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Robotic Fettling of Cast Iron Component

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ABSTRACT

Robots in the industrial environment are mostly used for repetitive, pre-defined tasks with little variance and adaptability .Industrial robots have a great inherent flexibility due to their kinematical degrees of freedom and the versatility of manageable tools, sensors and other periphery devices. The effort needed to program and configure the entire robot system. The accuracy and working of the robot determines the result of the applications. One such application is fettling operation. Fettling is the process of removing excess material from castings. This excess material is often formed at the die's parting lines during the casting process as molten material is injected into the die at high pressure. By using a robot as a positioning tool for the fettling operation, the process can be carried out safely and with consistent results. Fettling is a highly arduous and man power intensive metal removal process. Automated fettling involves programmed motion in several axes to simulate manual operation. Fettling cells are designed specially to suit to operation requirements. They have a robust mechanical design along with state of the art electronics and software. The actual advantage of fettling cells lie not only in the fact that you can save on man power- it also increases quality, reproduces work, processes precisely and ensures that production remains flexible.

1.INTRODUCTION

Over the past two decades, automation in manufacturing has been transforming factory floors. These days, it's hard to imagine the production landscape without industrial automation systems. Growing requirements of high product quality, paired with expectations of equally high reliability in high volume production, mean that the scale of industrial automation will continue to grow. Much of what was previously produced by human hand can no longer be achieved in terms of cost and quality. Energy efficiency, mobility and security are the main challenges facing modern society. Industrial automation products address all of these needs, providing outstanding reliability & robustness, excellent quality and leading-edge innovations. Rich functionality and

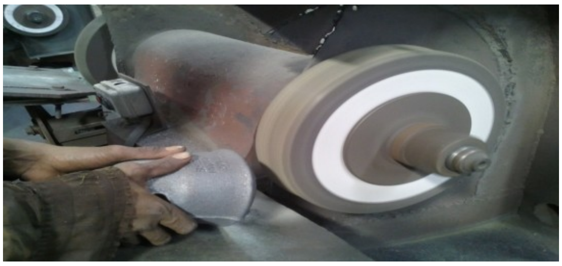
extensive integration capabilities ensure easy design-in and fast time-to-market.

Fettling process:-Metal casting (or simply casting) it based on the property of liquid to take up the shape of the vessel which contains it. The process of metal casting involves pouring of molten metal into a mould, which is a cavity formed in some molding material such as sand. The mould cavity exactly resembles in shape and size with the product to be made. After pouring, the molten metal is allowed to freeze there, taking up the shape of the mould cavity and the product is thus cast, is called a **casting**. The castings as obtained after solidification carry unwanted projections. Also sand particles tend to adhere to the surface of castings. The castings are therefore sent to fettling section when the projections are cut off and surface cleaned for further work.

Definition:-The word is derived from a root word "**Fettle**" which means to trim or clean the rough edges or to condition. Raw castings often contain irregularities caused by seams and imperfections in the moulds, as well as access ports for pouring material into the moulds. The process of cutting, grinding, shaving or sanding away these unwanted bitsiscalled **"Fettling."*Fettling*** is the ***means*** by which a crude casting is turned into a cost effective qualitycomponent

Chipping

Cutting



Grinding

Surface finishing

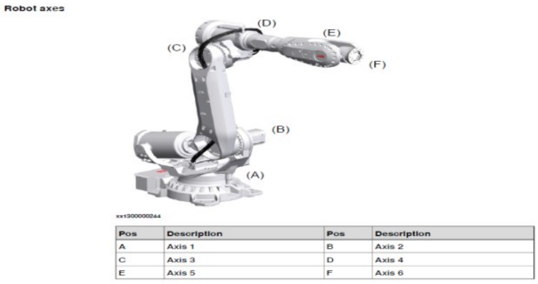
Importance of fettling:-To remove excess molding materials and casting irregularities from a cast component to have a good surface finish grinding the surplus metal from casting. To cover previous process errors.Fettling is one of the important activities in foundry but equally neglected. Many leading foundries in India kept the fettling as it is without adding any modern tool and equipment.

