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ROBOTIC AUTOMATION ON COMPUTER NUMERICAL CONTROL MACHINE

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Abstract*. Along with the advancement of robot technology, Computer Numerical Control (CNC) machine robot automation is becoming more popular. While some Computer Numerical Control engine process independently with a part catcher, a perpendicular granting center requires an extraneous individual to keep the engine processing. Collective and Mechanical robots be the main options for robotize perpendicular Computer Numerical Control grating machines. This study aims to specifically investigate and find the most effective type of robot to be used as a machine capable of maintaining the Haas VF-2 perpendicular crushing center. The method used in this study is the Overal Equipment Effectiveness (OEE) model approach with five different actions, starting with scope, unit setting, evaluation, fee calculation, and integration of the evaluation to present the value of each cell. The purpose of the model used in this study is to determine which robot is more effective for use in industry.*

As the result, this study demonstrates the important difference between the robot cells on the site and the overall effectiveness of the equipment, besides that the fee differences in the production of robot cells are not too large, but if the focus is on adding robots then the fee differences must be considered carefully. The hazard assessment proved surprising. This study shows that the risk factors in VF-2 treatment using cooperative robots and mechanical robots can be ignored. The impact of takt time also has an important role. Taking each factor into account for the production machining of the VF-2 mechanical robot is more conducive to use because its performance level is almost two times better and in terms of use, it is also much safer. For future work, maintaining a continual level of danger estimate during working on various parts is a very important thing to pay attention to. In addition, when the geometry and materials of machine parts are developed, the collective allocation is no longer valid, so danger estimates must be carried out more carefully to ensure operator safety.

Keywords*: Robotic Machine Automation, Computer Numerical Control Machines, Overal Equipment Effectiveness, Mechanical robots.*

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INTRODUCTION

Sophisticated software and hardware are starting to enter the realm of robotics in the current era of industrial manufacturing. Automated robots are capable of performing various human jobs like employees. Robotic automation here also includes the initiation of manufacturing development design with complete mechanization in mind. In terms of manufacturing, there are two types of robots, one of which is the mechanical robot which is a “reprogrammable multifunctional manipulator designed to move materials, parts, or specific devices through variable programmable motions for the performance of various tasks” (Odrey et al,. (Odrey et al., 2008)). Mechanical robots consist of controllers, batteries, and robots. In one robot 6 panels are controlled by electric motors. Robots have been used to automate production on a extensive rate since 50 years ago, the use of robotic automation is mainly in the automobile and electronics fields. “In 2010 the second form of the robot was introduced to the manufacturing industry, that is universal robotics is the first cooperative robot made” (Othman, 2016). The automotive industry is also rapidly finding uses for new technologies. Odrey et al. (2008) describe a cooperative robot as “a robot specially designed to direct interactions within a defined collaborative workspace”. Compared to mechanical robots that require additional fence security, cooperative robots can work like humans, and have a large work area and potential.

In the standard process, there is a difference in this research for selecting the best type of robot that is objectively effective for performing various jobs. As the creation of Computer Numerical Control is treated to be the backbone of the manufacturing industry it is crucial to analyze the biggest efficient ways to efficiently automatize the engine. In this study, there are two types of solutions proposed to automate Computer Numerical Control machine maintenance, this study will describe the process of achieving a reliable solution to determine the most effective type of robot. The research hypothesis is "if a company wants to automate Computer Numerical Control machine cells, then the best way to take is to use mechanical robots as opposed to collaborative." To control the expectation, an essential activity will be set up to measure the crucial factor of the engine maintenance cells.

LITERATURE REVIEWS

With present robotic technology, it is available to automate around sixty percent of the Computer Numerical Control labor input of machine maintenance (Othman, 2016). Increasing automation will increase productivity and quality in machining processes while saving fees. In a study by Iwona et al., (2016), seeing a piece media report line decreased fees by fifty percent during the productivity expanded by thirty percent and application by eighty-five percent. The study literature proposes not automation will develop machining operations that presently require constant human input. Opportunities from this literature arise since the excellent way to robotize the machine supply measure by present technology and a suitable decision-making method is selected. There are several forms of production metrics, some of which are used to compare the effectiveness and capacity of symbiotic robots versus mechanical robots and there are a lot of metrics that have been completed to review the adaptability and capacity in plant manufacturing.

This research will focus on two forms, namely the evaluation of effectiveness (Asset Utilization) and productivity (Overall Equipment Effectiveness). Asset Utilization is "the actual output ratio that can be achieved if the factory operates at maximum capacity for 365 days a year producing 100% quality products" (James, 2017). “Overall Equipment Effectiveness is used in angular manufacturing to see availability, performance, and quality" (Sergio et al., (2015)). Aurelien, (2013) demonstrated the use of Overall Equipment Effectiveness to measure the changes that occur to increase the efficiency of the stamping machine. Overall Equipment Effectiveness demonstrate a fifty percent gain subsequently angular manufacturing and Total Productive Maintenance innovation were implemented. The persuasiveness of equipment equally Computer Numerical Control machines comes from the angular investigation of the work and quality. Furthermore, this data is summed up as a percentage expansion in Overall Equipment Effectiveness. Studies on "asset Utilization" by Richard (1998) and "Overall Environmental Equipment Effectiveness as a Metric of a Lean and Green Manufacturing System" by Sergio et al., (2015) explain the "capability to determine metrics on the productivity and capability of constructing processes, but in this research".

Iqbal et al., (2016) discussed the ability of mechanical automation to robotize applications equally in machine maintenance, painting, and assembly. The literature on robotic arm procedures is highly technical and does not address barriers to integration of the arms industry, including guardrails and hazard assessment. Furthermore, Iqbal et al., (2016) do not provide Overall Equipment Effectiveness or Asset Utilization Evaluation and do not specify how mechanical robots can affect performance or production quality in the industry and add value as an automation tool.

