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Overview of a Robotic Arm

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Abstract: Our project aims to increase the efficiency of industries and help to automate the manufacturing process and other day-to-day industrial activities. Right now automation is not that widespread among industries because of cost and other technical issues. We designed an industrial robotic arm. We have used specific materials to give long life and durability to the product. One of the most important motivations to design this product was to make it cost-efficient so that it can be used by small and medium enterprises who have left aside in competition. We have used high modulus carbon fibre, aluminium metal matrix composites, carbon fibre reinforced plastic, and aluminium foreign casting alloy 222. We have designed the model on fusion 360 software with appropriate dimensions. We have also looked carefully at the competitions which we are going to face in near future and have carefully planned the strategy to increase our market share slowly and steadily.
Keywords: CAE Analysis, CAD, FMEA, TRIZ, NPD

I. MISSION STATEMENT

Robotic arms are in demand for industrial production, processing, and manufacturing roles i.e. any task which needs precise, fast and repeatable movement. Robotic arms are fast, accurate and reliable, and can collectively be programmed to perform an almost infinite range of different operations. There has been cost reduction for industrial robotic arms which has seen more widespread use today than ever before - whether desktop mounted or installed as part of a high-volume production line, robotic arms are now commonly found across a broad range of industries and sectors.

II. PROBLEM STATEMENT

A common problem faced in small and medium-sized businesses that create small batches of products do not become productive enough when an industrial robot is permanently installed. A portable robot that can adjust to the needs of the product could be the answer. It would have a reduced moving mass, resulting in less power use and "greener" robots.

The key feature of industrial robots over conventional methods are:-

1) Repetitive work cycle
2) Consistency and accuracy
3) Difficult handling task for humans
4) Multi Shift operations
5) Reprogrammable
6) Interfaced to another computer systems

III. REVIEW OF EXISTING PRODUCT

IRB 1100	IRB 120	IRB 1660ID	IRB 2400	IRB 140
Class-leading performance for high-quality manufacturing	Compact and lightweight	High performance ID robot for arc welding and machine tending	Dedicated high performance robot for process applications	Collision Detection option, with full path retraction
Compact and small footprint design ensures flexible installation	Fast, accurate and agile, Optimized working range	Outstanding weld quality, Up to 10% shorter cycle times	High reliability and long intervals between maintenance.	Well suited for packing applications and guided operations together with PickMaster
Payload: 4kg	Payload: 3kg	Payload: 6kg	Payload: 20kg	Payload: 6kg

Fig 1: Review of existing product

IV. SWOT ANALYSIS

A. Strength

Increased need for automation in manufacturing facilities is expected to drive the need for industrial robots. Increasing deployment of the traditional industrial robots for industrial automation is expected to boost. Because of increasing labour costs and a low robot density (robots installed per thousand workers) made it difficult for manufacturers to have a low manufacturing cost advantage. Our robots are cost-effective and easier to deploy are an ideal means of automation for small and medium scale 9 enterprises. In order to support automation, several governments are offering subsidies to the industries to help them boost the robot density in their manufacturing units.

B. Weakness

We are using Carbon Fibre to increase the strength of our robotic arm to give it a sturdy look and long life. But still it's a little costly in India which may add extra cost to the final product during the initial stages. Once we are manufacturing in bulk we expect a reduction in cost.

C. Opportunity

The Government of India has provided an incentive of Rs 1.45-trillion package by extending the production-linked incentive (PLI) scheme to 10 manufacturing sectors with a main focus on the automobile and automobile components sector. Since our manufacturing is based in India, we can greatly benefit from this. With huge benefits available for companies if they automate we have a great opportunity to be a part of this change and bring automation at affordable costs.

D. Threats

The Japanese government has a USD 221 million subsidy as a part of its China exit policy for Japanese companies to shift their base to India and other regions. With established players setting up their bases in India we may face difficulties in acquiring major customers.

V. NPD CYCLE

NPD is the process of transforming a market opportunity and a set of assumptions about product technology into a marketable product. The ability of enterprises to compete and survive in the market is connected to their ability to innovate, which includes their ability to design, manufacture, and deliver new products and services to the market. Every New Product Development journey starts with an idea, which forms the foundation for further development. These new project development journeys have the potential to cause a digital disruption when the new product successfully meets a need in a way that is unique, untried, and out of-the-box. The seven stages of the New Product Development process include — idea generation, idea screening, concept development, and testing, building a market strategy, product development, market testing, and market commercialization.