2. LITERATURE REVIEW

For the past few decades, research has been going on about Robotic Fettling. Many authors have reviewed and applied different path optimizing methods for effective fettlings. Shirinzadeh, P.L. Teoh, M. Roberts (2000) proposed a computer assisted robotic fettling technique using visual feedback. In particular, emphasis is placed on the establishment of a technique and investigating its performance for the determination of the casting profile. Also examines the process parameters associated with high speed fettling operations.Warnecke, H.J., Abele, E., (1983) proposed the application of industrial robots in fettling shops caused considerable problems, due to the tolerances of the castings and the variation of the burrs. The tool-, work piece-, and robot- related fettling tolerances were analysed and are presented in this report. To compensate for these tolerances, either elastic tool suspensions (passive systems) or sensors (adaptive control) may be used. Different measured quantities and manipulated variables provide for a large variety of system solutions.Roos, E., Behrens, A., (1997) proposed the requirement to increase productivity by reducing the standstill time of production equipment has reinforced the use of simulation within the robotics sector in recent years. Considerable deviations occur during the transfer of an off-line generated user program from a simulated to a real production cell. These deviations affect the certainty of planning and raise doubt as to the suitability of off-line programming for everyday industrial use. The following contribution deals with the causes and effects of simulation errors during the transfer of an off-line generated user program. It presents an application-oriented test method to measure simulation errors and a practice-oriented procedure to adapt a simulated manufacturing task to the real environment. Allen PK, Yoshimi B, Ticino A, (1991) proposes a real-time tracking algorithm in conjunction with a predictive filter to allow real-time visual serving of a robotic arm that is tracking a moving object is described. The system consists of two calibrated (but unregistered) cameras that provide images to a real-time, pipeline-parallel optic-flow algorithm that can robustly compute optic-flow and calculate the 3-D position of a moving object at approximately 5-Hz rates. These 3-D positions of the moving object serve as input to a predictive kinematic control algorithm that uses an alpha - beta - gamma filter to update the position of a robotic arm tracking the moving object. run Gotham gudla (2012) proposed the work envelope of a robot does not capture the effect of tool orientation. Applications will require the tool to be at a certain orientation to perform the tasks necessary. It is therefore important to introduce a parameter that can capture the effect of orientation for multiple robots and configurations. This is called the functional work space, which is a subset of the work envelope would capture the effect of orientation. This research discusses the development of establishing an assessment tool that can predict the functional work space of a robot for a certain tool-orientation pair thus aiding in proper tool, tool path, fixture, related configuration selection and placement. Several solutions are studied and an analytical and a geometric solution is presented after a detailed study of joint dependencies, joint movements, limits, link lengths and displacements through visual, empirical and analytical approaches. The functional workspace curve for a manipulator with similar kinematic structure can be created using the geometrical solution discussed in this research. It is difficult to derive a general paradigm since different parameters such as, joint limits, angles and twist angles seem to have a different effect on the shape of the workspace. The geometrical solution employed is simple, easy to deduce and can be simulated with a commercial software package. Design decisions pertaining to configuration and reconfiguration of manipulators will benefit by employing the solution as a design/analysis tool.

