters (pg. 61), charging systems (pp. 62–64), exhaust systems (pp. 65–66), engine management (pp. 67–91), and exhaust emissions (pp. 92–97).

5. *Kinjiro*

Kinjiro, titled “Fuel Injection Apparatus for Internal Combustion Engine,” published August 14, 2002. Ex. 1008, codes (54), (43). Kinjiro relates to a fuel injection apparatus where, “if knocking is detected by a knock detection means, fuel is injected from both fuel injection valves in a first fuel injection valve provided in an intake passage and a second fuel injection valve for injecting fuel directly into a combustion chamber.” *Id.* ¶ 7. We reproduce Kinjiro’s Figure 1 below.

[FIG. 1]

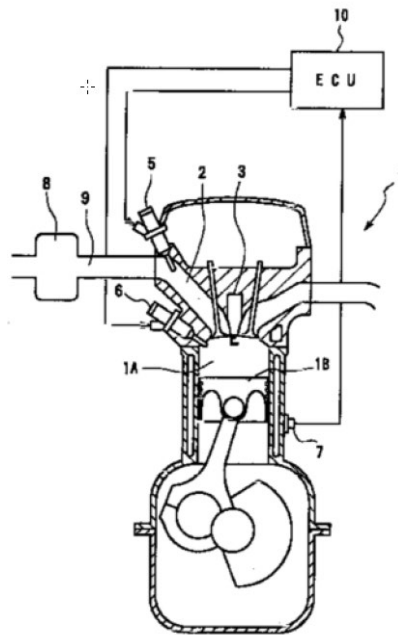


Figure 1 illustrates the main structures of Kinjiro’s fuel injection apparatus. Ex. 1008, 8 (“Brief Description of the Drawings”). Kinjiro’s engine 1, a spark-ignition engine, includes cylinder 1A, piston 1B, intake passage 2, and spark plug 3. *Id.* ¶ 10. The engine also includes injector 5, located in intake

passage 2, and injector 6, located in cylinder 1A. *Id.* ¶¶ 11–13, Fig. 1. Engine 1 also includes knock sensor 7 and electronic control unit 10. *Id.* ¶¶ 12–13.

Kinjiro discloses that its engine operates in two states—a “normal operating state,” where knocking is not occurring, and a “specified operating state,” which is entered when knocking occurs. Ex. 1008 ¶¶ 13, 14. During the normal operating state, fuel is injected using injector 5 only and during the specified operating state, fuel is injected using both injectors 5 and 6 (referred to as “split injection mode”). *Id.* ECU 10 initiates the specified operating state when knock sensor 7 indicates that engine knocking is occurring. *Id.* ¶¶ 13, 20.

II. ANALYSIS

A. Applicable Law

In *inter partes* reviews, a petitioner bears the burden of proving unpatentability of the challenged claims, and the burden of persuasion never shifts to the patent owner. *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail in this proceeding, Petitioner must support its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). Accordingly, all of our findings and conclusions are based on a preponderance of the evidence.

Petitioner’s three asserted grounds of unpatentability are each based on obviousness under 35 U.S.C. § 103(a).

Section 103(a) [of 35 U.S.C.] forbids issuance of a patent when “the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person

having ordinary skill in the art to which said subject matter pertains.”

KSR Int’l Co. v. Teleflex Inc., 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art;⁹ and (4) when available, objective evidence, such as commercial success, long felt but unsolved needs, and failure of others.¹⁰ *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

“[O]bviousness must be determined in light of *all the facts*, and . . . a given course of action often has simultaneous advantages and disadvantages, and this does not necessarily obviate motivation to combine” teachings from multiple references. *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1165 (Fed. Cir. 2006) (emphasis added); *see also PAR Pharm., Inc. v. TWI Pharms., Inc.*, 773 F.3d 1186, 1196 (Fed. Cir. 2014) (“The presence or absence of a motivation to combine references in an obviousness determination is a pure question of fact.”).

B. Level of Ordinary Skill in the Art

The level of skill in the art is “a prism or lens” through which we view the prior art and the claimed invention. *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). Petitioner contends that a person having ordinary skill in the art at the time of the invention “would . . . have at least a bachelor’s degree in engineering and at least five years of experience in the field of internal combustion engine design and control.” Pet. 9 (referencing

⁹ We address the level of ordinary skill in the art in Section II.B., below.

¹⁰ Neither party has identified objective evidence in the record for us to consider.

Ex. 1003 ¶ 10 (providing Dr. Clark’s testimony regarding the level of ordinary skill in the art)). Petitioner contends that additional experience could compensate for a different type of education. *Id.* Petitioner adds that additional experience could substitute for some education and that additional education may substitute for some experience. *Id.*

Patent Owner does not dispute this characterization of the level of ordinary skill in the art. Patent Owner’s declarant states that “[t]he relevant art is the general area of internal combustion engine design and controls. The person of ordinary skill in the art is a person with a bachelor’s degree in mechanical engineering, or a related field, and at least five years of experience in the field of internal combustion engine design and controls.” Ex. 2002 ¶ 40. Mr. Hannemann adds that “[i]ndividuals with different education and additional experience could still be of ordinary skill in the art if that additional experience compensates for a deficit in their education and experience stated above.” *Id.*

We find that Mr. Hannemann’s definition of the level of ordinary skill in the art is substantially the same as Petitioner’s characterization. We accept the parties’ characterization of the level of ordinary skill in the art, which we find is consistent with the level of skill reflected in the ’519 patent and the prior art of record. For example, the background section of the ’519 patent discusses things that are “known” in the relevant art and supports our finding that the artisan of ordinary skill would have an engineering degree and experience with internal combustion engines. *See* Ex. 1001, 1:31–2:14. Similarly, the prior art includes teachings directed to internal combustion engine design. *See, e.g.,* Ex. 1005, 1:10–2:19 (discussing the field of invention and background for Kobayashi); Ex. 1006 ¶¶ 1–7 (describing the field of invention, prior art, and problem addressed in Yuushiro); Ex. 1007,

2 (discussing fuel mixing for an internal combustion engine in Rubbert); Ex. 1008 ¶¶ 1–7 (describing the field of invention, prior art, and problem addressed in Kinjiro); Ex. 1031 (providing an “Automotive Handbook”).

C. Claim Construction

In *inter partes* reviews, we interpret a claim “using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b).” *See* 37 C.F.R. § 42.100(b)(2019). Under this standard, we construe the claim “in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” *Id.* Only claim terms that are in controversy need to be construed and only to the extent necessary to resolve the controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017).

In parallel litigation in U.S. District Court for the District of Delaware, the District Court conducted a claim construction hearing on January 8, 2020. Ex. 1040, 1. The District Court issued a Claim Construction Order in which the Court construed certain terms disputed in that litigation. Ex. 1041. The Court’s reasoning is set forth in the transcript of the claim construction hearing. Ex. 1040. In the Order, the Court also identified and adopted the litigants’ agreed-upon constructions of certain terms. Ex. 1041, 3–4.

As a result of the District Court’s claim construction Order, the parties stipulated to non-infringement of the asserted claims of the ’519 patent and Patent Owner appealed the constructions to the Federal Circuit. Reply 9; PO Resp. 30–31. The Federal Circuit affirmed the constructions. Ex. 1052 (providing the Federal Circuit’s Rule 36 affirmance); *see generally* 37 C.F.R. § 42.100(b) (providing that “[a]ny prior claim construction

determination concerning a term of the claim in a civil action . . . that is timely made of record in the *inter partes* review proceeding will be considered”).

As will be evident from our analysis below, we determine that we need not expressly construe any claim term to resolve the parties’ disputes in this proceeding. *See Nidec Motor Corp.*, 868 F.3d at 1017.

D. Ground 1: Claims 19–22 as Allegedly Obvious Over Kobayashi and Yuushiro

Petitioner contends that the combination of Kobayashi and Yuushiro renders claims 19–22 obvious. Pet. 1, 12–29.

1. Independent claim 19

a) Reasons to combine Kobayashi and Yuushiro

Independent claim 19 recites, in relevant part, “where the fuel management system controls fueling from a first fueling system that directly injects fuel into at least one cylinder as a liquid and increases knock suppression by vaporization cooling and from a second fueling system that introduces fuel into the cylinder by port fuel injection” and “where during a driving cycle there is a first torque range where both fueling systems are used at the same torque and where the fraction of fuel in the cylinder that is introduced by the first fueling system is increased so as to prevent knock as torque increases.” Ex. 1001, 8:45–56. Petitioner contends that “Kobayashi discloses an engine . . . that uses both [port injection] and [direct injection] where the fuel quantity injected via the disclosed injection mechanisms is determined based on a fuel map.” Pet. 12 (referencing Ex. 1005, 9:44–47, 12:14–21; Ex. 1003 ¶ 150). Petitioner further asserts that “Kobayashi discloses reliance on [port injection] fuel in both low and high loading conditions . . . [and uses] a second, spark-ignited [direct injection] fuel in

high loading conditions to ignite the [port injection] fuel and avoid knocking.” *Id.* at 13 (referencing Ex. 1005, 9:44–50, 12:7–12, 15:65–16:27; Ex. 1003 ¶ 150).

Petitioner contends that Yuushiro discloses a fuel map where only port injection fuel is used at a light load and both direct injection fuel and port injection fuel are used at a higher load. Pet. 14. Petitioner contends that “Yuushiro illustrates in F[igure] 3 that as load increases in the reference load zone, the quantity of [direct injection] fuel (Q_d) increases.” *Id.* at 24–25.

Petitioner’s proposed modification is to apply the teachings of Yuushiro’s fuel map to Kobayashi. *See, e.g.*, Reply 10 (“A [person having ordinary skill in the art] would have therefore recognized Yuushiro’s [direct injection] strategy would be applied to extend Kobayashi’s [direct injection] fuel quantity.”); Tr. 23:12–14 (“[T]he proposal that’s been advanced is that the person of skill in the art looking at Kobayashi would add the fuel map, look to the fuel map of the Yuushiro reference to fuel the engine.”).

Petitioner contends that it would have been obvious to improve Kobayashi’s fuel map to include an increase in the direct injection fuel, and that Yuushiro discloses such a map. Pet. 13–20 (referencing Ex. 1003 ¶¶ 158–166). Petitioner contends that Yuushiro “discloses [direct injection] fuel making a substantive contribution to engine torque under high loading conditions . . . [and] augments and improves the system of Kobayashi in that it supports a higher fuel to air ratio in the cylinder and allows for the amount of [direct injection] fuel to be increased as load is increased.” *Id.* at 16 (referencing Ex. 1003 ¶ 155).

We first consider Petitioner’s primary assertion of a motivation, which is as follows.

A [person of ordinary skill in the art] would have also understood that by relying on a lean air/fuel mixture, Kobayashi *has a limit to its engine power output*. The [person of ordinary skill in the art] would have looked to known techniques to increase engine power output, including increasing the ratio of fuel to air in the cylinder to be at or near a stoichiometric ratio.

Pet. 15 (referencing Ex. 1003 ¶¶ 160–161) (emphasis added). Petitioner contends that a person having ordinary skill in the art would have modified Kobayashi in accordance with Yuushiro’s teaching of the use of more direct injection fuel to provide “a substantive contribution to engine torque under high loading conditions.” *Id.* at 16. Petitioner contends that Kobayashi is underpowered due to the use of a lean mixture, and that one of ordinary skill in the art would have been motivated to increase the direct injection fuel to generate more power, i.e. to provide a substantive contribution to torque, and to modify the air-fuel ratio to be stoichiometric. *Cf. id.* (“Yuushiro augments and improves the system of Kobayashi in that it supports a higher fuel to air ratio in the cylinder and allows for the amount of [direct injection] fuel to be increased as load is increased.”).

In response, Patent Owner, focusing on the sharp differences between the references’ teachings, argues that a person of ordinary skill in the art would not have been motivated to modify Kobayashi in the manner proposed by Petitioner. *See* PO Resp. 31–37. Patent Owner argues, for example, that

if Kobayashi’s engine is operated, as Petitioner suggests, with additional directly injected fuel at high loads (from Yuushiro) it would . . . eliminate the lean burn operating principles that are fundamental to Kobayashi and necessary for its stated objective of using lean air fuel mixtures to significantly reduce the emission of the air pollutants from the engine.

PO Resp. 36 (citations omitted).

Petitioner replies that a person having ordinary skill in the art “would have therefore recognized Yuushiro’s [direct injection] strategy would be applied to extend Kobayashi’s [direct injection] fuel quantity.” Reply 10 (referencing Ex. 1003 ¶ 158). Petitioner argues that Patent Owner’s assertions about the differences between Kobayashi and Yuushiro ignores the proposed modification, that would use Yuushiro’s fuel map in Kobayashi’s engine. *Id.* at 11. In sur-reply, Patent Owner argues that “Kobayashi’s operation under high loading conditions is completely incompatible with Yuushiro, because Yuushiro’s operating principle requires mixing of additional directly injected fuel with port injected fuel in the heavy load regime in order to increase the amount of fuel available to the engine at high loads” and for “high loading conditions,” Kobayashi “operat[es] with a ‘large value to the excess air ratio.’” Sur-reply 13.

We find Petitioner’s reasoning lacks an adequate explanation that connects the contention that Kobayashi has limited power with the critical contention that one of ordinary skill in the art would have looked to and applied another reference that teaches, as discussed below, increasing power by using a different air-fuel ratio and a different use of the direct injection fuel. *Cf.* PO Resp. 35 (arguing that Petitioner is incorrect in asserting that one would turn to Yuushiro’s fuel map because Kobayashi’s engine operation is too lean.). The Petition does not, for example, contain an explicit assertion that a person of ordinary skill in the art would view Kobayashi’s level of power production to be a problem in need of a solution. *See* Pet. 15. Similarly, Dr. Clark’s cited testimony jumps from asserting that Kobayashi’s lean mixture has a negative impact on its power to asserting that “[a]s a result, the person of ordinary skill in the art would have looked to known techniques to increase the power output of the engine.” Ex. 1003

¶ 152. Dr. Clark does not provide a basis for his testimony that Kobayashi has limited power nor does he elaborate on the assertion that if a limit on power results, as implied, then one would desire to greatly increase the power output of Kobayashi's engine. *See id.* ¶¶ 152–153. Because of this lack in further support for this testimony, we give Dr. Clark's opinion on this point little weight. *See* 37 C.F.R. 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”).

Kobayashi's engine uses an atypical combustion process and reflects a carefully balanced design having the advantages of high fuel efficiency, reduced emissions, and avoidance of knock. *See* Ex. 1005, 1:13–16, 11:53–64 (“[T]he engine adopting the premix compression ignition combustion system has the advantages of the less emission of the air pollutants and the less fuel consumption.”); *accord* PO Resp. 35; Ex. 2002 ¶ 43. Kobayashi explains the problem addressed as follows.

For protection of the global environment, reducing the emission of air pollutants from the internal combustion engine is highly demanded. Another strong demand is further reduction of the fuel consumption, in order to lower the emission of carbon dioxide as a cause of global warming and reduce the driving cost of the internal combustion engine.

Ex. 1005, 1:27–32. Kobayashi addresses these concerns by using a compression ignited port injected fuel (e.g., gasoline) and air mixture containing an excess amount of air beyond that necessary to support combustion, i.e. a lean fuel mixture. *See, e.g., id.* at 23:5–9. Kobayashi explains that such a mixture avoids knock but does not self-ignite by compression when the engine operates at high loads. *See id.* at 18:1–9. Kobayashi, therefore, at high loads, directly injects a relatively small amount

of hydrogen or other high octane value fuel, the spark ignition of which creates a pressure spike in the cylinder thereby compressing and igniting the lean port injection fuel mixture. *Id.* at 18:9–14, 32–34 (“The engine 10 of the embodiment ignites the hydrogen-air mixture to trigger auto ignition of the gasoline-air mixture under the high loading conditions.”); 20:15–32 (explaining that only a small quantity of hydrogen or the like is required). Thus, at high engine loads, Kobayashi uses two air-fuel mixtures and two successive combustions, with the latter producing the power to drive the engine. *See id.* at 2:35–65; Tr. 24:1–9.