METHODS

In this study, the method used has several actions of the process. The first action in the method used here is to determine the scope of computer numerical control machine maintenance cells for this study. The second action is a separate two-cell arrangement calculated to meet the industry blueprint for safety although meeting functional machine maintenance is a necessity. The 3rd action is the assessment of the output in the determined cells by adopting the Overall Equipment Effectiveness model. Furthermore, 4th action is the calculation of the fees identical with different cells, and the last action is the interpretation model which will be unified into the global assessment estimate which produces a value for the different cells to regulate the most capable robotic system. Below is more discussion, the Overall Equipment Effectiveness model was determined to include service utilization in the availability division, even if the asset utilization comes into the fee, and will show the characteristics between robots and human machines that treat it highest completely.

For these robot-to-robot comparisons, Overall Equipment Effectiveness in the procedure will be sufficient to regulate that robot in competent enough. 1st, the unit consist of one Computer Numerical Control machine, the Haas VF-2-SS. These are the available vertical mills available in the research geographic area. In addition, the unit consist of the raw material area that the robot will use to extract material to run the machine. Post-machining, the coordinate measuring machine will be used to validate machine dimensions. After inspection of the Coordinate Measuring Machine, the robot will have the completed parts in either the pass or fail areas. The last item in the unit is a robot. Core components along with the Haas VF-2, Coordinate Measuring Machine, and component repository field will remain unchanged during robotic and the safety base will change accordingly.

2nd, the robotic cells will be directed to adopt the "Fanuc robot". That architecture development will consolidate the security essential for the unit to be quite useful according to mechanical robot specifications. The other robots "Universal Robotics UR10" are comparable to both Fanuc's robots and are considered the most proportionate in size and payload, the main contrast falsity only in the capability to perform in combining versus industrial unit settings. Both robots share the same architecture, data processing, and control panel. 3rd is Overall Equipment Effectiveness will be adopted to study and the strength of different cells will be analyzed. This action will follow existing industry standards. Overall Equipment Effectiveness is an old metric adopted to assess the strength of production equipment. Overall Equipment Effectiveness consists of 3 parts: accessible, performable, and quality. The detail of different sections is influenced by Overall Equipment Effectiveness and by the ratio for different if 3 -sections, Overall Equipment Effectiveness is determined.

4th, the fee of the different cells will be determined. This will combine the robot's financial fees and security considerations. In addition, other unit items including Computer Numerical Control machines and Coordinate Measuring Machines are set as constant values for creating machining cells and values as reference points for robot assimilation fees. Hypothetically, if the different fee of the symbiotic robot was 2x expensive as that of a mechanical robot, it seem significant. Nonetheless, if neither is significant comparative to other fees, this will matter less in the overall decision of which robot to use. This is an example and will be calculated in the fee section. Finally, the analysis will be adopted to recognize the outcomes of different actions summing up the strength of different robots. The 3 main estimate factors are fee, authenticity, and safety. In addition, hazard assessment is taken into account to consider security issues. The unity of all above actions will be combined with all factors of the development and will help all estimate. An executive survey was also conducted in the Computer Numerical Control manufacturing industry to approve the expectation about which factors are the most significant.

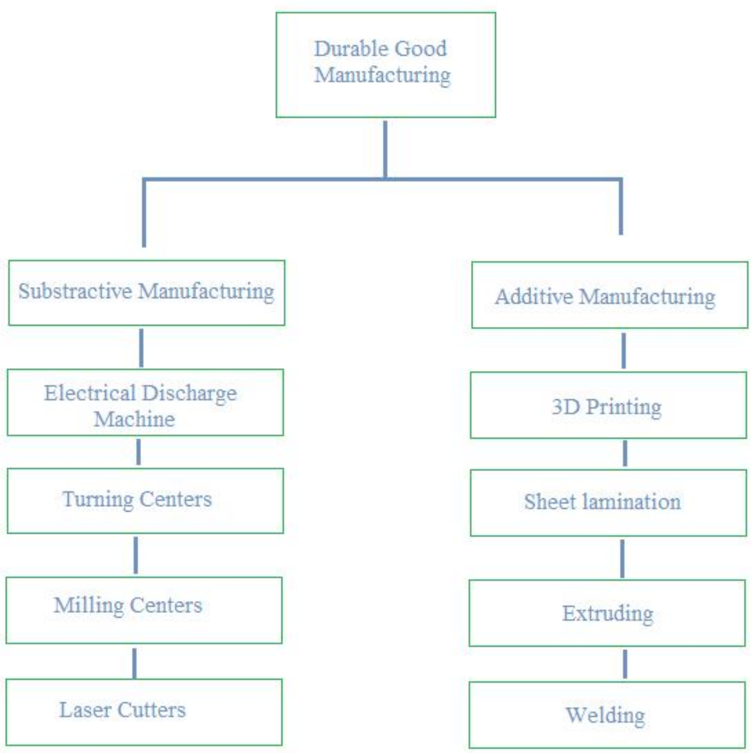


Figure 1. Concept Map

Outlook

The outlook of mechanization is a robotic machining cell. The 1st element to analyze is a Computer Numerical Control machine. In the Computer Numerical Control class, there is a lot of category of machines that can produce spare parts and be automated by the "Fanuc" robot. The term Computer Numerical Control desired elected dismiss to the outlook of this project. constructing has two types of goods, these are durable goods and non-durable goods. Durable goods such as a car or furniture parts. Non-durable goods include items such as food and beverages. To focus of this study, machines in the dependable equipment class are of concern. In durable goods constuctive, Computer Numerical Control machines spill into the class of preservative or subtractive manufacturing.