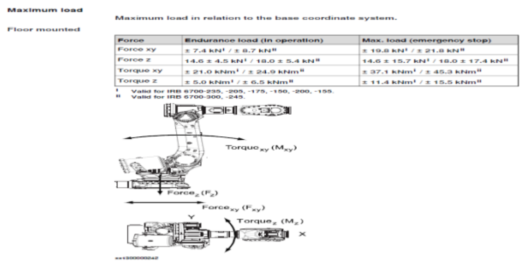
3. ROBOT INSTALLATION

The IRB 6700 series is ABB Robotics 7th generation of high payload, high performance industrial robots. Based on the famous IRB 6640 series, with large working range, the very high wrist torque, the service friendly modular built up and the availability, significant for ABB's robots, the IRB 6700 robot family goes even further. With focus on high production capacity, compact design and low weight, simple service and low maintenance cost. The IRB 6700 is ideal for process applications, regardless of industry. Typical areas are for example Spot Welding, Material Handling and Machine Tending. The robot is painted with two-component epoxy on top of a primer for corrosion protection. To further improve the corrosion protection additional rust preventive are applied to exposed and crucial areas, e.g. has the tool flange a special preventive coating. Although, continuous splashing of water or other similar rust formation fluids may cause rust attach on the robots unpainted areas, joints, or other unprotected surfaces. Under these circumstances it is recommended to add rust inhibitor to the fluid or take other measures to prevent potential rust formation on the mentioned. The entire robot is IP67 compliant according to IEC 60529 - from base to wrist, which means that the electrical compartments are sealed against water and solid contaminants. Among other things all sensitive parts are better protected than the standard offer. Selected Foundry plus 2 features: Improved sealing to prevent penetration into cavities to secure IP67Additional protection of cabling and electronics Special covers that protect cavities Well-proven connectors Nickel coated tool flange Rust preventives on screws, washers and unpainted/machined surfaces Extended service and maintenance program The Foundry plus 2 robots can be cleaned with appropriate washing equipment according to the robot product manual. Appropriate cleaning and maintenance is required to maintain the protection, for example can rust preventive be washed off with wrong cleaning method.



Robot Axis

SL.NO	PARAMETERS	VALUES
1.	Robot Specification	IRB 6700 with IRC-5 CONTROLLER
2.	Turn Table Rotation	+/- 180°
3.	Tool Stand-1	Spindle Head With Dia 400 Diamond Grinding Wheel
4.	Tool Stand-2	Spindle Head With Dia 100 Diamond Grinding Wheel
5.	Conveyor	SLAT CHAIN CONVEYOR (3M)
6.	Required Input Power	3-phase, 415 V
7.	Earth Resistance	Less than 0.5 ohms
8.	Cutting Tool Motor-1	15 HP
9.	Cutting Tool Motor-2	2 HP
10.	Conveyor Motor	1 HP
11.	Overall Layout Dimensions	6500*5000*3000 mm (L*W*H)



Robot Load

ROBOT CONTROLLER INSTALLATION:-The robot controller includes options for controlling the full range of functions for the manipulator and the fettling applicator. Generally, all the controls for a complete fettling application control system are available in the system, which includes functions such as: Installing and setting up the system creating, updating and testing motion programs creating, updating and changing sequences Executing special fettling related instruction Recovery procedures following production stops

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Controller

Teach pendant unit

In order to be able to adapt the package to special needs, the I/O configuration and data definitions can be modified. Before you start programming, you must check that the configuration settings are suited for your application. The robot control system is intended for use with a close collaboration between the Teach Pendant Unit, TPU, and the PC tools. The pendant is designed for most robot-near tasks such as jogging and teaching of programs, while more complex tasks and tasks that do not involve the robot physically, will be done in offline programming software.

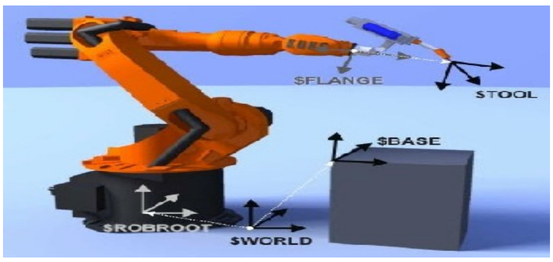
S. No	Name	Specification	Description
3.2 ON CONTROL PANEL			
01	Drives Ready	Lamp (Green)	
02	Component Selected	Lamp(Amber)	Selected component will glow
03	Emergency Switch	Mushroom head push button	To cut OFF supply to control circuit in emergency
3.2 PUSH BUTTON BOXES & INDICATORS			
Main Push Button Box			
01	Control On	IPB (Green)	To switch on the power to control circuit
02	Manual/Auto Mode	2 Pos. Selector Switch	Self-explanatory
03	Start Cycle	IPB (Green)	To give cycle command in Auto mode, Lamp glows when cycle started
04	Motors On/Off	2 Pos. Selector Switch	To turn On/Off Grinding Tools
05	Conveyor On/Off	2 Pos. Selector Switch	To turn On/Off Conveyor
06	Gripper Open/Close	2 Pos. Selector Switch	To open or to close robot gripper
07	Robot Home	Lamp (Amber)	Glows when robot is in home position
08	Conveyor Home	Lamp (Green)	Glows when conveyor is in home position
09	Robot Busy	Lamp (Green)	Glows when robot is working
10	Fault Active	Lamp (Red)	Glows when any Fault occurred
11	Emergency Switch	Mushroom head push button	To cut OFF supply to control circuit in emergency

