An apparatus is adaptable for selectively assembling various wheels to complementary hubs defining a radial mechanical connection with the wheel. A tool is movable relative the vehicle body and adaptable for moving the wheel to the hub. A tool of the apparatus is adaptable for adjusting the radial mechanical connection. A camera is connected to the tool to generate visual image of the wheel or the hub. A controller operably communicates with the tool and the camera for regulating operational movements of the tool.
SYSTEM FOR MOUNTING WHEELS TO VEHICLE RELATED APPLICATIONS

[0001] This Application claims the benefit of the provisional patent application 60/086,030 for a System for Mounting Wheels to a Vehicle, filed on May 31, 2005, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The subject invention relates to a method and an apparatus for assembling automotive vehicles and, more particularly, to a method and an apparatus for assembling a wheel to a body of the automotive vehicle.

[0004] 2. Description of the Prior Art

[0005] In the assembly of automotive wheel rims and tires, the tire is mounted onto the wheel rim and then inflated before the wheel is mounted onto an automotive vehicle. Numerous vehicle assembly lines for mounting the wheels are known in the prior art and are widely used today in the automotive industry. These assembly lines are taught by the U.S. Pat. No. 5,125,298 to Smith; U.S. Pat. No. 5,345,675 to Yamanaka et al.; and U.S. Pat. No. 5,640,750 to Yoshida et al. The U.S. Pat. No. 5,345,675 to Yamanaka et al., for example, teaches a nut supply robot and a wheel mounting robot mounted on a mounting base. The nut supply robot holds nuts taken out from a parts feeder, for fixing each wheel. The wheel mounting robot grips a desired wheel placed on a wheel placement station and mounts the wheel to its corresponding front and rear wheel hubs. The wheel mounting robot has an arm and a chucking unit. A pair of cameras is spaced from the wheel mounting robot and are fixed by a tripod. One of these cameras takes an image of the front wheel hub of the vehicle while the other camera takes an image of the rear wheel hub. An image processing apparatus is adjacent the wheel mounting robot for processing the image information outputted from these cameras. Each of these cameras detects the center of each of the front and rear wheel hubs. A second set of cameras are mounted on the wheel mounting robot and are located in front of, and symmetrically with respect to the center of the wheel hub of the vehicle to approximately coordinate the center of the wheel hub calculated from the image of the wheel hub taken by the cameras mounted on the tripod. Revised coordinates of the center of the wheel hub, a rotational displacement from a standard rotational position of the wheel hub, and a turning angle of the wheel hub toward the right or left with respect to a progressive direction of the vehicle are calculated from the images obtained by the cameras mounted on the robot.

[0006] The wheel mounting robot taught by the U.S. Pat. No. 5,345,675 to Yamanaka et al. requires multiple cameras with two of them positioned on the mounting robot and two of them being spaced from the mounting robot. The method of mounting the wheel to the vehicle taught by the U.S. Pat. No. 5,345,675 to Yamanaka et al. requires multiple cameras and additional space on a manufacturing floor thereby diminishing flexibility of the modern manufacturing environment. In addition, the U.S. Pat. No. 5,345,675 to Yamanaka et al. does not teach or suggest a tool adaptable for fastening a nut on each hub bolt provisionally affixed to the hub of the vehicle body for fitting and securing the wheel to the vehicle body.

[0007] The U.S. Pat. No. 5,640,750 to Yoshida et al. teaches a wheel assembling apparatus for assembling different types of wheels to different types of vehicle bodies conveyed along a vehicle assembling line has a robot for fastening a plurality of nuts to hub bolts provisionally affixed to the wheel so as to assemble the wheel held by the robot hand to the vehicle body. The robot is provided with a center pin attachment to which different types of center pins, having been prepared correspondingly to center holes of the different types of wheels, are selectively and removable attached. The center pin attached to the robot hand is fitted into the center hole of the wheel hub and locates the wheel in position with respect to the robot hand. The wheel assembling apparatus cooperates with a pair of cameras adaptable to visually inspect and determine whether the wheels are properly assembled to the vehicle body. The cameras are spaced from the robot which requires extra space for practicing the wheel assembling apparatus.

[0008] Alluding to the above, the U.S. Pat. No. 5,125,298 to Smith teaches a wheel mounting station that includes a hub orientation sensing assembly defined by a vision guidance system comprising a camera and a robot controller adaptable to receive a signal from the camera and transmitting a guide signal to a robot. Similar to the aforementioned wheel assembly apparatus, this camera is spaced from a tire mounting device. This layout requires additional space of a manufacturing floor which diminishes flexibility of the modern manufacturing environment.