"Additive Manufacturing is a procedure of adjacent materials layer by layer to develop 3D objects" (Iwona et al., (2016)). **"Subtractive Manufacturing"** opening by the strong set and eliminate stuff. Usually, the raw set of material is chased and cut to length. This process was unified into marked mass in the 1940s and is used to make parts that are continuous and appropriate. "Subtractive Manufacturing" is most effective when creating simple geometric parts with a low level of complexity. Subtractive creation limitations exist when the section has square corners or is within features. In addition to removing material, "subtractive manufacturing" is a bit pricey. Genetically when composing subtractive procedures, materials removed in the process are treated as misuse and accordingly add to the fee of the final product. Figure 1 illustrates a durable goods concept map. This is a capable process for creating hard conditions, because of this subtractive automation of constructing Computer Numerical Control perpendicular crushing machines be the focus on this study.

Data

The item of manufacturing activity for this study is a simple calculation and will be fabricated by adopting the subtractive method of perpendicular crushing centers. Table 1 is a brief adaptation of the full list of the data contain the values for robotic auto-machining cells. Combined in the table are the specialized specifications for the items in the cell. One big deviation of it is shown in the table 2, the difference in weight and max linear speed of the 2 different types of robots. Mechanical robots have an estimated maximum speed that is 3x faster than cooperative robots. These unit data sheets will be adopted later in unit architecture to exhaustive an exposure estimate.

Cell Data List		
Item	Value	Unit
Part Weight	<3	lbs
Part Size	3x3x3	(LxWxH) in
Space	<150	ft^2
Usage/Week	<60	hrs
Time	24/5	Hours/Day
Industrial Robot Max Speed	36	ft/s
Collaborative Robot Max Speed	6	ft/s
Effective Mass	<8	lbs
Robot Reach	36	inches
CNC Table Travel	30x16x20	(XxYxZ) inches

Table 1. Unit Data List

Introduction to Unit Design

With a defined scope, a machining unit is created. The model have 2 objectives consecutive to the type of robot, whether is it ideal or not for automating Computer Numerical Control machines. The first design function is to ensure that there is sufficient space to complete the assignment. This consist of the separation of relatives of objects that are close together. Second, validate design safety in the design of hazard assessment. By the analogous location of factors in the design of a plan, the design can be used to anticipate the areas of consideration to the operator. Hazard assessment is 1 of the biggest focus points of this study. Risk is especially important in a manufacturing habitat where the operator is close to the hazard. Hazard assessment performs risk study at entire area along the automation process.

Unit Design Floor Plan

The focus of this study is to analyze which robot is most effective in completing machine maintenance tasks. The floor plan was advanced to establish the practicality of the factors functioning as a method. Adopting the 2D Solidworks, the different stuff is weary to scale and defined in a 2D floor plan. When assimilation factors into the system, their reach and direction are the biggest attention. For different individual cells, the base joint range, J-1 as a full circle. This is important to recognize because once the robot goes around in a circle it will reach its limit. Another way of thinking is that the robot can rotate plus or minus half of circle degree from its center line. This rotation curb set up a dead zone in the robot's counters.

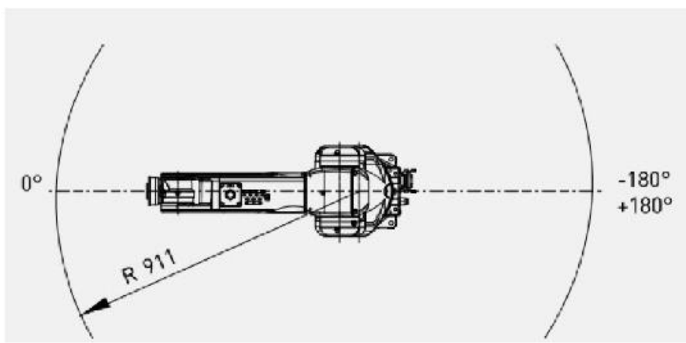


Figure 2: Robot Rotation

The gap of computer numerical control machines is completely composed inside the oven. Its orientation is a key consideration when incorporating it into a floor plan. A Computer Numerical Control machine conceivably reflection of abake stuff, it has a door on the front and it has to be put in speculation of this port. Accordingly, a Computer Numerical Control machine will have the opposite direction on the rear edge of the unit as a microwave normally faces the kitchen wall. Part of the machines have exclusive directions but the Haas-VF-2 has a front center door. The Haas orientation provides a Visual of the Haas engine and dimensional directions (figure 3).

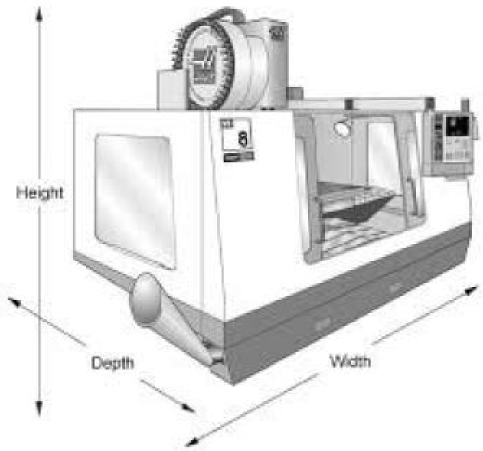


Figure 3. Haas orientation

Guardrails are the essential characteristic of collaborative and industrial unit designs. This results in a more linear floor plan to consume. In a manufacturing skill, the size of a quadratic is constant and has an advance value, so it will most likely be considered negative, representation of the guardrail is shown in figure 4.

