

MODULAR LASER CLADDING SYSTEM

FIELD

This invention relates to a modular laser cladding system to perform on-site laser cladding repairs on railway rails.

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BACKGROUND

There are currently numerous techniques for performing cladding in a workshop, each with its own specific characteristics in terms of materials employed, quality of the clad layer, and various practical issues, including throughput speed, process compatibility, and cost. Laser cladding is a high-quality additive manufacturing technique that produces a clad with extremely low dilution, low degree of porosity, and good surface uniformity. Laser cladding produces minimal heat input on the part, which largely eliminates distortion and the need for post processing and avoids the loss of alloying elements or hardening of the base material. In laser cladding, metal powder and laser aided metal deposition add metal material to the surface in a controlled manner. A stream of a metallic powder is fed to a focused laser beam creating a melt pool at the target surface. The laser head is scanned across the target surface based on a user-defined scan pattern and path, depositing a coating of the metallic material.

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Rail defects are one of the primary causes of rail failure. Depending on their severity, many of these defects can lead to expensive and time-consuming total rail replacement events. The defects are often present at the rail head surface. Thus, localized repair via laser cladding is a viable solution to avoid total replacement of rail sections. Crossings and switches are high value rail track components that can also benefit from on-site laser cladding repair operations compared to the time and costs involved with complete total replacement of a worn or damaged crossing. Regular laser cladding repairs thus help prolong rail steel service life and ensure reliable operation of the rail track system. However, laser cladding of rails requires a portable high power laser system for safe on-site laser cladding operations.

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To mitigate high costs and shorten maintenance time resulting from total replacement, there is thus a need to provide a safe and efficient on-site laser cladding system designed to repair worn and damaged crossing nose sections and also the switch rail sections in a cost effective way. Besides restoration of defective running rail surfaces, it is desirable to provide point repair capability for repairing damaged thermite weld heads and rail head shelling defects as

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well.

SUMMARY

Disclosed is a portable modular laser cladding system designed with a capability for on-site repair and remanufacturing of damaged rail tracks as well as for laser cladding works in a workshop or in other industries such as oil and gas, offshore, aerospace, at shipyards, ports and so on. The system comprises an assembly of components that enables it to perform remote and on-site laser cladding. The system features a modular design whereby components of a laser cladding apparatus are configured on a plurality of deployable trolleys according to their respective functions. The system can be towed by locomotives and wagons to an approximate target cladding site or area and deployed close to the target site and cladding area. The modular laser cladding system can be launched from a well-wagon or a train gantry vehicle. One of the components of the laser cladding apparatus comprises a laser cladding head having a robot arm provided with an end effector to perform the cladding operation on a steel rail of a rail track. The system may be implemented in various ways, by loading and transporting the system on different types of train wagons such as the locomotive towed wagon or well wagon. It can be carried on a Train Gantry Vehicle (TGV) used for rail replacement and maintenance work. Another option is to use a Road-Rail Vehicle (RRV) that can operate on rail track as well as conventional roads.

According to a first aspect, there is provided a modular laser cladding system comprising: a plurality of deployable trolleys, each trolley comprising a rollable trolley base and a trolley enclosure in engagement with the trolley base, the trolley enclosure configured to allow the trolley to be lifted and moved by a hoisting mechanism; and a laser cladding apparatus comprising a plurality of laser cladding components mountable in a variable configuration on the plurality of trolleys.

The plurality of deployable trolleys having the plurality of laser cladding components mounted thereon may be deployable linearly on a set of rail tracks to perform laser cladding on at least one of the rails of the set of rail tracks.

Each trolley may further comprise a mounting base plate attached to the trolley base, wherein the system may further comprise a plurality of component base plates configured to have mounted thereon each of the plurality of laser cladding components, and wherein the

component base plates may be variably and detachably mountable to any one of the mounting base plates.

5 The plurality of trolleys having the plurality of laser cladding components mounted thereon may be mountable on a chassis for towing to a laser cladding site.