Yuushiro, in contrast, mixes, in the high load range, a relatively greater amount of direct injection fuel with a port injection fuel and ignites the mixture of fuel and air by compression, thereby powering the engine. *See* Ex. 1006 ¶¶ 52–53 (“[F]uel injected in-cylinder [the direct injection fuel] is mixed with the premixed gas [the port injection fuel] to become a combustible air-fuel ratio.”); *see, e.g.*, Ex. 2002 ¶ 109 (“Yuushiro uses direct injection to increase the amount of fuel during high load conditions; but Kobayashi has a *limit on how much fuel can be compressed and ignited* without experiencing severe knocking and uses direct injection of a small amount of fuel to auto ignite the lean air-fuel mixture.”). Petitioner proposes a modification using a greater amount of direct injection fuel for the purpose of powering the engine (as opposed to merely igniting the port injection fuel) and using a stoichiometric mixture—where the air and fuel are balanced such that there is no excess air. *See* Pet. 15; *see also id.* at 16 (relying on Yuushiro for the teachings of direct injection “fuel making a substantive contribution to engine torque under high loading conditions” and “support[ing] a higher fuel to air ratio in the cylinder and allow[ing] for the amount of [direct injection] fuel to be increased as load is increased.”);

Ex. 1001, 3:60–62 (explaining that “stoichiometric mixtures” are where “the amount of air contains oxygen that is just sufficient to combust all of the fuel”).

Again, Kobayashi uses a very particular fueling and combustion scheme with the goal of creating a fuel-efficient and low-emissions engine. As discussed above, Petitioner proposes jettisoning Kobayashi’s system using two successive combustions of two air-fuel mixes where the direct injection fuel is not used for power production and where a lean power producing mixture—the air and port injection fuel mixture—is used, and replacing that with a power producing stoichiometric mixture of direct injection fuel, port injection fuel, and air, and where significantly more direct injection fuel is used. It may be true and not surprising that a person of ordinary skill in the art would have recognized that achieving Kobayashi’s low fuel consumption and low emissions goals yields an engine that could have more power, just like it would not be surprising to learn that an economy car does not have the acceleration of a sports car. However, it is not facially evident, and Petitioner does not explain adequately, why lower power in the fuel efficient, emissions-friendly engine of Kobayashi would have provided a reason for a person of ordinary skill in the art to perform the major design modifications required by Petitioner’s proposed modification. In weighing the evidence on which Petitioner relies and the counterbalancing evidence, including evidence on Kobayashi’s objectives and the differences in combustion schemes between Kobayashi and Yuushiro, we find the counterbalancing evidence more persuasive. Accordingly, we do not find to be persuasive Petitioner’s reasoning to combine based on Kobayashi’s lower power output.

Under the “Motivation to Combine” heading and after proposing to modify Kobayashi to use a stoichiometric air-fuel ratio, Petitioner makes the statement, “[o]perating at or near a stoichiometric ratio would enable conventional three-way catalysts and support emissions reduction.” Pet. 15–16 (referencing Ex. 1025, 655 (Internal Combustion Engine Fundamentals); Ex. 1003 ¶¶ 153–154). To the extent that Petitioner contends that emissions reduction through catalysis provides a reason to modify Kobayashi, we do not find this reason persuasive because Petitioner does not explain adequately why that would be so, particularly where, as unmodified, Kobayashi already uses the lean air-fuel mix to reduce emissions. *See* Ex. 1005, 23:5–9 (“The premix compression ignition combustion system combusts the air-fuel mixture having a large excess air ratio and thus *significantly reduces the emission of air pollutants*, such as carbon monoxide and hydrocarbons, according to the mechanism discussed below.”) (emphasis added). To the extent that Petitioner contends that catalysis-facilitated emissions reduction in the modification solves a problem, it appears that the problem is created by Petitioner’s proposed modification of the air-fuel ratio to be stoichiometric.

Petitioner also argues that a person of ordinary skill in the art “would have been further motivated to look to Yuushiro given the similarities in design between Kobayashi and Yuushiro.” Pet. 16–17 (referencing Ex. 1005, 9:47–50, 11:57–64; Ex. 1006 ¶¶ 12, 17, 39, 55; Ex. 1003 ¶¶ 156–157). For the reasons discussed above, we do not find that Kobayashi and Yuushiro are as similar in design as Petitioner suggests, and, therefore, we are not persuaded that “similarities in design” provide a “further motivation,” as Petitioner argues. *Accord* PO Resp. 32–35. Indeed, in the same paragraph directed to purported similarities, Petitioner highlights the

important differences between the two references in the amounts of direct injection fuel and the uses thereof. *See* Pet. 16–17 (“While Kobayashi employs minimal fuel solely for knock management, Yuushiro improves Kobayashi, as it uses additional [direct injection] fuel that manages knock and provides for additional knock free torque production by the engine.”); *see also id.* at 17 (highlighting, in the very next paragraph, another important difference: “Whereas Yuushiro uses [direct injection] fuel that autoignites and ignites the [port injection] fuel, Kobayashi uses a spark-ignited [direct injection] fuel that resists autoignition.”).

In summary, we find, on the complete record, that Petitioner has not demonstrated, by a preponderance of the evidence, that a person having ordinary skill in the art would have been motivated to combine the teachings of Kobayashi and Yuushiro as Petitioner proposes. We find that Petitioner fails to support the asserted reasons for its proposed modification by rational underpinnings. *See KSR Int’l Co.*, 550 U.S. at 418 (stating that, to facilitate the analysis of an obviousness position, the proponent should provide “some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”).

b) Conclusion as to claim 19, Ground 1

For the reasons provided above, we conclude, on the complete record, that the information in the Petition fails to demonstrate, by a preponderance of the evidence, that claim 19 is unpatentable under 35 U.S.C. § 103 over Kobayashi and Yuushiro.

2. Dependent claims 20–22.

We do not discern anything in Petitioner’s contentions with respect to claims 20–22 for Ground 1 that remedies the deficiencies identified for claim 19, above. Accordingly, we conclude, on the complete record, that the

information in the Petition fails to demonstrate, by a preponderance of the evidence, that claims 20–22 are unpatentable under 35 U.S.C. § 103 over Kobayashi and Yuushiro.

E. Ground 2: Claims 1–6 and 9–22 as Allegedly Obvious Over Rubbert, Yuushiro, and Bosch

Petitioner asserts that claims 1–6 and 9–22 are unpatentable over Rubbert, Yuushiro, and Bosch. *See* Pet. 2, 29–50. We first address Petitioner’s reasons to combine Rubbert, Yuushiro, and Bosch, and then address the subject matter of claims 1–6 and 9–22.

1. Reasons to combine Rubbert, Yuushiro, and Bosch

Petitioner contends that “Rubbert discloses a dual injection, load dependent, spark ignited engine.” *Id.* at 29 (referencing Ex. 1003 ¶ 214); *see also* Ex. 1007, code (57) (“A method for mixture formation in a mixture-compressing, external-ignition internal combustion engine with fuel injection proposes that a respective air-fuel mixture is formed by a combination of induction pipe [i.e., port] injection and direct injection through partial injection amounts controlled or regulated depending on the load.”). Petitioner explains that “[m]any of the details required to implement Rubbert’s invention would be known,” and a person having ordinary skill in the art “would have understood that these controls would be defined by [fuel] maps.” Pet. 29 (referencing Ex. 1003 ¶ 214).

Petitioner contends that a person having ordinary skill in the art would have been motivated to look to the teachings of a known load-based fuel map that employs both direct injection and port injection and that provides specific quantities of fuel, such as the one taught by Yuushiro. Pet. 30 (referencing Ex. 1006 ¶ 39; Ex. 1003 ¶ 215). Dr. Clark testifies that “Rubbert is silent as to the actual quantity of fuel that is directly injected,

instead stating only that the injection quantities are based on load,” but “that many of the details required to implement Rubbert’s invention would be known by a person of ordinary skill in the art.” Ex. 1003 ¶ 214. Dr. Clark testifies that “[g]iven that Rubbert explicitly confirm[s] that its fuel injection amounts [are] based on load, the person of ordinary skill in the art would have been motivated to select a known fuel map that follows Rubbert’s teachings and provides specific quantities of fuel to be port injected and direct injected.” *Id.* ¶ 215. Dr. Clark concludes that “the person of ordinary skill in the art would have relied on the teachings of Yuushiro, exemplified by the fuel map in its disclosure and would have had a reasonable expectation of success in doing so.” *Id.*

Petitioner contends that “Yuushiro echoes the teachings of Rubbert” and that a person having ordinary skill in the art “would have understood that Yuushiro’s fuel map is designed to rely on an increasing amount of [direct injection] to prevent knock *as engine load increases.*” Pet. 30 (referencing Ex. 1003 ¶ 217). Petitioner adds that an artisan of ordinary skill would have looked to Yuushiro despite the fact that Yuushiro is directed to a compression ignition source. *Id.* at 31 (referencing Ex. 1003 ¶ 219). Petitioner contends that a person having ordinary skill in the art “would have recognized that the [direct injection] strategy of Yuushiro could be applied to extend the [direct injection] fuel quantity of Rubbert.” *Id.* Petitioner explains that both Rubbert and Yuushiro “seek to create an ignition source for the same purpose” and that a person having ordinary skill in the art would have understood that Yuushiro’s map could be used for either type of ignition, compression or spark. *Id.*

Patent Owner argues that “[t]here would have been no motivation to combine the fuel map of Yuushiro, a compression ignition engine, with

Rubbert, a spark ignition engine.” PO Resp. 50 (referencing Ex. 2002 ¶ 169). That is, Patent Owner argues that “Yuushiro . . . would not be considered by one skilled in the art for any teaching of how to prevent knock in a spark ignition system,” as Yuushiro is directed to a compression ignition engine. *Id.* at 51 (referencing Ex. 2002 ¶ 171).

Patent Owner also argues that Rubbert’s teachings are inconsistent with Yuushiro’s fuel map. PO Resp. 50–51. Patent Owner argues that, for light engine loads, Rubbert teaches using both port injection and direct injection, and Yuushiro teaches using port injection only. *Id.* at 51. Also, for heavy engine loads, Rubbert teaches using mostly direct injection and Yuushiro teaches “at least half the fuel in the heavy load regime is injected by *port injection*.” *Id.*

Patent Owner argues that Rubbert refutes Petitioner’s reasoning that a person having ordinary skill in the art would have looked to Yuushiro to save direct injection fuel, as Rubbert teaches to use mostly or all direct injection fuel in the high load range. PO Resp. 53. Patent Owner argues that, as such, Rubbert teaches away from Yuushiro’s fuel map. *Id.* (referencing Ex. 2002 ¶ 175). Patent Owner adds that, in the low load range, Rubbert expressly teaches a need for some directly injected fuel to achieve stable combustion. *Id.* at 53–54.

Petitioner replies that, as Patent Owner’s declarant testifies, that Rubbert would not need directly injected fuel at low engine loads if the engine was operated at stoichiometric air-to-fuel ratios and that Yuushiro teaches using such stoichiometric ratios. Reply 16–17 (referencing Ex. 1050, 175:4–7 (Hannemann Deposition); Ex. 1003 ¶ 234; Ex. 1007, 2). Petitioner adds that the combined teachings would result in an engine that

would operate at low loads without the need for directly injected fuel. *Id.* at 17 (referencing Ex. 1003 ¶ 217).

Petitioner also replies that a person having ordinary skill in the art would have understood that different approaches can be used to achieve stable combustion at low loads, including intake heating (such as in Yuushiro) and rich fuel mixtures. Reply 17 (referencing Ex. 1031, 356, 358, 416, 428, 437¹¹; Ex. 1006 ¶¶ 10, 13).

Petitioner also replies that, in the full load range, Rubbert does not *require* zero port injection. Reply 17–18. Petitioner argues that Yuushiro’s fuel map is illustrative and that the key teaching from the map is that port injection and direct injection are regulated based on engine load and the amount of direct injected fuel increases with increasing load. *Id.* at 18.

In sur-reply, Patent Owner repeats its arguments that Rubbert teaches using mostly direct injection fuel in the high load regime and some direct injection fuel in the low load range to achieve stable combustion. Sur-reply 22–23. Patent Owner adds that, because Yuushiro is a compression ignition engine, it need not rely on direct injection fuel at low loads, unlike Rubbert, which teaches that using directly-injected fuel to achieve stable combustion. *Id.* at 23–24 (referencing Ex. 1007, 2, col. 1; Ex. 2002 ¶ 181). Patent Owner also argues that Yuushiro does not rely on intake heating to achieve stable combustion in the low load range. *Id.* at 24.

We find, based on the complete record and weighing all of the related evidence, that Petitioner has demonstrated, by a preponderance of the evidence, that a person having ordinary skill in the art would have had

¹¹ This citation and subsequent citations use the page numbers from Bosch, rather than the exhibit pagination added by Petitioner.

reason to combine the teachings of Yuushiro's fuel map with Rubbert's engine. We credit Dr. Clark's testimony that Yuushiro and Rubbert disclose comparable teachings and that Yuushiro's fuel map provides additional details beyond Rubbert's teachings. *See* Ex. 1003 ¶¶ 215–217; *see also id.* ¶ 259 (“Rubbert, however, does not explicitly teach a range in which only port injection is used, albeit Rubbert suggests that in lower loads the larger proportion of fuel is port injected.”). We credit this testimony, in part, based on the express disclosures in Yuushiro and Rubbert. Both references disclose load-based fuel strategies and a concern for engine knock. Ex. 1006 ¶¶ 38–39; Ex. 1007, 2. Significant to our finding is that both Yuushiro and Rubbert disclose fuel strategies that rely on most or all port injected fuel at low engine loads and increasing amounts of direct injection fuel at high loads. *See, e.g.,* Ex. 1003 ¶ 218 (“While the specific details of fuel maps can change between each engine and engine types, the person of ordinary skill in the art would have understood that as load is increased, the amount of fuel is increased according to a lookup table or map.”); *cf. KSR Int’l Co.*, 550 U.S. at 418 (“[T]he [obviousness] analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ.”).

We also credit Dr. Clark's testimony as it is supported by Mr. Hannemann's testimony. For example, Mr. Hannemann testified that an engine designer would start with a pre-existing fuel map and then calibrate an engine using that map. *See* Ex. 1050, 116:18–117:12; *see also* Ex. 1003 ¶ 218 (“Indeed, fuel maps are a standard tool that are used by engine calibrators when calibrating an engine.”).

We have considered Patent Owner’s argument concerning the different ignition sources used for Yuushiro’s engine and Rubbert’s engine and find it unpersuasive of a deficiency in Petitioner’s reasoning. We credit Dr. Clark’s testimony, which provides, in part, that Yuushiro’s fuel “strategy would be applicable across internal combustion engines having an ECU and fuel injection.” Ex. 1003 ¶ 218. As Dr. Clark testifies, “Rubbert and Yuushiro both seek to create an ignition source for the same purpose.” *Id.* at ¶ 219. Dr. Clark testifies that a “person of ordinary skill in the art would consider the implementation details of Yuushiro to be standard and would have understood that because the implementations details were used to improve the Yuushiro engine, they could likewise implemented in the Rubbert engine.” *Id.* Dr. Clark bases this opinion, at least in part, on common teachings in Rubbert and Yuushiro of increasing direct injection fuel to avoid knock. *Id.* Mr. Hannemann’s testimony also supports our finding. Mr. Hannemann testified as to the similarities of a compression ignition engine and a spark ignition engine, and the similarities of fuel management systems for those engines. *See* Ex. 1050, 28:10–36:21.

