Preliminary study of an automotive assembly plant

Education, School

Politecnico Di Torino 1 Facolta' di Ingegneria Automotive Engineering FINAL ASSEMBLY ??? Preliminary study of an automotive assembly plant for high volume production(1300cars/day with 2 type of cars, 4 doors and 2 doors respectivly, and flexible in volume, 3 shifts of workers) Ma Wei supervisor: Prof. COZZARI GIULIANO Index 1. General infomation from theinternship2. 1 high production volume of the assembly plant 2. 2 pace calculation 2. 3 area calculation and process layout 2. 4 flexibility and automization of the system 2. “ make or buy” decision 2. Review of tutorials and further applications of the tutorial 3. 6 General knowledges aquired from the assembly lecture 3. 7 Extension of the tutorial 3. 8. 1 product breakdown structure(PBS) ; bill of material(BOM) 3. 8. 2 work breakdown structure(WBS) 3. Time analysis and relative calculations 3. 1 working time analysis(WCT, takt time) 3. 2 system length and area calculation 3. 3 facility layout 4. Tool and equipment selection 1. General infomation from the internship 1. high production volume of the assembly plant As is define in the internship reoprt, the production volume of the plant that we study is 1300cars/day, with 3 shifts of workers making the planned working time up to 21 hour a day. We developed a rough plan for the entire assembly production process, and then divided our thesis into four parts according to the function of each part. Following the sequence of each part, they are respectively: Stamping process, body in white process, painting process and fianl assembly process.

Normally each department is separated with one another, located in different locations inside an assembly plant, and each department has its own building structure, thus we call them stamping shop, body in white shop, painting shop and final assembly shop. Moreover all of these building structures are placed considering the convenience of the entire manufacturing process, to facilitate the flow of materials and parts, to simplify stocks management. For example, stamping shop normally locates near the gate with a stock area to facilitate the incoming of sheet metal.

Body in white shop and painting shop lies in between final assembly shop and stamping shop, in order to shorten transfer process. Finally, final assembly shop often locates beside the supplier park, where massive subgroup parts of a car are stocked. 1. 2 pace calculation Since our focus is on the word " high volume", we must estimate the overall pace of the plant. The required standard time can be calculated considering: 1. 1300 cars/day. 2. 3 shifts of workers with 7 availiable working hours per shift. 3.

Overall equipment efficiency= 90% 4. Standard time STn is the time needed to assemble a car, starting from pressing shop up to final test at final assembly shop. AWT(available working time)= 3*7*60= 1260 min STn= AWT/1300= 0. 97min= 58sec. It means that each 58 seconds there will be a car coming out from the plant. 1. 3 area calculation The area calculation is decided in the internship report, through the benchmarking result of many plants and we chose the average area of the plants that is most close to our requirements.

And here is the decision: Stamping| BIW| Painting| Final Assembly| 40800? | 60900? | 48000? | 71400? | Usually the process layout is like this(I will only focus on the final assembly process): But for the final assembly, I find it more advanced for logistic and warehouse management is I choose the final assembly line like this: In my later discussion, we can see more advantages of this kind of solution according to the three main sub-processes of final assembly. 1. 3 flexibility; automization of the system

Equipments are most devoted resource since nowadays factories are normally capital intensive. So we have to determine the automization level at the first approach of an assembly plant. The four processes, stamping, body in white, painting and final assembly, have their own process capability and different automization level. Here is the automization level selection criteria and methods to be flexible of the system. And we will make our choice accordingly. Stamping STAMPING| COST AND THE CHOICE| 1. ransfer muiti-station mechanical presses with a very high cadence(over than 15 cycles/min) fitting with very high production rate(over than 600 series/day)| Very high, not fitable for our plant because according our make or buy decision, we only make necessary body parts in order to save capital and better focus on " core business". | 2. traditional mechanical or new generations hydraulic presses with a medium cadence(between 10 and 15 cycles/min), interconnected by automatic systems, fitting for medium production rate(60-600 series/day)| This fits our production system adequately.