The system may further comprise the chassis.

The chassis may comprise a Wagon, Well-Wagon, TGV or RRV.

10 The chassis (wagon, well wagon, TGV, RRV) may comprise a launching mechanism provided at one end the Well-Wagon for example and configured to lower a first trolley of the plurality of trolleys from the well wagon onto a set of rail tracks, the first trolley having mounted thereon a robotized cladding system comprised in the laser cladding apparatus.

15 The launching mechanism may comprise a hoisting mechanism configured to lift and to lower the first trolley and hydraulic actuators configured to supply an extension manoeuvre and a rotary manoeuvre to the hoisting mechanism.

20 The launching mechanism may comprise sliding guides extending from the first end of the well wagon onto the set of rail tracks and configured to allow the first trolley to slide thereon from the well wagon onto the set of rail tracks.

25 The chassis may comprise a train gantry vehicle, the train gantry vehicle comprising a first platform spaced apart from a second platform by an elongate frame, wherein wheels may be provided under each of the first platform and the second platform to allow rolling of the train gantry vehicle on rail tracks.

30 A first trolley of the plurality of trolleys having mounted thereon a robotized cladding system comprised in the laser cladding apparatus may be provided in a laser cladding zone between the two platforms, wherein a second trolley of the plurality of trolleys may be provided on the first platform and wherein a third trolley of the plurality of trolleys may be provided on the second platform.

35 The plurality of trolleys may comprise three trolleys, wherein the laser cladding components may include a robotized cladding system, a powder feeder unit and gas canisters, and

wherein the robotized cladding system, the powder feeder unit and the gas canisters may be mounted on a first trolley of the three trolleys and other components of the laser cladding apparatus may be mounted on a second trolley and on a third trolley of the three trolleys.

- 5 The first trolley may be spaced apart from the second trolley and the third trolley when the system is in use.

The plurality of trolleys may be identical.

10 **BRIEF DESCRIPTION OF FIGURES**

In order that the invention may be fully understood and readily put into practical effect there shall now be described by way of non-limitative example only exemplary embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

- 15 FIG. 1 is a perspective view of an exemplary deployable trolley.

FIG. 2 is an exploded assembly view of the trolley of FIG. 1.

FIG. 3 is a perspective view of a first exemplary laser cladding system comprising a plurality of the trolleys of FIG. 1 and a plurality of laser cladding components of a laser cladding apparatus mounted on the plurality of trolleys.

- 20 FIG. 4 is a perspective view of a second exemplary laser cladding system comprising a plurality of the trolleys of FIG. 1 and a plurality of laser cladding components of a laser cladding apparatus mounted on the plurality of trolleys.

FIG. 5(a) is a perspective view of a mounting base plate of the system of FIG. 4.

FIG. 5(b) is a perspective view of a component mounting plate of the system of FIG. 4.

- 25 FIG. 6 is a flowchart of an exemplary sequence of assembly of the system of FIG. 4.

FIG. 7 is a perspective view of the system of FIG. 3 deployed on a well wagon.

FIG. 8 is a top view of the deployment of FIG. 7.

FIG. 9 is close-up perspective views of different zones of FIG. 7.

FIG. 10 is a perspective view of the system of FIG. 4 deployed on a well wagon.

- 30 FIG. 11(a) is a perspective view of the system of FIG. 3 deployed on a train gantry vehicle.

FIG. 11(b) is a sectional perspective view of the system of FIG. 3 deployed on a train gantry vehicle.

FIG. 12(a) is a sectional top view of the deployment of FIG. 11(b)

FIG. 12(b) is a top view of the deployment of FIG. 11 (a).

FIG. 13 is close-up perspective views of different zones of FIG. 11(b).

DETAILED DESCRIPTION

Exemplary embodiments of a modular laser cladding system 100 will be described below with reference to FIGS. 1 to 13, where the same reference numerals refer to the same or similar parts.

