Design, Development and Analysis of Multi-Nozzle Coater-Arm

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Abstract

Tablet coating is one of the Pharmaceutical Process in which coating material is being sprayed on granulated tablets. There are several types of equipment used in order to coat the tablets. Among them the one with perforated pan is quite effective in order to get proper flow of air when there is simultaneous process of spraying wetting and drying. Now there is the need of spraying system in order to get desired coating of tablets. In small size coaters the spraying system is not much complex as there is only one spray gun but in order to increase production there is need of multiple spray system in which multiple sprays can be mounted on single arm but then it increase weight of system and handling of the particular spray arm is difficult. The purpose of this study is to automate the coater spray arm in order to facilitate multiple spray system with automation to improve productivity and to provide easy handling to customer.

Keywords: coting, spray arm, multi-nozzle, automation, pan-coater

I. INTRODUCTION

Tablet coating is the essential process in which coating material is applied as the outer layer on granulated compressed form of tablet. Purpose of tablet coating is to provide taste and odor masking, control drug release rate, provide unique identification to tablet, protect active pharmaceutical ingredient from dust, chemical protection, etc. Tablet coating can be done in pan coater system or fluidized bed system. But, in the pan coater system process is simpler and stresses on the tablet surface are less but time required for processing is more. Traditionally, the level of instrumentation and automation of coating equipment has been low and subsequently, the coating process is difficult to control. To improve the reproducibility and predictability of the coating process and consequently the quality and safety of the final product, demand for instrumentation and automation of coating equipment in pharmaceutical industry has increased. Furthermore the reduction of product cost has become an important factor in the pharmaceutical industry as a requirement for efficient production. An automated film coating process and critical process parameter monitoring system would provide a useful tool for controlling the process and for understanding the phenomenon during the process. Tablets are usually coated in perforated coating pans by spraying the coating solution on the free surface of the tablet bed and subsequent drying of the solution as air flow system through a perforated pan ensure rapid and continuous drying conditions. Now in Pan coater system as the diameter of the pan increases, no of spray guns required to coat that much quantity of tablets also increases, but , that increases the total weight of the spraying system which creates an issue in handling or operating spray arm. As the process of tablet coating is started , the batch processing time may be more than 1hour, within that time according to the coating operation required coating uniformity movement of spraying arm is necessary, but every time stopping the process and moving the arm in required position consumes time and efforts. This project is performed on pan coater SC700, product by ACG Pharma Technologies Pvt Ltd The objective is to have an automated system in the process area so that without stopping the process desired position of the spraying arm can be achieved. But the challenge in this task is as the spraying system and whichever mechanism will be used will come in direct contact with the tablets and indirectly that will be coming in contact with human body, hence there are many limitations in designing a system for automation of spay arm , as according to the Pharmacy-norms there should not be any mechanical part or system which has grooves or crevices or sharp corner as it may lead to contamination if spray particle or powder particle come in contact with them Also using any hydraulic system or gear in the process area is not allowed as that require lubricating system and if there is any oil leakage the oil may spill out in process area and spoil the whole batch. Hence two goals should be achieved by the desired system, first is the results of coating should be reproducible and second is that after finishing one batch the whole mechanism or system designed should be easy to clean.

II. FUNCTIONAL PRINCIPLE OF PAN COATER

The Coater is designed to coat tablets. The tablets are loaded into the product pan where they collect in the form of a product bed. The coating of the tablets within the product pan is achieved by means of spraying and dispersing the medium onto the product and then drying with preconditioned air. The rotating movement of the product pan and the mixing baffles prevents the tablets from sticking to each other and provides for a thorough mixture of the product as well as the necessary homogeneous distribution of the suspension. The spray medium is sprayed over the product bed through a spray nozzle. Depending on requirements, this can

be done either continuously or through a series of programmed spray cycles. The tablets are dried by the process air that is sucked through the product bed. The discharge system allows a dust- and contamination-free discharge of the product bed. The outlet air fan produces negative pressure in the Coater throughout the process. Optimum product processing conditions can be selected to suit individual product requirements. Reliable and efficient acquisition of all relevant operating data is possible. The individual product requirements that constitute the process cycle can be recorded and repeated precisely [1].