Figure 4. Safety Fence

In additionthe correlation and comparable linear measure value of the different cells (table 2). The Collaborative unit has an opening box Record rate of 103 sqft but it is repeated because some of the space around it is not applicable to the another uses. The new site size with more square and oval shapes has a total of 116 square feet. In each area consumed each unit was drastic, this is owing to the necessary weal fences around mechanical robots required to acept satisfy risk estimate value. Collaborative cells have a site that takes up thirty-nine percent of the modern unit site. This is an important diversity in a minor production facility.

Space Usage Comparison	
Robot Type	Sqft
Industrial	296.33
Collaborative	116.17

Table 2. Comparison of Space Use

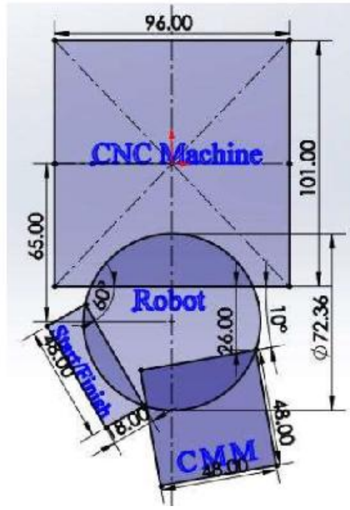


Figure 5: Collaborative unit Floor Plan

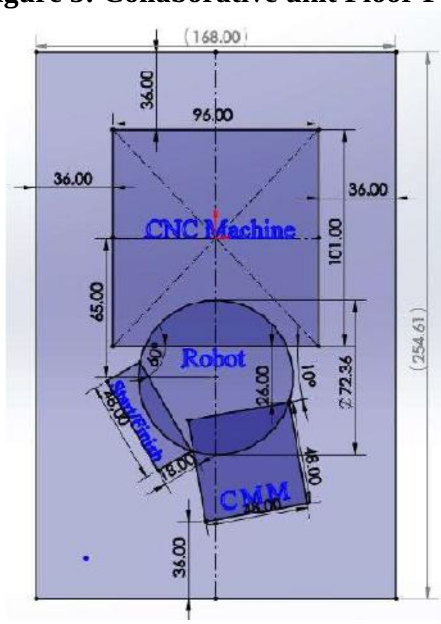


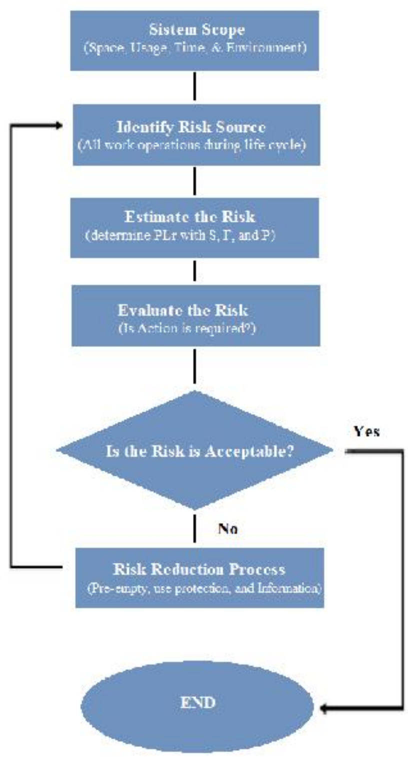
Figure 6: Plan of Industrial Cells

The Unit Design Hazard assessment

The context of hazard appraisal is the awareness, calculation, and hazard assessment of the level of hazard tangled in an area, an analogy with standards, and the selection of familiar risk levels. To comply with the ISO, all single stuff exceed the hazard assessment process from the manufacturer. Nonetheless, when straightening through these items, an additional hazard assessment must be carried out to ensure the safety of the entire automation system. Risk estimate is a 4 to 5-step process depending on whether the identified risks are adequate. The scheme described 4 actions required sequentially. If a 5-action for compressing risk is required, the process must be followed for the planned execution as well. The outlook must be detailed first. The quest to find outlook consist of “What does the project or system include?” or "Who will interact with him?" Referring to the earlier outlook category, the details of this outlook have been predetermined. Furthermore, it is necessary to identify the various potential risks that operators may face in completing autonomous machining unit support tasks. Standard and redundant operating procedures Tight safety layers cut down sources of hazard that may result in permanent injury. In Table 3: The 5 biggest risks identified for different cells were the files for more calculation. 1I is the 1st risk in a mechanical robot unit, and 1-C is the 1st risk in a cooperative robot cell. 1I is a risk that is mainly impacted by the operation of a Computer Numerical Control machine that is not related to robots. When a job is done in a Computer Numerical Control plant. Because of the complexity establish in productivity, diverse occupation can be made having a variety of raw material sizes and finished part geometries. The specifics associated with each unique job may require specially modeled jaws. This is an example of the function involved in a commutation engine. The different robots independently go through the same turnover as stated in twenty-one and 2C. If Parts vary in size, the gripper spokes can be isolated by the 2 screws on different side of Supplements for greatet gripper finger contours.

Risk Identification		
Op #	Operation	Risk
1I	Changeover of CNC Machine	Dropping tooling, breaking tool, crashing machine, pinch points
2I	Changeover of Robot	Dropping gripper, pinch points, robot crashing
3I	Changeover of CMM	Dropping fixture, pinch points, machine crash
4I	Resupply of Raw Material	Pinch points, misload
5I	Removing finished parts	Pinch points
1C	Changeover of CNC Machine	Dropping tooling, breaking tool, crashing machine, pinch points
2C	Changeover of Robot Gripper	Dropping gripper, pinch points, robot crashing
3C	Changeover of CMM	Dropping fixture, pinch points, machine crash
4C	Resupply of Raw Material	Pinch points, misload
5C	Removing finished parts	Pinch points

Table 3. Risk Identification



Gambar 7. Hazard assessment flowchart (Mathieu, 2016)

The 3rd action is the hazard assessment process. From 2nd action, a total of 10 process containing risks was consistent and presented in Table 3. The hazard assessment looks at different operations and regulates a lot of values that lead to a Performance Level Rating. The Performance Level Rating value is derived from 3 parameters (harshness of the injury (S), the density of liability to the hazard (F), and the likelihood of elusive the hazard (P)). S is defined as 1 of 2 values, it is: S1 is a minor injury, usually fluctuating and S2 is a genuine injury, usually irreversible ensuing in death. F indicates the level of frequency and duration of exposure to language in a person. F has also defined a aritmetical value of 1 or 2. F1 is for operations with infrequent density and short hazard times during F2 is for constant operations and long hazard times. Finally, P id defined the probability of elusive the hazard. P1 illustrates it is available under certain circumstances during the value of P2 indicates more likely and almost impossible.

