Design and Fabrication of Double disk Lapping Machine for Gudgeon Pin

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Abstract: **An engineer is always focused towards challenges of bringing ideas and concepts to life. Therefore, sophisticated machines and modern techniques have to be constantly developed and implemented for economical manufacturing of products. Advanced researches approaches a topic of actuality in the machine manufacturing field, by combining the modern trends in the manufacturing processes (surfaces' lapping) in processing some special materials (ceramics, composites) in conditions of minimum cost/ maximum quality, with modern technologies. Machine lapping is meant for economic lapping of batch qualities. In machine lapping, where high accuracy is demanded. Bonded abrasives in the form wheel are chosen for commercial lapping. Machine lapping can also employ abrasive paper or abrasive cloth as the lapping medium. New machines and techniques are being developed continuously to manufacture various products at cheaper rates and high quality. So, we are going to make a machine for Double Disc Lapping Machine and make it multipurpose & should be used as Micro Finishing machine is simple to maintain easy to operate. Hence, we tried our hands on "Double Disc Lapping Machine." Lapping machine is one of the principal machines in industry. It is mainly used as the name indicates to micro polishing the material surfaces.**

Keywords: Micro Finishing, Lapping, both sides, low-cost machine

1.INTRODUCTION

Quality of surface is an important factor to decide the performance of a manufactured
Product. Surface quality affect product performance like assembly fit, aesthetic appeal that a potential customer might have for the product. A surface is defined as the exterior boundary of an object with its surroundings, which may be any other object, a fluid or space or combination of these. The surface encloses the object's bulk mechanical and physical properties. Lapping and polishing is a process by which material is precisely removed from a work piece (or specimen) to produce a desired dimension, surface finish, or shape. The process of lapping and polishing materials has been applied to a wide range of materials and applications, ranging from metals, glasses, optics, semiconductors, and ceramics. Lapping and polishing techniques are beneficial due to the precision and control with which material can be removed. Surface finishes in the nanometer range can also be produced using these techniques, which makes lapping and polishing an attractive method for materials processing. A surface is what we touch, when we held a manufactured object. Normally dimensions of the object are specified in its drawing relating the various surfaces to each other. These nominal surfaces, representing the intended surface contour of the manufactured part, are defined by line in the drawing (machine). The nominal surfaces of the object are represented by perfect straight lines, perfect circles, round holes, absolute perpendicularity and straightness. A variety of processes are used to make the designed parts. In totality the manufacturing result is wide variations in surface characteristics. It is important to know the technology of surface generation. Only then the root causes of deviations can be determined and fixed to get the good results.

1.1. Problem statement of project:

The lapping is the major operation performed in industry, and to perform this operation in manpower is require which results in to high cost of production, more time require to complete the operation, affect the accuracy of product so that system we

are trying to do a work on new system in lapping/polishing. The lapping machine available can perform the work of lapping at only one side & after doing lapping second side is to turn for lapping which loss time, efforts & cost of production. We are trying to make a new machine for reduce problems in existing system. The statement of project is **"design & fabrication of double disc lapping machine"** for the lapping of different sizes of cylindrical machine parts as per requirements for industry.

1.2. OBJECTIVE:

1) To reduce the efforts & man power during machining.

2) To maintain the accuracy in lapping process.

3) This type of m/c provides work practically at low cost, low maintenance, low capital investment in less space.

4) To performed the most rigid operation with high speed at a time for both side of job surface.

1.3. Scope:

The scope of this machine to perform the most rigid operation with high speed at a time for both side of job surface for the lapping of different sizes of cylindrical machine parts as per requirements for industry.

2.LITERATURE REVIEW

Tiberiu Dobrescu, Nicoleta-Elisabeta Pascu, Gabriel Jiga, Constantin Opran, done the work on, Optimization Criteria of Plane Lapping Machines, according to his work, this paper reviews experimental research regarding brittle materials processing with super finishing machine The main criteria for determining the characteristics of superfinishing machines can be grouped into: energy consumption criterion, technologically criterion and dynamic criterion can be determined and the main criteria optimization plan lapping machines. The optimization of the characteristics of brittle materials superfinishing machine is very important because

they directly influence the quality of workpieces surfaces. The performances of the superfinishing machine linkages are increasingly higher, due to the following requirements: very high quality workpieces surface, reduced time for feed workpieces to machine tools, better interconnections between machine tools are used in the technological process, high flexibility.

Silicon wafer lapping with abrasive particles of 18 μm has been obtained as a result of the arithmetic average surface roughness having a value closed at the different specific pressing force of the lapping (standard 80%, 60% and 40%). These forces of specific lapping pressure which provide different material removal rates, with the possibility of choosing depending on the needs and characteristics of the machine. To obtain the less arithmetic mean roughness value Ra with the specific pressure on lapping standard it lasts five minutes. This is very important from the point of view of productivity. In the case of abrasive particles lapping of 4 μm to 8 μm - there was an optimum specific pressing force of lapping between the specific pressing forces of lapping used in the experiment cases (in the case of the use of particles of 8 μm the specific optimum pressure force of lapping is 80% from the specific pressure force of standard lapping, and in the case using particle of 4 μm the specific optimum pressure force of lapping is 80% from specific pressure force of standard lapping). The existence of a specific pressure force of optimal lapping for each size of abrasive grains is due to the different action of the mechanism of removing of the material with each specific pressing force of lapping.

