

CHAPTER V

COMMERCIAL AND ECONOMIC FEASIBILITY REPORT

V.1 Introduction

This report has been prepared on purely theoretical and hypothetical assumptions made, with respect to the commercial scale manufacturing process of the new drug delivery system proposed based on (a) the well established commercial scale conventional hard gelatin capsule manufacturing process (1), and (b) the method of preparation of the new controlled drug delivery system using laser drilled capsules, developed on the laboratory scale (Chapter II). However, the economic feasibility report of the proposed process is based on some facts and figures related to continuous manufacturing process of conventional hard gelatin capsule, employed in industry today.

Preparation of the proposed new laser drilled drug delivery system involves making the conventional hard gelatin capsule GIT resistant by formalin vapour treatment (Chapter II, page 52) and drilling minute pores on the body of the capsule using a CO₂ gas laser (Chapter II, page 56). Hence the objectives of this report were to :

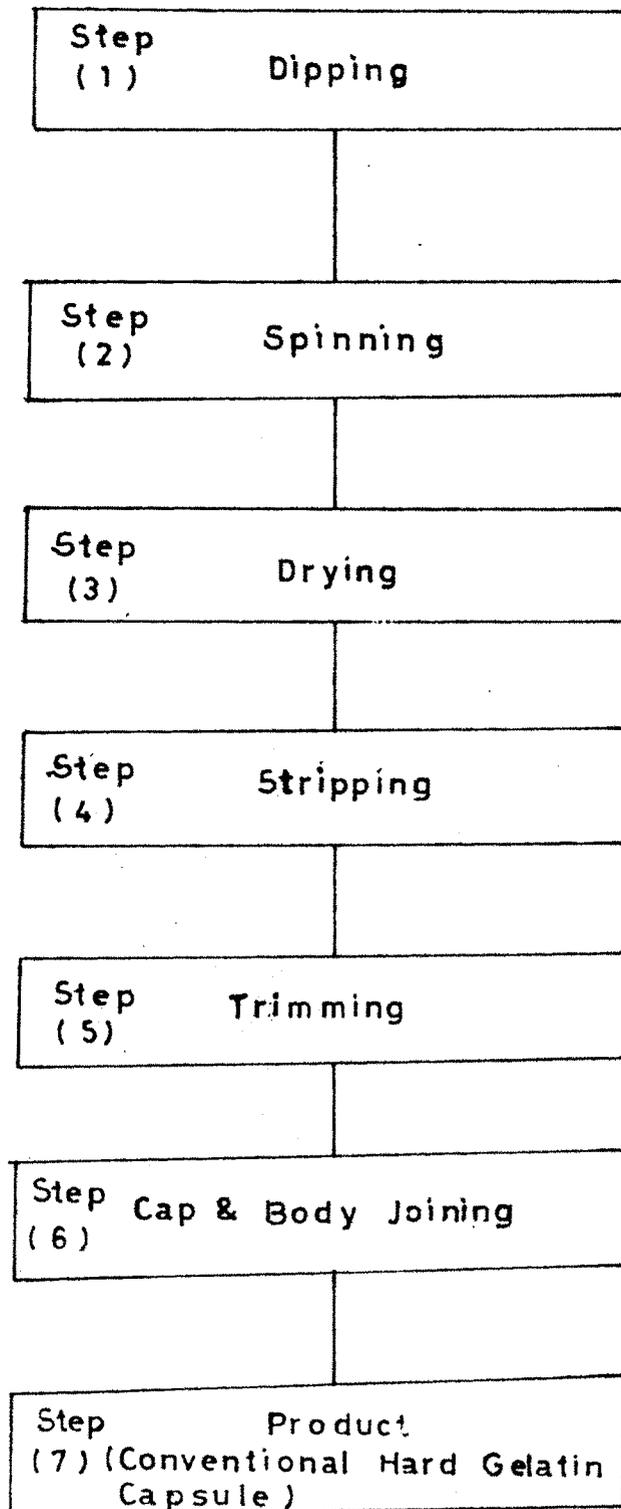
- (i) propose a commercial scale continuous manufacturing process for laser drilled GIT resistant capsules,

based on commercial scale manufacturing process of conventional hard gelatin capsules employed presently, and laboratory scale preparation method of laser drilled GIT resistant capsule developed in the present study; and

- (ii) prepare an approximate economic feasibility report of laser drilled GIT resistant capsules as compared to conventional hard gelatin capsules.