In general, the modular laser cladding system 100 comprises a plurality of deployable trolleys 60 and a laser cladding apparatus comprising a plurality of laser cladding components 70-90, 10-15 that can be mounted in a variable configuration on the plurality of trolleys 60. As mentioned, the actual configuration or arrangement of which laser cladding components 70-90, 10-15 to mount on which of the plurality of trolleys 60 can be varied, and is predetermined before deploying the system 100 for use according to the application for which the system 100 is to be used. The trolleys 60 are deployable in the sense that they can be readily transported to any desired location and each of the plurality of trolleys 60 is moveable relative to the other trolleys 60 among the plurality of trolleys 60. The system 100 is therefore modular and portable to accommodate different locations and applications of use of the system 100. In an exemplary embodiment of use, the plurality of deployable trolleys 60 and the plurality of laser cladding components 70-90, 10-15 may be deployed linearly on a set of rail tracks (not shown) to perform on-site laser cladding on at least one of the rails of the set of rail tracks, i.e., the trolleys 60 are deployed in line with each other on the same set of rail tracks. In one embodiment, the plurality of trolleys 60 may be identical to reduce production costs of the system 100.

As shown in FIGS. 1 and 2, each trolley 60 comprises a rollable trolley base 18 and a trolley enclosure 30 in engagement with the trolley base 18. The trolley base 18 may have a loading capacity of one ton. To allow the trolley base 18 to roll, the trolley base 18 is provided with rolling elements 20 configured to engage the rail tracks. In an exemplary embodiment, the rolling elements 20 may comprise castor wheels 20 configured and positioned to engage the rail tracks. Alternatively (not shown), the rolling elements 20 may comprise rail track wheels.

The trolley enclosure 30 of each trolley 60 defines a space with its corresponding trolley base 18 within which one or more of the laser cladding components 70-90, 10-15 may be

mounted on the trolley base 18. The trolley enclosure 30 of each trolley 60 is configured to allow the trolley 60 to be lifted, carried and deployed by a hoisting mechanism, such as a crane (not shown). Once deployed, the trolleys 60 can be further manoeuvred manually, rolling on the rolling elements 20, to the cladding area to perform localized laser cladding site repairs and remanufacturing operations. The trolley enclosure 30 provides structural support to the trolley base 18 on which are mounted at least one of the components 70-90, 10-15 of the laser cladding apparatus in a space defined between the trolley enclosure 30 and the trolley base 18, thereby allowing the trolley 60 to be hoisted by a hoisting mechanism (e.g. a crane, not shown) without affecting lateral movement enabled by the trolley base 18.

In an exemplary embodiment, the trolley enclosure 30 may comprise an outer cage 30 having hoisting rods 40 provided at a top of the outer cage 30 to connect the trolley enclosure 30 to the hoisting mechanism, as shown in the figures. By configuring the trolley enclosure 30 as an outer cage 30 that is largely open, ease of access to the laser cladding components 70-90, 10-15 is provided for operation or maintenance work. Alternatively (not shown), the trolley enclosure 30 may include one or more walls or roof in addition to or in place of the outer cage 30 depicted in the figures.

Each trolley 60 preferably also comprises trolley bumpers 50 provided at the front and rear ends of the trolley 60 such that the plurality of trolleys 60 can be safely stacked end-to-end in contact with each other without damage to the trolleys 60. In an exemplary embodiment, the trolley bumpers 50 may be provided on the trolley enclosure 30 as shown in FIGS. 1-4 as a bottom rim of the trolley enclosure 30 fully surrounds the trolley base 18 when assembled. Alternatively (not shown), the trolley bumpers 50 may be provided on the trolley base 18 depending on the configuration of engagement between the trolley base 18 and the trolley enclosure 30. For example, the trolley enclosure 30 may be separately provided and attached to the trolley base 18 via securing means such as bolts. Alternatively (not shown), the trolley base 18 and trolley enclosure 30 may be integrally formed as a single structure or provided integrally with each other via welding of the trolley enclosure 30 to the trolley base 18.