We have also considered Patent Owner’s argument that Rubbert teaches away from the fueling strategy in Yuushiro, because Rubbert discloses a strategy using some direct injection at low engine loads and mostly or all direct injection at high engine loads, and find these teachings do not amount to a teaching away. “A reference may be said to teach away when a person of ordinary skill, upon reading the reference, . . . would be led in a direction divergent from the path that was taken by the applicant.” *In re Haruna*, 249 F.3d 1327, 1335 (Fed. Cir. 2001) (quoting *Tec Air, Inc. v. Denso Mfg. Mich. Inc.*, 192 F.3d 1353, 1360 (Fed. Cir. 1999)); *see, e.g., In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004) (holding that, to teach

away, the prior art must “criticize, discredit, or otherwise discourage the solution claimed”). Patent Owner does not adequately explain how the teachings of a *different* strategy in Rubbert “criticize, discredit, or otherwise discourage” employing Yuushiro’s fuel injection map with Rubbert’s engine.

Although we find that Rubbert’s differing strategy does not rise to a teaching away, we do weigh this evidence against a motivation to combine. However, in weighing all of the evidence concerning the motivation to combine Yuushiro’s teachings with Rubbert, we find that the preponderance of the evidence weighs in favor of Petitioner’s position. *See, e.g.*, Ex. 1003 ¶ 217 (discussing the advantages of port injection versus direct injection); Ex. 1031, 358, 416, 428, 429, 437 (discussing factors affecting combustion at different loads); Ex. 1050, 175:4–7 (“Q. So in your opinion if it was a stoichiometric ratio you wouldn’t need the additional [direct injection fuel] that Rubbert discloses? A. Correct.”).

Next, we find, based on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that a person having ordinary skill in the art would have had reason to combine the teachings of Bosch with respect to spark retard, turbocharging, and a knock sensor. Petitioner contends that a person having ordinary skill in the art would have been motivated to look to Bosch to provide implementation details with respect to spark retard, turbocharging, and closed loop control for engine knock. Pet. 31 (referencing Ex. 1003 ¶¶ 220–222). Petitioner reasons that a person having ordinary skill in the art “would have been motivated to reduce the displacement of the engine while maintaining desired power.” *Id.* at 32 (referencing Ex. 1003 ¶ 222; Ex. 1001, 1:40–47). Petitioner contends that employing “spark retard would be beneficial to reduce that amount of fuel

that is directly injected.” *Id.* Petitioner reasons that a person having ordinary skill in the art “would have been motivated to reduce knock using well-understood methods, including spark retard, turbocharging, and through the use of a knock sensor.” *Id.*

Petitioner explains that Bosch is “a widely relied-upon desk reference” that “discloses turbochargers, the mechanics of spark ignition and knock, along with explanations as to why a [person having ordinary skill in the art] would rely on spark retard to improve engine operation.” Pet. 32 (referencing Ex. 1031, 372–374; Ex. 1003 ¶ 222). Petitioner adds that Bosch “confirms that turbochargers were a major focus (along with [direct injection]) at the time Rubbert and Yuushiro were filed.” *Id.* Dr. Clark testifies that, as confirmed by Bosch, a person having ordinary skill in the art would have understood that the use of spark retard would be beneficial to protect the engine and reduce the amount of fuel that is directly injected and, thus improve efficiency and reduce emissions. Ex. 1003 ¶ 222.

Petitioner contends that Bosch discloses using a knock sensor “to adjust engine variables to eliminate knock, including . . . spark retard.” Pet. 32 (referencing Ex. 1031, 464–465; Ex. 1003 ¶ 222). Dr. Clark testifies that “a person of skill in the art would have looked to a system that included closed loop control alone and/or in conjunction with open loop control. Bosch uses a knock sensor to adjust engine variables to eliminate knock, including but not limited to spark retard.” Ex. 1003 ¶ 222 (relying, at least in part, on Ex. 1031, 464–65).

Petitioner contends that “given the ubiquitous nature of spark retard, turbochargers, and closed loop control in spark ignition engines, a [person having ordinary skill in the art] would have had a reasonable expectation of success and have expected a predic[t]able result.” Pet. 32 (referencing

Ex. 1003 ¶ 222); *see also* Ex. 1003 ¶ 222 (“Bosch further confirms that a person of ordinary skill in the art would have had a reasonable expectation of success in the combination in that Bosch confirms that open loop and closed loop are operated to together in that “[a]n open control loop can be a subordinate part of another system, and can interact in any fashion with other systems.” (quoting Ex. 1031, 164–165)).

Patent Owner does not address Petitioner’s reasons to combine Bosch with Rubbert and Yuushiro. *See* PO Resp. 50–54.¹²

In summary, we find, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that a person having ordinary skill in the art would have been motivated to combine the teachings of Rubbert, Yuushiro, and Bosch as Petitioner proposes. We find that Petitioner provides reasons for its proposed modifications and, as we discuss above, these reasons are supported by rational underpinnings. *See KSR Int’l Co.*, 550 U.S. at 418 (stating that, to facilitate the analysis of an obviousness position, the proponent should provide “some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”).

2. *Independent claim 1*

Claim 1 first recites “[a] fuel management system for a turbocharged or supercharged spark ignition engine.” Ex. 1001, 7:25–26 (the “spark ignition engine” recitation of claim 1).¹³ Petitioner contends that “[t]o the extent the preamble of [c]laim 1 is limiting, Rubbert discloses a spark

¹² We address any arguments that Patent Owner may make as to Petitioner’s reasoning when we address below the “spark retard” limitation of claim 1.

¹³ Petitioner characterizes this recitation as the preamble. Pet. 33. We note that claim 1 does not have a transitional phrase that separates a preamble from the main body of the claim. *See* Ex. 1001, 7:25–42.

ignited internal combustion engine.” Pet. 33 (referencing Ex. 1007, 2; Ex. 1003 ¶ 224). Petitioner acknowledges that Rubbert is silent as to whether its engine is turbocharged or supercharged. *Id.* (referencing Ex. 1031, 372–374; Ex. 1003 ¶ 225). Petitioner contends that Bosch discloses turbocharging engines and that a person having ordinary skill in the art “would have understood that the addition of a turbocharger reduced the displacement of engines while maintaining desired power.” *Id.* (referencing Ex. 1001, 1:37–41 (citing Ex. 1032); Ex. 1003 ¶ 225). Petitioner adds that the ’519 patent confirms that turbocharging was well known. *Id.* (referencing Ex. 1001, 1:35–41).

We find, on the complete record, that the combination of Rubbert, Yuushiro, and Bosch discloses a spark ignition turbocharged engine. *See, e.g.,* Pet. 33; Ex. 1007, 2; Ex. 1031, 372–374; Ex. 1003 ¶ 224–225; *cf.* Ex. 1001, 1:35–39 (“*It is known* that the efficiency of spark ignition (SI) gasoline engines can be increased by high compression ratio operation and particularly by engine downsizing. The engine downsizing is made possible by the use of substantial pressure boosting from either turbocharging or supercharging.” (emphasis added)). Because we find that the proposed combination discloses the subject matter of the “spark ignition engine” recitation of claim 1, we need not determine if the recitation is a preamble or if it is limiting. We credit Dr. Clark’s testimony directed to the “spark ignition engine” recitation of claim 1, in part, because it is consistent with our reading of the prior art of record.

Patent Owner does not dispute Petitioner’s contentions with respect to the “spark ignition engine” recitation of claim 1.

Claim 1 next recites “where the fuel management system controls fueling from a first fueling system that directly injects fuel into at least one

cylinder as a liquid and increases knock suppression by vaporization cooling and from a second fueling system that injects fuel into a region outside of the cylinder.” Ex. 1001, 7:26–31 (the “first and second fueling systems” limitation of claim 1). Petitioner contends that Rubbert discloses using direct injection fuel and port injection fuel and controlling the use of these two types of fuels based on engine load. Pet. 34 (referencing Ex. 1007, 2; Ex. 1003 ¶ 228).

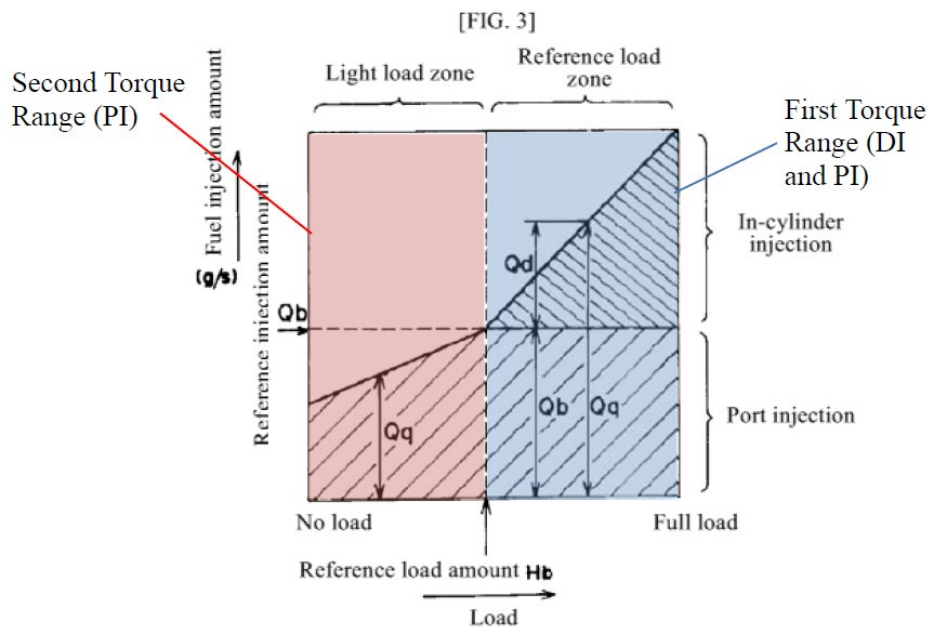
Petitioner further contends that Yuushiro “augments” Rubbert’s disclosure and that Yuushiro also relies on both port injection and direct injection of engine fuel. Pet. 34 (referencing Ex. 1006 ¶¶ 25–26; Ex. 1003 ¶ 230). Petitioner contends that the recitation “by vaporization cooling” is not entitled to patentable weight, indicating that vaporization cooling is an inherent property of direct injection. *Id.* at 34–35 (citing *In re Crish*, 393 F.3d 1253, 1258 (Fed. Cir. 2004); *Santarus, Inc. v. Par Pharms., Inc.*, 694 F.3d 1344, 1354 (Fed. Cir. 2012)). Petitioner contends, however, that a person having ordinary skill in the art would have appreciated at the time of the ’519 patent that direct injection causes vaporization cooling and, also, that Yuushiro discloses vaporization cooling. *Id.* (referencing Ex. 1006 ¶¶ 17, 19, 53; Ex. 1003 ¶¶ 31, 32, 231).

We find, on the complete record, that the combination of Rubbert, Yuushiro, and Bosch discloses a fuel management system that controls fueling from a direct injection fuel system, which injects fuel as a liquid and increases knock suppression by vaporization cooling, and port injection system, which injects fuel into a region outside of the cylinder. *See, e.g.*, Pet. 34–35; Ex. 1007, 2; Ex. 1006 ¶¶ 17, 19, 25–26, 53 ; Ex. 1003 ¶¶ 31, 32, 228–231. We credit Dr. Clark’s testimony directed to the “first and second

fueling systems” limitation of claim 1, in part, because it is consistent with our reading of the prior art of record.

Patent Owner does not dispute Petitioner’s contentions with respect to the “first and second fueling systems” limitation of claim 1

Claim 1 also recites “where there is a range of torque where both fueling systems are used at the same value of torque.” Ex. 1001, 7:32–33 (the “both fueling systems” limitation of claim 1). Petitioner contends that both Rubbert and Yuushiro disclose that, for certain engine loads (interpreted to be the same as engine torque), their engines employ direct injection and port injection fuel systems at the same time. Pet. 35–36 (referencing Ex. 1007, 2; Ex. 1006 ¶ 39, Fig. 3; Ex. 1003 ¶¶ 233–236). Petitioner provides an annotated version of Yuushiro’s Figure 3, which we reproduce below.



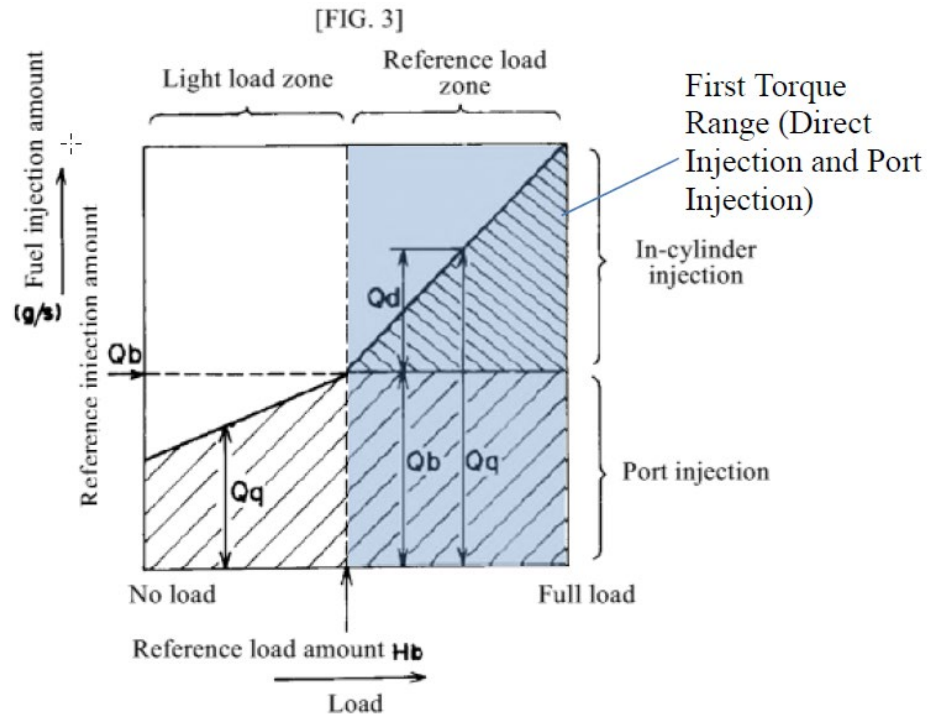
Id. at 36. The annotated figure provides an exemplary fuel injection map with labels identifying a first torque range (colored in blue) and a second torque range (colored in pink). *See* Ex. 1006, 10. In the “first torque range,”

the annotated figure shows that both port injection and in-cylinder (that is, direct) injection are used.

We find, on the complete record, that the combination of Rubbert, Yuushiro, and Bosch discloses a range of torque where both direct injection and port injection fueling systems are used at the same value of torque. *See, e.g.*, Pet. 35–36; Ex. 1007, 2; Ex. 1006 ¶¶ 38–39, Fig. 3; Ex. 1003 ¶¶ 233–236. We credit Dr. Clark’s testimony directed to the “both fueling systems” limitation of claim 1, in part, because it is consistent with our reading of the prior art of record, and, specifically, Yuushiro’s Figure 3.

Patent Owner does not dispute Petitioner’s contentions with respect to the “both fueling systems” limitation of claim 1.