[0009] The opportunity remains for a new design of a wheel mounting system for installation of various wheels into respective hubs of a vehicle body at a low cost, reduced time, thereby improving manufacturing process and reducing space in manufacturing environment. As such, the present invention eliminates one or more of the aforementioned problems associated with these prior art designs.

SUMMARY OF INVENTION

[0010] An apparatus of the present invention is adaptable for selectively assembling wheels to complementary hubs extending from a vehicle body movable along an assembly line of an assembly plant. A radial mechanical connection defined between each hub and the wheel is adjusted before the vehicle body is released from the assembly line. A tool adaptable for multi-axial movement relative to the vehicle body is utilized to move the wheel from a wheel storing location and to place the wheel adjacent the hub thereby mechanically engaging the wheel with the hub. The tool is defined by a robot having an arm and a wrist portion multiaxially movable relative to one another. A front plate of the wrist portion includes a plurality of mechanical devices, such as, for example, spindle nutrunners, which are radially spaced about the front plate. These spindle nutrunners adjust the radial mechanical connection as the wheel is engaged with the hub. A camera is disposed in the front plate of the tool. Preferably, the camera is surrounded by the spindle nutrunners. The camera is adaptable for scanning and generating three dimensional image of at least one of the wheel and the hub before the wheel is placed on the hub and before the radial mechanical connection is adjusted. A controller operat-
tively communicates with the tool and the camera. A comparative software of the controller is pre-programmed with data of different configurations of the wheels and the hubs. The comparative software is adaptable to receive a signal generated by and send from the controller and to compare the signal with the pre-determined data to determine a match between the pre-determined data and the required configuration of the wheel. And signaling tool through said controller to engage the wheel and to move the wheel to the hub for adjusting the radial mechanical connection between the wheel and the hub as the match between the evaluation signal and said pre-determined data is identified.

[0011] An advantage of the present invention is to provide for a tool adaptable for mounting wheels to the vehicle body wherein the tool includes a single 3-dimensional camera connected to and movable with the tool relative to the vehicle body for wheel pattern and brake disc studs recognition.

[0012] Another advantage of the present invention is to provide a vehicle assembly system that increases mount and torque of nuts against the wheel.

[0013] Still another advantage of the present invention is to provide an improved design of the assembly of the wheels to the vehicle body that is not extremely complicated, like aforementioned prior art designs, and is quite practicable, particularly when processing a variety of wheel sizes and designs.

[0014] Accordingly, the assembly, shown in the present invention is new, efficient, and provides for an effective way for selectively mounting the wheels of various configurations into the respective hubs at a high speed thereby offering the flexibility needed in the modern manufacturing environments and reducing space of the manufacturing floor of the assembly plant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0016] FIG. 1 is a general view of an assembly station for mounting wheels on an automotive body;

[0017] FIG. 2 is a front view of a robotic device illustrating a front plate having a plurality of spindles radially spaced from the center of the front plate and a 3-dimensional camera disposed in the center of the front plate;

[0018] FIG. 3 shows a side view of a robotic device having an inventive tool for gripping the wheel and mounting the wheel to the automotive body;

[0019] FIG. 4 is a perspective view of an alternative embodiment of the inventive tool adaptable to be operated by a technician;

[0020] FIG. 5 is a perspective view of another alternative embodiment of the inventive tool slidably movable along an overhang rail or track and adaptable to be manually operated by a technician; and

[0021] FIG. 6 is a general view of an alternative embodiment of the assembly station for mounting wheels on an automotive body having a plurality of manually operated tool.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Referring to FIG. 1, a system of the present invention, generally shown at 10, is designed for selectively assembling various wheels, shown in phantom at 12, to complimentary hubs (not shown) extending from an axle (not shown) of a vehicle body 14. The wheel 12 includes a rim and a tire disposed about the rim or the rim without the tire. As appreciated by those skilled in the art, each hub and the wheel 12 define a radial mechanical connection therebetween, such as bolts (not shown) extending outwardly from the hub and respective nuts (not shown) for fastening the wheel 12 to the hub. The system 10 includes a conveyance device, generally indicated at 16, for moving the vehicle body 14 along an assembly path A through a gated area 18. Preferably two or more carousels 20, 22 deliver the wheels 12 to the assembly path A. The carousels 20, 22 are located adjacent one another and are separated by the assembly path A. Each carousel 20 and 22 are designed to supply the wheels 12 having different configurations. Preferably two or more robotic devices, generally indicated at 24 and 26, are positioned in opposite relationship with respect to one another about the assembly path A. Each robotic device 24, 26 is movable along a track 28 extending parallel to the assembly path A. Each robotic device 24, 26 is adaptable for multi-axial movement relative to the vehicle body 14 and the conveyance device 16. Each the robotic device 24 or 26 is manipulated by a controller, generally shown at 28. The controller 28 will be discussed in greater detail as the description of the present invention proceeds.

