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A REVIEW PAPER ON THE DEVELOPMENT OF A VARIOUS ROBOTIC END EFFECTOR

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Abstract: ***The paper presents a brief of the experimental work, analysis work to develop various types of robotic end effectors and manipulators in the field of robotics and automation. Researchers were also focused to develop a robotic end effector to collect the soil sample from the hazardous site and further went for investigation in laboratory. For carry out the end result at site or at territorial areas some researchers also worked and developed a station or platform which can easily mounted on vehicle. For the hazardous sites, launch vehicle and unmanned vehicle was also developed. Some researchers were also worked on to develop a combination of a sample collecting unit and a test unit for getting fast results. Further the analysis and the simulation work was also done through various software such as ANSYS, FEA tools etc. Research work was also carried to developed large workspace of robotic configuration for the efficient work. Various robotic configurations were also improved by the researcher. For the delicate and light duty work a new piezoelectric composite material was also proposed by researcher. In bio medical field robotic hand was developed for orthopaedic surgery of femur.***

Keywords: robots, end effector, unmanned vehicle, robotic configuration, automation

I. INTRODUCTION

In today's era robots are the one of the most important and essential system of the society. From head to toe numerous applications are carried out through robotics for ease and fast working environment. Various researchers are seeking great interest and involved in research work. The research work is carried out to develop user friendly robots so that a general person can reach easily. Now a day's not only robotic arm but humanoid robots are also developed so that they can feel, sense, think even dream at night with the help of artificial intelligence technology.

Review paper based on to develop a robotic end effector to collect the soil sample from the hazardous zones. Multiple researches are carried out to develop manned and unmanned controlled robot or vehicle for the hazardous field. Research paper also represents the development of CAD model in softwares such as Solidworks, Creo, and AutoCAD etc. Static structural analysis was also done in ANSYS to check the deformation, stress, strain, strain energy etc. to develop a model on proposed site. Modal or Vibration analysis was also done by to check whether the designed object is exceeded the natural frequency or not. Through this analysis system become safe and able to avoid the natural frequency by changing the material or design parameters. Simulation was done to show the stress distribution at various zones of femur. This methodology was helpful for efficient drilling operation with less time consumption.

There are many industries which require the robots such as Automobile Industry, Bio-medical, Manufacturing plants, space application etc. An industrial or commercial robot manufacturing depends upon the numerous parameters in which first is to identify the need of customer. After user need it also requires the workspace envelope, total weight, movement or degree of freedom, resolution, accuracy etc. Workspace envelope is that surrounded area in which the robots can works easily. It varies with the various configurations as RRR, RRP, SCARA, RPP and PPP. Resolution of the robot is the work ability of joints with higher accuracy, means exact motion is needed at the application area. The accuracy represents the closeness to the desired position.
The repeatability shows the repetition of the robot movements and again come back to the previous position multiple times. The maximum load carried at end effector is called payload which varies with the applications. Degree of freedom of robotic arm represents the possible independent movement with certain constraints. As the DOF increases, time taken to complete the task increases. World fastest robot based on SCARA configuration works on 3 degree of freedom. Articulated robots have higher DOF which works on complex situations and large workspace. Designing of Industrial robots are not an easy task. It requires a lot of skills from designer to get the optimal results. If all the required parameters are known then the process will go through the various steps, which are indicated in the wheel as shown in below figure:

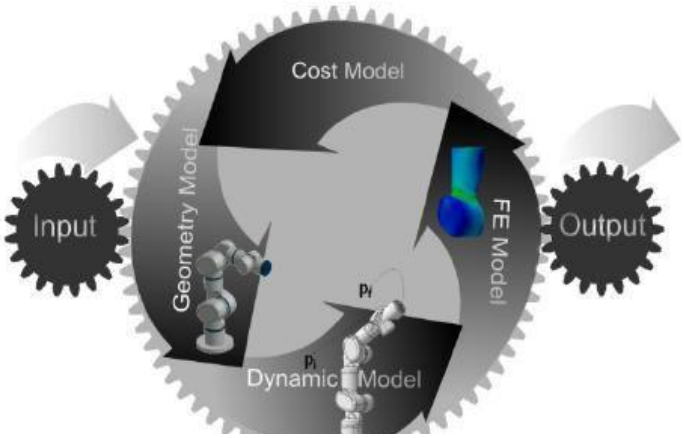

Figure 1: Industrial robot design process

The designing of the Industrial robot starts with the requirements of the user and the various process parameters. After the process parameters finalization, dseigning of the various parts associated with robot starts. All the design parameters including the smaller parts such as screw, pin etc. is considerd for the conceptual design with dimensions. In geometry model, designing of model is made in CAD software viz. AutoCAD, Solidworks, CREO, Fusion 360 etc. The time associated to design a model is depends upon the complexity of the object and also the efficiency of designer.
In dynamic simulation movement of the body, joints are calculated. When the final geometry is finalized in Solidworks or any CAD software, it may be converted in *.step* or *.iges* files, for the further analysis in simulation software like ANSYS. Once the model was imported the various boundary conditions will be applied followed by meshing or discretization. Various analyses in ANSYS in which Static structural helps to find the deformation, Maximum and minimum Von-mises stresses, strain energy, strain, factor of safety etc. Accuracy depends upon the mesh size. Modal analysis is also performed to obtain the failure occurs due to vibrations in ANSYS simulation. If the excitation frequency meets the natural frequency of the system, resonance occurs. Various modes of vibrations may be set among the frequency range 0 Hz to Maximum limit. Total deformation in various modes are obtained, among them higher deformation frequency was discarded. Through these FEA calculations stiffness of the structure is obtained. In Rigid body dynamic analysis the value of displacement, velocity, acceleration and kinetic energy is found. After selecting the suitable material and boundary conditions, cost estimation is calculated. High density material is heavy in weight and vice versa. Final selection of prototype or modal is based upon the price of the modal based upon weight and market price available. It represents the inner wheel of figure.

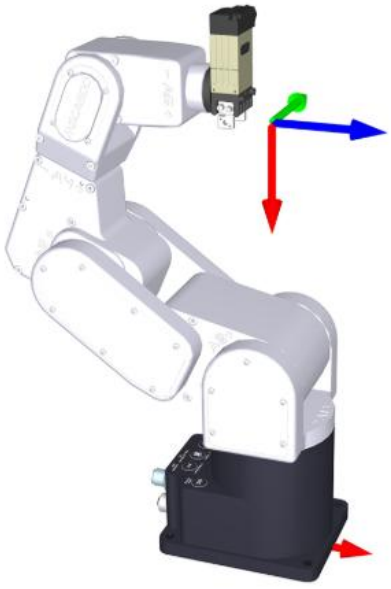

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Figure 2: Robotic hand showing various DOF

II. CURRENT STATUS OF RESEARCH

Jaselskis and Anderson **[1]** developed a sampling system at Ames laboratory to provide real time analysis of hazardous waste using LA-ICP-AES (laser ablation- inductively coupled plasma - atomic emission spectrometry) technique. Test was conducted by MDLEST in which Robot sampling accessory was attached providing 3 degree of freedom. It was

equipped with sampling and sub-surface sampling probes to improve sample quality, reduction in sampling time and cost and also improves the safety of worker. The technique was not suitable for detecting volatile organic compound samples.

Kim *et al.* [2] designed and developed a tele-operated guided vehicle based on laser principle at hazardous place. To eliminate human interaction with hazardous contaminants manipulator is operated by master controller. System has efficiency for the safety of worker, less time consumption and less costing. Adoption of unmanned vehicles with master slave reduced physical and mental pressure and feels like real driving situation.

Hansen *et al.* [3] proposed a system for preparing and testing of targeted nucleic acids. It contains a pipetter, extractor, assay reader, and other components. An automated system is used for receiving the sample, an extraction device is used to extract the component from the sample, a detection device to detect the presence of extracted component by extraction device, a robot adapted to automatically transfer the sample to the extraction device. System used an industrial grade SCARA robotic arm which provides accurate, repeatable and reliable positioning of the pipetter that uses less reliable robotic components.

Qian*et al.* [4] proposed a new small tele operated robot for nuclear radiation and chemical detection. The proposed robot can easily climb stairs, run over rubble and navigate narrow passages. The remote terminal will able to access the real-time video, audio, detection data and other sensor readings while the operators were at other place. In highly nuclear radioactive and chemically contaminated areas it detects the radiation level and recycles radioactive sources. The robotic system operates reliably and meets the technical requirements.

Valijato*set al.* [5] research work is focused on universal mobile robotic platform to collect and store soil samples from fields and measure it parameters simultaneously. Platform navigates and operates automatically with the installed software and remote server connection. Mechanical design of the soil sampling device and control software is also introduced and discussed. During testing, the current system was found out to be 50% faster than traditional method. Cloud based control software was also used to improve the efficiency.

***Colbaugh and Jamshidi* [6]** developed a robot control system which meets the actual requirement of hazardous waste site. A solution was also proposed of an adaptive scheme for controlling the kinematically redundant manipulators. The proposed controller is capable of accurate positioning without calculating the robot inverse kinematic transformation. Simulation was also done for a fourdegree of freedom redundant robot under adaptive impedance control through which it was easily perform the tasks in waste-handling sites.

***Lee and ElMaraghy* [7]** used a CAD based offline programme ROBOSIM, an analysis systems for robotic manipulators. It determines the displacement, velocity and singularity checks of end-effector. Various advantages are seen such as decreased production downtime, increase productivity, storage of data for posterity, and development of different task strategies. It does not include the matching of simulation model to real time work environment and also it was a difficult task to creating a graphical CAD database.

***Yoshikawa* [8]** proposed a measurement of manipulability for positioning and orienting robotic end-effectors. Optimal postures and working positions for different manipulators was developed. Finally the best postures and designs were described for human arms and fingers. This work also provides the design and functionality of orthogonal, polar and cylindrical coordinate manipulators.