In the system 100, as shown in FIG. 3, the plurality of laser cladding components 70-90, 10-15 are mounted on the plurality of trolleys 60 in a predetermined configuration before use. Appreciably, the predetermined configuration can be varied depending on the intended

application of use of the system 100.

To further modularize the system 100, as shown in FIGS. 4 and 5, each trolley 60 may further comprise a mounting base plate 22 attached to and fully covering the trolley base 18, and the system 100 may further comprise a plurality of component base plates 23 configured to have mounted thereon each of the plurality of laser cladding components 70-90, 10-15. The component base plates 23 are detachably mountable to any one of the mounting base plates 22 and are smaller than the mounting base plate 22 to allow variable positioning of each component base plate 23 on a mounting base plate 22. In an exemplary embodiment as depicted in FIGS. 4 and 5, the mounting base plate may be provided with a series or array of mounting peg holes 24, similar to a peg board, while the component base plates 23 are each provide with a number of mounting holes 25 that align with a corresponding number of the mounting peg holes 24. Preferably, the mounting peg holes 24 are located a fixed length apart from one another in a regular array. The laser cladding components 70-90, 10-15 are fixed on the component base plates 23 in order to ensure that the mounting holes 25 where the mounting bolts are to be fixed from the component base plates 23 are aligned with the mounting peg holes 24 on the mounting base plate 22. The mounting peg holes 24 thus enable the configuration and location of one or more of the laser cladding components 70-90, 10-15 on the mounting bases plate 22 to be readily customized according to needs of the application of use of the system 100, by facilitating easy detachment and reattachment of the component base plates 23 on the mounting base plates 22. The laser cladding components 70-90, 10-15 fixed on the component base plates 23 may be moved onto the mounting base plates 22 on the trolley bases 18 using cranes, ramps, rollers and so on (and similarly removed) if their size and/or weight prohibit manual movement.

The configuration shown in FIG. 4 is a proposed configuration for laser cladding repair of rails of a rail track. This configuration can be changed for other applications such as when the laser cladding operation needs to be done at a workshop floor environment, by reconfiguring arrangement of the laser cladding components 70-90, 10-15 on the mounting base plates 22 for better accessibility to the laser cladding target (not shown). To secure mounting of the laser cladding components 70-90, 10-15 on the component base plates 23 and mounting of the component base plates 23 on the mounting base plates 22, in an exemplary embodiment, bolts, nuts, and washers may be used to fix the mounting base plate

22 to the component base plates 23 and the laser cladding components 70-90, 10-15. In this way, each mounting base plate 22 serves as an intermediary mounting feature between the laser cladding components 70-90, 10-15 and the trolley 60. This enables the laser cladding components 70-90, 10-15 to be easily dismounted from the trolleys 60 and used in other applications without disassembling the individual components 70-90, 10-15, thereby maintaining and taking advantage of the modular nature of the design of the laser cladding system 100.

An exemplary assembly sequence of the modular laser cladding system 100 is illustrated in the flow chart of FIG. 6, where it can be seen that the component base plates 23 are first mounted on the mounting base plates 22, followed by mounting the laser cladding components 70-90, 10-15 on the component base plates 23, and finally mounting the mounting base plates 22 (having already mounted thereon the component base plates 23 and thereon the laser cladding components 70-90, 10-15) on the trolleys 60 in a configuration appropriate for a desired application of use of the system 100.

The mounting base plates 22 and component base plates 23 described above thus serve as detachable intermediary plates between the laser cladding components 70-90, 10-15 and the trolleys 60. This enables the laser cladding components 70-90, 10-15 to be dismounted from the trolleys 60 and used for other laser cladding applications at a depot, workshop or any factory site. It also enables the configuration of the laser cladding components 70-90, 10-15 to be customised on or off the trolleys 60 depending on the needs of the application.