Value with P, S, and F labels is for 10 activities (table 10). The S values in all 10 activities are purposeful to be Lv-1 whereas in column F the values are all Lv-2. The reasons for Lv-2 for each activity are generally different. The regularity of having and being classified. Accordingly, a transition as 1I only can be done on opening but during it does occur the engineer can allocate a significant total of time to process the engine if a new part is being built. Whereas the 5I risk is adverse, this risk is more common when the engineer might remove part of the unit after a shift.

Risk Evaluation				
Op #	Operation	S (Severity)	F (Frequency)	P (Possibility)
1I	Changeover of CNC Machine	S1	F2	P1
2I	Changeover of Robot Gripper	S1	F2	P1
3I	Changeover of CMM	S1	Γ2	P1
4I	Resupply of Raw Material	S1	F2	P1
5I	Removing finished parts	S1	F2	P1
1C	Changeover of CNC Machine	S1	F2	P1
2C	Changeover of Robot Gripper	S1	F2	P1
3C	Changeover of CMM	S1	F2	P1
4C	Resupply of Raw Material	S1	F2	P1
5C	Removing finished parts	S1	F2	P1

Table 4. Hazard assessment

By adopting the values on Table 4, hazard assessment schema (Figure 8) is chased by the completion of the hazard assessment mode. On that schema, an operation for severe risk potential advantage to high risk, careless of likelihood. So, the mechanical robot unit needs a safety block to make it available for the operator to work at full speed in robotic proximity. Nonetheless, during performing a switch operation, the robot can take into a protected teaching mode that bounds the speed and sensitivity with that the robot stops moving. This outcome is a devaluation in the severity of the injury. For a cooperative robot, the recognition, learning, agility, and awareness is continual meaning the robot does not pose a severe hazard of disagreement at different time. So, the Robot does not need a safety fence to get an acceptable hazard assessment rate.

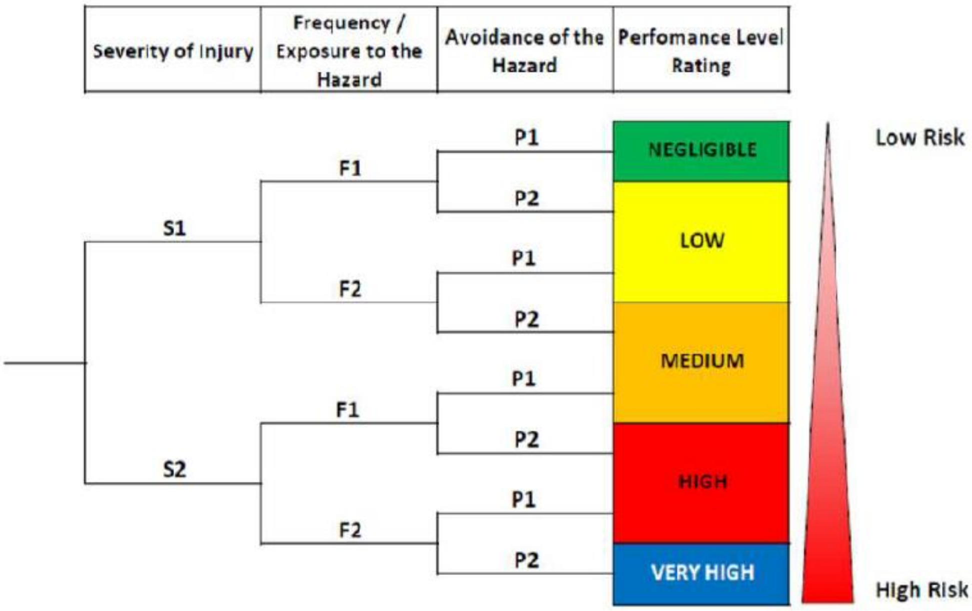


Figure 8. Hazard assessment Flowchart (Mathieu, 2016)

The results of the hazard assessment are in Table 5. Adopting the capacity to analyze the operations that need to be maintained unit continued, the hazard are consistent in Table 3. Next, a hazard assessment table is made to establish and regulate the P, F, and S levels for different operations. By this data, the hazard assessment flowchart determines the level of hazard for different operations, totaling up the hazard from the mechanical system. The final action in the hazard assessment process is to set a threshold for what level of hazard would be tolerable and match it to the assessment level of hazard. Table 5 shows all value risks are at a low level. A low level of hazard results in a safe level of satisfaction so that no iterations are carried out to reduce operating risk. Adopting these items equal guardrails for mechanical robots, momentum and strength limiters for cooperative robots allows operations to remain at a low level of hazard assessment.