Claim 1 also recites “where the fraction of fuel in the cylinder that is introduced by the first fueling system decreases with decreasing torque and the fuel management system controls the change in the fraction of fuel introduced by the first fueling system using closed loop control that utilizes a sensor that detects knock.” Ex. 1001, 7:34–39 (the “fuel fraction” limitation of claim 1). Petitioner contends that a person having ordinary skill in the art would have relied “on the disclosure of Yuushiro that demonstrates that as load changes (increases / decreases) in the reference load zone, the quantity of fuel that is directly injected likewise changes (increases / decreases).” Pet. 37 (referencing Ex. 1003 ¶ 239). Petitioner provides a different annotated version of Yuushiro’s Figure 3, which we reproduce below.



Id. at 38. This annotated version of Yuushiro's Figure 3 shows the fuel map, with the first torque range identified and colored in blue. Yuushiro's figure shows that the amount of direct injected fuel (Q_d) increases with increasing load between the reference load amount (H_b) and the full load amount (the first torque range).

Petitioner acknowledges that neither Rubbert nor Yuushiro discloses a knock sensor. Petitioner contends that a person having ordinary skill in the art would have understood "that knock sensors were well known and commonly used to control knock." Pet. 38. Petitioner contends that Bosch discloses using a knock sensor, which monitors for structure-borne noise and sends a signal to the engine control unit. *Id.* (referencing Ex. 1031, 464; Ex. 1003 ¶ 242). Petitioner adds that an artisan of ordinary skill would have understood that a knock sensor would have been added to Rubbert's engine to trigger an engine variable used to eliminate knock. *Id.* at 39 (referencing Ex. 1031, 464; Ex. 1003 ¶ 242).

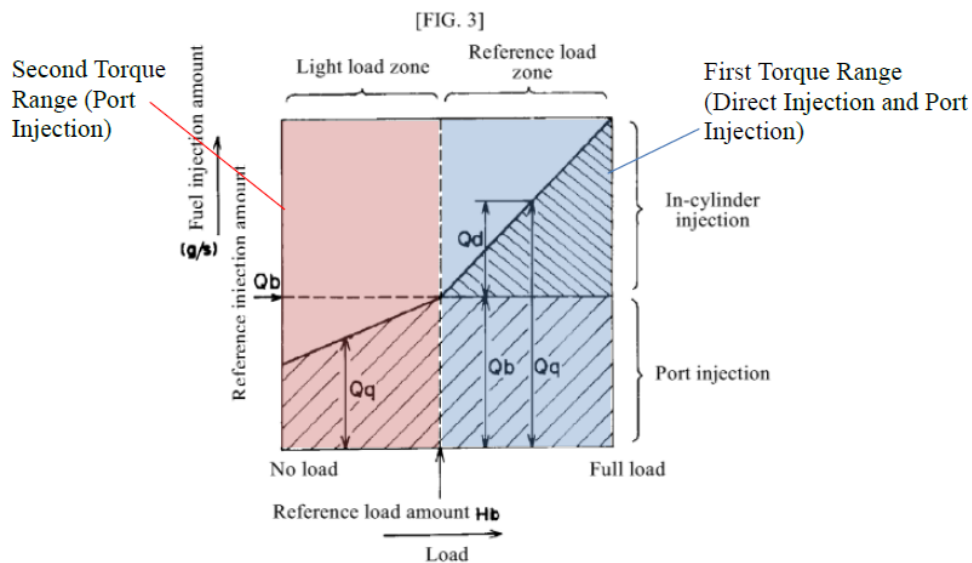
We find, on the complete record, that the combination of Rubbert, Yuushiro, and Bosch discloses that the fraction of fuel directly injected into the cylinder decreases with decreasing torque and that the fuel management system controls the change in the fraction directly injected into the cylinder using closed loop control that use a knock sensor. *See, e.g.*, Pet. 37–39; Ex. 1006 ¶¶ 38–39, Fig. 3; Ex. 1031, 464–465; Ex. 1003 ¶¶ 238–242. We credit Dr. Clark’s testimony directed to the “fuel fraction” limitation of claim 1, in part, because it is consistent with our reading of the prior art of record, including Yuushiro’s Figure 3 and Bosch’s description of knock sensors. Mr. Hannemann’s testimony also confirms that knock sensors were well known. *See, e.g.*, Ex. 1050, 55:12–56:12 (discussing knock sensors).

Patent Owner does not dispute Petitioner’s contentions with respect to the “fuel fraction” limitation of claim 1.

Finally, claim 1 recites “where the fuel management system also employs spark retard so as to reduce the amount of fuel that is introduced into the cylinder by the first fueling system.” Ex. 1001, 7:40–42 (the “spark retard” limitation of claim 1). Petitioner acknowledges that neither Rubbert nor Yuushiro discloses spark retard. Pet. 39. Petitioner contends that “Bosch discloses that it was customary as of 1993 to use spark retard to eliminate combustion knock in spark ignition engines.” *Id.* (referencing Ex. 1031, 360; Ex. 1003 ¶ 245). Petitioner adds that Bosch discloses a system that determines when to employ spark retard based on sensed parameters, including intake-manifold pressure. *Id.* (referencing Ex. 1031, 472; Ex. 1003 ¶ 245).

Petitioner contends that, “when considering the fuel map of Yuushiro [in a spark ignition engine], retarding the spark would increase the value of Hb because the mixture would experience later ignition, as taught by Bosch,

and, hence, lower temperature and pressures that reduce the propensity for” knock. Pet. 39–40. Petitioner explains that employing spark retard would increase the value of Q_b of Yuushiro’s map (Figure 3), which would increase the torque range where port injection only is used. *Id.* at 40. As a consequence, the amount of directly injected fuel (Q_d on Yuushiro’s map) would be reduced. *Id.* We reproduce an annotated version of Yuushiro’s Figure 3, below.



Ex. 1003 ¶ 246. The annotated figure provides an exemplary fuel injection map with labels identifying a first torque range (colored in blue) and a second torque range (colored in pink). *See* Ex. 1006, 10. Significant to this analysis, the annotated figure shows that no direct inject fuel (Q_d) is used in the second torque range (the lower torque, or load, range). As such, if the reference load value, H_b , is increased, the second torque range would cover a larger range. Consequently, the first torque range would cover a small range, resulting in less direct injection fuel used.

Patent Owner argues that “Bosch ***does not teach*** using spark retard to ‘reduce the amount of fuel that is introduced into the cylinder’ by direct injection as recited in [c]laim 1.” PO Resp. 58; *see id.* at 54–55 (applying

arguments directed to Bosch and spark retard made for Ground 3 to the current ground, Ground 2). Patent Owner argues that “spark retard does not improve efficiency” and “spark retard as taught by Bosch does not reduce the amount of fuel that is directly injected.” *Id.* at 59.

First, Patent Owner argues that Bosch expressly teaches that spark retard reduces engine efficiency. PO Resp. 59 (referencing Ex. 1031, 360; Ex. 2001, 374 (Internal Combustion Engine Fundamentals); Ex. 2002 ¶ 215). Second, Patent Owner argues that Petitioner’s declarant admitted that employing spark retard would increase the amount of fuel used. *Id.* at 60 (referencing Ex. 2004, 97:4–21, 98:1–3 (Clark deposition); Ex. 2002 ¶ 217). Patent Owner also criticizes Dr. Clark’s direct testimony regarding the “spark retard” limitation of claim 1, arguing that Dr. Clark compared two different engines with different compression ratios. *Id.* (referencing Ex. 2002 ¶ 217).

Petitioner replies that a person having ordinary skill in the art would have understood that employing spark retard, as taught in Bosch, would reduce the amount of *directly* injected fuel required to prevent knock. Reply 25 (referencing Ex. 1031, 465; 1003 ¶ 396; Ex. 1001, 6:49–53). Petitioner also replies that “Patent Owner’s ‘two different engines’ theory rests on a flawed premise that engine designers do not consider whether to retard the spark to suppress knock when designing more efficient engines.” *Id.* at 26 (explaining that “Mr. Hannemann confirmed that, at the engine design phase, ‘everything else being equal,’ increasing the compression ratio can increase efficiency.” (referencing Ex. 1050, 66:18–23)). That is, Petitioner contends that a person having ordinary skill in the art would have understood that different parameters, such as compression ratio, might be manipulated to affect engine efficiency. Petitioner concludes that “an engine

designer ‘could develop the engine that had the same propensity to knock with a higher compression ratio’ to achieve greater overall efficiency by looking to tools such as adding [direct injection fuel], including a knock sensor, or increasing spark retard.” *Id.* (referencing Ex. 1050, 67:2–22).

In sur-reply, Patent Owner argues that “Petitioner’s analysis of two different engines fails simply because . . . the claim phrases do not apply to two different engines, but rather to the use of spark retard to enable reduction of the amount of direct injection in a given spark ignition engine.” Sur-reply 27. Patent Owner adds that “Bosch teaches *increasing* the amount of directly injected fuel used in a given spark ignition engine, rather than *reducing* the amount.” *Id.*

We interpret Patent Owner’s arguments to, first, address Petitioner’s reasons to employ spark retard, and second, address whether the proposed combination actually discloses the subject matter of the “spark retard” limitation of claim 1. We address these two arguments in turn.

First, we find, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that a person having ordinary skill in the art would have had reason to employ spark retard in Rubbert’s engine employing Yuushiro’s fuel map. We recognize that Bosch discloses that spark retard “is not entirely without problems.” Ex. 1031, 360. Bosch also discloses that at higher compression ratios, “it is therefore necessary to reliably detect and avoid combustion knock.” *Id.* We find that the proposed combination mitigates this issue. As claim 1 recites, and Petitioner proposes, the engine includes a knock sensor. *See* Ex. 1001, 7:34–39; Pet. 37–39. The knock sensor would help mitigate knock. *Accord* Ex. 1050, 55:12–56:12 (discussing knock sensors).

We credit Dr. Clark’s testimony, which explains that a person having ordinary skill in the art would have had reason to employ different conventional techniques, in conjunction, to control knock, including employing spark retard and a knock sensor. Ex. 1003 ¶ 222. We credit this testimony, in part, because it is supported by Mr. Hannemann’s testimony. *See, e.g.*, Ex. 1050, 67:15–22 (testify about employing spark retard to mitigate knock and stating that “in order to use spark retard as a strategy, you need to equip the vehicle with a knock sensor.”).

We are also not persuaded by Dr. Clark’s deposition testimony, relied on by Patent Owner, that spark retard would require more fuel. As Dr. Clark explains, a designer would look at the overall efficiency of an engine and the use of spark retard would help achieve that, by reducing knock at higher loads. Ex. 2004, 99:3–19.

Even if we credit Patent Owner’s argument, Patent Owner fails to address Petitioner’s other reasoning—reducing the amount of fuel that is *directly* injected, improving engine operation, and reducing knock. Pet. 32; *see also Winner Int’l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 n.8 (Fed. Cir. 2000) (“The fact that the motivating benefit comes at the expense of another benefit, however, should not nullify its use as a basis to modify the disclosure of one reference with the teachings of another. Instead, the benefits, both lost and gained, should be weighed against one another.”). Dr. Clark testifies that, in addition to improving efficiency, spark retard protects the engine, reduces the amount of fuel *directly* injected, and reduces emissions. Ex. 1003 ¶ 222. We credit this testimony. The record indicates that spark retard reduces knock, which would protect an engine and improve its operation. *See* Ex. 1031, 360, 464 (“Internal-combustion engines are damaged by combustion knock.”); Ex. 1050, 67:15–22. Indeed, the ’519

patent indicates that spark retard may be used to avoid knock in situations where direct injection fuel is not available. Ex. 1001, 6:46–53. We take this limited disclosure in the ’519 patent to indicate that the inventors recognized that spark retard was well known and that a person having ordinary skill in the art would have understood how to implement spark retard and how it reduces engine knock, thus obviating the need to further describe spark retard in the Specification. *See also* Ex. 1031 (indicating that spark retard is a “common practice”); Ex. 1003 ¶ 211 (“Bosch is a well-known text that . . . discloses the processes and mechanics involved in spark retard and knock.”).

Accordingly, we find that Patent Owner’s argument does not demonstrate a deficiency in Petitioner’s reasoning, as it addresses only one component of that reasoning, rather than the reasoning as a whole. As we describe above, we find that the preponderance of the evidence supports Petitioner’s overall position.

Second, we find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combined teachings of Rubbert, Yuushiro, and Bosch results in an engine that, by employing spark retard, would use less direct injected fuel. We agree with Petitioner that spark retard results in less engine knock. *See* Pet. 39; Ex. 1003 ¶ 245; Ex. 1031, 360. It follows, then, that the Hb point on Yuushiro’s fuel map would move to the right if spark retard is employed. *See* Pet. 39–40; Ex. 1003, 246–247; Ex. 1006 ¶¶ 38–39, Fig. 3. The Hb point is the maximum engine torque (load) for which port injection only is used. *See* Ex. 1006 ¶¶ 38–39, Fig. 3. This point is set, as adding additional port injected fuel would cause knock. *See id.* As such, employing spark retard, which also reduces knock would allow greater amounts of port injected fuel, which, in turn, would result in less direct injected fuel. *See id.*

For the reasons discussed above, we find, on the complete record, that the combination of Rubbert, Yuushiro, and Bosch discloses that the fuel management system employs spark retard so as to reduce the amount of fuel that is introduced into the cylinder by the first fueling system.

In conclusion, on the complete record, Petitioner has demonstrated, by a preponderance of the evidence, that independent claim 1 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

3. *Independent claim 13*

Independent claim 13 differs from claim 1 in that it requires “the fuel management system [to] use[] information from a sensed parameter to control spark retard so as to decrease the amount of fuel that would otherwise be provided by the first fueling system.” *Compare* Ex. 1001, 8:14–26 *with id.* at 7:25–42. Petitioner relies on its contentions for claim 1 in arguing that claim 13 is obvious over Rubbert, Yuushiro, and Bosch. Pet. 45–46. With respect to claim 13’s requirement that the fuel management system use a sensed parameter to control spark retard, Petitioner contends that the combination of Rubbert, Yuushiro, and Bosch discloses using a knock sensor and intake-manifold pressure to decrease knock and decrease the amount of fuel that is directly injected. *Id.* at 45 (referencing Ex. 1031, 360, 464, 472; Ex. 1003 ¶¶ 299–304).¹⁴

We find, based on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses using a knock sensor and intake-manifold

¹⁴ Petitioner also references its analysis of the “spark retard” limitation of claim 1, which we discuss above, and its analysis of claim 5, which we discuss below. *See* Pet. 45 (referencing § VII (B)(6) and (10), which are found at Pet. 39–40, 42).

pressure to decrease knock and decrease the amount of fuel that is directly injected.

Patent Owner does not dispute this contention. We have addressed Patent Owner's other arguments directed to claim 13 in our analysis for claim 1.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that independent claim 13 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

4. *Dependent claims 2–6, 9–12, 14–18*

a) *Claims 2 and 16*

Dependent claim 2 depends from claim 1 and further recites “where the spark retard is employed to [sic, “so”] as to reduce the amount of fuel that is provided by the first fueling system to zero.” Ex. 1001, 7:43–45. Similarly, claim 16 depends from claim 13 and recites “where spark retard is employed so as to reduce the use of the first fueling system to zero.” *Id.* at 8:34–36.

Petitioner contends that, as discussed above in connection with the “spark retard” limitation of claim 1, employing spark retard reduces the amount of directly injected fuel used by the engine. Pet. 40; *see also id.* at 39–40 (describing the effect on Qd and Qb by employing spark retard in connection with the “spark retard” limitation of claim 1); Ex. 1003 ¶¶ 246–247 (same), 249–253 (addressing claim 2)). That is, employing spark retard increases the value of Hb, which increases the torque range for which port injection fuel only is used and, consequently, reduces the range for which direct injection is used. *See* Pet. 39–40, 46; Ex. 1003 ¶¶ 246–247, 249–253,

323–330. Petitioner contends that, as such, there are certain values of torque for which no direct injection fuel is needed (that is, direct injection is reduced to zero) because spark retard is used to increase Hb. Pet. 40.