Components of an exemplary laser cladding apparatus that may be mounted on the trolleys 60 may comprise a powder feeder unit 70, gas canisters 80, a gas canister cage 90, a robot arm controller pendant 10, a robotized cladding system 11, a chiller unit 12, a tool rack 13, a laser oscillator unit 14 and a power generator unit 15.

The powder feeder unit 70 is connected to a deposition head via a tube. The powder feeder unit 70 can hold two hoppers of metal powder for multi-material cladding purposes. The powder feeder unit 70 controls flow of metal powder to the robotized cladding system 11. Alternative powder feeders 70 can be considered if more than two hoppers are desired.

The gas canisters 80 supply a carrier gas and a shielding gas to the laser processing head via a pipeline. The carrier gas carries the metal powder to a deposition nozzle of the deposition head while the shielding gas ensures a consistent quality of metal powder deposition at the melt pool area by shielding the melt pool area from the surrounding atmosphere to minimize oxidation. The carrier gas and the shielding gas may comprise a same inert gas such as argon, or may comprise different inert gases. The gas canisters cage 90 provides secure storage of the gas canisters 80 during movement of the trolleys 60 and during the laser cladding operation.

- 10 The robot arm controller pendant 10 allows a human operator to manually control the robot arm of the robotized cladding system 11, to write controller programs, or edit pre-existing controller programs.

The robotized cladding system 11 comprises a six-axis robot arm having an end-effector.

- 15 The robot arm is configured as a linear gantry robot arm whereby the robot arm can traverse across a linear track guide to access the cladding area. The powder feeder 70, gas canisters 80, laser oscillator 14 and laser delivery system are connected to the end-effector configured for performing laser cladding operations.

- 20 A charged coupled device (CCD) or a pyrometer (not shown) can be used as a sensing means for process-monitoring control. Sensors employed in the system 100 should be mounted on the robot arm to measure process data characteristics from the melt pool in real time. The data is subsequently fed to the process monitoring control system.

- 25 The chiller unit 12 supplies cooling fluid for the laser system via a pipeline that runs to the laser processing head. The tool rack 13 stores various types of robotized machining tools and end effectors and spare deposition heads. Different end effector tools can be provided at the robot arm to perform different tasks such as machining for surface preparation, laser cladding operation, and post-process grinding. Fixed tool change positions and dimensions are preferably pre-programmed and stored in a tool library in the robot arm console 10. Operators can call the relevant tools to perform the repair tasks. Other end effector attachments can also be provided at the tool rack 13 to supplement the laser cladding process. This includes attachments such touch trigger probes, process monitoring sensors, machining

tools, and grinding tools.

The laser oscillator unit 14 amplifies laser power to a user-defined value and delivers it the laser processing head via a fibre optic cable. The laser processing head subsequently utilizes
5 a configuration of mirrors that direct the laser source to a target melt pool location. The power generator unit 15 supplies power necessary for using the components of the laser cladding apparatus.

As shown in FIGS. 3 and 4, the laser cladding components 70-90, 10-15 are provided in
10 operational connection with each other on trolleys 60. The components 70-90, 10-15 are mounted and grouped into respective zones. Depending on the application requirements, allocations of the components 79-90, 10-15 per zone can be modified, the zones can be rearranged, and additional components can be added or removed. The zones include all the functional components of the robotized cladding system and also encompass the necessary
15 equipment to do simple maintenance of the system 100 and the storage to carry the tools, equipment, and consumables required for the work.