Key functions of controls

TEACH PENDANT UNIT (TPU):-The teach pendant unit, is designed to be very efficient device for doing robot-near tasks such as jogging etc. To keep complexity down, it has been made with less emphasis on complex operations that are typically done more easily on an ordinary PC, such as advanced programming tasks and configuration setup. The basic idea behind the pendant is that it shall be just as user friendly as a game controller, to provide a fast and precise way control robot movements. In addition, it is equipped with a colour LCD screen, buttons for menu navigation and run control, an emergency stop button, and a live handle is built into the grip.The pendant is mainly designed to be held with both hands ion a parallel grip handle switches. In this way, the pendant is also equally suited for left and right handed people. For operations with less, emphasis on the live handle, such as in Automatic mode, it is also possible to hold it in a 'palette' or 'cradle' grip where the pendant rests on the left forearm. Hence, the Emergency Stop button is readily available to be operated with either hand.

TOOL CENTRE POINT:-The position of the robot and its movement are always related to its tool coordinate system i.e. the TCP and applicator orientation. To get the best performance of the robot, it is important to define the tool centre point as correctly as possible. The robot is primarily designed for surface treatment operations which implies that some of the robot arm's wrist. To enable the control system to operate correctly when different types of applicators used, a number of parameters called Tool Data must be entered into the system. All points in a robot program and the robot's path and speed between these points refer to appoint at a specified distance in front of the centre line of the applicator. This point is called Tool Centre Point, TCP.

PROCEDURES FOR DEFINING TCP:-To define the TCP of a tool, you need a fixed reference tip within reach of the robot. You then jog to a number of robot positions, pointing to the reference tip from different directions. To get possible accuracy, the angle between these points should be as large as possible.



Tool centre point

CALIBRATION:-Fine calibration is made using the calibration pendulum.

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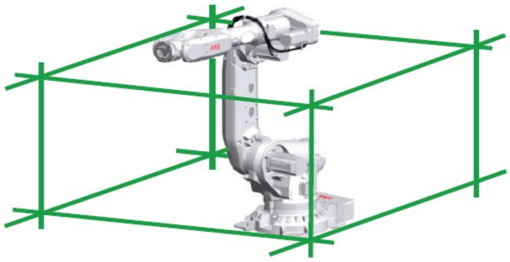
Calibration

Calibration	Position
Calibration of all axes	All axes are in zero position
Calibration of axis 1 and 2	Axis 1 and 2 in zero position
	Axis 3 to 6 in any position
Calibration of axis 1	Axis 1 in zero position
	Axis 2 to 6 in any position

Calibration

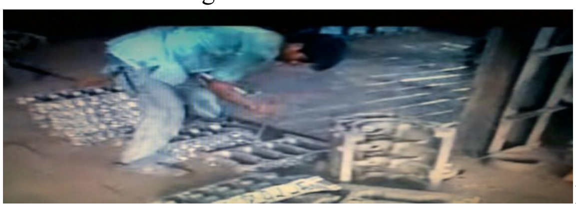
Absolute Accuracy (AbsAcc) is a calibration concept, which ensures a TCP absolute accuracy of better than ± 1 mm in the entire working range (working range of bending backward robots, for example IRB 6700, are limited to only forward positions).