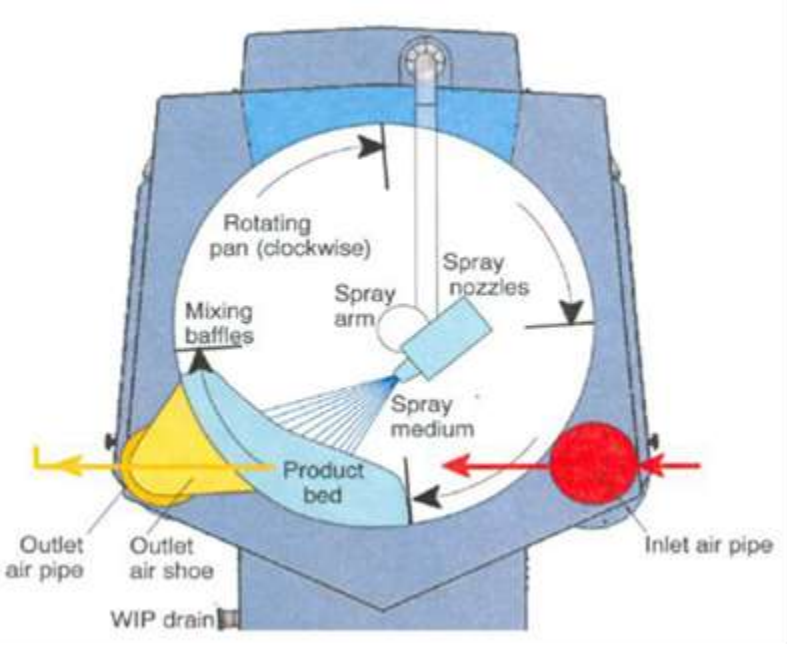


Fig. 1: Schematic diagram representing functional principle of pan coater [1]

III. PAN COATER

The product pan consists of two conical end pieces and a cylindrical, fully performed, central part. There is a opening at the front and a solid flange welded onto the back to attach the pan to the pan bearing. The interior of the pan can be accessed through the front door. The pan is completely made of stainless steel (AISI 316L). Removable mixing baffles re mounted inside the coating pan. They ensure a homogenous blending of the product. Fig 2 showing cad model of SC700Pan coater having pan diameter 1780mm, Maximum working volume 700litre.

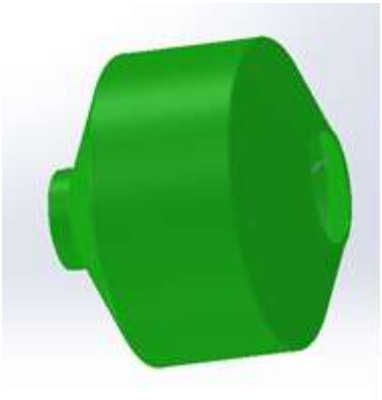


Fig. 2: pan coater

IV. NEED OF AUTOMATION OF COATER ARM

To improve the reproducibility and to predict the factors involved in the coating process and indirectly the quality and safety of the final tablets, there is a need of automation of coating equipment in pharmaceutical industry has increased. An automated film coating process would provide a useful tool for controlling the process and for understanding the coating related factors during the process. Tablets are usually coated in perforated coating pans by spraying the coating solution on the free surface of the tablet bed and subsequent drying of the solution as air flow system through a perforated pan ensure rapid and continuous drying conditions. Now in Pan coater system as the diameter of the pan increases, no of spray guns required to coat that much quantity of tablets also increases, but, that increases the total weight of the spraying system which creates an issue in handling or operating spray arm. As the process of tablet coating is started , the batch processing time may be more than 1hour, within that time according to the coating

operation required coating uniformity movement of spraying arm is necessary, but every time stopping the process and moving the arm in required position consumes time and efforts.

V. MATERIAL SELECTION

The parts which come in contact with the product are made up of stainless steel AISI 316L (containing 0.03% C, 17% Cr, 65% Fe, 2% Mn, 2.5% Mo, 12% Ni, 0.045% P, 0.03% S, 1% Si) and the Parts which come in contact with the process gases are made up of AISI304 (containing 0.03% C, 18-20% Cr, 65% Fe, 2% Mn, 8-12% Ni, 0.045% P, 0.03% S, 1% Si). AISI 316 has superior corrosion resistant Properties, it provides resistance to inter-granular corrosion following welding or stress relieving. Molybdenum content helps in resistance to marine environments and low carbon content reduces corrosion in medical in-plant use. Whereas, AISI 304 has less carbide precipitation in heat affected zo during welding . It has application in chemical equipment evaporator, cooling coils and dairy equipment.