V.2 Commercial Feasibility

The fully automatic machine most commonly used for conventional hard gelatin capsule manufacture consists of mechanisms for automatically dipping, spinning, trimming and cap and body joining (Scheme 16; Steps 1 to 7). A stainless steel mold pin on which the capsules are formed controls some of the final critical dimensions of the capsule. A commonly used commercial scale equipment generally contains 486 pairs of pin bars, each containing 20 pins. These pairs of pin bars are dipped into a gelatin sol of carefully controlled viscosity, to simultaneously form caps and bodies. The pins are spun through two and one-half revolutions, to distribute the gelatin uniformly. During the spinning cycle the gelatin may be set or gelled by a blast of cooled air. Then the pins are moved through a series of drying kilns for gradual and precisely



Scheme 16 - Different Steps Involved in the Continuous Manufacturing Process of Conventional Hard Gelatin Capsules.

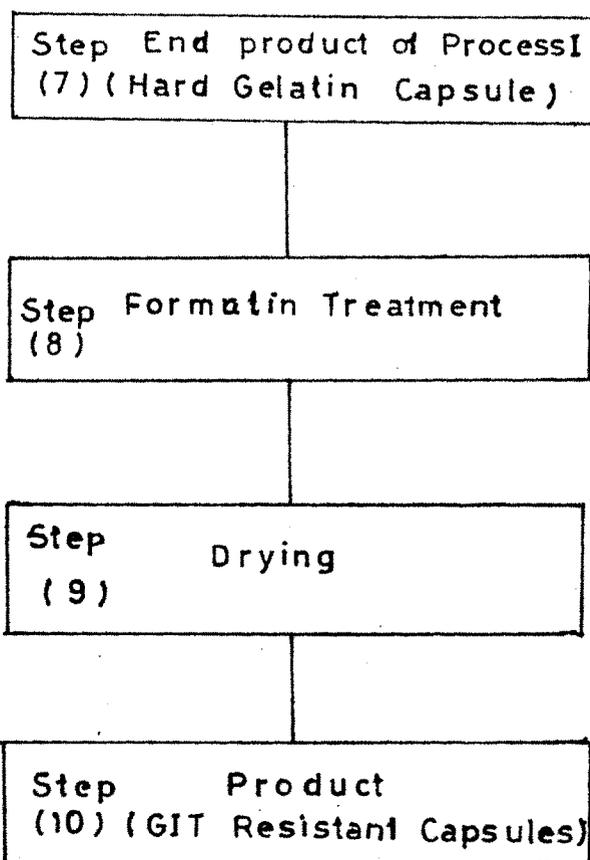
controlled removal of water. The capsules are stripped by bronze jaws and trimmed to length by stationary knives. After being trimmed to exact length the cap and body sections are joined and ejected from the machine. The entire cycle of the process takes about 45 min (Scheme 19). The equipment is about 37' in length requiring about 2500 sq. ft. centrally airconditioned area. The rated output capacity of the equipment is about 6.0 to 7.5 lac capsules/24 hr and the plant and equipment cost is about Rs.1.0 Crore.

The proposed laser drilled GIT resistant capsule manufacturing process (Scheme 20) based on process I, II and III depicted in Schemes 16, 17, and 18, includes the following changes as compared to the conventional hard gelatin capsule manufacturing process discussed earlier :

- i) Formalin vapour treatment (Step 8, Scheme 20) after drying step 3, Scheme 20.
- ii) Repeatition of the drying process (Step 3¹, Scheme 20) after formalin treatment.

