

DRUG ENCRUSTATION TOOL FOR STENTS

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ABSTRACT

Drug Encrustation tool is a drug coating tool that coats the medicinal drugs on drug eluting stents. This tool is specially built to coat the medicinal drug on the inner side of the drug eluting stent there by reducing the high risk of blood clot in the coronary artery. A drug-elutingstent is a coronary stent placed into narrowed, diseased coronary arteries that slowly releases a drug to blocked cell proliferation. This prevents fibrosis that, together with blood clots. These blood clots are known as restenosis which are caused due to the damage that are caused to the endothelial cells by the medicinal drugs. The tool designed by us will encrust the drug on the outer side of the stent. This tool uses a specially designed Sodium Polyacrylate absorbent to absorb the drug that are coated on the inner side of the drug eluting stent thereby reducing the risk of restenosis.

Keywords: *Biomedical, Cardiovascular Surgery, Drug Eluting Stent, Slider Crank Mechanism, In Stent Restenosis*

I. INTRODUCTION

A stent is a small mesh tube that's used to treat narrow or weak arteries. Arteries are blood vessels that carry blood away from your heart to other parts of your body. A stent is placed in an artery as part of a procedure called percutaneous coronary intervention (PCI), sometimes referred to as coronary angioplasty. PCI restores blood flow through narrow or blocked arteries. A stent helps support the inner wall of the artery in the months or years after PCI. Doctors also may place stents in weak arteries to improve blood flow and help prevent the arteries from bursting. Stents usually are made of metal mesh. Some stents are coated with medicine that is slowly and continuously released into the artery. These stents are called drug-eluting stents. The medicine helps prevent the artery from becoming blocked again. A drug-elutingstent (DES) is a coronary stent placed into narrowed, diseased coronary arteries that slowly release a drug to block cell proliferation. This prevents fibrosis that, together with clots, could otherwise block the stented artery, a process called restenosis.

In conventional stent coating machine the drug is coated on both inner and outer surface of the stent as the stents are simple wire frame structure. So, the drugs cannot be coated only the outer surface. These drugs in the drug eluting stents are used to reduce the block in the coronary artery.

This Drug Encrustation Tool is operated using two D.C motor. This D.C motor is using to rotate the flywheel which reciprocates the spray nozzle attached to a slider. According to the speed of the motor and other properties, the parts of the Encrustation tools are designed. By using this coating tool in hospitals to coat drugs in stent, it might be very useful for the public. In spite of using costlier machines to coat drugs, we can use this machine which saves our time and Easy to operate.

As it removes the drug that is coated in the inner side of the stent. It reduces the restenosis risk.

II. MATERIALS AND COMPONENTS

2.1 Pump

A pump is a device that moves fluids (liquids or gases) by mechanical action. The pump runs on 9V battery which delivers a pressure of 0.12 bar. It forcibly delivers the drug fluid into the rotating stent material, so that the drug is uniformly coated along the walls of the stent.

2.2 Stent Holder

It is made up of aluminum alloy which holds the stent. This assembly is connected to a DC motor, so it rotates the stent in the rotating shaft.

2.3 Mist Sprayer

It is made up of plastic. It is highly corrosive resistant. so it may not react with the coating drug. It is mounted on to the slider which in turn reciprocates over sliding rod. It sprays the drug over the rotating stent in the shaft. It gets pressurized drug from the pump.

2.4 Absorbent

It is a sodium Polyacrylate rod which is placed in the inner surface of the Drug eluting stent. This rod is kept in close tolerance with the stent's inner surface. During the coating process the absorbent absorbs the drugs that are coated on the inner surface of the stent leaving a very thin layer of coating in it. It has no effect with the drugs that are coated on its outer surface.

III. WORKING METHOD

Initially the Drug eluting stent to be coated by medicinal drug is loaded on the rotating shaft. The spray nozzle can be varied with variation in pressure of the pump. Drug is stored in a storage reservoir and is pumped to the Spray nozzle at a high pressure.

As power is supplied to the motors it starts running. The shaft on which the stent is placed starts to rotate the stent due to the rotation of a motor it is coupled with it. The Spray Nozzle arrangement slides in slider rod due to slider crank mechanism. The spray Nozzle arrangement which is placed just above the rotating stent sprays the drug on the rotating stent.