VI. DESIGN REQUIREMENT

In order to design an automated spraying system for coater arm it is essential to find out factors which play important role in the system and we need to prioritize them. Spray related Parameters are Spray Gun design, No of guns, Spray rate, Gun to bed distance, Atomizing air pressure , Pattern air pressure, Angle of spray gun to tablet bed which affect Droplet size of spray, spray pattern shape and its distribution which then ultimately affect Film quality of final product[3].

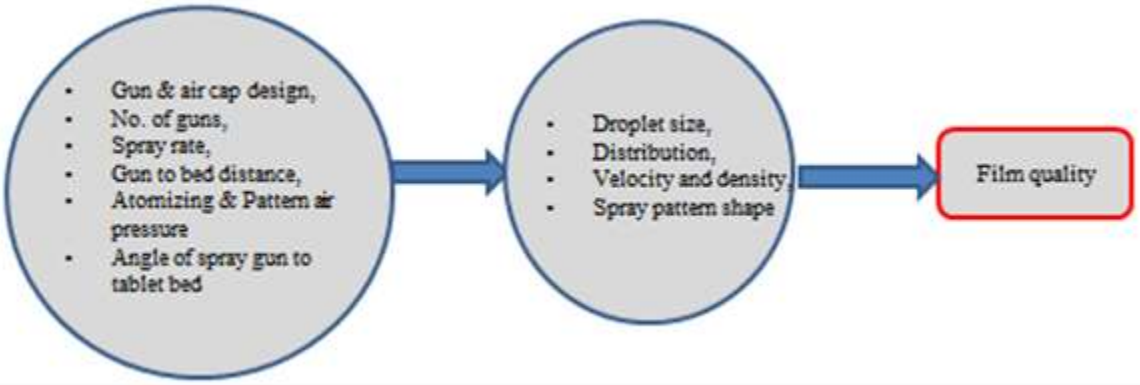


Fig. 3: Factors to be considered while designing a Spraying system

A. Spray Gun Selection:

Spray gun type and specifications plays an important role in producing spray pattern . Spray gun is supplied with Spray Medium, Atomizing air, and control air. Pattern air adjustment screw is to control the spray pattern shape . Spray gun should not attract dust particle to the spray cone which leads to frequent deposition, hence, ACG Pharma Technologies have decided to use Patented ABC (Anti Bearding Cap) Spray Nozzle which keeps dust away from the nozzle face by keeping spray nozzle clean and contamination-free [1].

B. Atomizing Air Pressure and Pattern Air Pressure:

Atomizing air disperses liquid coating material into small droplets. Atomizing air has influence on fineness of atomization of coating liquid. Patter air Pressure decides the spray pattern shape. Atomizing air pressure and pattern air pressure should be adjusted appropriately to achieve elliptical spray pattern shape which should not overlap to avoid localized over-wetting [2] and provide uniform coating.

C. No. of Guns, Spray Rate, and Gun to Gun Distance:

According to the Pan size, Pan diameter, Tablet quantity, gun to gun distance spray pattern shape, desired system weight required number of guns varies. For SC700 as the diameter of pan is 1780mm and capacity is 700litre also by adjusting gun-to-gun distance in order to achieve elliptical spray pattern required no of spray guns to be mounted on spray arm can be decided . Spray pattern determines the number of tablets that get coated during each rotation of pan and each pass through the application zone covered by spray zone. High spray rate may increase the moisture content of the air in the pan and also result in sticking and twinning of the tablets but if the spray rate is very low then spray may get dry before applying on tablets resulting in coating efficiency. Gun to gun distance plays vital role in tablet coating as the spray pattern shape will directly affect the coating uniformity of the tablets. If the spray pattern of guns disturbing adjacent spray gun pattern or they are overlapping then in some part of spray zone thick coating can be observed which will produced uneven coating on final product, hence, it is desired that the spray pattern shape

should not overlap. Desired shape of spray pattern is elliptical as elliptical shape covers maximum area under spray zone which then reduces spraying time. Following figure represents elliptical spray pattern for uniform coating on final product.