We find, on the complete record, that Petitioner demonstrates by a preponderance of the evidence that, by employing spark retard, the amount of directly injected fuel that would have been used in a certain torque range would be reduced to zero. *See* Pet. 39–40; Ex. 1003 ¶¶ 246–247, 249–253, 323–330; Ex. 1006 ¶¶ 38–39, Fig. 3. Because employing spark retard would increase the value of Hb on Yuushiro’s fuel map (that is, move it to the right, creating an Hb_{new} value), the torque range from Hb to Hb_{new} would employ port injection only, rather than port injection plus direct injection. So, in this range, direct injection would be reduced to zero because spark retard is used.

Patent Owner does not dispute Petitioner’s contentions with respect to claims 2 and 16.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claims 2 and 16 are unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

b) Claims 3 and 11

Claim 3 depends from claim 1 and further recites “where when the torque is increased the increase in the fraction of fuel that is introduced by the first fueling system is minimized while still preventing knock.” Ex. 1001, 7:46–49. Similarly, claim 11 depends from either claim 1 or claim 3 and further recites “where the fuel management system minimizes the increase in the fraction of fuel in the cylinder that is provided by the first fueling system as torque is increased.” *Id.* at 8:8–11.

Petitioner contends that Yuushiro discloses the subject matter of claims 3 and 11. Pet. 41, 44. Petitioner contends that

In a reference load zone, the minimum amount of fuel is directly injected because Yuushiro teaches directly injecting only the amount of fuel necessary to obtain the required power output while maintaining knock free operation at the desired torque, e.g., according to $Q_d = Q_q - Q_b$, where Q_d is the [direct inject] fuel injected, Q_q is the total fuel injected, and Q_b is the reference load injection. That is, the [person having ordinary skill in the art] would understand that Yuushiro teaches directly injecting only the amount of fuel necessary to obtain the required power output while maintaining knock free operation at the desired torque ($Q_q - Q_b$) is provided.

Id. at 41 (referencing Ex. 1006, ¶ 39; Ex. 1003 ¶ 257).

We find, on the complete record, that Petitioner demonstrates by a preponderance of the evidence that the combination of Rubbert, Yuushiro, and Bosch discloses that, when the torque is increased the increase in the fraction of fuel that is introduced by the first fueling system is minimized while still preventing knock. We agree with Petitioner that Yuushiro discloses using only port injected fuel below the reference load point, that is, the point where knock begins. *See* Ex. 1006 ¶ 39, Fig. 3; Ex. 1003 ¶ 257. Only then is direct injected fuel used to satisfy the power output requirement and still preventing knock. *See id.* We credit Dr. Clark's testimony, as it is consistent with our understanding of Yuushiro.

To further explain this finding, we understand Yuushiro to disclose using only port injection in the region from no load to the reference load value (H_b). *See, e.g.,* Ex. 1006, Fig. 3 (providing Yuushiro's fuel map). If additional power is required above the reference load amount, the power requirement, Q_q , must be met by either port injection only, direct injection only, or a combination of port injection and direct injection, with this third

option illustrated in Yuushiro's Figure 3, reproduced above (in connection with our analysis of the "spark retard" limitation of claim 1, and elsewhere). In other words, to meet power demand, the fuel must come from somewhere. If the engine uses port injection alone, then knocking would occur, because, in the reference load zone, Q_q is greater than Q_b , the maximum amount of port-injected fuel before knocking occurs. Because Yuushiro's disclosed process limits the amount of port-injected fuel to Q_b , the direct injection amount (Q_d) must satisfy the remaining fuel requirement ($Q_q - Q_b$). Also, with increasing Q_q in the reference load zone, the fraction of fuel represented by Q_d must increase. That is to say, to meet increasing load requirements in the reference load zone, the fuel management system proportionally increases the amount of directly injected fuel so that the amount of fuel that is port injected is maintained at the maximum level (Q_b) to prevent engine knock. In this way, the fraction of directly injected fuel prevents knocking (since it allows port injection to remain at Q_b) and meets the power requirements in the reference load zone. And, because the fuel management system maintains port fuel injection at a level Q_b , then only the minimum amount of direct injection fuel necessary is used—only the amount need to satisfy the additional power need and no more. *Accord* Ex. 1006 ¶¶ 38–39, Fig. 3; Ex. 1003 ¶¶ 256–257.

Patent Owner does not dispute Petitioner's contentions with respect to claims 3 and 11, other than in its argument for claim 19, which we address below, in connection with our analysis of claim 19. *See* PO Resp. 50.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claims 3

and 11 are unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

c) Claim 4

Claim 4 depends from claim 1 and further recites “where without employing the spark retard there is a range of torque in which only the second fueling system is used.” Ex. 1001, 7:50–52. Petitioner contends that Yuushiro discloses a range of torque (the light load range) for which only port fuel injection is used without employing spark retard. Pet. 42 (referencing Ex. 1006 ¶¶ 12, 39; Ex. 1003 ¶¶ 259–262).

We find, on the complete record, that Petitioner demonstrates by a preponderance of the evidence that the combination of Rubbert, Yuushiro, and Bosch discloses that, without employing the spark retard there is a range of torque in which only the second fueling system (port injection) is used. *See, e.g.*, Ex. 1006 ¶¶ 12, 39; Ex. 1003 ¶¶ 259–262.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 4.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 4 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

d) Claim 5

Claim 5 depends from claim 1 and further recites “where the fuel management system employs the spark retard in response to sensed information and both the sensed information and information about knock are used to control the fuel that is introduced by the first fueling system.” Ex. 1001, 7:53–57. Petitioner contends that “[t]he combination of Rubbert, Yuushiro, and Bosch discloses using spark retard controlled by sensed

information, e.g., intake-manifold pressure, in addition to information from a knock sensor, to control the amount of fuel that is introduced by [direct injection] as is described with respect to [c]laim 1.” Pet. 42 (referencing Ex. 1031, 360, 464, 472; Ex. 1003 ¶¶ 263–269).

We have addressed this subject matter above, in connection with our analysis of claim 13, finding that it is disclosed by the combination of Rubbert, Yuushiro, and Bosch. Patent Owner does not dispute Petitioner’s contentions with respect to claim 5.

For the reasons discussed above and discussed in connection with our analysis of claims 1 and 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 5 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

e) Claim 6

Claim 6 depends from claim 1 and recites “where the maximum torque that the engine provides occurs when both the first and second fueling systems are used at the same value of torque.” Ex. 1001, 7:58–61. Petitioner contends that both Rubbert and Yuushiro disclose the subject matter of claim 6. Pet. 42–43 (referencing Ex. 1006 ¶ 39, Fig. 3; Ex. 1007, 2; Ex. 1003 ¶¶ 271–273). With respect to Yuushiro, Petitioner contends that in the higher torque, or load, range, up to full load, Yuushiro discloses operating with both port injection and direct injection. *Id.*

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch disclose at the maximum engine torque, both the first and second fueling systems are used at the same value of torque. *See, e.g.*, Pet. 42–43; Ex. 1006 ¶ 39, Fig. 3; Ex. 1007, 2; Ex. 1003 ¶¶ 271–273. This relationship

is best seen in Yuushiro's Figure 3, where at full load, port injection fuel value of Q_b is combined with a direct injection fuel value of $Q_q - Q_b$, where, in this instance, Q_q is the point on the line in Figure 3 corresponding to the "Full load" point on the x-axis. *See* Ex. 1006 ¶ 39, Fig. 3.

Patent Owner does not dispute Petitioner's contentions with respect to claim 6.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 6 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

f) Claim 9

Claim 9 depends from claim 1 and recites "where both the first and second fueling system are used when the highest knock resistance is required." Ex. 1001, 8:1–3. Petitioner contends that "[t]he highest knock resistance would be required at the highest engine loads." Pet. 43 (referencing Ex. 1036, 31). Petitioner contends that both Rubbert and Yuushiro disclose that both port injection and direct injection are used at high engine loads. *Id.* (referencing Ex. 1006, Fig. 3, ¶ 39; Ex. 1007, 2; Ex. 1003 ¶¶ 274–277).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses using both the first (direct injection) and second (port injection) fueling system when the highest knock resistance is required. *See, e.g.,* Pet. 43; Ex. 1006, Fig. 3, ¶ 39; Ex. 1007, 2; Ex. 1003 ¶¶ 274–277. This relationship is best seen in Yuushiro's Figure 3, where at full load, port injection fuel value of Q_b is combined with a direct injection fuel value of $Q_q - Q_b$, where, in this instance, Q_q is the point on the line in Figure 3

corresponding to the “Full load” point on the x-axis. *See* Ex. 1006 ¶ 39, Fig. 3.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 9.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 9 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

g) Claim 10

Claim 10 depends from claim 1 and recites “where as the torque is increased the increase in the fraction of fuel in the cylinder that is provided by the first fueling system is substantially equal to that needed to prevent knock.” Ex. 1001, 8:4–7. Petitioner contends Yuushiro discloses “that as torque (or load) increases, the quantity of fuel that is directly injected likewise increases to prevent knock.” Pet. 43 (referencing Ex. 1003 ¶¶ 279–280). Petitioner add that, “[a]s admitted, an increase in [direct injection] fuel over a range ‘[] suggests that the fraction of fuel in the cylinder that is provided by the first fueling ([direct injection]) system increases only to the extent needed to prevent knock.” *Id.* at 43–44 (referencing Ex. 1036, 23) (second alteration in original).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses a fuel management system where as the torque is increased the increase in the fraction of fuel in the cylinder that is provided by the first fueling system is substantially equal to that needed to prevent knock. As we discuss above in connection with our analysis of claims 3 and 11, Yuushiro’s Figure 3 discloses a fuel map where the amount of direct

injection fuel is equal to the amount needed to prevent knock. This is the case because Yuushiro teaches that the amount of fuel injected through port injection is increased until it reaches a level (Q_b , which corresponds to a load value H_b , the reference load value) for which, if more port fuel injection is used, knocking will occur. Ex. 1006 ¶ 39, Fig. 3; *accord* Ex. 1050, 183:19–22. Accordingly, for demands for additional fuel to achieve higher loads, that is, loads greater than the reference load value H_b , the amount over Q_b is added by direct injection. Otherwise, the demand would need to be satisfied by port injection, and knock would occur. *See* Ex. 1006 ¶ 39, Fig. 3; Ex. 1003 ¶¶ 280–281; Ex. 1050, 183:19–22. In this way, the quantity of direct injection fuel increases to prevent knock as load increases in the reference load zone.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 10.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 10 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

h) Claim 12

Claim 12 depends from claim 1 and recites “where the second fueling system uses port fuel injection.” Ex. 1001, 8:12–13. Petitioner references its analysis for claim 1, demonstrating that the second fueling system is port injection. Pet. 44; *see* 1006 ¶ 39, Figs. 1, 3; Ex. 1007, 2 (referring to port injection as “induction pipe injection”); Ex. 1003 ¶¶ 288–291.

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses a second fueling system that uses port fuel injection.

See, e.g., Ex. 1006 ¶¶ 21–27 (describing engine), Fig. 1 (showing port injector); Ex. 1007, 2 (describing induction pipe injection); Ex. 1003 ¶ 290 (showing an annotated version of Yuushiro’s Figure 1 and identifying port fuel injector and direct fuel injector).

Patent Owner does not dispute Petitioner’s contentions with respect to claim 12.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 12 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

i) Claim 14

Claim 14 depends from claim 13 and recites “where input from the knock sensor is utilized in a closed loop control system that controls the fraction of fuel that is introduced into the first fueling system.” Ex. 1001, 8:27–30. Petitioner contends that “[t]he combination of Rubbert, Yuushiro, and Bosch discloses the use of a knock sensor in a closed loop control system to control [direct injection] as a manipulated variable to suppress knock.” Pet. 46 (referencing analysis of “fuel fraction” limitation of claim 1; Ex. 1003 ¶¶ 312–317).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses that input from the knock sensor is utilized in a closed loop control system that controls the fraction of fuel that is introduced into the first fueling system. *See, e.g.*, Ex. 1031, 464–465; Ex. 1003 ¶¶ 312–317.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 14.

For the reasons discussed above and discussed in connection with our analysis of claims 1 and 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 14 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

j) Claim 15

Claim 15 depends from claim 13 and recites “where both the first and second fueling systems are used at the same value of torque.” Ex. 1001, 8:31–33. Petitioner references its analysis for the “both fueling systems” limitation of claim 1. Pet. 46 (referencing § VII(B)(4); Ex. 1003 ¶¶ 318–322). Patent Owner does not dispute Petitioner’s contentions with respect to claim 15.

For the reasons discussed above and discussed in connection with our analysis of claims 1 and 13 (as well as claims 6 and 9), we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 15 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

k) Claim 17

Claim 17 depends from claim 1 and recites “where the engine is turbocharged or supercharged and the level of turbocharging or supercharging is reduced so as to decrease the amount of fuel from the first fueling system.” Ex. 1001, 8:37–40. Petitioner contends that a person having ordinary skill in the art “would have understood that Rubbert is compatible with turbocharging and does not exclude the possibility of turbocharged engines, particularly given that turbochargers were a major focus (along with [direct injection]) at the time Rubbert was filed.” Pet. 47 (referencing Ex. 1003 ¶ 332). Petitioner adds that “Bosch discloses

turbocharged engines” and “that with turbocharged engines, boost/intake pressure can be employed as a manipulated variable.” *Id.* (referencing Ex. 1031, 465; Ex. 1003 ¶¶ 333–334).

Dr. Clark testifies that, in a turbocharged engine, “at least two control variables . . . contribute to the reduction of knock”—reduction of boost or addition of direct inject fuel. Ex. 1003 ¶ 335. Dr. Clark opines that “[a] person of ordinary skill in the art would recognize that . . . reduction of boost will permit the engine to operate with reduced direct injection without altering the propensity of the engine to knock.” *Id.*

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses a turbocharged or supercharged engine where the level of turbocharging or supercharging is reduced decreases the amount of fuel from the first fueling system. We credit Dr. Clark’s testimony, as it is consistent with the teachings in Rubbert, Yuushiro, and Bosch. *See, e.g.*, Ex. 1006 ¶¶ 38–39 (describing the operation of port injection and direct injection, including addressing knock); Ex. 1007, 2 (same); Ex. 1031, 465 (“This reduces the boost pressure and, as a consequence, the tendency to knock.”). Mr. Hannemann also confirms this testimony. *See, e.g.*, Ex. 1050, 65:9–66:6 (discussing the benefits and tradeoffs of a turbo-charger, including increasing compression adds to the propensity for spark knock).

Patent Owner does not dispute Petitioner’s contentions with respect to claim 17.

For the reasons discussed above and discussed in connection with our analysis of claims 1 and 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that

dependent claim 17 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

l) Claim 18

Claim 18 depends from claim 13 and recites “where closed loop control with a knock detector is used to increase the relative amount of fuel from the first fueling system as torque is increased.” Ex. 1001, 8:41–44. Petitioner contends that claim 18 “is substantially similar to” the “fuel fraction” limitation of claim 1 (Petitioner’s element “1.C”), except claim 18 is directed to increasing fuel amount and the “fuel fraction” limitation of claim 1 is directed to decreasing fuel amounts. Pet. 48. Petitioner concludes “[n]evertheless, [c]laim 15 is unpatentable for at least the same reasons.” *Id.* We agree, as the disclosure in Yuushiro illustrates the relationship between engine load and direct injection fuel quantities, with the map of Yuushiro’s Figure 3 showing the linear relationship that applies whether load in the reference zone is increasing or decreasing.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 18.