Due to the rotation of the stent the drug gets coated on its surface. Since the stents are wire framed structure some amount of the drug passes into the inner side of the stent. The drug coated on the inner surface of the stent damages the endothelial cells and causes blood clot. It is removed by using an absorbent which is placed in the inner side of the rotating shaft.

The length of the stroke can be varied using a pin arrangement. The shaft attached to the stent holder should be varied with the variation in the dimensions of the stent. The absorbent used should be changed after each use.

Polymer absorbent like Sodium Polyacrylate is used to absorb the drug. Cotton absorbent wrapped over the shaft can also be used as an alternate absorbing material.

IV. DESIGN CALCULATION

4.1 Design of Shaft Diameter

Diameter of the shaft has been designed as follows:

$$C\theta = \frac{T}{J}$$

$$L = J$$

$C = 0.270 \times 10^5 \text{ N/mm}^2$ for aluminium alloy from data book

$$\theta = 1^\circ \text{ (Assume)} = \frac{1 \times \pi}{180} = 0.01745 \text{ radians}$$

$$L = 150 \text{ mm}$$

$$T = \frac{\pi \times \tau \times D^3}{16}; \quad \tau = 60 \text{ N/mm}^2 \text{ for aluminium alloy from data book}$$

$$J = \frac{\pi \times D^4}{32}$$

$$\frac{0.270 \times 10^5 \times 0.01745}{150} = \frac{\pi \times 60 \times D^3 \times 32}{16 \times D^4 \times \pi}$$

$$D = 9.1 \text{ mm}$$

Standard Shaft diameter = 10 mm

4.2 Design of Fasteners

From http://www.engineersedge.com/fastener_thread_menu.shtml

4.2.1 Calculation of Tensile Strength Area of Screw Thread. (A_t)

$$A_t = 3.1416 \left(\frac{E_s \text{ min}}{2} - \frac{0.16238}{n} \right)^2$$

Where,

$E_s \text{ min}$ = Minimum Pitch Diameter of External Thread

n = Number of threads per cm

From PSG databook page 5.42 Corresponding to Major diameter $D_{\text{major}} = 10$

$E_s \text{ min} = 8.16 \text{ mm}$

$$n = 6.29$$

$$A_t = 3.1416 \left(\frac{8.6}{2} - \frac{0.16238}{6.29} \right)^2$$

$$A_t = 13.42 \text{ mm}^2$$

4.2.2. Calculation of Thread Pitch Circle Diameter

$$d_p = (D - 0.64952 \cdot p)$$

Where,

D = Major Diameter

p = pitch of the thread

Pitch $p = 1.5$ from PSG databook page 5.42

$$d_p = (10 - (0.64952 \times 1.5))$$

$$d_p = 9.025 \text{ mm}$$

4.2.3. Calculation of Thread Shear Area

$$A_{th} = 0.5 \pi d_p L_e = 0.5 \pi L_e (D - 0.64952 p)$$

Where,

L_e = Thread Engagement Length

d_p = Pitch circle diameter of thread

D = Major Diameter

p = Pitch

$$L_e = 7.2 \text{ mm}$$

$$A_{th} = 0.5 \times \pi \times 9.025 \times 14.4$$

$$A_{th} = 102.07 \text{ mm}^2$$

4.2.4. Calculation of Length of Thread

$$L_e = \frac{2 \times A_t}{K_n \max \pi \left(\frac{1}{2} + 0.57735 n (E_s \min - K_n \max) \right)}$$

Where:

A_t = Tensile Stress Area

$K_n \max$ = Maximum minor diameter of internal thread.

$E_s \min$ = Minimum pitch diameter of external thread.

n = Number of threads per cm

$$L_e = \left(\frac{2 \times 13.42}{0.812 \pi \left(\frac{1}{2} + 0.57735 \times 6.29 (8.16 - 0.812) \right)} \right)$$

$$L_e = 0.387 \text{ mm}$$

4.2.5. Calculation of Shear Area for External Thread (Screw or Fastener)

$$A_s = \pi n L_e K_n \max \left(\frac{1}{2n} + 0.57735 (E_s \min - K_n \max) \right)$$

$$A_s = \pi \times 6.29 \times 0.387 \times 0.812 \left(\frac{1}{2 \times 6.29} + 0.57735 (8.16 - 0.812) \right)$$