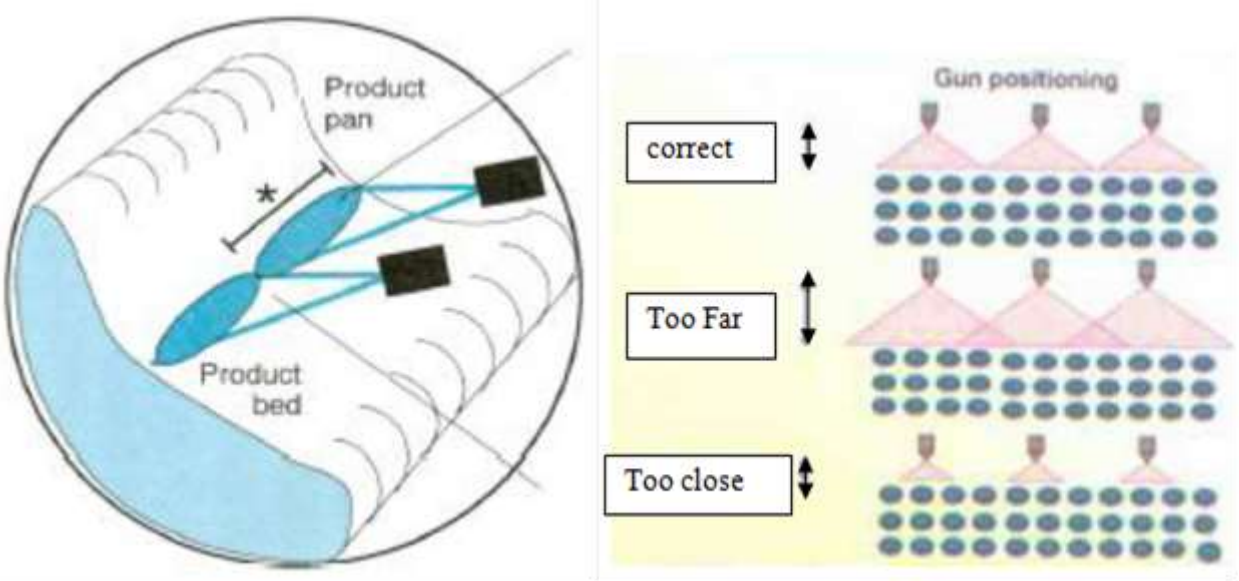


Fig. 4: Representation of elliptical shape of spray pattern in order to achieve uniform coating

D. Spray Gun to Bed Distance and Angle of Spray Gun to Tablet Bed:

The gun to bed distance is the distance between the tip of the spray nozzle and imaginary plane on the cascading bed of tablets. Hence, before hitting the tablet surface the distance travelled by the spray droplets is the distance from spray un to tablet bed. Gun to bed distance adjustment is done by operator by his own decision while performing coating operation on tablets by observing coating thickness. Optimum gun to bed distance should be selected as if the gun to bed distance is too high then spray droplets may get dry before reaching to the tablet bed and if the distance is too low then tablets may get over-wetted. An automated mechanism is required to control the movement of spray arm that is to control and adjust the gun to bed distance from outside without stopping the process. Generally gun to bed distance varies in the range of 15cm to 35 cm depending upon process and coating requirement.

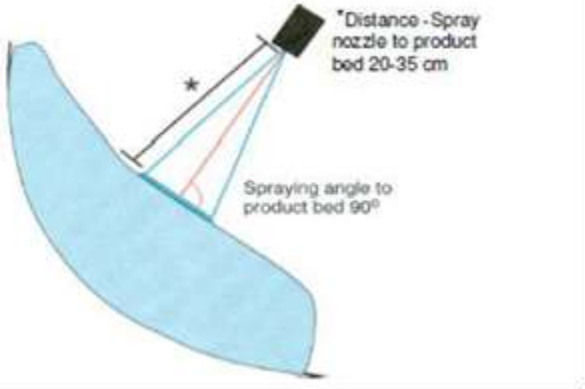


Fig. 5: Representation of desired spray gun to bed distance and angle of spray gun to tablet bed

Figure5 represent the desired gun to bed distance and angle of spray gun to tablet bed. Spraying angle to the tablet bed should be 900 but according to the coating achieved rotation of the spray gun arm up to 450 from initial position is desired which require an automated system.