Since our assumed working cycle time is 6sec(= 10 cycles/min) and it meets the requirement of 1300cars/day. On the other side, this is capital intensive but not as expensive as the first one. | 3. traditional hydraulic or water forming presses, with manual loading/unloading, with low cadence, fitting for low production rate(less than 60 series/day)| This criterion is not fit for mass production. Nowadays labor intensive production is used for the elite market.

| Major factors influcing cost: press and dies depreciation, maintenance costs and material handling.

And thus it is very important to maintain a good level of overall equipment efficiency and a good utilization level. Furthermore, in order to keep the production cost low, sheet metal usage degree must be optimized, through detailed study of cutting schemes and stamping methods andtechnology(sheet metal stamping dimensioning). | Flexibility: the process flexibility is reached to the required level(2 different types of cars with 9 different parts to stamp) through changing of dies according to detailed production plan. We should avoid to change dies too frequently, for the sake of saving more productive up time.

The production plan should follow the material requirement plan of later processes, and the logistic department should set adequate arrangements for the finished parts. | Body in white ?? For high or medium volumes body in white welding and assembling, hard automation(robot intensive) and flexible production systems are used. ?? Assembling tools are specific for the parts of each type of car. ?? System flexibility/convertibility is achieved through specific tools rapid change, so that it is possible to set easily the mix model level on the same equipment or line.

Major factors influencing cost: specific equipment and tools depreciations, maintenance and materials handling cost. Overall equipment efficiency and utilization level. Painting Painting process is a continuous flow process and each process are sequenced. We can divide it into two categories: 1) pre-painting treatments. 2) painting. 1). In reference of automazation and flexibility, the pre-painting process is not strictly relevant because, for example, processes such as washing, degreasing or phosphating are not robot intensive, they actually are continous flow process with only a few operations.

And each type of BIW(in our plants, refer them as type A and type B) can be processed in the same way with the same time, temperature and many other conditions. 2). The painting process is robot intensive because it is applied by automatic robots with electrostatic spray, along with automatic controlled air, temperature and humidity inside the painting booth. This process is relatively complex and harmful to human body. So in case of mass production, no labor force is enrolled in this process.

Flexibility: Since equipments and tools are not specifically developed for each type of car, flexibility can be easily obtained by changing the process automatization software. And customized order-to-make product is mainly reflected in this process. Controlling program should be adjustable in order to change the color of the car easily. Major factors influcing cost: specific direct material(dye) and energy consumption, manpower necessary to manage the process and equipment maintenance costs. Final Assembly In terms of final assembly, manpower accompanied by flexible conveyor system is needed.

This process is mainly labor intensive because many complex operations, such as cockpit module, steering leverages, seats and mobile parts are performed by technicians, but not machines. Certain level of automatization is required for simple operations such as joining, mechanical groups screwing and fixed glasses application. Moreover, ergonomic is important for labor intensive operations, so that assembling stations and conveyor systems have to be comfortable for the operators. For example the tow conveyors is an ergonomic solution for screw drivers.

It can lift up the heavy body from BIW, to make the operator reach the lower part of the body. Recently new type of tow conveyors became more convenience since they allow technicians to stand on them and move along the operation line. Flexibility: product models mix along the final assembly line, thus flexibility can be obtained by high level of logistics and organizational complexity, which must use modern product and process information technologies, called “ digital factory”. Moreover, “ just in time” principle must be applied in supplying subassembly modules to the final assembly line.

Major factors influcing cost: direct manpower, material handling, specific logistic information technology systems. 1. 4 “ make or buy” decision In evaluation of make or buy decision, several factors should be considered: ITEMS FOR “ MAKE” DECISION| ITEMS FOR “ BUY” DECISION| 1. Availability of development capacities inside the company, at least equivalent to the one offered by External suppliers. | 1. Not availability of specific “ know how” to develop in a competitive way the specific component or service. | 2. Better protection of company’s know how in relation to products/processes considering core business| 2.