[0023] Referring to FIG. 3, each robotic device 24 and 26 is defined by a mounting tool, generally indicated at 32, a robot arm 34 pivotably engaged within a base support portion 36 by an elbow joint 38 thereby facilitating multi-axial movement of the mounting tool 32 connected to the robot arm 34. The robot arm 34 moves the mounting tool 32 into position to mount the wheel 12 engaged by the mounting tool 32 to the hub. The mounting tool 32 includes an end effector connection 40 with a spring tension (not shown) extending between the mounting tool 32 and the robot arm 34 to facilitate multi-axial movement of the mounting tool 32 relative to the hub. The mounting tool 32 includes an operational unit 44 extending along a longitudinal axis I and a base plate 46 connected to the operational unit 44. A plurality of spindles or spindle nut runners 50 are radially spaced around the longitudinal axis I at the base plate 46 to complement with radial mechanical connection of the hub. Preferably, the spindles 50 are Atlas Copco nutrunners, which do not intend to limit the present invention.

[0024] A pair of arms 52 and 54 are operably connected to the operational unit 44 for clamping the wheel 12 as the wheel 12 is moved from the carousels 20 or 22 to be mounted to the hub. The arms 52 and 54 are hydraulically or electrically operated and are adaptable for multi-axially movement relative to the longitudinal axis I with respect to different operational modes of the mounting tool 32. A 3-dimensional camera, generally indicated at 56 in FIG. 2, is connected to the base plate 46 at the longitudinal axis I. The camera 56 is disposed in the center of the base plate 46 with the plurality of the spindle nut runners 50 being radially spaced around the camera 56, as best shown in FIG. 2. The camera 56 is adaptable to scan the wheel 12 and the hub to determine a size, angle, and location of aperture defined
within an edge of the wheel 12, location of the bolts extending from the hub, and the like. The image of the wheel 12 or the hub generated by the camera 56 provides the perception of depth of the wheel 12, the depth of the openings defined in the wheel 12 to receive the complementary pins extending from the hub. The information about the size, angle, and location of the aperture and the pins is further transmitted to the controller 28 operably communicating with the camera 56.

Preferably, the controller 28 includes a computer (not shown), which operably and electronically communicates with the robotic devices 24, 26 and which is cooperable with the camera 56. The computer has an input/output interface, a central processor unit, a random access memory, i.e. RAM, and a read only memory, i.e. ROM. The input interface is electrically connected with the robotic devices 24, 26 and the camera. The controller is pre-programmed with the various tire wheel size and types of the hub the wheel is mounted to. The ROM stores a program, i.e. a comparative software that determines proper mating order and mating engagement between the particular wheel 12 and the hub. The controller 28 compares the image received from the camera 56 with a plurality of pre-stored data of various images stored in memory of the comparative software and identifies the particular configuration of the wheel 12 and location of the apertures defined in the wheel 12 with the complementary location of the bolts or pins extending from the hub. Each of the images stored in memory is associated with structural characteristics and physical dimensions of the corresponding wheel 12 and hub including the orientation of the aperture. The comparative software is adaptable to receive a signal generated by and send from the controller 28 and to compare with the pre-determined data to determine whether there is a match between the wheel 12 scanned by the camera 56 and the pre-determined data of the wheel 12 required to be installed on a particular body style or type of the vehicle 14. The comparative software generates an output signal identifying the match to the controller 28, which then signals the tool 32 to clamp the wheel 12 and to move the wheel 12 to the hub adjusting the radial mechanical connection between the wheel 12 and the hub as the match is identified. However, if the match is not determined, the controller 28 will direct the tool 32 to cancel the operation until correct type of the wheel 12 is delivered to the robotic device 24, 26 by the carousel 20 or 22.