For the reasons discussed above and discussed in connection with our analysis of claims 1 and 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 18 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

5. Independent claim 19

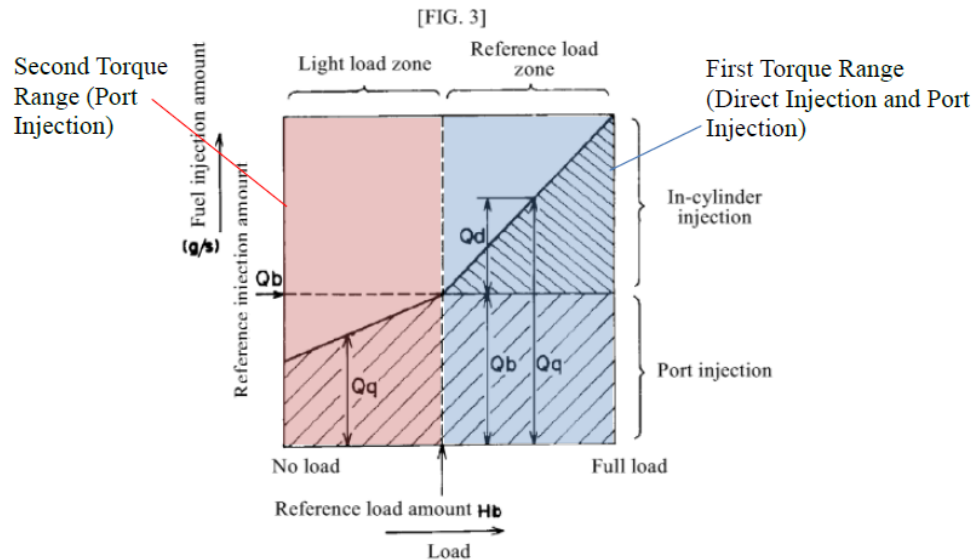
Petitioner contends that the subject matter of claim 19 “is substantially similar to” claims 1, 3, 8, and 10. Pet. 48–49. Patent Owner argues that Petitioner fails to demonstrate that the combination of Rubbert, Yuushiro, and Bosch discloses “increasing the fraction of fuel directly injected ‘so as

to prevent knock as torque increases’ as recited in independent [c]laim 19.” PO Resp. 55. Patent Owner argues that “Yuushiro does not teach or suggest this claim limitation for the reasons addressed above,” which we interpret to mean for the reasons argued in the Patent Owner Response directed to Yuushiro for claim 19, Ground 1. *Id.*

Patent Owner argues that Yuushiro limits the amount of *port* fuel injection to prevent knock, such that the amount of fuel directly injected does not prevent knock. PO Resp. 42–43. Petitioner replies that “Yuushiro limits the [direct injection] fuel amount (Qd) to the fuel amount needed to power the engine without knocking.” Reply 14. Petitioner explains that “Yuushiro’s fuel map teaches only one way to meet the load requirements in the reference load zone—increase the [direct injection] amount *to prevent engine knock* such that the maximum amount of [port injection] fuel (Qb) is maintained.” *Id.* at 14–15. In sur-reply, Patent Owner argues that knock cannot be prevented if it is already being prevented by Yuushiro’s limiting port injection. Sur-reply 17.

Patent Owner does not demonstrate a deficiency in Petitioner’s position. We find, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses increasing the fraction of fuel directly injected so as to prevent knock as torque increases. Patent Owner’s argument ignores the simple fact that, in the reference load region, the required engine power must come from somewhere—either from port injected fuel, direct injected fuel, or a combination of both. As we discuss above in connection with our analysis of claim 3 under this ground, we understand Yuushiro to disclose using only port injection in the region from no load to the reference load value. If additional power is required above the

reference load amount, the power requirement, Q_q , must be met by either port injection only, direct injection only, or a combination of port injection and direct injection, with this third option illustrated in Yuushiro's Figure 3 (an annotated version is reproduce below).



Pet. 36. The annotated figure provides an exemplary fuel injection map with labels identifying a first torque range (colored in blue) and a second torque range (colored in pink). See Ex. 1006, 10. As illustrated, if the engine uses port injection alone to satisfy the load requirement in the reference load zone, then knocking would occur, because, in the reference load zone, Q_q is greater than Q_b , the maximum amount of port-injected fuel before knocking occurs. So, to prevent knock as torque (load) increases from the reference load amount into the reference zone, port injection alone cannot be used.

Accordingly, because Yuushiro's disclosed process limits the amount of port-injected fuel to Q_b , the direct injection amount (Q_d) must satisfy the remaining fuel requirement ($Q_q - Q_b$). Also, with increasing Q_q in the reference load zone, the fraction of fuel represented by Q_d increases. That is to say, to meet increasing load requirements in the reference load zone, the fuel management system proportionally increases the amount of directly

injected fuel so that the amount of fuel that is port injected is maintained at the maximum level (Q_b) *to prevent engine knock* (again, knock is prevented by this direct injection fuel because, but for this direct injection fuel, the engine would need to rely on port injection to satisfy the load demand, and knocking would result). In this way, the fraction of directly injected fuel prevents knocking while meeting the power requirements in the reference load zone. And, because port fuel injection at a level of Q_b is maintained, then only the minimum amount of fuel necessary is used—the amount that makes of the difference between Q_q and Q_b to satisfy the load demand. *Accord* Ex. 1006 ¶¶ 38–39, Fig. 3; Ex. 1003 ¶¶ 182, 256–257, 356–360; Ex. 1050, 183:19–22 (“Q. And is it your opinion that if Yuushiro added additional PI fuel above the line Q_B that the engine would knock? A. Yes.”); Sur-reply 19 (“Yuushiro must use its directly injected fuel to meet an *increasing* load while at the same time it must keep the port injected fuel amount *constant*.”). We credit Dr. Clark’s testimony, as it is consistent with our understanding of Yuushiro and confirmed by Mr. Hannemann.

Patent Owner also argues that the combination of Rubbert, Yuushiro, and Bosch fails to disclose the limitation of claim 19 requiring “the fuel management system [to] match[] the fraction of fuel that is provided by first fueling system with the amount needed to prevent knock at a given value of torque.” PO Resp. 55, 56; Ex. 1001, 8:57–60. Again, Patent Owner references “reasons given above,” which we interpret to mean arguments made in the Patent Owner Response directed to Yuushiro for claim 19, Ground 1. PO Resp. 56.

Patent Owner argues that “Yuushiro does *not* teach or suggest using *any* amount of directly injected fuel to prevent knock, let alone that a directly injected fraction is *matched* or minimized to an amount necessary to

prevent knock.” PO Resp. 46. Patent Owner argues that “based on the teachings of Yuushiro, the engine taught in that reference *cannot match the fraction of directly injected fuel to the fraction needed to prevent knock because its directly injected fuel amount must be rigidly tied to load without the ability to change the port injected fuel amount.*” *Id.* at 49; *see also id.* at 46–49 (explaining Patent Owner’s argument in detail).

Petitioner replies that Patent Owner’s declarant confirms that “[o]nly after Yuushiro reaches a point where it cannot add more [port injected fuel] but needs more fuel to reach a desired load amount does it add the matching necessary [direct injection] amount (no more).” Reply 15 (referencing Ex. 1050, 135:22–136:1, 137:12–17; Pet. 14, 22–24; Ex. 1003 ¶¶ 149, 169, 186–187). In sur-reply, Patent Owner repeats that “Yuushiro must use its directly injected fuel to meet an *increasing* load while at the same time it must keep the port injected fuel amount *constant.*” Sur-reply 19.

Patent Owner does not demonstrate a deficiency in Petitioner’s position. We find, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Rubbert, Yuushiro, and Bosch discloses a fuel management system that matches the fraction of fuel that is provided by first fueling system with the amount needed to prevent knock at a given value of torque. We base our finding on the same reasoning as we applied above in connection with our analysis of “so as to prevent knock” language of claim 19. Again, Yuushiro teaches that, for engine loads (torque) in the light load zone, port fuel injection only is used, with the amount of fuel increases as load increases to the reference load value. *E.g.*, Ex. 1006, Fig. 3 (showing Q_q increasing linearly with increasing load in the light load zone). Once the engine load increases above the reference load value, the amount of fuel that is port injected

remains constant and the load above the reference load value is satisfied by direct fuel injection. *Id.* There seems to be no dispute in this understanding. *See* PO Resp. 45–49; Reply 14–15.

As Petitioner contends, the amount of direct injected fuel is only the amount needed to satisfy the additional power demand. Pet. 26–27; *see, e.g., id.* at 27 (“In the reference load zone, the minimum amount of fuel is directly injected because Yuushiro teaches directly injecting only the amount of fuel necessary to obtain the required power output while maintaining knock free operation at the desired torque, e.g., according to $Q_d = Q_q - Q_b$. . .”). So, for a load value in the reference load zone near the reference load amount, a small amount of direct injection fuel is used. Ex. 1006, Fig. 3 (showing Q_d equal to the required amount of fuel to meet the load less the maximum port injection quantity, Q_q). As load demand increases in the reference load zone, the amount (fraction) of direct injected fuel increases linearly, with the amount of fuel being only that amount needed to meet load demand— $Q_q - Q_b$. *Id.* That is, the minimum amount of direct injection fuel is used to satisfy the power requirement (that is, matches) while still preventing knock. Because, if less direct injection fuel was used (that is, less than this minimum, matched amount), then the fuel would have to come from port injection, and the port injection fuel value would exceed Q_b , so knock would occur.

For the reasons discussed above and those discussed in connection with our analysis of claims 1, 3, 8, and 10, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 19 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

6. *Dependent claims 20–22*

a) *Claim 20*

Claim 20 depends from claim 19 and further recites “where there is a second torque range where only the second fueling system is used and the highest value of torque in the second torque range is lower than at least one value of torque in the first torque range.” Ex. 1001, 8:63–67. Petitioner contends that Yuushiro discloses a fuel map where, in the second torque range (the light load zone), only port injection (second fueling system) is used. Pet. 49–50 (referencing Ex. 1006 ¶¶ 12, 39; Ex. 1003 ¶¶ 371–374). Petitioner adds that Yuushiro’s map shows its second torque range (the light load zone) is lower than the first torque range (the reference load zone). *Id.* at 50 (referencing Ex. 1006 ¶ 39; Ex. 1003 ¶¶ 375–377).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Yuushiro discloses a second torque range where only the second fueling system is used and the highest value of torque in the second torque range is lower than at least one value of torque in the first torque range. *See, e.g.*, Ex. 1006 ¶¶ 12, 39, Fig. 3; Ex. 1003 ¶¶ 371–377.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 20.

For the reasons discussed above and discussed in connection with our analysis of claims 1 and 19, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 20 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

b) Claim 21

Claim 21 depends from claim 19 and further recites “where the fuel management system minimizes the amount of fuel from the first fueling system while still preventing knock.” Ex. 1001, 9:1–3. Petitioner references its analysis for claim 3. Pet. 50. Patent Owner does not dispute Petitioner’s contentions with respect to claim 21, other than in its argument for claim 19. *See* PO Resp. 50.

For the reasons discussed above and discussed in connection with our analysis of claims 1, 3, and 19, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 21 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

c) Claim 22

Claim 22 depends from claim 19 and further recites “where the maximum knock resistance required by the engine is in the first torque range.” Ex. 1001, 9:4–6. Petitioner references its analysis for claim 9. Pet. 50. Patent Owner does not dispute Petitioner’s contentions with respect to claim 22.

For the reasons discussed above and discussed in connection with our analysis of claims 1, 9, and 19, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 22 is unpatentable under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch.

F. Ground 3: Claims 1–6 and 9–22 as Allegedly Obvious Over Kinjiro and Bosch

Petitioner contends that claims 1–6 and 9–22 are unpatentable over Kinjiro and Bosch. Pet. 50–70. We first address Petitioner’s motivation to

combine Kinjiro and Bosch, then address the subject matter of claims 1–6 and 9–22.

1. Reasons to combine Kinjiro and Bosch

Petitioner recognizes that “Kinjiro does not explicitly disclose the use of spark retard in suppressing knock” but contends that “it is suggested throughout the disclosure.” Pet. 52. Petitioner contends that a person having ordinary skill in the art “would have understood that the use of spark retard would be beneficial to protect the engine and reduce the amount of fuel that is directly injected and, thus improve efficiency and reduce emissions.” *Id.* at 52 (referencing Ex. 1003 ¶ 396). Petitioner contends that a person having ordinary skill in the art “would have looked to Bosch” and that “Bosch confirms that a [person having ordinary skill] would rely on spark retard to improve engine operation in a known way.” *Id.* (referencing Ex. 1031, 360; Ex. 1003 ¶ 396).

Petitioner contends that “Bosch, like Kinjiro, also discloses the use of a knock sensor to adjust engine variables to eliminate knock, including but not limited to spark retard.” Pet. 52 (referencing Ex. 1031, 464–65; Ex. 1003 ¶ 396). Petitioner contends that a person having ordinary skill in the art “would have understood from the teachings in Bosch that the Kinjiro knock sensor would have been applied to the management of other engine variables that influence knock, including [direct injection] quantity as disclosed by Kinjiro and spark retard.” *Id.* at 52–53 (referencing Ex. 1003 ¶ 396). Petitioner contends that direct injection and spark retard perform in similar ways to avoid knock, so there would have been a reasonable expectation of success in the combination. *Id.* at 53.

Petitioner also contends that Kinjiro is silent as to whether its engine includes a turbocharger. Pet. 53. Petitioner explains that turbochargers were

a “major focus” at the time Kinjiro was filed and that a person having ordinary skill in the art would have added a turbocharger to improve fuel economy and reduce emissions. *Id.* (referencing Ex. 1003 ¶ 397); *see also* Ex. 1001, 1:35–44 (indicating the use of turbocharging was known as a way to “obtain the same performance in a significantly smaller engine”).

Patent Owner argues that a person having ordinary skill in the art would not have modified Kinjiro with Bosch’s teachings of spark retard, as Kinjiro teaches spark advance. PO Resp. 57. Petitioner replies that Kinjiro employs a knock sensor to act on direct injection to reduce knock and also “explains that it is conventional ‘to suppress the knocking by retarding the ignition timing.’” Reply 20 (referencing Ex. 1008 ¶¶ 3, 20–21). Petitioner explains that “both increased [direct injection] and spark retard can be used for a few cycles to eliminate knock . . . and spark retard and [direct injection] are ubiquitous in spark ignition engines.” *Id.* at 20–21 (referencing Ex. 1050, 59:19–23; 123:21–124:4). Petitioner concludes that a person having ordinary skill in the art “would have understood using spark retard as taught by Bosch would be beneficial in Kinjiro’s engine.” *Id.* at 21 (referencing Pet. 52; Ex. 1003 ¶ 396; Ex. 1050, 55:16–20). In sur-reply, Patent Owner repeats that “Kinjiro teaches *advancing* the ignition timing rather than *retarding* it.” Sur-reply 26 (referencing Ex. 1008 ¶ 37).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that a person having ordinary skill in the art would have had reason to incorporate spark retard into Kinjiro’s engine. We find that Petitioner’s reasoning is adequately supported by rational underpinnings, including that an artisan of ordinary skill would have had reason to employ spark retard to reduce knocking to improve engine performance. We credit Dr. Clark’s testimony, as it is consistent with our

understanding of the disclosures in Kinjiro and Bosch. For example, Dr. Clark testifies that Kinjiro employs a knock sensor and that Bosch teaches using a knock sensor in conjunction with spark retard. Ex. 1003 ¶ 396; Ex. 1031, 360, 464–465. Dr. Clark also testifies that “a person of ordinary skill in the art would have understood that the use of spark retard would be beneficial to protect the engine and reduce the amount of fuel that is directly injected.” Ex. 1003 ¶ 396; *see also* Ex. 1031, 464 (“Internal-combustion engines are damaged by combustion knock.”).