Risk Assessment		
OP #	Operation	PLr
1I	Changeover of CNC Machine	LOW
2I	Changeover of Robot Gripper	LOW
3I	Changeover of CMM	LOW
4I	Resupply of Raw Material	LOW
5I	Removing finished parts	LOW
1C	Changeover of CNC Machine	LOW
2C	Changeover of Robot Gripper	LOW
3C	Changeover of CMM	LOW
4C	Resupply of Raw Material	LOW
5C	Removing finished parts	LOW

Table 5. Risk Value

Overall Equipment Effectiveness

The target of this case is to crop dimensionally authentic parts at the minimum possible fee. Overall Equipment is an industry standard used to evaluate various aspects that affect the overall purpose of a production machine. The main concerns in machine tools are Computer Numerical Control, safety, performance improvement, and fee. With a detailed hazard assessment, the effect of each type of robot on Overall Equipment Effectiveness will be determined. The objective of the Overall Equipment Effectiveness analysis of collaborative and mechanical robots is to feature accepted and exclusive areas that can add value to production machinery.

Overall Equipment Effectiveness here is enabled to see the persuasiveness Iin unified method. A fair contrast must be made between capability and persuasiveness to understand the full value of the Overall Equipment Effectiveness standard. The effectiveness is determined by turning at what possibly can be generated correlated to the things that are produced. Overall Equipment Effectiveness provides a method for considering the various impacts essentially produced on the system. Overall Equipment Effectiveness consists of 3 groups ("availability" (A), "performance" (P), and "quality" (Q)). All categories carry equal density in the overall effectiveness of the estimation. Availability indicates the available total time of the machine that runs the applicable job. The things like change over disturb the exixtence of a method. The 2nd factor in the Overall Equipment Effectiveness equalization is performance, it will pay attention to the use of time to regulate even if the engine is still processing at a highest level. The last is quality, where the relationship between the part composed and the part produced contains good dimensions and exterior finish values. The variables for different determining values are B and A, where both variables have the same units, namely time so that Overall Equipment Effectiveness becomes a measureless rate which is often explicit as a advantage.

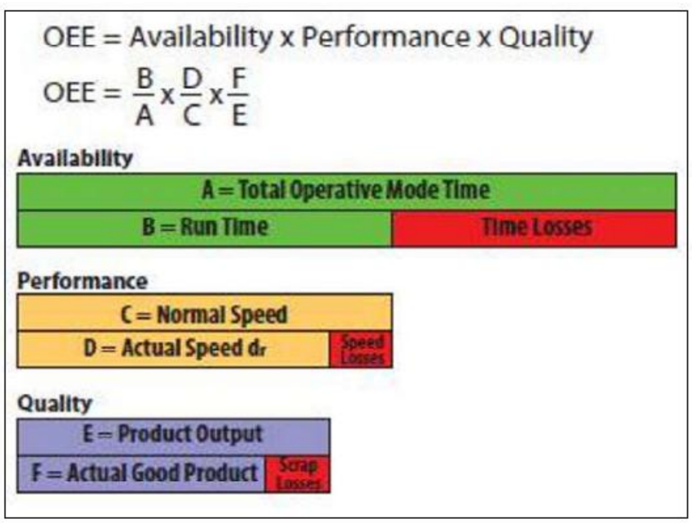


Figure 9. Overall Equipment Effectiveness Paul, (2017)

Availability of "Overall Equipment Effectiveness"

Availability is a metrical for comparing the total time an engine can process to the number of times in a day. The term "capable of walking" means, the unit has everything it needs to make parts. So now the work was set, then the material will be ready to take, and the entity can maintain the machines. The factors cause loss of time, namely: (a) turnover, (b) lack of materials, (c) equipment damage, and (d) lack of work. The waiting time (the time when a machine can be running but is waiting for an external material) is destructive to availability in Overall Equipment Effectiveness. The lost time in a week for the 2 robot cells shown in Table 6. These values differ for some reasons associated with security. Mechanical robots are directed to work in detached areas when humans will not prevent them. Now, because of this reason, mechanical robot cells are completely enclosed with guardrails. To supply materials or bring back finished parts, cells must be available then the robot will stop until the door is closed and the operator is free from the workspace cell. Just after resupplying materials or bring-back completed parts into the collaborative cell, the robot will operate under a dual unnecessary security system with speed and power limitations.

The cooperative robots can work over humans and don't need difficult fences. For this operator task, the robot does not expertise a loss of time as mechanical robots do. For the last, the time loss over unit turnover and maintenance is continual between the 2 characterize of robots. Daily and weekly keeping mission burden humans in a robotic workspace and path with closed Computer Numerical Control machines. The calculation of the availability of Overall Equipment Effectiveness involves the loss of time over the sennight versus the amount of time accessible. The robot can processing ownerless full time a day and a week. It will give an absolute operating mode time of 10,080 minutes. From Table 6 above and the ratio equation in Figure 9, the total lost time value is used to find the Overall Equipment Effectiveness value for existence. The outcome is shown in Table 7 below. Note the general percent opportunity diversity by the two variety of robots over a week. This is 4% contrast to 57% less lost collaborative time correlated with the mechanical robots.

Overall Equipment Effectiveness: Availability			
Robot Type	Hours Available	Time Lost	Availability Ratio
Collaborative	10080	570	94.35%
Industrial	10080	990	90.18%

Table 7. Overall Equipment Effectiveness Availability

Performance on "Overall Equipment Effectiveness"

The performance of a machining unit is purposeful by how fast the unit can work correlated to real-time on a daily or weekly basis. It is afflicted by all difficulties in the cell. Because of this, the performance needed for the analysis of the robot is of absolute importance. In unit automatic machining, the Computer Numerical Control machine is not modified automatically by the operator, accordingly, it is affected to be running at one hundred percent along with the coordinate measuring machine. Robot performance is associated with recurrent and speed. The recurrent of mechanical robots and cobots is the smallest and most irrelevant characteristic to have support of it. The standard on block strength for drawing parts of a dimensional strength of plus or minus in zero point double-zero five thousand inches.