$$A_s = 46.12 \text{ mm}^2$$

4.3 Design of Flywheel

4.3.1. Calculation of Mass Moment of Inertia (I)

$I = m k^2$ $m \rightarrow$ mass of flywheel in kg

$$I = m \times \left(\frac{r}{2} \right)^2 \quad k \rightarrow \text{radius of gyration}$$

$$I = 0.5 \times \frac{40 \times 10^{-3}}{2}$$

$$I = 0.01 \text{ kgm}^2$$

4.3.2. Calculation of Mean Speed (N)

$$N = \frac{N_1 + N_2}{N}$$

where $N_1 \rightarrow$ Maximum speed

$N_2 \rightarrow$ Minimum speed

$$N = \frac{N_1 + N_2}{2} = \frac{60 + 30}{2} = 45 \text{ rpm}$$

4.3.3. Calculation of Angular Velocity (ω)

$$\omega = \frac{2\pi N}{60} = \frac{2 \times \pi \times 45}{60} = 4.7 \text{ rad/s}$$

4.3.4. Calculation of Radius of Gyration (k)

$$k = r/2$$

$$k = 0.04/2$$

$$k = 0.02 \text{ m}$$

4.3.5. Calculation of Coefficient of Fluctuation of Speed

$$C_s = \frac{N_1 - N_2}{N} = \frac{60 - 30}{45} = 0.66$$

4.3.6. Calculation of Maximum Fluctuation of Energy (ΔE)

From PSG Design databook,

$$\Delta E = I \omega^2 C_s$$

$$\Delta E = 0.01 \times 4.7^2 \times 0.66$$

$$\Delta E = 0.145 \text{ Nm}$$

4.3.7. Dimensions of Flywheel

$$\rho = \frac{m}{v}$$

where $\rho=7200\text{kg/m}^3$ (for mild steel)

$$7200 = \frac{0.5}{v}$$

$$v = \frac{0.5}{7200} = 6.9 \times 10^{-5} \text{ m}^3$$

we know that $v = \pi DA$

$$6.9 \times 10^{-5} = \pi \times 0.008 \times A$$

$$A = 2.7 \times 10^{-4} \text{ m}^2$$

$$A = b \times t$$

But $b = 5t$ from PSG design databook

$$2.7 \times 10^{-4} = 5t^2$$

$$t^2 = 5.5 \times 10^{-5} \text{ m}^2$$

$$t = 7.4 \text{ mm}$$

$$b = 5t$$

$$b = 5 \times 7.4$$

$$b = 37 \text{ mm}$$

V. FIGURE

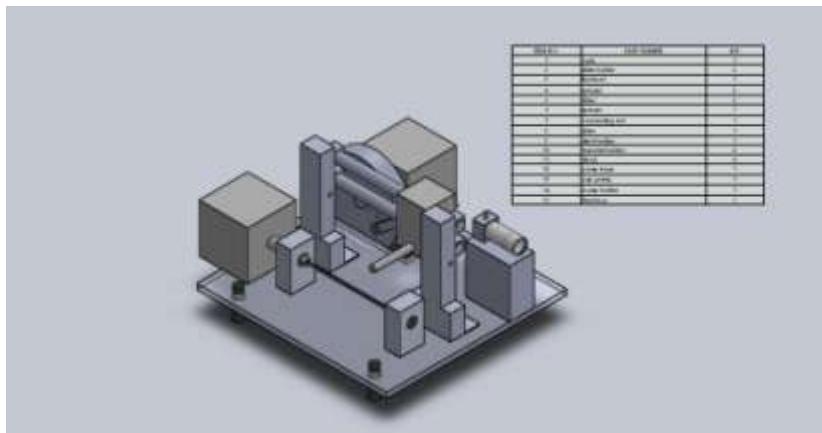


Fig. 5.1 Isometric View of Drug Encrustation Tool

VI. CONCLUSION

The aim of this work is to reduce the manual risk and the time taken, when encrusting drugs on drug eluting stent. It works as automatic machine and reduces the time taken for coating drug.

In our machine, the body is made up aluminium; the major parts assembled in the Drug encruster machine are light weighted. Hence it is easy to lift and it is portable. The drug encruster is fully automatic and no need any manual work to operate the machine. So this will reduce the manual work and very much useful to the mankind.

The cost of Drug Encrustation tool is very low it reduces the inventory for the coating tool. It reduces the cost of the Drug Eluting Stent to a large extent. This tool reduces the high risk of restenosis by removing the drug on the inner surface the stent which causes it.

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