Referring back to Fig. 1, two bowl feeders, generally indicated at 60 and 62, respectively, are located adjacent each robotic device 24, 26. Each bowl feeder 60 and 62 is included in the present system 10 to deliver nuts of four and five pattern diameters to assemble tires of different configuration. The bowl feeders 60 and 62 are positioned adjacent the conveyance device 16. As the vehicle body 14 leaves the gated area 18, a first back-up station 64 and a second back-up station 66, adjacent each robotic device 24, 26, respectively, are provided to fasten the nuts with the bolts, remove the entire wheel 12 from the hub, if, for example, an error is made, or for any other back up operation. Each back-up station 64 and 66 is operated by technicians and includes an overhead rail (not shown) and a pair of manually operated mounting tool, each is generally shown at 70 in FIGS. 1 and 4. Each tool 70 is slidably movable relative to the assembly path A along a secondary track 72. The functional aspects of the tool 70 are similar to the aforementioned mounting tool 32. The tool 70 includes an operational block, generally indicated at 72 defined by a front plate 74 and a rear plate 76 interconnected by side panels 78. A plurality of spindles 80 are radially spaced around the front plate 74 to complement with the radial mechanical connection of the hub. Preferably, the spindles 80 are Atlas Copco nut-runners, which do not intend to limit the present invention. At least two arms 82 having an L-shaped configuration are operably connected to the operational block 72 at the front plate 74 for clamping the wheel 12. The arms 82 are hydraulically or electrically operated and are multi-axially movable with respect to different operational modes of the manually operated tool 70. Preferably the vision system, i.e. 3-dimensional (not shown) is connected to the operational block 72 and is adaptable to scan the wheel 12 and the hub to determine a size, angle, and location of aperture defined within an edge of the wheel, location of bolts extending from the hub, and the like. The camera of the operational block 72 is disposed in the center of the front plate 74 with the plurality of the spindle nut runners 80 being radially spaced around the camera. The information about the size, angle, and location of the aperture and the bolts is further transmitted to a compact controller system 84 disposed at the manually operated tool 70. The compact controller system 84 is operatively communicated with the controller 28. A handle 86 is connected to the operational block 72 to be used by the technician, as illustrated in FIG. 1.

FIG. 5 shows an alternative embodiment of the manually operated tool 70, which is generally indicated at 90. Preferably, several tools 90 are slidably movable relative to the assembly path A along the respective overhead tracks (not shown). The functional aspects of the tool 90 are similar to the aforementioned mounting tool 32 and the tool 70. The tool 90 includes an operational block, generally indicated at 92 defined by a front plate 94 and a rear plate 96 interconnected by side panels 98. A plurality of spindles 100 are radially spaced around the front plate 94 to complement with the radial mechanical connection of the hub. Preferably, the spindles 100 are Atlas Copco nut-runners, which do not intend to limit the present invention. At least two arms 102 having an L-shaped configuration are operably connected to the operational block 92 at the front plate 94 for clamping the wheel 12. The arms 102 are hydraulically or electrically operated and are multi-axially movable with respect to different operational modes of the manually operated tool 90. Similarly to the tools 32 and 70, a vision system, i.e. 3 dimensional or 2 dimensional camera (not shown) is connected to the operational block 92 and is adaptable to scan the wheel 12 and the hub to determine a size, angle, and location of aperture defined within an edge of the wheel, location of bolts extending from the hub, and the like. The camera of the operational block 92 is disposed in the center of the front plate 94 with the plurality of the spindle nut runners 100 being radially spaced around the camera. The information about the size, angle, and location of the aperture and the bolts is further transmitted to a compact controller system 104 disposed at the manually operated tool 90. The compact controller system 104 is operatively communicated with the controller 28. A handle 106 is connected to the operational block 92 to be used by the technician, as illustrated in FIG. 1. The compact controller systems 104 and 84 operate similar to the controller 28. The controller systems 104 and 84 include a computer (not shown), which
operably and electronically communicates with the tools 32 and 70 and the respective cameras. The computer has an input/output interface, a central processor unit, a random access memory, i.e., RAM, and a read only memory, i.e., ROM. The input interface is electrically connected with the robotic devices 32 and 70 and the respective cameras. The controller is pre-programmed with the various tire wheel size and types of the hub the wheel is mounted to. The ROM stores a program, i.e., a comparative software that determines proper mating order and mating engagement between the particular wheel 12 and the hub. The controller systems 104 and 84 compares the image received from the cameras with a plurality of pre-stored data of various images stored in memory of the comparative software and identifies the particular configuration of the wheel 12 and location of the apertures defined in the wheel 12 with the complementary location of the bolts or pins extending from the hub. Each of the images stored in memory is associated with structural characteristics and physical dimensions of the corresponding wheel 12 and hub including the orientation of the aperture. The comparative software is adaptable to receive a signal generated by and send from the controller systems 104 and 84 and to compare the signal with the pre-determined data to determine whether there is a match between the wheel 12 scanned by the cameras and the pre-determined data of the wheel 12 required to be installed on a particular body style or type of the vehicle 14. The comparative software generates an output signal identifying the match to the controller systems 104 and 84, which then signals the tool 32 to clamp the wheel 12 and to move the wheel 12 to the hub for adjusting the radial mechanical connection between the wheel 12 and the hub as the match is identified. However, the match is not determined, the controller systems 104 and 84 will direct the tool 32 to cancel the operation until correct type of the wheel 12 is delivered. Each controller systems 104 and 84 include a screen 107 to facilitate interaction between the technician 69 and the respective tools 32 and 70 by allowing the technician to monitor the assembly process and intervene when necessary.