All the other steps of manufacture remain similar as described under conventional hard gelatin capsule manufacture, however the end product in this case being GIT resistant capsules (Step 9, Scheme 20). These capsules are then subjected to laser drilling using a CO₂ gas laser

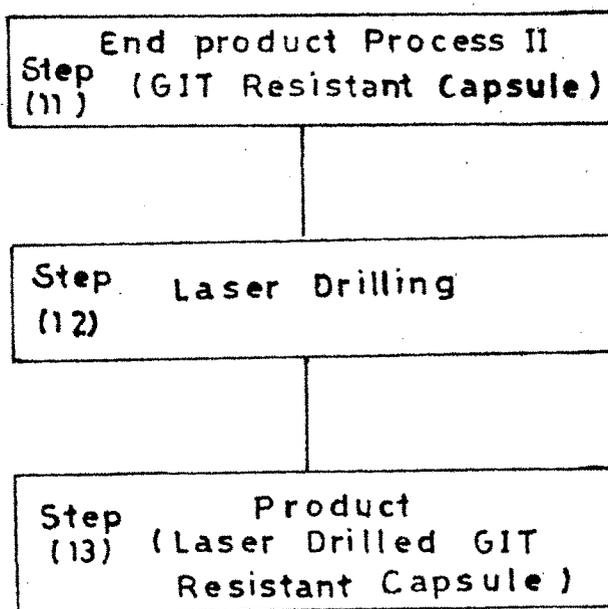
Process-II



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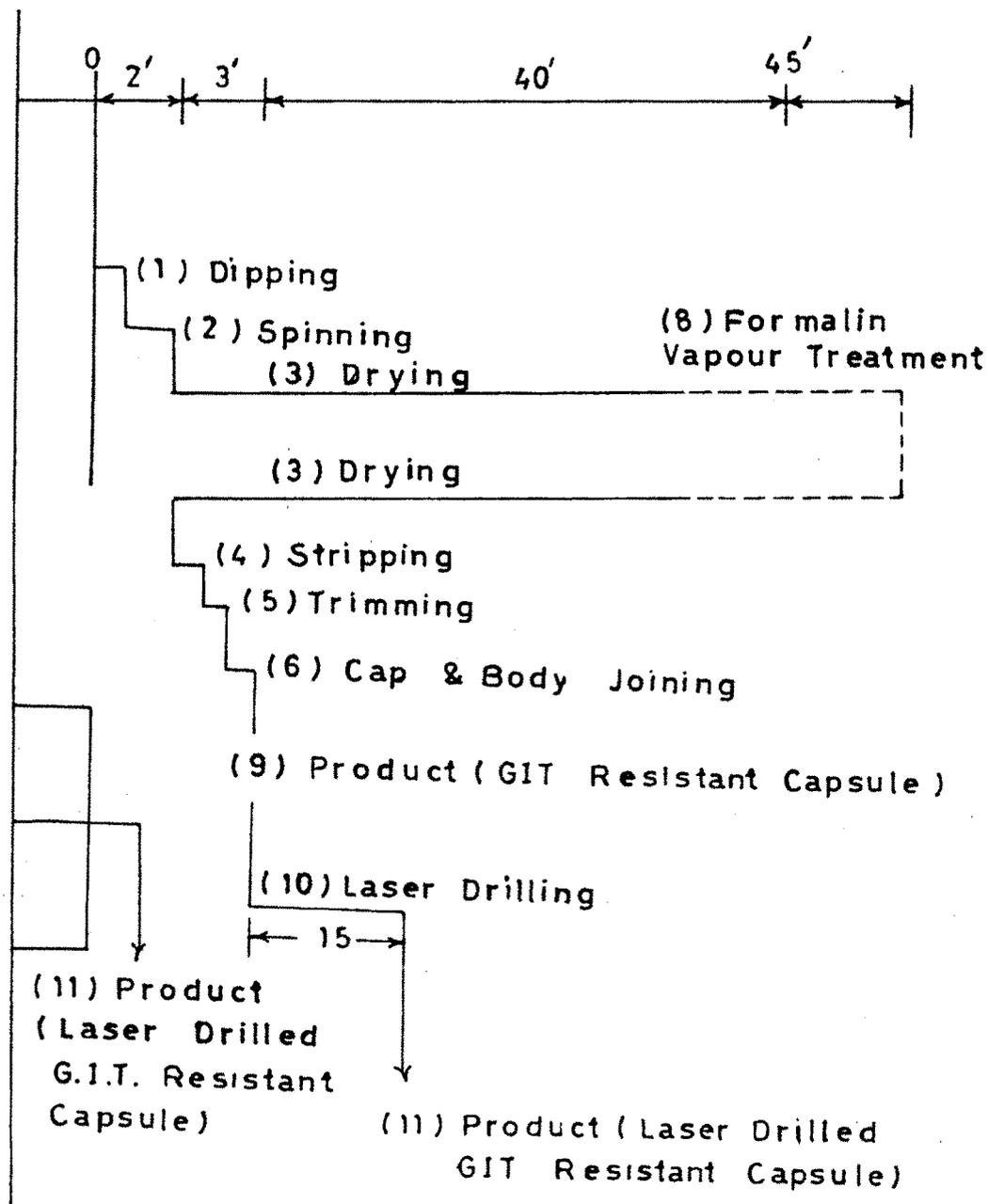
Scheme 17 - Different Steps Involved in Laboratory Scale Preparation of GIT Resistant Capsules.