***Pamanes and Zeghloul* [9]** presented a technique for the optimal placement of robotic manipulators. An optimization problem is developed for placement such as upper and lower bounds, points in a path taken, number of joints etc. The work does not describe any collision avoidance techniques which becomes crucial in a cluttered environment.

R. Maldonado-Echegoyen*et al.* [10] worked on the kinematic analysis of translation parallel robot. Displacement, velocity and acceleration analysis was done by analytical method and screw theory. Deformation analysis was also done through the experimental set up developed by him. Workspace of robotic movement was also increased by the previous one.

Lin Qi*et al.*[11] done a FEA based analysis of drilling operation on femur as rigid plastic and elasto-plastic material. The simulation result shows the stress distribution at various zone of femur. The drilling force applied during the orthopaedic surgery whether affects the bone or not and at what extent. It is helpful to develop the safe surgical tool which can easily work on high speed machining and large scale deformation.

A.N.W.QI *et al.*[12] designed and developed a robotic arm which is capable to lift the light weight material in industry. The robotic arm was fabricated by 3D printer and the material used is ABS. Experimental rig was also developed to validate the result obtained in experiment.

Puran Singh *et al.* [13] designed and developed a drilling manipulator for robot which can be used for the various wielding operations. The technique developed was cheaper and time oriented. It also provides the more flexibility of angle movement in operating condition. The entire component was designed manually and developed in AutoCAD.

Milan *et al.* [14] presented FE method solution of the displacement, velocity and acceleration distributions in the unidirectional composite plate consisting of carbon fibres embedded in the epoxy matrix using ANSYS 11.0.

Mayur and Prashant [15] developed an EOAT (End of arm tooling) which is capable for washing the cylinder head in automobile industry. EOAT is basically a gripper of two parallel fingers that can be folded and unfolded by pneumatic actuators. Further CAD model and ANSYS analysis was also done to validate the accuracy of results.

Singh *et al.* [16] provided statics analysis which was conducted on a nickel chrome steel and structural steel crank shafts from a single cylinder four stroke engine. They created a three dimensional model of crankshaft in Pro/E software .The load was then applied to the FE model and boundary condition where applied as per the mounting conditions of the engine in the ANSYS Workbench.

Pratap& Reddy [17] presented the Kineto-Elasto dynamic analysis of robot manipulator. The study performed dynamic analysis to find the velocities, accelerations and joint torques for moving the end-effectors in the considered path trajectory with the help of MATLAB-2008a software. The study also provides elastic deformations of the Robot manipulator arms using joint torques, static loading due to link's masses, masses at joints and payload by using ANSYS-12.0 software package.

H.S.Tzou [18] presented a light weight and delicate robotic end effector using polymeric piezoelectric material. It contains two layers of polymeric piezoelectric PVDF, one in tension and another in compression which generates opposite polarity during deformation through which beam can bend in prescribed direction. This bending action can pick up the object from inside or outside. FEA analysis was also done to verify the result obtained experimentally.

Mir-Nasiri [19] suggested new design of robotic arm with a parallel structure, but with a functionality or geometry similar to the serial structure of a SCARA robot. His new design has a number of advantages compared to a SCARA robot and to other conventional manipulators with parallel structures. This paper and related research aimed at overcoming the problems encountered in the design, modelling and application of such robotic arms.

R.C.Anderson *et al.*[20]Mars mission was scheduled through MSL to collect the rock sample and in-depth examination of physical and chemical properties. CHIMRA, a rock sample collecting unit is situated over the rover to collect the various samples through the drilling action. A tungsten carbide drill bit, dust collection unit, sample exit tube was attached for said purpose. System is capable of taking a wide variety of rock and regolith materials, butit was not able to collect sample of kaolinite, limestone, volcanic breccia, Belleville Basalt, Saddleback Basalt, and vesicular basalt.

III. CONCLUSION

Following conclusions were drawn from literature survey:

- For hazardous environment many researchers focused to develop Un-manned vehicles, tele-operated vehicles, automatic collecting machines, controller, laser operated vehicles etc.
- Further End effectors are also developed and mounted on vehicles for testing of sample, gripping, excavation, scrubbing, drilling, suction, electro-magnetic actions etc.
- Various modelling software is also used for the accurate positioning in real situation by the analysis of forward kinematics, inverse kinematics and the simulations of end effectors.
- A new material is also suggested for the robotic arm in light and delicate work.
- In bio medical field, robotic end effector efficiency is also tested and FEA analysis was done to validate the results.
- Finite element method is best suited for finding out the stress distribution in manipulator interface.
- Most of the researchers focused on CAD/CAE based system for analysis and verifying the design of robotic manipulator.
- Payload and work envelope are critical aspect of any robot manipulator for analysis purpose.
- Industrial robot to work at high speed and sensitivity together with having a wide range of workspace.

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