A. Benefits Of New Product Development Process

1) Helps check the technical feasibility of the idea
2) Ensures faster time to market
3) Effectively addresses the customer needs
4) Multiplies the chances of success
5) Reduces technical debt
6) Better management of the feature creep
7) Negates the opportunity cost

Currently, many innovative design techniques are available to assist designers in the development of products. Among them, the TRIZ is mostly used at the conceptual design stage to generate design concepts and solve problems. Study explored the implementation of TRIZ with the alignment of NPD and SCM to strengthen the innovation and productivity of new products so that the SMEs can use it for the purpose of sustainable business operation.

B. Target Customer

This part of the mission statement identifies the primary market as well as any secondary markets that should be considered in the development effort. Identifying a target market helps your organization develop effective marketing communication strategies. A target market is a set of individuals sharing similar needs or characteristics that your company hopes to serve. These individuals are usually the end users most likely to purchase your product.

Small and medium-sized businesses (SMEs) and large businesses are both targets for these robots. These robots are being used for both new and established applications, resulting in widespread adoption. These factors have played a crucial role in propelling the industrial robots industry forward.

The following are the target customers by industry:
1) Automotive
2) Electrical & Electronics
3) Chemical, Rubber & Plastics
4) Machinery
5) Metals
6) Food & Beverages
7) Precision & Optics

C. Product Specification

The functions that an Industrial robot is capable of performing
1) Soldering and Welding
2) Materials Handling
3) Assembling & Disassembling
4) Painting and Dispensing
5) Milling, Cutting, and Processing
6) Based on these functions, the target customer for the product is identified.

D. CAD Images

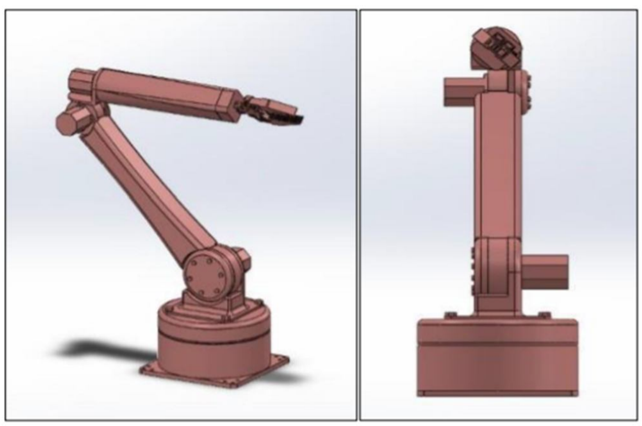

Fig 2: Isometric view and the side view of the Robotic arm

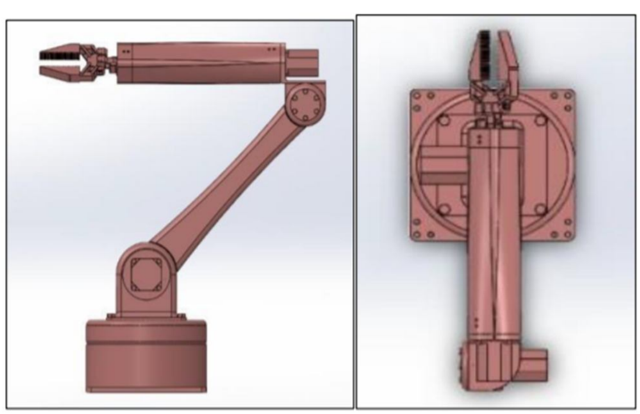

Fig 3: Front view and the top view of the robotic arm

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E. Rendered Image

Fig 4: Front view of robotic arm in rendered view

Fig 5: Movement of the robotic arm in rendered format

Our Project File: https://a360.co/3ExQ1Kh

VI. MATERIAL SELECTION

UPPER ARM	HIGH MODULUS CARBON FIBER
WRIST	Aluminum metal matrix composites (AlMgSi)
FOREARM	CFRP (carbon fiber reinforced plastic)
BASE	ALUMINIUM FOREIGN CASTING ALLLOY 222

Fig 6: Materials used in various part of the robotic arm

A. FMEA

FMEA is a method for identifying and mitigating possible risks. We utilised this method to examine all potential defects, as well as their causes and consequences, in a robotic arm. In order to come up with the best model, we did the following. We found opportunities to enhance the arm structural components' design

The FMEA also identifies which parts are more likely to fail, such as castings, which are more prone to failure than other parts As a result, found chances to improve the arm structure's design components in order to obtain a model that is optimised All modes of failure of industrial robot is summarised in a table that is provided ahead of time.