Process II

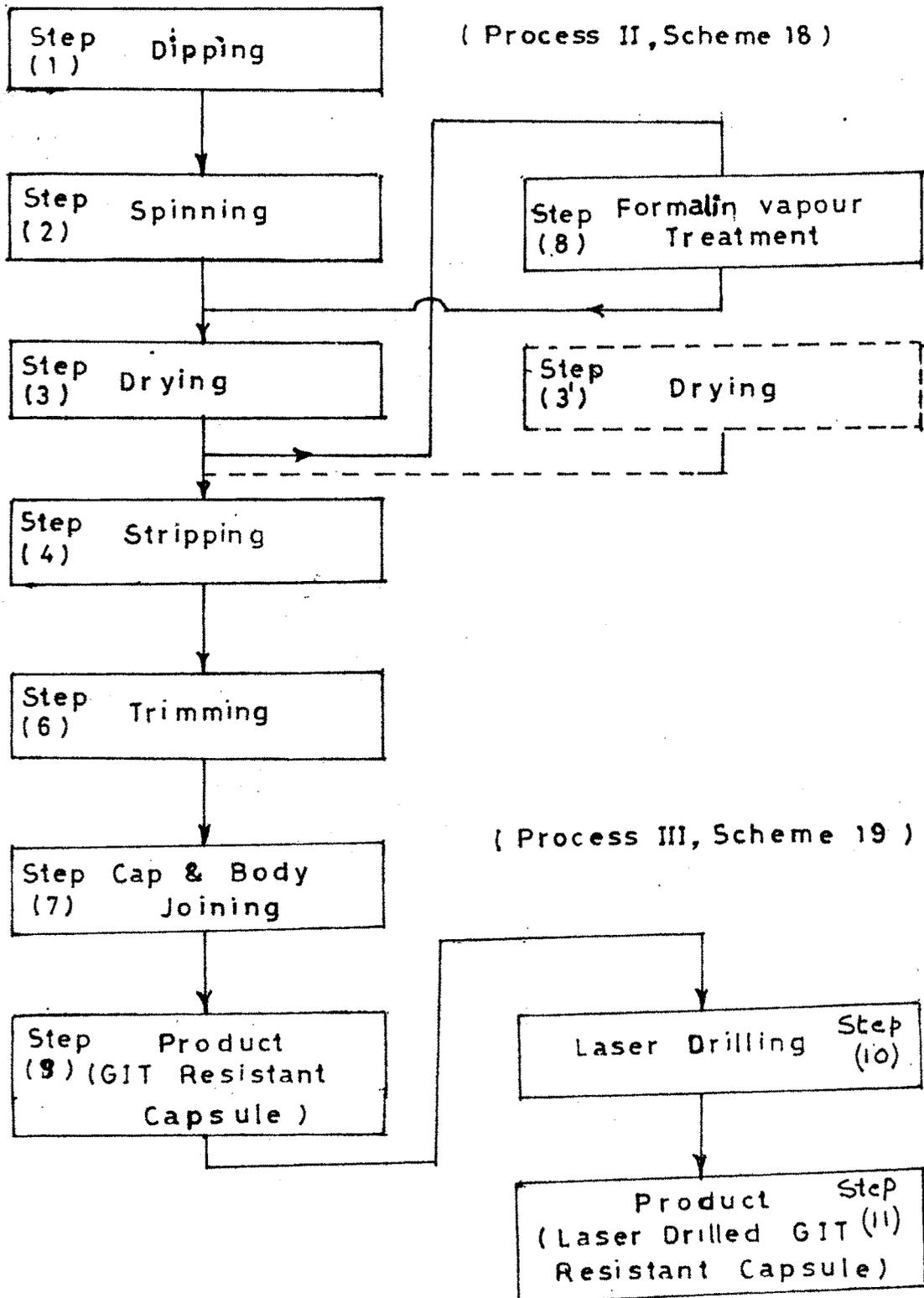


Scheme 18 - Processing Steps Involved in the Laboratory Scale Preparation of Laser Drilled GIT Resistant Capsules.

Time in Minutes



Scheme: 19 - Time Cycle of the Proposed Commercial Scale Continuous Manufacturing Process of GIT Resistant Laser Drilled Capsules.