Availability of reliable suppliers for the components or services required, in relation to the company’s targets. | 3. Needs of internal processes integration by logistic flows and final product quality level improving. | 3. Availability of alternative supplying sources in the geographical areas of strategic interest for the company. | 4. Not valid alternatives to component or services purchasing. | 4. Opportunity to simplify internal production processes and focus production resouces (man power and capital) on " core business"| 5. Necessity to utilize existing productive capacities inside the company. 5. Opportunity to reduce company owned investment by using or incrementing supplier's productive capacities avaliable, assuming them the risk of volumes depending on the trend of market. | ITEMS FOR " CO-MAKERSHIP" DECISION| 1. New necissities of production capacities developing but not enough economy scale to proceed in an autonomous way. | 2. Partners have common or complementary interest in developing in a synergic and competitive way the new solutions required to guarantee the industrial mission. | 3. Partners have at disposal complementary or synergic technological capacities so that roduct/process innovation could be speed up without incrementing too much economical investments. | In genaral, an assembly plant doesn't manufacture the sub group components of the car, for the sake of lean production, technology concentration and cost minimization. So no matter whether they are outsourced or manufactured by the same industrial group of other plants, we can consider them " buy" parts. It is easy to explore these elements from the vehicle systems point of view: All above mentioned elements and systems are out-sourced and they are assembled into higher level subassemblies aside the principle assembly line.

These elements and systems are based on evolutive technical solutions, which “ know how” belongs generally to specialized companies components producers; A strong cooperation between those companies and car makers is necessary in case of technical projects development and experimentation and homologation on vehicle phases. 2. Review of tutorials and further applications of the tutorial 2. 1 General knowledges aquired from the assembly lecture During the assembly technology course, we gained the concept of automotive final assembly and aquired some basic knowleged about this process.

First of all, the difinition of automotive final assembly can be concluded from the lecture: the final manufacturing process joining all of the finished subgroup components and modules to finish the car and make it functionlized, through different stages of assembly process with the right consequence. The final assembly process should consider from both management point of view and technological point of view: management concerns main subassembly groups and modules Here we consider the assembly of only these components in order to simplify the process.

Also, some subgroups assembly are introduced in the lecture, which are normally performed inside the final assembly shop but not on the principle line. These sub-assembly parts should be considered since they are not out-sourced but manufactured inside the plant—stamping shop. So we won’t get the finished, assembled parts until we assemble them by ourselves, inside the final assembly shop. Along with subgroups assembly, ergonomics concern is introduced, which is a non negligibly problem in setting up the plant. Ergonomic: a). A study of the relation between people and their workenvironment. b).

Is used to prevent injuries and illnesses associated with the design of physical work. c). Is used to increase employee safety and comfort and to optimize work performance and quality. Due to the complexity of the system and inconvenience caused by the huge weight of the body in white and finished parts, ergonomic problem is closely related with the working stations and carrier systems that we use. Thus each process of the system uses specific equipment to orientate the car body in the right direction to technicians, and specific tools to hold finished parts to let technicians move them easily. ow conveyors let the installation of suspension more easily Moreover, the right sequence of final assembly is introduced. I will strictly follow this sequence to develop my assembly shop, because any mistake in sequence makes it impossible to build up later steps and lead the entire process tofailure. Then I will build up working time analysis. 2. 2Extension of the tutorial 2. 2. 1 product breakdown structure(PBS) ; bill of material(BOM) Product breakdown structure is hierarchical and can be represented by the following scheme(tree diagram) F A B1 B2 C21 C13 C12 C11 E D F A B1 B2 C21 C13

C12 C11 E D In which: A= final module (a car) B= 1st level subassembly (powertrain, suspension system…) C= 2nd and 3rd level subassembly (complete engine, transmission…) D= completed elements (cylinders, engine shafts…) E= partially completed elements (pistons, valves…) F= raw materials Using PBS, it is possible to: a). Manage the designs and standard carry-over solutions with other product lines. b). Underline links between elements, subassemblies and final product. c). Precise “ make or buy” decision for each element. d). Activate manufacturing engineering plan for “ make” parts.). Activate purchasing orders for “ buy” parts. f). Confirm cost for module components, considering the targets defined in the setting phase, according to the purchasing management system. Now let me define the PBS of the final assembly. I won’t list the lower levels of subassembly parts because the final assembly area is responsible for assembling more than 3000 in/on the painted vehicle shell, and if I focus too much on the minor parts, it would draw the attention away from the study of the system. Also, I extend the content of PBS, to get a bill of material table, more detailed. . 2. 2 work breakdown structure The work breakdown structure is a tree structure, which shows a subdivision of effort required to achieve an objective. In order to reach the WBS, I need to analysis each working processes first. The following figure is what I have obtained from the internship report. All of the data in this figure is roughly estimated, but the sequence and layout of final assembly is expressed. Final assembly process can be functionally divided into: trim line assembly, chassis line assembly, final assembly and final testing.). Trim line assembly This station is focused on installing the following main components: the electric wiring and harnesses, the shell insulation and radiator insulation, the air duct system, the headliner, the condenser sub-assembly, the pedal sub-assembly, and the fire wall insulation. Other parts are also installed in this station such as the wiper links and the washer tank and its hoses and connections. To install the above described parts, a different conveyor system is adopted from the ones used in the paint area.