The robots in this study are detailed by outlook, the differential having the same 6 joints and building constructs. The robot arm travels, and cooperative robots have limited speed because they are considered wuiet over the humans. The characteristics between max speed will decide the displayproportion of Overall Equipment Effectiveness (table 8). The speed for different collaborative connections is limited to 250 deg/sec. The building construction and robot size are the same, when the robot is programmed to move, each joint varies in speed to keep the gripper in the proper vector orientation. When the different robots have the same development so they will follow the relative tool path (same). The Fanuc Robot is programmed with "FINE" and "CNT|" points and parameters that regulate the speed limit and affects the "TCP" line. This experiment expects them to follow the same program and overlook the other programming characteristics for integrity. The analogous speed of cobots to mechanical robots is the focus of data investigation from speed to performance. It is simulated that the attached joint for the speed of the mechanical robot will be the same as that of the cobot, which means mechanical robots set a normal speed for Overall Equipment Effectiveness performance and cobots always operate at a high loss.

Robot Speed Data			
Robot Type and Joint	Industrial (deg/s)	Cobot (deg/s)	Cobot/Industrial
Robot Max Speed J1	370	250	67.57%
Robot Max Speed J2	310	250	80.65%
Robot Max Speed J3	410	250	60.98%
Robot Max Speed J4	550	250	45.45%
Robot Max Speed J5	545	250	45.87%
Robot Max Speed J6	1000	250	25.00%
Average Speed	530.83	250	54.25%

Table 8 Performance of "Overall Equipment Effectiveness"

Overall Equipment Effectiveness performance value for mechanical robots is one hundred percent even in the future it can be treated by other robots programmed in the same environment by each programming structure. The particular stuff is can't play an important aspect in this study because the innovation will be continual among 2 robots. The performance challenge has to appear from mechanical robots. The Cobot Overall Equipment Effectiveness value for Performance is fifty-five point twenty-five percent. This amount of value is necessarily fewer than the industry performance level. That 2-values will influence the overall effectiveness of the equipment.

The Quality of Overall Equipment Effectiveness

The quality regulates even if the elements produced to meet the drawings. During the part is machined, the machine should be programmed so the cutter will know which place to go and what kind of material should be removed. Drawings define all about parts consisting of the geometric dimensions and tolerances, materials, coatings, and surface finishes. The part is then checked after complete machining is complete to establish the machining operation and cut out the correct total of elements (material). Coordinate measuring machines (CMM) are used in unit robots to check the parts geometrically. Traditionally in production facilities, the Coordinate Measuring Machine and the time necessary to continue the machine are much more pricey. By this arrangement of machining cells, this classical limit is avoided. This is complementary to robots which tend to be Coordinate Measuring Machines and Computer Numerical Control machines. In addition, each part is inspected as it is machined, if any error occurs in the machining run, the Coordinate Measuring Machine will snap it and the to cut down the number of damaged parts unit can stop. This shows the different aspects of Overall Equipment Effectiveness can influence other equity. In the conventional effectiveness study, if the machine is continuously running it will show high effectiveness but with Overall Equipment Effectiveness, it will be worse to maintain running making the broken parts as Overall Equipment Effectiveness covers and calculates all elements of the process of making great parts. The Overall Equipment Effectiveness aspect condition in this study will be fairly characterized by a value of 1 among robot cells. Even if the robots necessarily improve the manufacturing aspect over the accuracy and flexibility related to the humans, this study intends to measure the robots. Adopting humans as a reference point can help to provide a connection to the situation with a present model that is adopted in some industries.

The result of "Overall Equipment Effectiveness"

The "Overall Equipment Effectiveness"dor different unit is determined. All element of value for the three categories of availability, performance, and quality is shown in Table 9. The expectations made during the computation of all of these values are extensive. Overall Equipment Effectiveness of a robot is highly dependent on the field, in which it will function and the closeness of the community. The difference in Overall Equipment Effectiveness by the opportunity as long as the robot loses while the operator is supplying the unit is not significant. This may vary in each machining environments. In calculating Overall Equipment Effectiveness the largest aspect is an achievement. Having the robot carry out at truncated quickness is quite well in circumstances where it is necessary to maintain a certain level of safety. In the case of machining maintenance, having the robot work at reduced speed to maintain a collaborative state is detrimental to the overall equipment effectiveness of the robot cell.

Overall Equipment Effectiveness				
Robot Type	Availability Factor	Performance Factor	Quality Factor	OEE
Industrial	0.9435	1	1	94.35%
Collaborative	0.9018	0.5425	1	48.92%

Table 9.The result of "Overall Equipment Effectiveness"

The Fee

Automation robot fees developin 3 forms: financial, common linear measure, and resource forms. Each form has an effect on determining the profit opportunity from investing in a new system.

1. The financial fee consists of the equipment

Equipment included in this fee are robots, Computer Numerical Control machines, and other factor items are served in Table 10. The constant fees for manufacturing unit machining are expressed. Following the fee for this equipment, the particular fee for adding in various types of the robot is specified. The fee varies for the "Fanuc CR 7id" Cooperative robot and the industrial "Fanuc LRmate 7id" is IDR22,000K and a difference of 40%. The meaning of this fee relies on the context of the system automation. If a unit is designed and constructed from space, as discussed in this discussion, this value is less significant than that of existing Computer Numerical Control machinery where robotic cells are ordinary automate. A look at the fee of the Robot relative to the standard equipment required for the machine is shown in Figure 10. These figures are generated using the values from Table 10. From these figures, collaborative equipment fees account for about nine percent of the number of instrumentation fees related to industrial cells.