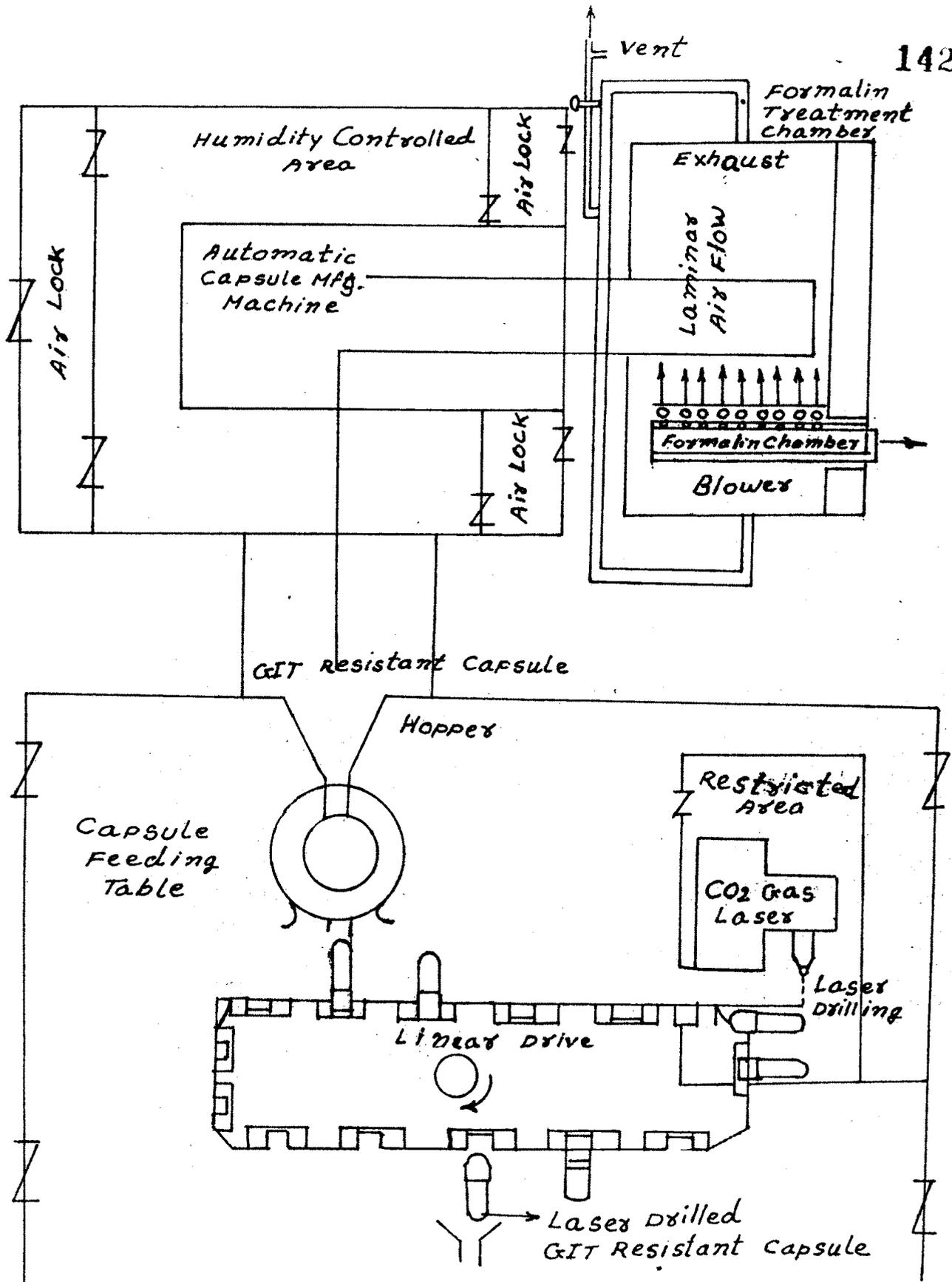


Scheme : 20- Different Processing Steps Involved in the Proposed Commercial Scale Continuous Manufacturing Process of GIT Resistant Laser Drilled Capsules.

(Step 10, Scheme 20) to make minute pores on the hardened body wall of the GIT resistant capsule to finally get the desired laser drilled GIT resistant capsule (Step 11, Scheme 20).

As shown in Scheme 20 the inclusion of two additional steps in the manufacture of laser drilled GIT resistant capsules as compared to conventional capsules i.e. formalin vapour treatment and repetition of the drying cycle has resulted in an increase of about 90 min in the time cycle. Hence the total time of the cycle in this case would be approximately 135 min i.e. thrice the time taken in the conventional hard gelatin capsule manufacture. The GIT resistant capsule manufacturing machine would therefore, need to be of thrice the length of a conventional machine i.e. $3 \times 37' = 111'$ with 3×486 pairs of pin bars containing 20 pins in each, in order to have a continuous manufacturing process. Accordingly the built up area required would be approximately 5,000 sq. ft. and the cost of plant and machinery, with the suggested modification, might go up by Rs. 20 to 30 lac approximately.

Scheme 21 shows the plant and equipment layout proposed for the manufacture of laser drilled GIT resistant capsules. The total built up area required for the plant would be around 10,000 sq. ft.. The capsule manufacturing



Scheme 21 - Plant and Equipment Layout for the Proposed Manufacturing Process of GIT Resistant Laser Drilled Capsules.

machine would necessitate the modifications suggested above as compared to conventional equipment for the reasons explained above.