No.	Function/Component	Failure Mode	Failure effects	Potential causes	Risk Analysis				Actions recommended
					Freq.	Sev.	Det.	RPN	
1	Cabling	No power, no signal	Robot stops	Broken Cable	2	9	4	72	
				Bad Connection	4	4	7	112	
				Twisted cable	5	4	6	120	
2	Castings	Castings break		Defects in material	6	5	8	240	Quality Controls
				Wrong Material	2	6	3	36	
				Wrongly Calculated	4	6	9	216	Review calculations
				Collision	7	5	10	350	Crash Tests
		Loose screws	Components fails off	No washer	3	4	8	96	
				Wrong Dimension	3	3	8	72	
				Threads too soft	2	3	9	54	
				Wrongly tightened	4	4	9	144	
3	Motors	No signal	Robot stops	Broken Motor	1	9	3	27	
				Overheated	5	5	2	50	
				Bad Connection	2	4	6	48	

Fig 7: FMEA analysis of the Robotic arm

B. Cost Analysis

Industrial robot prices have reduced by more than 25% since 2014, and are predicted to drop by another 22% by 2025. A robotic arm for industry can cost anywhere from $25,000 to $400,000. Other peripherals like as controllers, a teach pendant, end of arm tooling (EOAT), and software must be included when calculating the cost of an industrial robot system. Total system costs could double once these application-specific peripherals are added. For $1,000 or less, you can get a robot for a school, university, or other non-industrial application, but these robot arms are not suitable for industrial use.

Robot size (reach), number of axes, application, end of arm tooling (EOAT), and safety components are the most important factors in determining cost. In general, the larger the reach and payload, the higher the cost of the robot. However, the cost of an industrial robot system is influenced by application-specific peripherals and safety components such as collision sensors and safety cages. While collaborative robots lack the speed and power of traditional industrial robots, they are relatively inexpensive. The popular Baxter robot from Rethink Robots, for example, starts around $22,000. The price rises to $36,750 with the inclusion of a pedestal for $3,000, a gripper for $1,750, and a two-year software service contract for $7,000. Based on 40 working hours per week over a three-year life span, this equates to around $4 per hour.

C. CAE Analysis

Finite element analysis was performed on a few components to evaluate its Factor of safety (FoS) across its topography.