In an exemplary configuration of the system 100, on the first trolley 60-1, as depicted in FIGS. 3(a) and 4(a), are mounted the powder feeder unit 70, the gas canisters 80, the gas
20 canister cage 90, the robot arm controller pendant 10 and the robotized cladding system 11. On the second trolley 60-2, as depicted in FIGS. 3(b) and 4(b), are mounted the chiller unit 12, the tool rack 13, and the laser oscillator unit 14. On the third trolley 60-3, as depicted in FIGS. 3(c) and 4(c), is mounted the power generator unit 15. In use, the first trolley 60-1 is deployed where laser cladding is to take place, i.e., at the laser cladding area which may be
25 designated as Zone A. The robotized laser cladding system 11 performs the laser cladding operations in this zone. Clear safety demarcations should be indicated around the robot arm. This demarcation defines the boundary of Zone A. This area should be clear of all personnel during operation of any robot arm movement or laser cladding operations. Before conducting the laser cladding operation, a laser shielding box covering the robotised laser cladding
30 system module is preferably set up to ensure the safety of the system operators. The second and third trolleys 60-2, 60-3 are deployed a distance away from the first trolley 60-1 at an area that may be designated as Zone B, a system back-end area. This zone is designed for operators to access and perform any system maintenance, configuration changes, and supply

monitoring. The two trolleys 60-2, 60-3 in Zone B may be positioned together or apart from each other, depending on how they are deployed, as will be described in greater detail below.

A further area that may be designated as Zone C may be set up apart from the trolleys 60 to serve as a controller and workbench area 20. Operators can utilize the workbench area 20 to perform tasks such as assembly, inspection, measurements, and maintenance. Tools and fixtures can also be stored here. This zone is also designed for operators to control the robotized cladding operations as well as perform the above-mentioned workbench tasks in. A computer control system 18 and equipment storage cabinets 19 may be provided in Zone C, as well as remote controls of the robot arm controller 10. All personnel should be preferably be present in this zone during the operation of the robotized laser cladding system 11 on the first trolley 60-1. Tasks such as refilling of powder feed, replacing the carrier gas and shielding gas canisters may be performed in this zone. The computer control system 18 is where the process monitoring control and robot arm programming can be done. The control system 18 is electrically connected to the chiller 12, the laser system 11, the powder feeder 70, the carrier and shielding gas modules 80 and the laser oscillator 14. The process data can be fed from the robotized laser cladding system 11 to the control system 18 where operators can record, monitor, and control the laser cladding process in real time. In the equipment storage cabinets 19 may be stored spare parts, tools, equipment, and consumables necessary for remote laser cladding operations. For instance, various powder feed material types, or special and custom tools used for assembly, disassembly, and maintenance of the system can be stored here.

An important feature of the modular system 100 is its mobility and ease of deployment. With the robotised cladding system 11 at Zone A tethered to the other laser cladding components in Zone B and C, the robotised cladding system 11 on the first trolley 60-1 can be deployed at a safe distance away from the other two trolleys 60-2, 60-3 and perform the laser cladding operation at multiple locations within a proximity around Zone B and Zone C. This mobility of the trolleys is fully taken advantage of within the exemplary embodiments shown in FIGS. 7 to 13. To move the laser cladding system 100 to the cladding site, a deployment chassis is used, as will be described below.

A first exemplary embodiment of deployment of the system 100 comprises use of a well

wagon 16 as shown in FIGS. 7 to 10. The well wagon 16 acts as the deployment chassis for the laser cladding system 100 to be mounted on and towed by one or more locomotives (not shown) to the approximate target cladding area. A launching mechanism 17 is provided at a rear end of the well wagon 16 and configured to lift and deploy the first trolley 60-1 on which is mounted the robotized cladding system 11 onto the rail track to be cladded, while the second and third trolleys 60-2, 60-3 remain on the well wagon 16 during the cladding operation. In an exemplary embodiment, the launching mechanism 17 may be equipped with four hydraulic actuators that supply an extension manoeuvre as well as a rotary manoeuvre, with a hoisting mechanism that secures and lifts the first trolley 60-1 onto the tracks. Once the first trolley 60-1 is on the rail tracks, it can be manoeuvred or pushed to the actual cladding repair site on its rolling elements 20 to perform the laser cladding operation. At the cladding repair site, the robotized cladding system 11 manoeuvres the end effector to reach the target cladding area to perform the cladding operation on the rail. In an alternative embodiment (not shown), the launching mechanism 17 may comprise detachable sliding guides that are mounted at the rear end of the well wagon and angled down to the rail tracks. The first trolley 60-1 can be lowered onto the rail tracks by rolling the first trolley 60-1 onto the top of the sliding guides on the well wagon 16 and sliding or rolling the first trolley 60-1 down the sliding guides onto the rail tracks. Safety railings 32 are preferably provided at the perimeter of the well wagon 16 and clear demarcations of the cladding area are preferably also provided to ensure the safety of the operators.