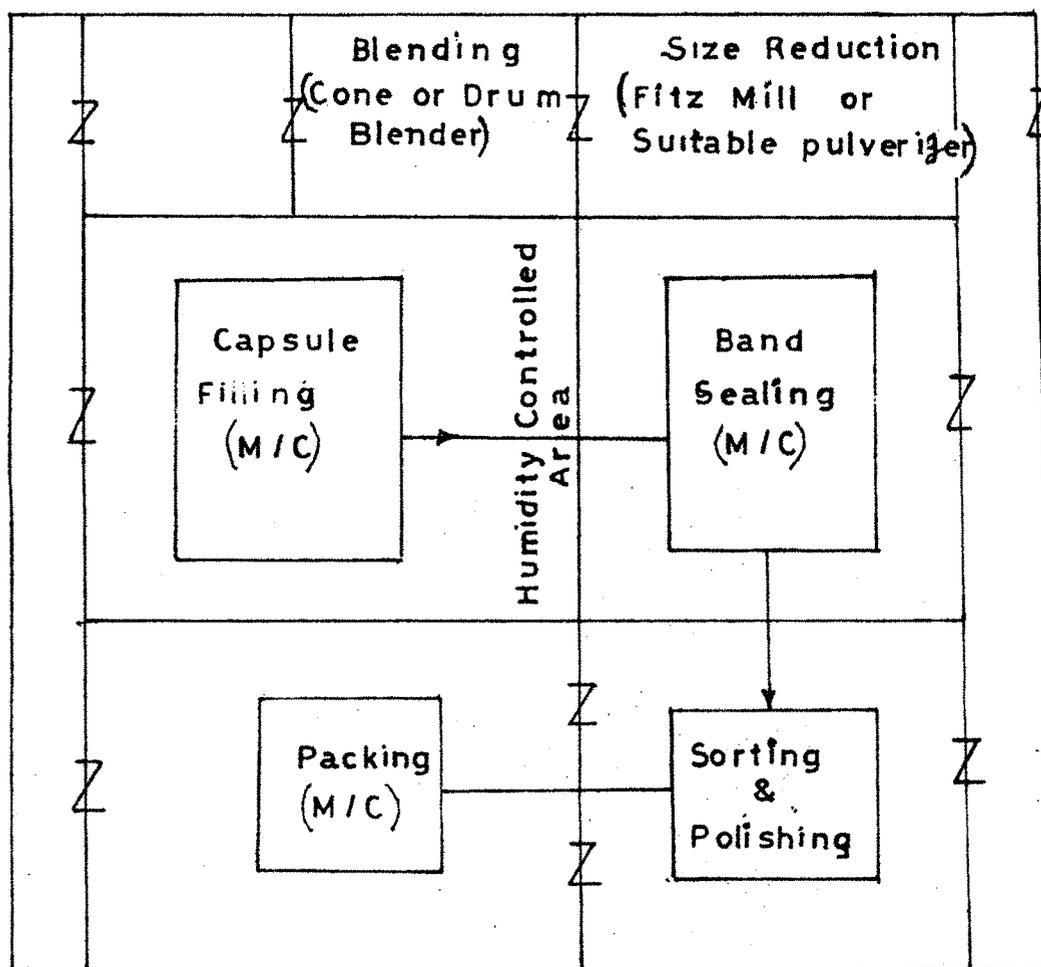
The formalin treatment chamber should be established in a restricted area and the treatment chamber is essentially a closed one with provisions for (a) formalin vapour generation, (b) blast of air with laminar flow, recirculation system and venting facilities and (c) temperature and humidity control. The cost of the chamber may be around Rs. 2.0 lac.

The capsule feeding table is designed to feed the capsules continuously onto the capsule holders arranged in a linear drive moving at a speed of about 2 mm/sec. with body in the upright position.

A 50 W CO₂ gas laser (Chapter II, page 56) would be ideal for making minute drilled pores on the body of the capsule. The operation cost of this laser inclusive of gas, electricity, water and other overhead expenses would be around Rs. 20/hr calculated based on the laser operating economics reported (2). The machine requires minimum set up and is automatically loaded and unloaded and a full time operator is not really needed for the operation. The equipment needs to be kept in a restricted area.