So the shell is transferred from the paint-line conveyor system into typically a double rail chain or self-moving conveyor (floor-mounted), the elevation and speed of the body-shell are adjusted so it suits the production workers and allow them spatial access and enough time to complete the job. Some manufacturers have adopted a moving belt system for the line workers so that they can keep up with higher production rates. The first step in the trim assembly area is to remove the shell doors to facilitate the installation process, so large fixtures can be used inside the shell to aid the workers.

The removed doors are hung on an overhead conveyor system that keeps running the doors through the plant without any value being added to them. A typical layout for the trim assembly area can be shown as following: b). Chassis assembly The chassis assembly area is also called the marriage area, where the power-train of the vehicle is coupled with the vehicle body-shell. To achieve this, the vehicle shells are transferred to an overhead conveyor system to permit the chassis installation from the bottom. The assembled ower-train components are supplied from a sub-assembly area typically called the engine-line assembly area. The engine-line area features all the steps needed to install the different hoses, controllers and cables to the main engine body, in addition to coupling the engine to the transmission and the torque converters. The engine sub-assembly utilizes different types of conveyance depending on the accessibility needed, the station's configuration (left- and right-side workers), and the weight of the assembled power-train; typically a combination of an overhead system and an AGV(automatic guided vehicle) is used.

The final assembled power-train is then mounted onto an AGV or a trolley equipped with a hydraulic lift, and then shipped to the marriage area. overhead conveyor and trolley with lifter In the marriage area, the vehicle shell will be synchronized with the AGV so both meet at a specific location that features the power torque machine that will use bolts and fasteners to join the power-train and shell together. Additionally, the elevation of the suspended shell is programmed according to specific settings to facilitate the mounting process. The powertrain is lifted via the hydraulic lift to meet the stationary shell.

This process sequence is shown in the above figure. Several features within the vehicle shell are typically used to guide the power-train assembly to ensure its location and orientation within the vehicle; some laser projection-based sensors might also be used to ensure accurate placement. In addition, power-tools with built-in torque sensors are used to ensure fault-proof operation. Applying the right torque is essential in delivering mechanically sound joints that will not fail or fatigue due to under-torque or over-torque conditions. A typical layout for the chassis line assembly area can be shown as following: |). Final assembly and testing area The final assembly area features the vehicle shell on tires for the first time. It is connected to the previous chassis assembly process, and each chassis assembly line can feed two final assembly lines. Thus for the sake of maximum utilization of the entire system, we set two final assembly lines. Each final assembly line is divided into three sequential parts: 1st. In the first part, preassembled bodies are put on a stop and go conveyor system, to facilitate the transferring from one station to the next.

And the bodies are arranged across the axle of the line, to facilitate front-end module assembling and to keep operations such as electric battery connections, air filter connections ergonomically. In this part fixed glasses are also assembled by automatic systems. 2nd. In the second part, car bodies are put on continuous double slat conveyor. Here, parts such as seats, garnishes, door modules, lighting systems and the rest parts of the vehicle are assembled. 3rd. In the third part, underbody operations such as adjusting the vehicle suspension and adjusting steering wheels are performed.