VII. MODEL DESIGN

Considering parameters required to fulfill basic parameters of coater arm and its need for automation but on the other hand keeping it easy to clean and to follow Pharma-Norms in order to maintain hygiene in the system following design has been modeled using concept of motion by pneumatic principle. Pipes are provided to supply spraying liquid, atomization air, control air to spray guns through hoses. Wash in place pipe is provided to wash system thoroughly. C-bracket is provided to mount the assembly. Pneumatic cylinder is provided to adjust gun-to-bed distance and angle of spray gun to bed by transferring reciprocating motion to the rotary

motion. Considering weight of each gun to be 1kg, then total weight of arm on which guns will be mounted may be up to 7kg. Also the whole assembly weight will be in the range of 10to 12 kg. If the lateral load acting on the cylinder is exceeding over the limit then there is abnormal friction of seals which causes air leakage as lateral load that can be applied to the piston rod is limited as per the pneumatic cylinder type and specification. If the lateral load is not within the allowable range indicated in the catalogue, then using a double rod cylinder, installing a guide or changing the bore size to suit the load are the solutions in order to make the load within the allowable range. But increasing bore size or using double rod cylinder will increase the weight of entire system, mechanism may get bulky which is not acceptable hence guide are provided in order to keep lateral load in allowable range.

Pneumatic cylinder activation is controlled by the control system available for pan coater system. In this mechanism according to stroke of cylinder gun to bed distance can be adjusted upto 15 cm to 30cm and to change angle of spray gun reciprocating motion is transferred to angular motion, using 100mm stroke almost 450 angle change can be seen. Fig 6 shows cad model of mechanism for automated multi-nozzle coater spray arm drawn in SOLIDWORKS

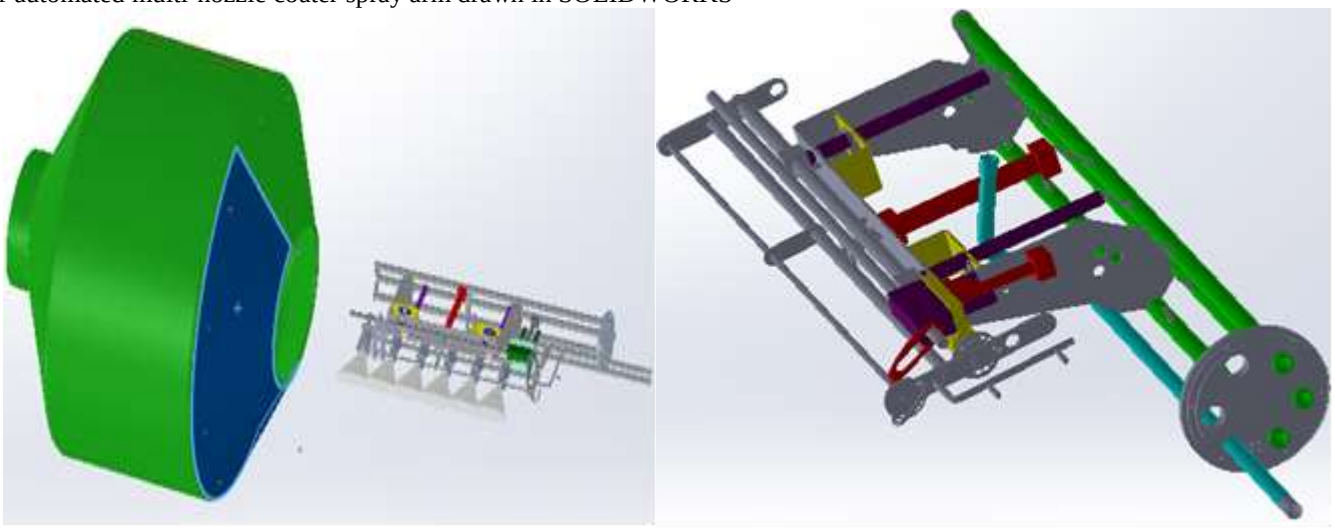
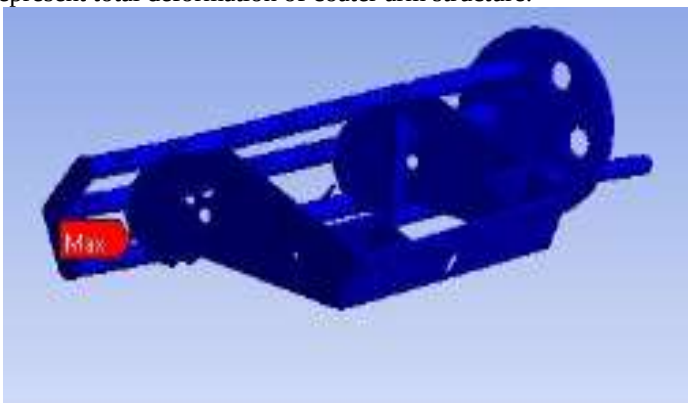