To the extent Patent Owner argues that Kinjiro teaches away from spark retard, we do not agree. As we discussed above in connection with our analysis of Ground 2, “[a] reference may be said to teach away when a person of ordinary skill, upon reading the reference, . . . would be led in a direction divergent from the path that was taken by the applicant.” *In re Haruna*, 249 F.3d at 1335; *see, e.g., In re Fulton*, 391 F.3d at 1201 (holding that, to teach away, the prior art must “criticize, discredit, or otherwise discourage the solution claimed”). We find that Kinjiro’s statements about spark advance do not criticize, discredit, or otherwise discourage spark retard. Instead, we find that Kinjiro is stating that, for an engine that does not use direct injection (for example, in the normal operating mode of Kinjiro), the engine would rely on spark retard to reduce knock. *See* Ex. 1008 ¶ 37. However, *during the period of time that Kinjiro operates in split injection mode*, it can actually use spark advance to improve engine output. *See id.* That is to say, Kinjiro’s disclosure about the benefits of spark *advance* are directed to operations during split injection mode only and are not directed to operations in the normal operating state. *See* Ex. 1008 ¶¶ 14, 37. Kinjiro’s statements are consistent with Dr. Clark’s testimony. Dr. Clark testifies the Kinjiro recognizes that spark retard can be

used to reduce knock. *See, e.g.*, Ex. 1003 ¶ 396 (“Kinjiro . . . acknowledges the use of spark retard for mitigation of knock.”).

In summary, we find, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that a person having ordinary skill in the art would have been motivated to combine the teachings of Kinjiro and Bosch as Petitioner proposes. We find that Petitioner provides reasons for its proposed modifications and, as we discuss above, these reasons are supported by rational underpinnings. *See KSR Int’l Co.*, 550 U.S. at 418 (stating that, to facilitate the analysis of an obviousness position, the proponent should provide “some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”).

2. *Independent claim 1*

Claim 1 recites, in relevant part, “where there is a range of torque where both fueling systems are used at the same value of torque.” Ex. 1001, 7:32–33 (the “both fueling systems” limitation of claim 1). Petitioner contends that, in Kinjiro’s split injection mode, where engine knock has been detected, both port injection and direct injection are used. Pet. 56 (referencing Ex. 1008 ¶¶ 14, 27; Ex. 1003 ¶ 409). Petitioner contends that split injection mode “is activated in response to detected knock, which occurs at or above *a specific engine load or output torque* (e.g., a first torque range).” *Id.* (referencing Ex. 1008 ¶¶ 14, 27; Ex. 1003 ¶ 409) (emphasis added).

Dr. Clark testifies that “Kinjiro discloses a knock sensor 7 that is used to define a first torque range (e.g., *a range of torques* where knock would persist if direct injection was not used).” Ex. 1003 ¶ 409 (referencing Ex. 1008 ¶ 12) (emphasis added).

Patent Owner argues that “Kinjiro does not teach that there is a ‘torque range’ throughout which both direct injection and port injection are used.” PO Resp. 61 (referencing Ex. 2002 ¶ 198)¹⁵. Patent Owner argues that

It does not follow that there is a “range” of torque in which the engine enters the specified state. Kinjiro could be in the specified state at only one torque value, or at discontinuous torque values, because the risk of knock can change over a torque range, as other engine variables change, and thus Kinjiro’s use of a knock detector could result in discontinuous use of the split injection mode.

Id. Patent Owner adds that “Petitioner offers no argument based on inherency to suggest that Kinjiro necessarily teaches a ‘torque range’ throughout which both direct injection and port injection are used.” *Id.*

Petitioner replies that “[t]he term ‘first torque range’ as used in [c]laims 1 and 19 simply refers to a state where both [direct injection] and [port injection] are used. The term has indeed been described as a ‘shorthand’ for which injection systems are being used.” Reply 22 (referencing Ex. 1049, 14). Petitioner argues that “Kinjiro ***by definition*** discloses a ‘first torque range’ the instant it switches into its ‘split injection mode.’” Nothing more is required.” *Id.* Petitioner argues that “Patent Owner’s exceedingly narrow construction is unwarranted.” *Id.*

In sur-reply, Patent Owner argues that Petitioner’s construction is contrary to the District Court’s construction of the term “torque range.” Sur-

¹⁵ Patent Owner directs this argument to recitations in independent claim 19. *See* PO Resp. 61 (providing a heading that identifies claims 19–22). Because we believe that this argument is equally applicable to claim 1, for consistency in this Decision, we address the argument here.

reply 27–28 (indicating the term “was construed according to its plain and ordinary meaning, which clearly implies a ‘range’ of torque values”).

As an initial point, Petitioner proposes a construction of “torque range” or “range of torque” to mean “the region on a torque-speed map that lies between a first specified value of torque and a second specified value of torque.” Pet. 3–5. As Patent Owner argues, the District Court construed the term “torque range” to have its plain and ordinary meaning. Ex. 1041, 2.

Petitioner seems now to abandon the construction proposed in the Petition, in favor of a description of the operational mode of the fuel management system. In addressing the “both fueling systems” limitation of claim 1, Petitioner argues that split injection mode “is activated in response to detected knock, which occurs at or above a specific engine load or output torque (*e.g., a first torque range*).” Pet. 56 (emphasis added). That is, the first torque range is defined at or above a specific load or output torque. Petitioner fails to demonstrate persuasively that split injection mode is activated *above a specific engine load* as Petitioner argues. Kinjiro discloses that split injection mode is activated when the knock sensor measures knock, not at a *specific* engine load. Ex. 1008 ¶¶ 13–14; Ex. 2002 ¶ 201. Petitioner’s claim construction position taken in the Reply seems to be a new position, contrary to what Petitioner asserts in the Petition—both in its construction of the term or in how Kinjiro satisfies the “both fueling systems” limitation of claim 1.

In summary, we find that Petitioner fails to demonstrate that Kinjiro discloses that there is a range of torque where both fueling systems are used at the same value of torque, under the construction Petitioner proposes in the Petition. Accordingly, we conclude that the Petitioner fails to demonstrate,

by a preponderance of the evidence, that Kinjiro discloses the “both fueling systems” limitation of claim 1.

Even if we apply the plain and ordinary meaning of the term “range of torque” to encompass discrete points within an overall range of torque values, which seems to be what Petitioner now argues, Petitioner’s obviousness position for claim 1 fails for another reason.

Claim 1 also recites “where the fraction of fuel in the cylinder that is introduced by the first fueling system decreases with decreasing torque and the fuel management system controls the change in the fraction of fuel introduced by the first fueling system using closed loop control that utilizes a sensor that detects knock.” Ex. 1001, 7:34–39 (the “fuel fraction” limitation of claim 1). Petitioner contends that Kinjiro discloses the use of a knock sensor, which forms a closed loop fuel management system. Pet. 57 (identifying knock sensor 7).

Petitioner also contends that the fraction of fuel supplied by the first fuel system (direct injection) increases or decreases as Kinjiro’s system moves between the normal operating mode and split injection mode. Pet. 57. Petitioner explains that, in the normal operating mode, direct injection is not used, so its contribution would reduce (to zero) as the engine moves to normal operation mode from split injection mode. *Id.*

Petitioner further explains that cylinder temperature increases with increasing torque and decreases with decreasing torque, as engine torque directly relates to cylinder pressure, which is associated with cylinder temperatures (with increasing temperature associated with an increasing tendency to knock). Pet. 57–59. Petitioner concludes that “[b]ecause temperature increases with increasing torque, Kinjiro teaches in Figure 6A that a leaner mixture (higher air fuel ratio) port injected fuel mixture should

be used at higher torque, requiring an increased ratio of direct injected fuel to compensate for the leaner port injected fuel mixture.” *Id.* at 59 (referencing Ex. 1008 ¶ 9); *see also* Ex. 1003 ¶¶ 411–417 (describing Kinjiro’s engine operations, and the relationship between cylinder temperature, pressure, and tendency for knock).

We find that Petitioner fails to demonstrate, by a preponderance of the evidence, that the fraction of fuel in the cylinder that is introduced by direct injection decreases with decreasing torque in Kinjiro’s fuel management system, or that Kinjiro discloses any relationship between torque and the fraction of fuel directly injected into the cylinder. Petitioner argues that there is a direct relationship between torque and cylinder temperature and pressure and, so, as torque increases, the amount of direct injection fuel will increase. *See* Pet. 57–59. Petitioner fails to explain persuasively how Kinjiro discloses that the *fraction* of fuel changes with changing torque.

At best, the evidence demonstrates that, when Kinjiro’s system moves from split injection mode to normal operating mode, the fraction of fuel that is directly injected decreases to zero. *See* Pet. 57. As we explain below, Petitioner fails to explain persuasively that this change from split injection mode to normal operating mode *corresponds to a decrease in torque*, as required by the “fuel fraction” limitation of claim 1.

Whether a reference inherently discloses a limitation is a question of fact. *PAR Pharm.*, 773 F.3d at 1194. “A party must . . . meet a *high* standard in order to rely on inherency to establish the existence of a claim limitation in the prior art in an obviousness analysis.” *Id.* at 1195–96 (emphasis added). “[T]he limitation at issue necessarily must be present, or the natural result of the combination of elements explicitly disclosed by the prior art.” *Id.* at 1196. Petitioner argues that “Kinjiro discloses that an

increase in cylinder temperature during split injection mode would *necessarily* lead to an increase in the ratio of” direct injection fuel to port injection fuel. Pet. 57 (referencing Ex. 1003 ¶ 414) (emphasis added). Petitioner adds that “[s]uch an increase in cylinder temperature would result, e.g., from an increase in torque.” *Id.*¹⁶

Petitioner’s evidence does not satisfy the high standard for inherency. Petitioner’s contention shows that an increase in cylinder temperature does not *necessarily* correspond to an increase in torque, as Petitioner argues that an increase in torque is an example of why there would be an increase in cylinder temperature. Similarly, Dr. Clark testifies that “[f]urthermore, Kinjiro discloses that an increase in cylinder temperature during the split injection mode would necessarily lead to an increase in the ratio of direct injection to port injection. Such an increase in cylinder temperature would result, *for instance*, from an increase in torque.” Ex. 1003 ¶ 414 (emphasis added). As such, Dr. Clark testifies that an increase in torque *could be* the reason for increasing cylinder temperature. Also, we note that Dr. Clark offers no supporting evidence for his testimony—indeed, he does not even cite to Kinjiro when testifying as to what Kinjiro discloses. *See* Ex. 1003 ¶ 414. Such expert testimony is entitled to little weight. *See* 37 C.F.R. 42.65(a) (“Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”).

In conclusion, we find that, even if Kinjiro’s disclosure of operating in split injection mode at discontinuous torque values constitutes a “range of

¹⁶ Although the “fuel fraction” limitation of claim 1 recites decreasing amounts of fuel due to decreasing torque, we understand Petitioner to be arguing the overall relationship between torque and cylinder temperature, and using increasing temperature/torque to make the argument.

torques,” Petitioner fails to explain persuasively a relationship between increasing or decreasing torque and increasing and decreasing values of directly injected fuel.

Accordingly, for the reasons above, we conclude that Petitioner does not demonstrate, by a preponderance of the evidence, that claim 1 is unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

3. Dependent claims 2–6 and 9–12

Dependent claims 2–6 and 9–12 depend from independent claim 1. We have reviewed Petitioner’s contentions with respect to these dependent claims. *See* Pet. 62–65. We find that nothing in these contentions persuasive overcomes the deficiencies we identify for claim 1 in our analysis above. Accordingly, for the reasons discussed above in connection with our analysis of claim 1 under Ground 3, we conclude that Petitioner does not demonstrate, by a preponderance of the evidence, that claims 2–6 and 9–12 are unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

4. Independent claim 13

Independent claim 13 differs from independent claim 1 in at least two significant ways—claim 13 does not recite subject matter comparable to the subject matter of the “both fueling systems” limitation and the “fuel fraction” limitation of claim 1, with respect to increasing or decreasing amounts of directly injected fuel as torque increases or decreases. We analyze Petitioner’s contentions with respect to claim 13, below.

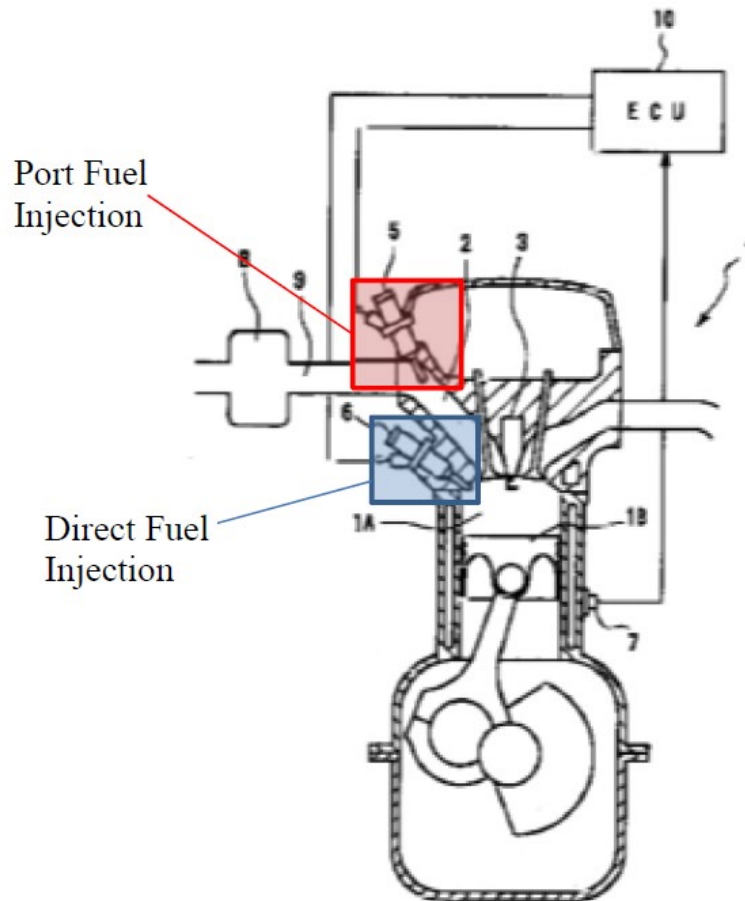
Claim 13 recites “[a] fuel management system for a spark ignition engine.” Ex. 1001, 8:14. Petitioner identifies this recitation as the preamble and contends that this subject matter is “substantially similar” to claim 1. Pet. 65 (referencing Ex. 1003 ¶¶ 458–461). For claim 1 under Ground 3, Petitioner contends that Kinjiro discloses a fuel management system for a

spark ignition engine. *Id.* at 54 (referencing Ex. 1008 ¶¶ 11–12, 14; Ex. 1003 ¶¶ 398–401).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that Kinjiro discloses a fuel management system for a spark ignition engine. *See, e.g.*, Ex. 1008 ¶¶ 11–12, 14; Ex. 1003 ¶¶ 398–401, 458–461. Patent Owner does not dispute Petitioner’s contentions with respect to this recitation of claim 13.