After the assembly is complete, the completed vehicle starts the testing phase, where the following tests are conducted: alignment tests for wheels and turning radius, headlight test, side-slip test, engine drum test, and the brake test. The alignment test focuses on adjusting the wheels through the manual adjustment of the top of the front and rear wheels and the camber of the front and rear wheels. Further alignments ensure that the steering wheel is positioned accurately. The alignment test is typically done in a chassis dynamometer chamber, shown in the figure. a chasis dynamometer

Additionally the turning radius can be tested and adjusted by measuring the right and left turning angles of the front wheels. The headlight test evaluates the photometric axis of the headlamps by projecting them on a screen and then measuring any deviations. The drum test is conducted by driving the vehicle into the chassis dynamometer to check the vehicle driving conditions. Also, the brake test evaluates the brakes' performance by applying and measuring the braking force of each wheel (drag, service brake, parking brake). Finally, I can obtain the WPS from the integration of each above process. 3.

Time analysis and relative calculations 3. 1 working time analysis(takt time, number of workers) In order to analysis the working time, I shall introduce the concept of takt time first. The takt time is the time that must pass between two succeeding unit completions in order to meet the demand, if the products are produced one unit at a time, at a constant rate during the net available work time. The value of the takt time drives the key design choices for the assembly system. The takt time is defined in equation (1). (1) When the takt time is known one could decide how many assemblers and stations that are needed.

It is quite hard to determine the number of assemblers needed in order to complete a product but here one basic method is presented. After the number of assemblers has been decided the number and layout of processes can be decided. The minimum number of assemblers can be calculated with equation 2. (2) If for example a product takes 100 minutes to assemble and the takt time is 1 minute, the process needs 100 assembler minutes every minute, consequently 100 assemblers. The formula does not take into consideration other activities that the operators perform apart from assembling such as picking and handling.

A production system is also dependent on support labor which will of course increase the number of assemblers needed. When one has determined that the process is in need of 100 assemblers, the next step is to decide in which way the work should be allocated between the assemblers and thereby which method of assembly that should be used. On the one hand, one operator could work with one product from start to finish for 100 minutes. On the other hand, the total work content could be divided into 100 operations each taking 1 minute to perform.

Now that the takt time concept is clear, I will start to analysis this according to my specific system. Actually, the first step in designing an assembly system is to calculate the takt time. I will calculate the takt time following these conditions: 1). The demand for daily production volume is 1300 units. 2). The system is operated by 3 shifts of operators. 3). The working hours per day for an operator are assumed to be eight hours. 4). Total downtime including scheduled and unscheduled maintenance, set-up times, breaks, lunch time is one hour per day.

Takt time = Net avaliliable working time per dayaverage damand per day = 3*8-1*601300 = 0. 97 minute = 58 second The planned cycle time will be lower based on that there are inefficiencies regarding manpower issues and overall equipment effectiveness: Planned cycle time = 58*0. 85*0. 9 = 50 second Then the minimum number of workers can be obtained, under the assumption that the total assembly time (adding the time deeded of each operation in each station, i. e. : the labor time required in order to finish the assembly of a single vehicle) is 21 hours (empirical).

We can assume that each operation is processed by an assembler because the final assembly is a labor driven process. No. of workers = total assembly timetakt time = 21*60*6058 = 1304 Thus, we have 1304 workers and if two workers are assigned to each work station, then we have 652 stations. Due to impossibilities for further analysis of working time, I can not get exactly the cycle time of each operation, but the time analysis methodologies should be stressed: a). Stopwatch study analysis For time measuring it is necessary to proceed as follows: 1).

Workers are preventively trained to apply working standards and are informed about stopwatch study analysis and ways to proceed. 2). By statistical criteria, the number of operative cycle to observe is determined, considering also dispersion phenomena of analyzed process. 3). For each one of the macro-phase of operative cycle, time employed is recorded. 4). Working speed is punctually compared to the normal one, introducing eventual adjustment. 5). Time adjustments(increasing) for each working phase are applied following specific tables, to consider tiredness and physical efforts taken on during working shift.

Applying the methodology is possible if the analyst is concerned about technologies of analyzed phases, in order to ensure in advance that working conditions follows manufacturing engineering plan, and proposing eventually necessary improvements. He must also observes movements considering ergonomics, defining normal and sustainable working speed. This evaluation implies also the application of specific rules related to physical efforts, tiredness, working positions and movements repetition.