[0028] An effector connection 108 with a spring tension 110 extends between the tool 90 and a post 112 cooperably with the overhead track to facilitate multi-axial movement of the tool 70 relative to the hub of the vehicle body 14. FIG. 6 illustrates an alternative embodiment of the inventive system, generally shown at 100, wherein a pair of the manually operated tools 70 or 90 are positioned on each side of the assembly path A for mounting the wheels 12 to the hub. This embodiment is practicable in an assembly facility of a smaller scale, such as tire shops, and the like.

[0029] While the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essence thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. An apparatus for selectively assembling wheels to complementary hubs extending from a vehicle body movable along an assembly line with each hub defining a radial mechanical connection with the wheel, said apparatus comprising:

a controller;

a tool for multi-axial movement relative the vehicle body for moving the wheel relative to the hub and for adjusting the radial mechanical connection as the wheel is engaged with the hub;

da device for scanning and generating three dimensional image of at least one of the wheel and the hub as said device moves in unison with said tool and signals said controller a configuration of at least one of the wheel and the hub thereby aligning the wheel relative the hub for making the radial mechanical connection in response to a signal received by said tool from said controller.

2. An apparatus as set forth in claim 1 wherein said device is further defined by a 3-dimensional camera connected to and movable with said tool relative the hub.

3. An apparatus as set forth in claim 2 wherein said tool is further defined by a robot having an arm and a wrist portion multi-axially movable relative to one another.

4. An apparatus as set forth in claim 3 wherein said tool is further defined by a plurality of spindle nut-runners and a front plate engaging said spindle nut-runners around said 3-dimensional camera.

5. An apparatus as set forth in claim 4 wherein said tool includes a pair of arms movable relative to said tool for clamping the wheel.

6. An apparatus as set forth in claim 1 including a comparative software of said controller having a pre-programmed data of different configurations of the wheels and the tires, said comparative software adaptable for receiving an evaluation signal from said controller and comparing said evaluation signal with said pre-determined data to determine a match and signaling tool through said controller to engage the wheel and to move the wheel to the hub for adjusting the radial mechanical connection between the wheel and the hub as the match between said evaluation signal and said pre-determined data is identified.

7. An apparatus for selectively assembling wheels to complementary hubs extending from a vehicle body movable along an assembly line with each hub defining a radial mechanical connection with the wheel, said apparatus comprising:

a tool for multi-axial movement relative the vehicle body for moving the wheel to the hub with said tool having a plurality of mechanical devices radially spaced about said tool for adjusting the radial mechanical connection as the wheel is engaged with the hub; and

a camera disposed between said mechanical devices and movable in unison with said tool for scanning and generating three dimensional image of at least one of the wheel and the hub.

8. An apparatus as set forth in claim 7 including a controller operatively communicating with said tool and said camera with said camera signaling said controller configu-
ration of at least one of the wheel and the hub thereby aligning the wheel relative to the hub for making the radial mechanical connection in response to a signal received by said tool from said controller.

9. An apparatus as set forth in claim 7 wherein said tool is further defined by a robot having an arm and a wrist portion multi-axially movable relative to one another.

10. An apparatus as set forth in claim 9 wherein each of said mechanical devices is further defined by a plurality of spindle nut-runners.

11. An apparatus as set forth in claim 10 wherein said tool includes a pair of arms movable relative to said tool for clamping the wheel.

12. An apparatus as set forth in claim 11 including a comparative software of said controller having a pre-programmed data of different configurations of the wheels and the tires, said comparative software adaptable for receiving an evaluation signal from said controller and comparing said evaluation signal with said pre-determined data to determine a match and signaling tool through said controller to engage the wheel and to move the wheel to the hub for adjusting the radial mechanical connection between the wheel and the hub as the match between said evaluation signal and said pre-determined data is identified.

* * * * *