V.3 Economic Feasibility

Table V.1 shows the cost calculations for the laser drilled GIT resistant capsules as compared to conventional hard gelatin capsules. The calculations are made considering a 50% increase in capital investment, 100% increase in overhead expenses and 66% reduction in output; in the case of laser drilled GIT resistant capsules as compared to conventional capsules. As shown in Table V.1 a laser drilled GIT resistant empty capsule would cost approximately four times the cost of a empty conventional hard gelatin capsule. However, when these empty laser drilled capsules are used in preparing a controlled release dosage form the above increase in price of empty capsule is very nominal as compared to the cost of a unit controlled release dosage form. The possible increase in cost of laser drilled capsule dosage form due to the inclusion of one extra step of band sealing (Scheme 22) would be practically negligible. Table V.2 shows a comparative cost analysis of a controlled release capsule dosage form prepared using laser drilled capsules with that of sustained release bead and conventional hard gelatin capsule formulations. As shown in Table V.2 the four times increase in the price of empty laser drilled capsule has resulted in an increase of only 10% in the selling price of the capsule dosage form as compared to a conventional hard gelatin capsule dosage



Scheme: 22 - Plant and Equipment Layout for the Manufacture of Capsule Dosage Forms Using GIT Resistant Laser Drilled Capsules.

Table V.1 : Approximate Cost Calculations of Empty Laser Drilled GIT Resistant Capsules as Compared to Conventional Hard Gelatin Capsules.

Cost Factors	Contribution to cost (%)	
	Conventional Hard Gelatin Capsules	GIT Resistant Laser Drilled Capsules
Raw Material	55	55
Fixed	8	12
Variable	12	25
Total Cost	75	$92 \times 3 = 276^*$
Profit (25% of selling price)	25	92
Selling Price	100	368 400**

* Considering the GIT resistant capsule production is 1/3 as compared to conventional capsules, the effect of this reduction on the cost would be $3(55+12+25) = 276$

** The cost of empty Laser Drilled GIT Resistant capsule would be approximately 4 times that of conventional capsules.

Table V.2 : Approximate Comparative Cost Analysis of Laser Drilled Capsule Dosage Form with a Sustained Release Bead and Conventional Hard Gelatin Capsule Formulation.

Cost Factor	Contribution to the cost of Capsule Formulation (%)		
	Conventional	Sustained Release Bead	Laser Drilled
Empty Capsule	3	3	12*
Drug	50	50	50
Additives	5	25**	5
Processing	25	40***	25
Profit	17	17	17
Total	100	135	110

* Four times increase in the cost of laser drilled empty capsules.

** Cost increase due to the use of release retarding materials, solvents, etc.

*** Cost increase due to investment on special processing equipments like Marumarizer and Pelletizer, additional processing steps, processing time, etc.

form, which is very nominal considering the fact that product we obtain is a slow release or sustained release type having definite advantages over conventional capsules. The use of laser drilled capsules however, would be more economical in designing controlled release dosage forms as compared to bead formulations, since the increase in cost of a bead formulation as compared to conventional product is about 35.0% against 10.0% in the case of laser drilled capsules (Table V.2).

V.4 Conclusions

The proposed continuous manufacturing process of laser drilled GIT resistant empty capsule though involves 30% higher capital investment with 50% increase in fixed cost, 100% increase in variable cost and 66.0% decrease in production, yet seems to be commercially and economically feasible. The proposed continuous manufacturing process of empty laser drilled GIT resistant capsules though produces capsule which costs almost four times the price of conventional hard gelatin capsule, it does not affect the cost of the finished formulation considerably. Thus design of a controlled release drug delivery system using laser drilled empty capsule is very economical as compared to other products like sustained release bead formulation (Table V.2) and it provides an improved, convenient and more effective capsule dosage form at very nominal additional cost.

REFERENCES

1. L. Lachman, H.A. Lieberman and J.L. Kanig, The Theory and Practice of Industrial Pharmacy, 2nd ed., Lea & Febiger, Philadelphia, p. 391 (1976).
2. R. Sounders, T. Conklin, G. Thomas, W. Shiner, D. Bennett and J. Bellis, Laser Operation, Equipment, Application and Design, McGraw Hill Book Co., New York, p. 171 (1980).

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