As a consequence, for each working phase analyzed, it is applied a time increasing coefficient, according to a standard table, elaborated on statistical and scientific considerations, by International Rules Institutions, with ergonomic, physiology, and working means experts associated. In case of uncertainty of working speed estimation, the analyst could perform observations on different subject, up to reach a calibrated evaluation. Furthermore, he can also use some available database, according to previous consolidated experiences.

For each group of operations, it is important that the experts separate active times from inactive times necessary for machine/equipment waiting or movements between different working stations. Actions to be adopted are related to inactive phases, that are not adding value phases. b). Time studying with modern techniques Same criteria of the first one, with the only difference that time observations are performed through video recording cameras, appropriately positioned and remote controlled, that allows measuring contemporary more operations, relating each other. c).

Analysis with pre-determined standard times MTM technique (Methods Time Measurement) consists of previously analysis that allows quantifying time necessary for each working micro-phase included in the operative cycle. Measurements are performed in office and are very precise and objective. Application requires a big effort in terms of analyst technician, with high cost and long elaboration times. For this reasons MTM technique fits with widespread repetitive operations. d). Instantaneous Observations Analysis It fits for auxiliary operations only, including office operations.

It is necessary that the analyst have good knowledge about function and roles of observed employees. He performs periodical inspections In the interested area and with established route by statistic method, so to cover all workplaces. He must evaluate: if workers are on their own workplace/if they are active/type of operation performed/type of tools used. 3. 2 system length and area calculation I will roughly calculate the length of the final assembly line. I say " roughly" because I will assume the distance between each product is 5m, and this distance is constant for all the three major processes belonging to final assembly.

Although this assumption couldn't be precise, this approach can represent the right process to calculate the system length. Firstly I will calculate the speed of the line: Speed = distancetakt time = 5m/58s = 0. 087 m/s Then I will apply this speed to the total assembly time: Length= speed*total assembly time= 0. 087m/s*21*3600= 6577m Finally, I should apply an modify coefficient, because large portion of the system paths are built for transferring, not value adding. 6577*150%= 9865m Once the length is calculated, I can apply it to the width of the line, which is hypothesized to be 10m. 865*10= 98650m2 And finally the subassembly line area should be calculated according to the same method, and added to the main line area. 3. 3 facility layout In arranging the plant layout, There are a lot of benefits: 1. Minimize the production time. 2. Minimize the production cost. 3. Minimize the material handling, in terms of time, cost and equipment type. 4. Minimize the investment in the equipment. 5. Utilize existing space more effectively. 6. Maintain flexibility of arrangement and operations. There are three basic types: process layout, product layout, and fixed-position layout.

According to the selection criteria, I will choose the product layout. A product layout (also called a flow-shop layout) is one in which equipment or work processes are arranged according to the progressive steps by which the product is made. The main issue over the final assembly line is the assembly line balancing. As we use the conveyor systems to carry the product, the time interval the product will stay in each workstation is identical, thus the cycle time of each workstation is identical as well (= 58s in our system).

At each workstation, work is performed on a product either by adding parts or by completing assembly operations. The work performed at each station is made up by many bits of work, termed tasks, elements, and work units. The total work to be performed at a workstation is equal to the sum of the tasks assigned to that workstation. The assembly-line balancing problem is one of assigning all tasks to a series of workstations so that each workstation has no more than can be done in the work- station cycle time, and so that the unassigned (that is, idle) time across all workstations is minimized.