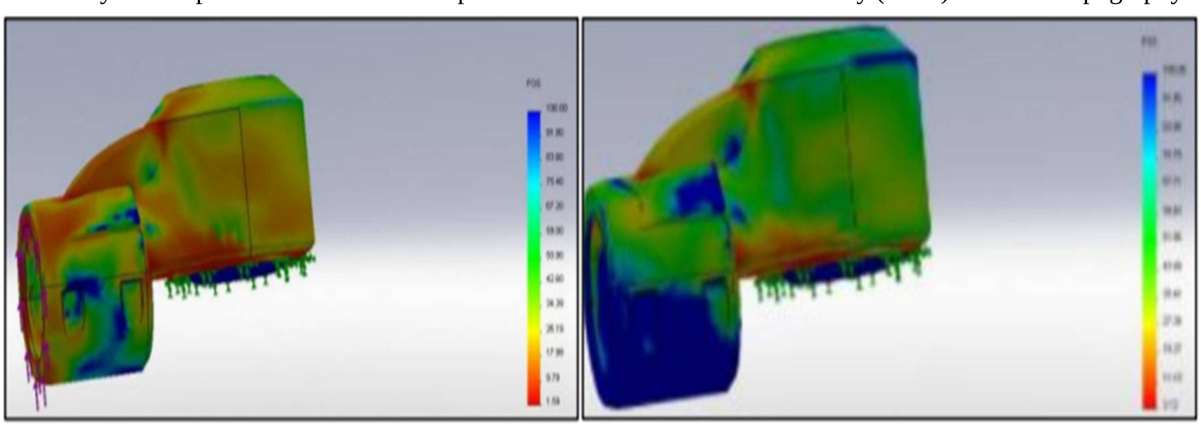


Fig 8: CAE analysis of the joint in Robotic arm

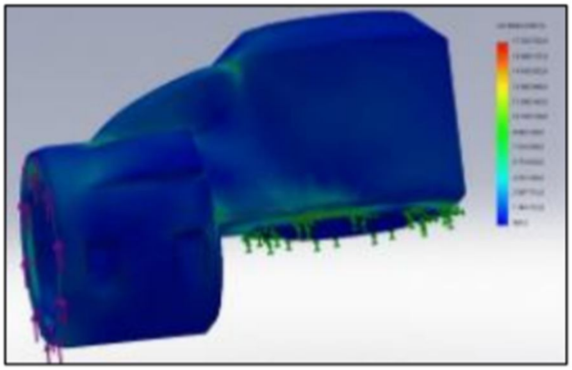


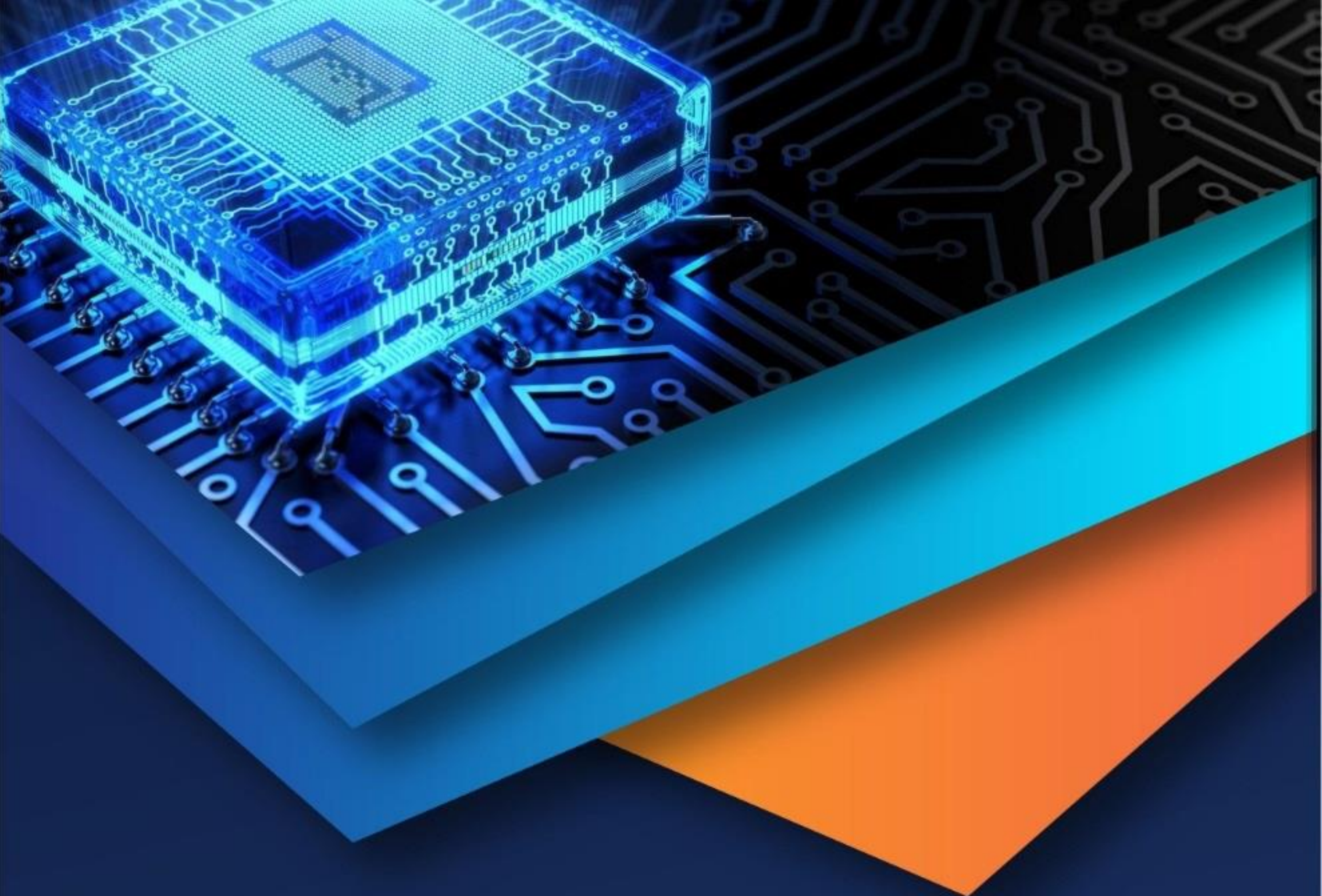
Fig 9: CAE analysis of the joint in Robotic arm

The results obtained are presented in the next slide. Von mises stress (Equivalent stress) is evaluated as well. The analyses prove that the material selection for the design is appropriate.

VII. CONCLUSION

This initiative intends to assist small and medium businesses in automating their operations at a low cost so that they may remain competitive and grow.

Competition is good. Monopoly, as we have seen, is not desirable, particularly in industries of public concern. Our team members collaborated to bring our skillsets together and bring our project to a close. Existing players in the market, primarily international players, have yet to break into the SMEs segment. We carefully selected materials that would ensure the long-term durability of our product and make the transition from manual to automated operations as smooth as possible. When we consider the product life cycle, our product is still in its early stages. There's a lot of room for us to expand and get clients.



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