A second exemplary embodiment of deployment of the system 100 comprises use of a train gantry vehicle (TGV) 21 as the deployment chassis, as shown in FIGS. 11 to 13. Like the well wagon 16, the TGV 21 acts as the chassis for the laser cladding system 100 to be mounted on and towed by one or more locomotives (not shown) to the approximate target cladding area. The TGV 21 is configured to roll on rail tracks and comprises two platforms 41, 42 separated by an elongate frame 43. Wheels 44 are provided under the platforms 41, 42 to engage the rail tracks. In an example of use, second trolley 60-2 as described above is mounted on the first platform 41 while the third trolley 60-3 as described above is mounted on the second platform 42. The first trolley 60-1 comprising the robotized cladding system 11 is deployed on the rail tracks within the frame 43 between the first and second platforms 41, 42, such that the section of rail tracks between the first and second platforms 41, 42 comprise the laser cladding area designated as Zone A. Appreciably, in this deployment,

Zone B, a system back-end area as described above, is separated into two locations comprising the two platforms 41, 42. In this embodiment, the TGV 21 together with the three trolleys 60-1, 60-2, 60-3 can be entirely hoisted by monorail cranes to laterally cross I-beam rail tracks in order to deploy and position the laser cladding system 100 at the target cladding area.

Appreciably, the chassis on which the system 100 is deployed is not limited to well wagons 16 or TGVs 21. The chassis can be extended to any suitable chassis design that can provide the mobility necessary for the laser cladding operations, using a separately provided locomotive to pull the chassis. Examples of other chassis that may be used to deploy the system 100 include the locomotive towed wagon and Road-Rail Vehicle (RRV) that can operate on rail track as well as conventional roads.

The above-described laser cladding system 100 thus provides a portable, modular, and on-site laser cladding system that enables remote repair and remanufacturing for railway applications on the track, train depot and even at maintenance sites. The system 100 can be a versatile on-site cladding system to do laser cladding work for railway applications. Its application can be extended to various other industries like, shipyard, port, oil and gas, offshore and aerospace industries where minimum downtime is prioritized. Instead of a long lead time for order and freight process of bringing in new parts, laser cladding can get the work done in a relatively short time frame with high quality repair or modification to the parts in terms of reliability and mechanical properties. The system 100 encompasses all the functional components of a robotized laser cladding system. It preferably also encompasses the necessary equipment to do simple maintenance of the system 100 and the storage to carry the tools, equipment, and consumables required for the work. The system 100 features a modular design where the components 70-90, 10-15 of a laser cladding apparatus are configured on a plurality of deployable trolleys 60, according to their respective functions. The system 100 allows for ease of modifications to future design arrangements. Changes in design can be adapted on different vehicle platforms or chassis designs. In one embodiment, the system 100 may comprise the laser cladding apparatus mounted on three trolleys 60 deployed on a well wagon 16 that transports the system 100 to a laser cladding area and deploys a first trolley 60 comprising the robotized laser welding system 11 onto the rail tracks via a launching mechanism 17 on the well wagon 16 to perform the laser cladding

operation. In another embodiment, the system 100 may comprise the laser cladding apparatus mounted on three trolleys 60 deployed on a train gantry vehicle that transports the system 100 to a laser cladding area and deploys a first trolley 60 comprising the robotized laser welding system 11 onto the rail tracks via a launching mechanism provided on the well wagon 16 to perform the laser cladding operation. The above-described laser cladding system 100 is thus a highly strategic and compelling option for rail track repair operations. It is a pioneering on-site point repair laser cladding system 100 that will benefit immediately the railway industry. On a global and regional scale, it can be rapidly commercialized as a new rail track repair service operation.