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Machinery Fee		
Items:	Qty	Cost
Haas VF2 SS	1	79,575.00
Hexigon CMM	1	45,000.00
Robotic accessories	1	8,000.00
CNC Machine acc.	1	5,000.00
	Subtotal	137,575.00
Industrial Cell		
Fanuc LRmate 7id	1	32,000.00
Safety Fencing	1	3,440.80
	Subtotal	35,440.80
Collaborative Cell		
Fanuc CR 7id	1	54,000.00
Light Curtain	1	1,500.00
	Subtotal	55,500.00
Industrial Cell Total		173,015.80
Collaborative Cell Total		193,075.00

Table 10: Machinery fees

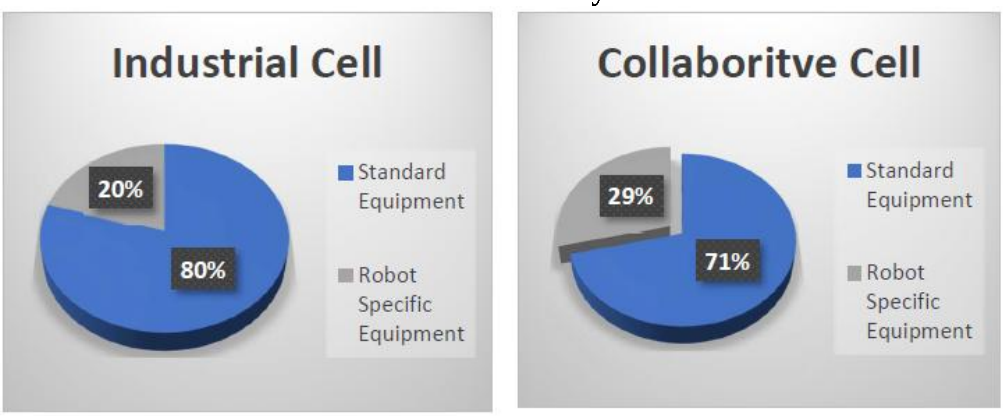

Figure 10: Proportionate fee

2. ***The fee for common linear measure in the manufacturing facility***

Rely on the easiness, the area can costly. The contrast in square feet for each unit comes from the safety fences needful to have mechanical robots. This fee is crucial to specify in fee terms. The data shows the mechanical robot unit is sixty-one percent bigger than the collaborative unit for this machine maintenance scenario. This must be weighed by a facility wishing to automate VF-2 engines to determine the impact.

3. ***The fee of integrating each of these resources within the firm will be the same relative fee***

Even though guardrails fee more to install, it fees displayed monetarily. This company resource section refers to the further power used on adjusted repairs or contrasting synthesize programs that transmit values to robots for accident preventionrejection. Such as the quality factor and Overall Equipment Effectiveness, due to different cells having the same relative fee this will not be a factor in the fee to be integrated.

RESULT

The outcome of the empirical unit investigation shown in Table 11. There is a important difference between the robotic cells on-site and the overall effectiveness of the equipment. The difference in fee to make each robot unit is not too big a difference, if cells with machines already exist and the extension of robots is the target, then the fee difference is a very important thing to pay attention to.

Results	
Cell Design: Footprint	
Industrial Cell	296.33 (sqft)
Collaborative Cell	116.17 (sqft)
Risk Assessment	
Industrial Cell	LOW
Collaborative Cell	LOW
Overall Equipment Effectiveness	
Industrial Cell	94.35%
Collaborative Cell	48.92%
Cost	
Industrial Cell Total	173,015.80
Collaborative Cell Total	193,071.00

Table 11: Results

Guardrails have a important effect on the particular complete unit site. Collaborative cells are thirty-nine percent of the industry's common linear measure, it can be decreased in different ways. For example, if two machines are bounded by one safety fence, the perimeter distance between each machine will decrease. After this, the unified technique needs to be redone to resolve the impact on risk and Overall Equipment Effectiveness. Likely, the differences seen are more meaningless and related to the generous increase in bandwidth as of the faster robots. The hazard assessment proved surprising. Marketing and talking about the value of cooperative robots are very much related to safety. This study shows that for treating having VF-2, the dangerous aspects of us adopting synergic versus mechanical robots are meaninglessThe important finding in reputale industry 4.0 towards the most powerful engine maintenance solutions. With the assigned risk value nonstop among the two samples of robots, the target engine to the global persuasiveness of the material.

The difference in the overall equipment efficiency values was the major finding of these two experiments. The difference in performance in each robot, and it have important brunt on persuasiveness. The particular two robots are related together. The brunt of (unit of time speed that must be achieved by the production team in meeting customer needs promptly) together with machining series and other aspects similarly Coordinate Measuring Machine time will also play a role. This analysis provides a reference point for studying production machining robot automation. Obviously, by considering each of these factors or research experiments, mechanical robots are more useful to VF-2 for manufacturing synthesis. Performance levels have nearly doubled although fixed lasting and justly secure if not safer danger estimate. The specific impact of work equipment also influences the danger estimate. Accepting security fences to enclose all units created this, so that workpiece differences between jobs do not require the same level of intensity to determine safety. Attention certainly still needs to be focused on the robot when automating new jobs to ensure the part matches the load capacity of the robot arm. In addition, the gripper robot also needs to apply a gripping force that is strong enough to overcome gravity and the force created when the robot moves at high speed.

Suggestion

Computer Numerical Control machine robot automation research is very important in creating a good and adequate manufacturing situation. Here several aspects of robotized perpendicular crushing machines are not closed in this study. For advice in future work is to maintain a continual action of hazard estimate while working on divergent sections. In addition, more attention should be paid to the safety fence if it is to be used as a strong durable explanation to control operators and robots securely. During the calculation and materials of machine parts modification, the collective allocation is never more accurate. The liability estimate must be carried out again with more thoroughness to establish driver security.

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