Robot Positioning

4. METHODOLOGY

Fettling is one of the important activities in foundry but equally neglected. Many leading foundries in India kept the fettling as it is without adding any modern tool and equipment.Most of our Indian foundries they think that fettling is outsource activity. Most of the activity is performed by manually. Very few foundries are having procedure for fettling, what to grind, how much to grind is based on experience of that individual operator. The small automation like “Snag Grinders”isinstalled. With such automation productivity increases as well as consistence in grinding. The following are the problems with manual fettling sho



Hot casting

Biscuit Removal

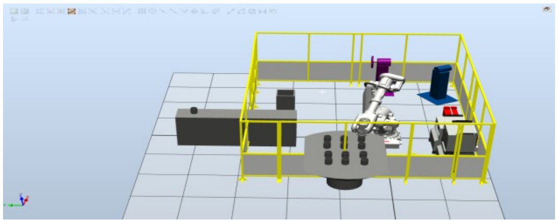
Manual Fettling, High efforts – low output, nodefinework area, no proper tools, dirty work area

Poor light condition

Manual Fettling in poor light

WORK SPACE DESIGN:-

The workspace of robot manipulator is defined as the set of points that can be reached by its end-effectors.The structure of workspace is defined by the structure of the robot and the dimensions of its links. Most robotic workspaces are noted by floor markings, fencing or other safety measures to keep humans from crossing into a dangerous area.



Off line workspace

ONLINE PROGRAMMING:-The most popular method of robot programming is probably the teach pendant. Over 90% of robots are programmed using this method. It involves moving the robot around, either by manipulation a force sensor or a joystick attached to the robot wrist just above the end effectors. As with the teach pendant, the operator stores each position in the robot computer. To program the robot, the operator moves it from point-to-point, using the buttons on the pendant to move it around and save each position individually. When the whole program has been learned, the robot can play back the points at full speed. This process is achieved directly jogging the robot in the workstation over the work piece. This would take long time to

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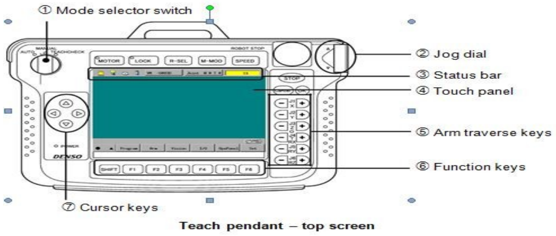
process, as it cannot be started until material input, installation and calibration of the whole workstation is made available. This would sometimes be dangerous and leads to damage of either work piece or robot. It requires a very keen observation during the process hence a very skilled labour. Once the total program is made editing and adding additional targets in between becomes tedious.



Teach pendant

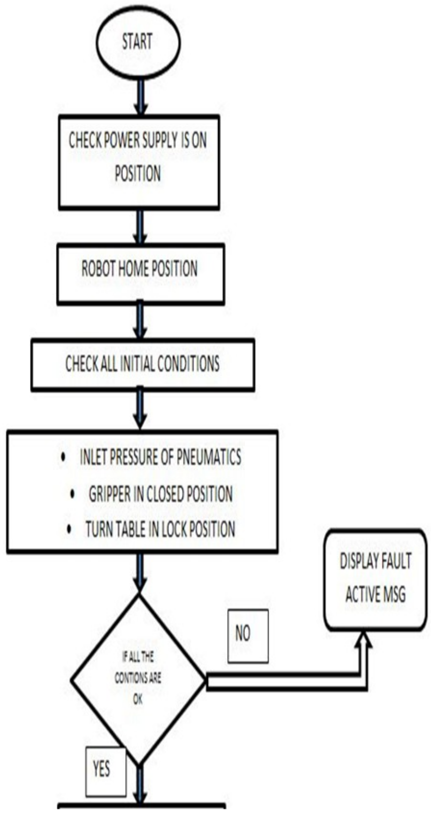
Online workspace

OFFLINEPROGRAMMING:-

Offline programming, or simulation, is most often used in robotics research to ensure that advanced control algorithms are operating correctly before moving them onto a real robot. Similar to the way in which CAD systems are being used to generate NC programs for milling machines it is also possible to program robots from CAD data. This process can be simulated in the software with the help of 3-D graphics. Parallel operations are processed and hence there reduces lag time. This would reduce physical damage to the workstation and also to the employee. Editing or adding additional targets and path modifications are quite easier in this process. This 3-D modelling software directly generates RAPID program for the path which can be directly inserted to the robot.