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Whilst there has been described in the foregoing description exemplary embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations and combination in details of design, construction and/or operation may be made without departing from the present invention. For example, in other embodiments, the modular and deployable design of the laser cladding system is not limited to trolleys compatible with train wagons. The design can be extended to other forms of portable laser cladding system designs including but not limited to a miniaturized or non-miniaturized laser cladding system carried by transport vehicles like trucks or vans. In the case of a portable miniaturized laser cladding system design, the system can be deployed and assembled in the form of handheld modules at the laser cladding site before proceeding to the laser cladding operation.

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CLAIMS

1. A modular laser cladding system comprising:

5 a plurality of deployable trolleys comprising three trolleys, each trolley comprising a rollable trolley base and a trolley enclosure in engagement with the trolley base, the trolley enclosure configured to allow the trolley to be lifted and moved by a hoisting mechanism; and

10 a laser cladding apparatus comprising a plurality of laser cladding components mountable in a variable configuration on the plurality of trolleys, the laser cladding components comprising a robotized cladding system, a powder feeder unit, and gas canisters,

15 wherein the robotized cladding system, the powder feeder unit, and the gas canisters are mounted on a first trolley of the three trolleys, and other components of the laser cladding apparatus are mounted on a second trolley and on a third trolley of the three trolleys.

- 20 2. The system of claim 1, wherein the plurality of deployable trolleys having the plurality of laser cladding components mounted thereon are deployable linearly on a set of rail tracks to perform laser cladding on at least one of the rails of the set of rail tracks.

- 25 3. The system of claim 1 or claim 2, wherein each trolley further comprises a mounting base plate attached to the trolley base, wherein the system further comprises a plurality of component base plates configured to have mounted thereon each of the plurality of laser cladding components, and wherein the component base plates are variably and detachably mountable to any one of the mounting base plates.

- 30 4. The system of any one of the preceding claims, wherein the plurality of trolleys having the plurality of laser cladding components mounted thereon are mountable on a chassis for towing to a laser cladding site.

5. The system of claim 4, wherein the system further comprises the chassis.

6. The system of claim 5, wherein the chassis comprises a well wagon.

- 35 7. The system of claim 6, wherein the well wagon comprises a launching mechanism

provided at one end of the well wagon and configured to lower the first trolley from the well wagon onto a set of rail tracks.

- 5 8. The system of claim 7, wherein the launching mechanism comprises a hoisting mechanism configured to lift and to lower the first trolley and hydraulic actuators configured to supply an extension manoeuvre and a rotary manoeuvre to the hoisting mechanism.
- 10 9. The system of claim 7, wherein the launching mechanism comprises sliding guides extending from the first end of the well wagon onto the set of rail tracks and configured to allow the first trolley to slide thereon from the well wagon onto the set of rail tracks.
- 15 10. The system of claim 5, wherein the chassis comprises a train gantry vehicle, the train gantry vehicle comprising a first platform spaced apart from a second platform by an elongate frame, wherein wheels are provided under each of the first platform and the second platform to allow rolling of the train gantry vehicle on rail tracks.
- 20 11. The system of claim 10, wherein the first trolley is provided in a laser cladding zone between the two platforms, wherein the second trolley is provided on the first platform, and wherein the third trolley is provided on the second platform.
12. The system of any one of the preceding claims, wherein the first trolley is spaced apart from the second trolley and the third trolley when the system is in use.
- 25 13. The system of any one of the preceding claims, wherein the plurality of trolleys are identical.