Claim 13 also recites that the fuel management system “controls fueling from a first fueling system that directly injects fuel into at least one cylinder as a liquid and increases knock suppression by vaporization cooling and from a second fueling system that provides fuel to the cylinder using port fuel injection.” Ex. 1001, 8:15–19 (the “first and second fueling systems” recitation of claim 13). Petitioner contends that this subject matter is “substantially similar” to claim 1. Pet. 65 (referencing Ex. 1003 ¶¶ 462–466). For claim 1 under Ground 3, Petitioner contends that “Kinjiro’s engine comprises a first fueling system ([direct injection]) that has an ‘injection hole preferably disposed in the combustion chamber so as to inject fuel directly into the combustion chamber’ and a second fueling system ([port injection]) provided in each intake passage.” *Id.* at 54–55 (referencing Ex. 1008 ¶¶ 10–11; Ex. 1003 ¶ 404). We reproduce an annotated version of Kinjiro’s Figure 1, below.

[FIG. 1]



Id. at 55. This annotated figure shows Kinjiro’s engine, with the port fuel injector labeled and highlighted in red and the direct fuel injector labeled and highlighted in blue.

Petitioner contends that “i[n]formation detected by a knock sensor is input to an [electronic control unit], which sets an operation control signal for each of the injectors. That is, Kinjiro’s system activates [direct injection] in response to knocking.” Pet. 55 (referencing Ex. 1008 ¶ 13, code (57), Fig. 5; Ex. 1003 ¶ 405).

Petitioner also contends that the recitation directed to vaporization cooling should not be given patentable weight, but that “one of ordinary skill

in the art would have appreciated at the time of the '519 [p]atent that direct fuel injection necessarily achieves knock suppression at least by vaporization cooling.” Pet. 56 (referencing Ex. 1003 ¶¶ 31, 32, 407).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that Kinjiro’s fuel management system controls fueling from a first fueling system that directly injects fuel into at least one cylinder as a liquid and increases knock suppression by vaporization cooling and from a second fueling system that provides fuel to the cylinder using port fuel injection. *See, e.g.*, Ex. 1008 ¶¶ 10–11, 13, Figs. 1, 5; Ex. 1003 ¶¶ 404–407; 462–466. With respect to the recitation concerning vaporization cooling, we credit Dr. Clark’s testimony, in part because it is consistent with prior art of record and supported by testimony from Mr. Hannemann. *See, e.g.*, Ex. 1050, 41:25–42:25, 104:19–105:8 (discussing vaporization of direct injection fuel and the effect of charge cooling).

Patent Owner does not dispute Petitioner’s contentions with respect to the “first and second fueling systems” recitation of claim 13.

Claim 13 also recites “where the fuel management system uses information from a sensed parameter to control spark retard so as to decrease the amount of fuel that would otherwise be provided by the first fueling system.” Ex. 1001, 8:20–23 (the “sensed parameter” limitation of claim 13). Petitioner contends that “[t]he combination of Kinjiro and Bosch discloses using spark retard controlled by a knock sensor and/or sensed information, e.g., intake-manifold pressure, to decrease the amount of fuel that is introduced by” direct injection.” Pet. 65 (referencing Ex. 1031, 360, 464, 472; Ex. 1003 ¶¶ 467–473).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Kinjiro, as modified by Bosch to include spark retard, discloses a fuel management system that uses information from a sensed parameter (for example, intake-manifold pressure) to control spark retard so as to decrease the amount of fuel that would otherwise be provided by the first fueling system. *See, e.g.*, Ex. 1031, 360, 464, 472; Ex. 1003 ¶¶ 467–473. Dr. Clark testifies that a person having ordinary skill in the art would have understood that employing spark retard would have reduced knock (and, as a consequence, the occurrence of moving into split fuel injection mode), which would reduce the use of direct injection fuel. Ex. 1003 ¶¶ 471–472. Dr. Clark also testifies that intake manifold pressure is a sensed parameter used to control spark timing. *Id.* We credit Dr. Clark’s testimony, in part, because it is consistent with the teachings in Bosch. *See* Ex. 1031, 360, 464, 472.

Patent Owner does not dispute Petitioner’s contentions with respect to the “sensed parameter” recitation of claim 13.

Finally, claim 13 recites “where the fuel management system uses input that includes input from the sensed parameter and input from knock sensor.” Ex. 1001, 8:24–27 (the “knock sensor” limitation of claim 13). Petitioner contends that “[t]he combination of Kinjiro and Bosch discloses using spark retard controlled by sensed information, e.g., intake-manifold pressure, in addition to information from a knock sensor, to control the amount of fuel that is introduced by” direct injection. Pet. 66 (referencing Ex. 1031, 360, 464, 472; Ex. 1003 ¶¶ 474–477; and also referencing analysis of claim 1 under Ground 3); *see also id.* at 60–61 (providing analysis for claim 1 regarding spark retard).

Petitioner contends that a person having ordinary skill in the art “would have . . . understood using the knock sensor to control [direct injection] as a manipulated variable to suppress knock and . . . the application of spark retard . . . permit[s] the engine to operate at higher levels of torque without knocking and, thus, . . . enable[s] the engine to operate in a normal mode.” Pet. 61 (referencing Ex. 1003 ¶ 421).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Kinjiro, as modified by Bosch to include spark retard, discloses a fuel management system that uses input that includes input from a sensed parameter (for example, intake-manifold pressure) and input from a knock sensor. *See, e.g.*, Ex. 1008 ¶ 33; Ex. 1031, 360, 464, 472; Ex. 1003 ¶¶ 419–421, 474–477.

Patent Owner does not dispute Petitioner’s contentions with respect to the “knock sensor” recitation of claim 13.

For the reasons above, we conclude that Petitioner demonstrates, by a preponderance of the evidence, that claim 13 is unpatentable under 35 U.S.C. 103 over Kinjiro and Bosch.

5. Dependent claims 14–18

a) Claim 14

Claim 14 depends from claim 13 and recites “where input from the knock sensor is utilized in a closed loop control system that controls the fraction of fuel that is introduced into the first fueling system.” Ex. 1001, 8:27–30. Petitioner contends that “Kinjiro discloses the use of a knock sensor in a closed loop control system to control [direct injection] to suppress knock.” Pet. 66 (referencing Ex. 1003 ¶¶ 478–479).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Kinjiro, and Bosch

discloses that input from the knock sensor is utilized in a closed loop control system that controls the fraction of fuel that is introduced into the first fueling system. *See, e.g.*, Ex. 1008 ¶¶ 7, 12, 13, 15; Ex. 1003 ¶¶ 478–479. As one example, Kinjiro discloses that “if knocking is detected [by knock sensor 7], a small amount of fuel which cannot self-ignite is injected from the main injector 5 into the intake passage 2 while the remaining fuel is directly injected from the sub-injector 6 into the cylinder (combustion chamber) during the compression stroke.” Ex. 1008 ¶¶ 13, 15.

Patent Owner does not dispute Petitioner’s contentions with respect to claim 14.

For the reasons discussed above and discussed in connection with our analysis of claim 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 14 is unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

b) Claim 15

Claim 15 depends from claim 13 and recites “where both the first and second fueling systems are used at the same value of torque.” Ex. 1001, 8:31–33. Petitioner references its analysis of claim 1, which contends, in relevant part, that Kinjiro discloses a split injection mode that employs both port and direct injection. Pet. 56, 66 (referencing Ex. 1008 ¶¶ 14, 27; Ex. 1003 ¶ 409).

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Kinjiro and Bosch discloses that both the first and second fueling systems are used at the same value of torque. *See, e.g.*, Ex. 1008 ¶¶ 14, 27; Ex. 1003 ¶ 409. Although, in our analysis in claim 1, we find that Petitioner did not demonstrate that Kinjiro discloses that the first fueling system increases or decreases fuel as

torque increases or decreases, we do find here that the preponderance of the evidence supports a finding that *at a single torque value*, both port and direct injection are used during split injection mode. *See, e.g.*, Ex. 1008 ¶¶ 13–15; *accord* PO Resp. 61 (“Kinjiro could be in the specified state [that is, split injection mode] at only one torque value, or at discontinuous torque values.”).

Patent Owner does not dispute Petitioner’s contentions with respect to claim 15.

For the reasons discussed above and discussed in connection with our analysis of claim 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 15 is unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

c) Claim 17

Claim 17 depends from claim 1 and recites “where the engine is turbocharged or supercharged and the level of turbocharging or supercharging is reduced so as to decrease the amount of fuel from the first fueling system.” Ex. 1001, 8:37–40. Petitioner acknowledges that Kinjiro does not disclose that its engine is turbocharged or supercharged. Pet. 66.

Petitioner contends, however, that “Kinjiro does not exclude the possibility of turbocharged engines” and that “Bosch discloses turbocharged engines as one type of reciprocating-piston engine with internal combustion.” Pet. 66 (referencing Ex. 1003 ¶¶ 487–488). Petitioner adds that “Bosch . . . discloses that with turbocharged engines, boost/intake pressure can be employed as a manipulated variable.” *Id.* at 67 (referencing Ex. 1031, 465; Ex. 1003 ¶ 489). Petitioner reasons that a person having ordinary skill in the art “would have understood that if [direct injection] is raised and boost is lowered . . . , the propensity of the engine to knock would

remain the same . . . [and reducing] boost [would have] permit[ted] the engine to operate with reduced direct injection without altering the propensity of the engine to knock.” *Id.*

We find, on the complete record, that Petitioner demonstrates, by a preponderance of the evidence, that the combination of Kinjiro and Bosch discloses a turbocharged or supercharged engine where the level of turbocharging or supercharging is reduced decreases the amount of fuel from the first fueling system. *See, e.g.*, Ex. 1031, 465; Ex. 1003 ¶¶ 487–489). We credit Dr. Clark’s testimony regarding the effects of turbocharging, as it is supported by testimony from Mr. Hannemann and by Bosch. *See, e.g.*, Ex. 1050, 65:9–66:6 (discussing the benefits and tradeoffs of a turbo-charger, including increasing compression adds to the propensity for spark knock).

Patent Owner does not dispute Petitioner’s contentions with respect to claim 17.

For the reasons discussed above and discussed in connection with our analysis of claim 13, we conclude, on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that dependent claim 17 is unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

d) Claim 18

Claim 18 depends from claim 13 and recites “where closed loop control with a knock detector is used *to increase the relative amount of fuel from the first fueling system as torque is increased.*” Ex. 1001, 8:41–44 (emphasis added). As discussed above in connection with our analysis of claim 1 under Ground 3, Petitioner fails to demonstrate, by a preponderance of the evidence, that the amount of directly injected fuel is increased with increasing torque.

For the reasons discussed above and discussed in connection with our analysis of claim 1, we conclude, on the complete record, that Petitioner fails to demonstrate, by a preponderance of the evidence, that dependent claim 18 is unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

6. *Independent claim 19 and dependent claims 20–22*

Claim 19 recites, in relevant part, “where during a driving cycle there is a first torque range where both fueling systems are used at the same torque and where the fraction of fuel in the cylinder that is introduced by the first fueling system is increased so as to prevent knock as torque increases.” Ex. 1001, 8:52–56 (the “torque range” limitation of claim 19).

As discussed above in connection with our analysis of claim 1 under Ground 3, Petitioner fails to demonstrate, by a preponderance of the evidence, that the amount of directly injected fuel is increased with increasing torque. In specifically addressing the “both fueling systems” limitation of claim 1 and the “fuel fraction” limitation of claim 1, we find that Petitioner fails to demonstrate, by a preponderance of the evidence, that Kinjiro discloses a torque range, *as construed by Petitioner in the Petition*, and that the fraction or amount of fuel directly injected by the first fuel system increases or decreases with increasing or decreasing torque. *Cf.* PO Resp. 61 (providing Patent Owner’s arguments as to why Kinjiro fails to disclose this subject matter, which we address in our analysis of claim 1).

Accordingly, for the reasons discussed above in connection with our analysis of claim 1 for Ground 3, we conclude that Petitioner fails to demonstrate, by a preponderance of the evidence, the subject matter of the “torque range” limitation of claim 19.

We have reviewed Petitioner’s contentions with respect to dependent claims 20–22, which depend from claim 19. *See* Pet. 68–69. We find that

nothing in these contentions persuasive overcomes the deficiencies we identify for claim 19 in our analysis above. Accordingly, for the reasons discussed above in connection with our analysis of claim 19 under Ground 3, we conclude that Petitioner does not demonstrate, by a preponderance of the evidence, that claims 20–22 are unpatentable under 35 U.S.C. § 103 over Kinjiro and Bosch.

III. MOTION TO EXCLUDE

Patent Owner moved to exclude Exhibits 1033 and 1034 and portions of Exhibit 1050. Paper 28. Because we do not rely on Exhibits 1033 or 1034 or the identified portions of Exhibit 1050, we dismiss the motion as moot.

IV. CONSTITUTIONALITY

Patent Owner argues that

Applying IPRs retroactively to pre-AIA patents violates the Fifth Amendment. *Celgene v. Peter*, 931 F.3d 1342 (Fed. Cir. 2019) (certiorari pending) was wrongly decided. APJs remain unconstitutionally appointed after *Arthrex v. Smith & Nephew*, 941 F.3d 1320 (Fed. Cir. 2019) [*cert. granted sub nom. United States v. Arthrex, Inc.*, 2020 WL 6037206 (Oct. 13, 2020)]; and now lack removal protections (5 U.S.C. § 7521(a)), in violation of the Administrative Procedure Act.

PO Resp. 64.

As Patent Owner’s argument indicates, the Federal Circuit has addressed Fifth Amendment and Appointments Clause challenges issues in, respectively, *Celgene Corp.*, 931 F.3d at 1362–63, *cert. denied*, 141 S.Ct. 132 (June 22, 2020), and *Arthrex*, 941 F.3d at 1325, 1337–38, *cert.*

granted, 141 S.Ct. 551 (Oct. 13, 2020). We are bound by those decisions. Accordingly, we decline to consider further those issues.

V. CONCLUSION¹⁷

After considering all the evidence and arguments presently before us, we conclude that Petitioner has demonstrated, by a preponderance of the evidence, that the Challenged Claims are unpatentable.

VI. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, claims 1–6 and 9–22 *are not shown to be unpatentable* under 35 U.S.C. § 103 over Kobayashi and Yuushiro;

FURTHER ORDERED that claims 1–6 and 9–22 *are shown to be unpatentable* under 35 U.S.C. § 103 over Rubbert, Yuushiro, and Bosch;

FURTHER ORDERED that claims 13–17 *are shown to be unpatentable* under 35 U.S.C. § 103 over Kinjiro and Bosch;

FURTHER ORDERED that claims 1–6, 9–12, and 18–22 *are not shown to be unpatentable* under 35 U.S.C. § 103 over Kinjiro and Bosch;

FURTHER ORDERED that Patent Owner's motion to exclude evidence is *dismissed* as moot; and

¹⁷ Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. See 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

FURTHER ORDERED that because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

In summary:

Claims	35 U.S.C. §	References	Claims Shown Unpatentable	Claims Not shown Unpatentable
1–6, 9–22	103	Kobayashi, Yuushiro		1–6, 9–22
1–6, 9–22	103	Rubbert, Yuushiro, Bosch	1–6, 9–22	
1–6, 9–22	103	Kinjiro, Bosch	13–17	1–6, 9–12, 18–22
Overall Outcome			1–6, 9–22	

IPR2019-01401
Patent 9,255,519 B2

FOR PETITIONER:

Christopher TL Douglas
Michael S. Connor
Lauren E. Burrow
Brian D. Hill
ALSTON & BIRD LLP
christopher.douglas@alston.com
mike.connor@alston.com
lauren.burrow@alston.com
brian.hill@alston.com

FOR PATENT OWNER:

Lawrence P. Cogswell III
Keith J. Wood
HAMILTON, BROOK, SMITH & REYNOLDS, P.C.
lawrence.cogswell@hbsr.com
keith.wood@hbsr.com