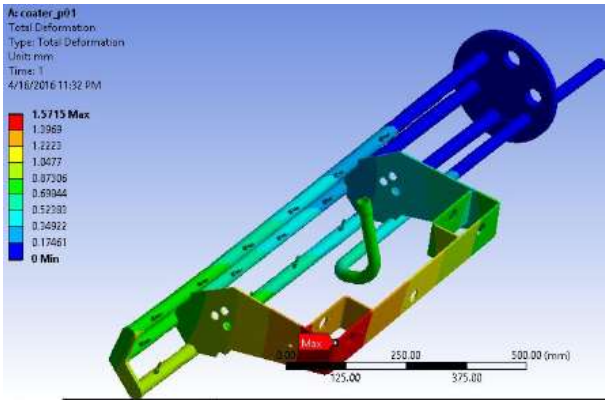
Fig. 6: Mechanism for automated multi-nozzle coater arm

VIII. NUMERICAL ANALYSIS

Numerical analysis is done to check whether the stresses are under permissible limit using ANSYS. As discussed earlier, parts which come in contact with process gases are made up of AISI304nmaterial having ultimate tensile strength 564MPa and Yield tensile strength 210MPa. In first case analysis is done to check rigidity of structure or frame which will be holding spray gun arm. Numerical analysis gives stress generated is 167.46Mpa that is less than allowable stresses and total deformation seen 0.82mm which is permissible. Fig 7(a) shows stress analysis of frame of coater arm and fig 7(b) shows total deformation of frame of spray coater arm. In second case stress analysis for entire spray arm system observed stress is 200.72MPa which is less than allowable stresses and total deformation observed is 0.418mm .Fig 7 (c) shows stress analysis of entire structure of coater arm and fig 7 (d) represent total deformation of coater arm structure.



(a)



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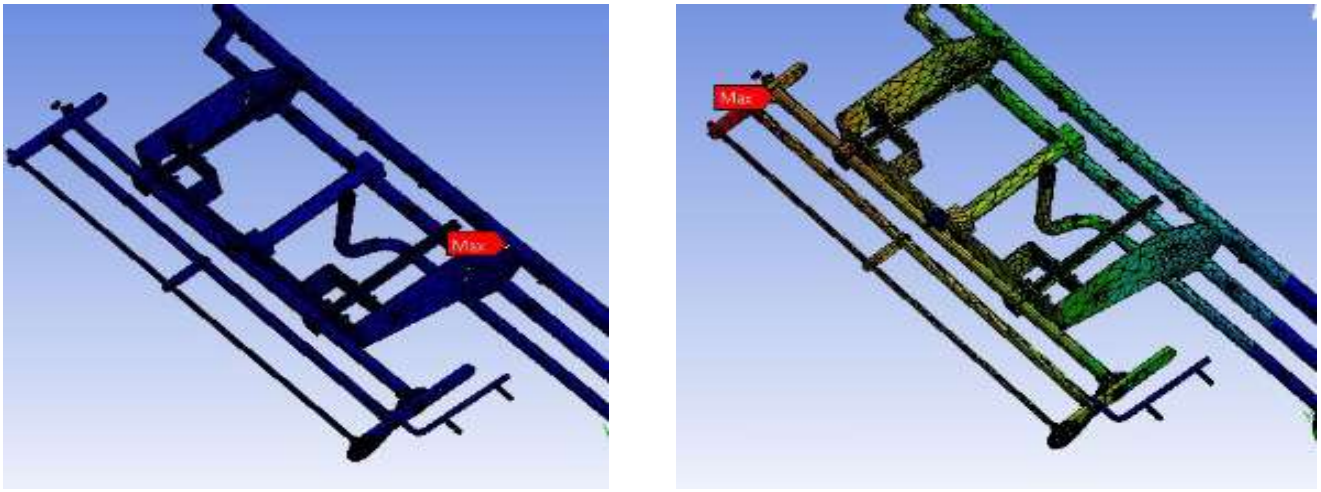

(c) (b)

Fig. 7: Numerical analysis of spray coater arm

IX. CONCLUSION

An automated system for multi-nozzle spray coater arm is designed and also numerical analysis is performed. This mechanism facilitate easy handing of coater arm for operator, as work load reduces, it reduces time wasted in handling the system. Easy to mount set-up, easy maintenance and contamination free automated system solution has been achieved. Also, Numerical analysis shows stresses generated are under permissible stress of the material.

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