5. ROBOTIC FETTLING PROCESS

In this Robotic Fettling of Motor Body, first select which component has to be fettled, after selecting the motor body component is placed on the Indexing Table on 6 Fixtures. Select Manual/Auto Selection from Operator Push Button box. **Power Supply**: Power supply, 3 Phase + Neutral, through 3 Phase Circuit Breaker (32 Amps), should be arranged with minimum 4 Sq.mm Copper Cables and proper double-earthen, connected to internal earth grid or separate earth electrode. This is to avoid unbalanced / welding body earth / electrical fault currents, which may damage electrical / sensitive electronic components. Before switching on the Robotic Fettling of Motor Body for Auto operations, check the following:



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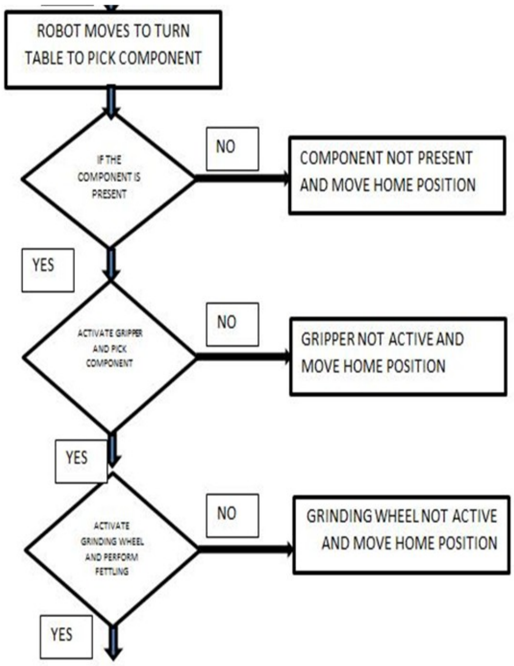

Flow chart

6. RESULTS

The project has been executed. The path for fettling process is generated for the motor body using off-line programming which is fie tuned through on-line programming. A general way of path generation and the most efficient programming has been finalized after on-line tuning. Installation of robot zone with all the equipment related were successfully installed and calibrated. Robots were manually jogged to check the flexibility. The project has been successfully tested off-line and the results are shown as video clipping. The same is verified by on-line program.

Cycle time

POSITION	to	PLACE	Air positions	Fettling time	Time in (sec)
Home	-	Pick up	2		2
Pick up			5		5
Pick up	-	Comp present check	3		3
Comp present check	-	Tool-1	6		6
Tool-1 fettling time				26 at 50 mm/sec	26
Tool-1	-	Tool-2	3		3
Tool-2 fettling time				50 at 40 mm/sec	50
Paint			9		9
Drop			3		3
Drop	-	Home	6		6
Total time in sec			37 sec	76 sec	113 sec

Cycle time

7. CONCLUSION

Most of the fettling process in any of the manufacturing industries happens online. This would increase the cycle time as the fettling path to be performed will be analysed only after the product is available on-line. As a result of this, productivity decreases. We can improve the productivity rate by generating the path for the fettling process of the product prior to the presence of it on-line. This could be possible by working through off-line programming process.

SIGNIFICANT CONTRIBUTIONS

There are various software that could help us in achieving off-line programming. But one of the most efficient and successfully running 3-D model based off-line programming is used in this study. This constitutes all varieties of robots that are presently in use for various automation processes. Coming to the fettling aspects of offline programming, this software is one of the most efficient way of approach. A profile based path is generated for the component and analysed and deemed suitable after the on-line testing. The path generation of any product using off-line programming would increase the productivity rate and reduces the total cycle time which in turn results in more efficient, uniform and quality of the product.

FUTURE SCOPE

Fettling is one of the important activities in foundry but equally neglected. Many leading foundries in India kept the fettling as it is without adding any modern tool and equipment. Best and sophisticated methods like robotics, PLC assisted automation to be incorporated in achieving good results Fettling operation is a very complicated study. This should be obtained in a very efficient manner to get the desired results. More decision making strategies and theories have to be incorporated to obtain more optimized solutions. Theories like artificial intelligence, neural networks and fuzzy logics would ensure optimized solution in generating better path for any complex designed product. Hence further research has to be propagated in these analysis based theories to optimize the obtained solution to further extent. This would ensure all the input and output parameters to be acquired in a very balanced manner. Further research in these fields has to be processed in order to improve the current results.

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