The problem is complicated by the relationships among tasks imposed by prod- uct design and process technologies. This is called the precedence relationship, which specifies the order in which tasks must be performed in the assembly process. The steps in balancing an assembly line are straightforward: 1 Specify the sequential relationships among tasks using a precedence diagram. The diagram consists of circles and arrows. Circles represent individual tasks; arrows indicate the order of task performance. 2 Determine the required workstation cycle time, the same as takt time Determine the theoretical minimum number of workstations required to satisfy the workstation cycle time constraint using the formula, the same as the number of workers calculation. 3 Select a primary rule by which tasks are to be assigned to workstations, and a secondary rule to break ties. 4 Assign tasks, one at a time, to the first workstation until the sum of the task times is equal to the workstation cycle time, or no other tasks are feasible because of time or sequence restrictions. Repeat the process for Workstation 2, Workstation 3, and so on until all tasks are assigned. Evaluate the efficiency of the balance derived using the formula Efficiency= sum of task timesactual number of workstations*workstation cycle time 6 If efficiency is unsatisfactory, rebalance using a different decision rule. Example: This table shows typical chassis assembly sequence of a car, and I will draw a precedence graph according to this table: Then, we can calculate the minimum number of workstations required: no. of workstations= 45+50+11+15+9+12+12+12+12+8+958 = 4 So we can arrange the precedence graph accordingly: And the final Efficiency= 1954*58= 84%

It can be seen that in station 4, only 9 seconds are employed among 58 seconds available time. To reduce this inefficiency, some independent operations can be added to this station. In this final assembly shop, we should analyze the work of all workstations, one by one, and reach a balanced assembly line finally. 4. Tool and equipment selection The final assembly area is considered a labor-driven process due to the high labor value-added work compared with other stations in the assembly plant. In this case, the right solution for labor and machine corporations is the key successful factor.

Trim line: For the trim line assembly, the conveyor system should be changed from the one used in the paint line. We use the floor-mounted conveyor for the trim line and specially, I want tostressthat since the plant should has a high production capacity, I choose to add an additional moving belt system to facilitate the workers for the high production rate. Moreover, for operations that will move heavy parts(doors, cockpits, windshield...), automation robots are selected instead of human labor. Robots are faster and more precise in installing heavy and big parts than human labor.

For wirings, insulating applications, fuel tanks, steering leverage and etc. , I will choose to use human labors because these operations are too complicated for robots, and some area are deep inside the body shell and intangible for robots. On the other hand human labors have the advantage of agility, allowing them to go inside the body shell. In addition, batter-driven screwdrivers(low and medium torque models) should be equipped by the assemblers, to allow them fast and accurate fastening. Here are some pictures of the above mentioned tools and equipments: loor-mounted conveyor with moving belt Chassis line: For the chassis line assembly, the overhead conveyor system is needed to lift the vehicle shell and thus allow the installation of the powertrain system. In order to guide the pre-assembled powertrain system, the AGV(automatic guided vehicle) is used. At the same time battery driver screwdrivers and electric torque wrenches with torque limiters are used by workers to assemble the body and the powertrain system. Also, in order to ensure accurate placement, some laser projection based sensors are needed.

Then the installation of wheels and exhaust system happens simultaneously. On the one hand line workers install exhaust system with the help of carrying robots. On the other hand multiple torque wrenches tightens the wheel. Of course tires must be handled with the help of the handling equipment in order to save time for the line workers. This process can spares much time for the powertrain assembly. The overhead conveyor system and the AGV. A multiple torque wrench is fast and precise A electric torque wrench with limiter A tire handler Final assembly line:

The vehicle is coupled with tires now, so a double slat conveyor system is selected to carry the body. In addition, a variety of arm and drop lifters are needed for the ergonomics consideration. Also, fluid filling machines is crucial in this stage: fuel tank, engine, transmissions… For the testing phase, we need testing machines. For example the chassis dynamometer is necessary for the alignment test, the turning radius test and the break test. The headlight test evaluates the photometric axis of the headlamps by projecting them on a screen and then measuring any deviations.

A double slat conveyor A chassis dynamometer A seat handling partner References: 1. COZZARI GIULIANO, Assembly technologies, 2010. 2. MARCO GOBETTO, Production Management, 2010. 3. Mohammed A. Omar, “ THE AUTOMOTIVE BODY MANUFACTURING SYSTEMS AND PROCESSES”, 2011 4. FILIP HELLMAN, BJORN LINDAHL, JONAS MALMBERG, thesis of “ Mixed-model assembly line at Volvo Construction Equipment” 5. Marshall L. Fisher and Christopher D. Ittner, “ THE IMPACT OF PRODUCT VARIETY ON AUTOMOBILE

ASSEMBLY OPERA TIONS: ANAL YSIS AND EVIDENCE” 6. technical note five: FACILITY LAYOUT