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3. METHODOLOGY

As the main problem founded which is regard with quality and times consume to perform the desire operation so to develop the machine is best solution to overcome the same problem. These machines will give maximum production with help of both side lapping at a time. The below flow chart shows the sequential operation/steps that will be performed during the project process.

Table.1.1. Proposed action plan.

Project Stage - I Action Plan					
Activities / Months	Sept	Oct	Nov	Dec	Jan
1.Problem Identification &Selection					
2.Literature Survey					
3. Concept design / development					
4. Material & fabrication					
5. Report Writing & Submission					

Description of Methodology:

We have proposed a methodology to solve the problems. Our methodology is divided in different parts, under different titles.

Sequence of proposed methodology is as follows –

- Proposed Methodology 1 – Problem Definitions
- Proposed Methodology 2 – Basic Information & literature survey
- Proposed Methodology 3 – Design of Components
- Proposed Methodology 4 –Selection of material & standard parts.
- Proposed Methodology 5 – Manufacturing process & testing.

4. Different Techniques Used for Surface Finishing:

Final finishing operations in manufacturing of precise parts are always of concern owing to their most critical, labor intensive and least controllable nature. In the era of nanotechnology, deterministic high precision finishing methods are of utmost importance and are the need of present manufacturing scenario. The need for high precision in manufacturing was felt by manufacturers worldwide to improve interchangeability of components, improve quality control and longer wear/fatigue life. Reviewed the historical progress of achievable machining accuracy during the last century. We also extrapolated the probable further developments in micro technology and nanotechnology. The machining processes were classifieds into three categories based on achievable accuracy viz. Conventional machining, precision machining and ultra-precision machining.

4.1. Grinding:

Grinding is the most widely used abrasive finishing process among all traditional processes used in production. In grinding the material is removed from the work piece surface by relative motion of the cylindrical wheel having abrasive particles embedded on its periphery. The abrasive particles are bonded together to form porous

Revolving body which when come in contact with work piece results in material removal. The abrasives on a grinding wheel are firmly bonded with an appropriate binder and at the same time also have possibility to allow grain fracture to renew cutting edges. Abrasive grain wears rapidly on grinding harder

materials so a less strongly bonded wheel is preferred for operation

4.2. Polishing:

Polishing is the removal of material to produce a scratch-free, specular surface using fine (<3□m) abrasive particles. Polishing is typically done at very low speeds using either polishing cloths, abrasive films, or specially designed lapping plates. Polishing with a cloth or lapping plate requires the use of free abrasive and is a very low damage process when performed properly. Plate material and cloth material are critical when polishing a particular sample as the properties of these substrates are important in the final polish quality of the specific job. Polishing with a lapping plate is a common process used in the case of metals and hard ceramic type materials. Polishing using copper composite plates or tin / lead lapping plates can produce high quality surface finishes with high removal rates.

4.3 Abrasive Material Used:

There is a wide selection of abrasives to choose from when selecting a lapping and polishing process. Selecting an abrasive is dependent upon the specimen hardness, desired surface finish, desired removal rate, lifetime, and price. There are four basic types of abrasives that are used in lapping and polishing processes: silicon carbide (Sic), aluminum oxide or alumina (Al_2O_3), boron carbide (B_4C), and diamond (C). All of these abrasives have distinct properties and are used for different materials and applications.

1) **Sic:** Sic is hard and generally has a needle or blocky structure. SiC is used in many applications where rough lapping is required. It seldom is used for polishing or applications that require smooth surface finishes.

2) **Al_2O_3:** Al_2O_3 is relatively hard and has a sharp, angular structure. Alumina is commonly used where fine surface finishes are required as it breaks down over time and gives excellent surfaces during lapping and polishing. Alumina is also relatively inexpensive.

3) **B_4C:** B_4C is harder than most other abrasives (excluding diamond) and has a blocky crystal structure. B4C provides excellent removal rates and is typically used

when fast removal with moderate surface quality is needed.

4) **Diamond:** Diamond is the hardest material known and has a sharp, angular structure. Diamond is extremely useful in lapping and polishing due to it's removal rates and surface finishing qualities. Diamond can produce excellent surface finishes combined with high removal rates.

5. CONSTRUCTION & WORKING

Main Parts of Lapping Machine are given below:

1) Induction Motor: 8600 RPM, 50watt.
2) Variable Speed Drive.
3) Pedestal bearings.
4) Drive shaft.
5) Fasteners: Nut & Bolts.
6) V- Belt drive.
7) Supporting frame structure.
8) Polish/Lapping wheels.

In lapping process, it consists of two M.S. plates, mounted on stand. In between two plates there is job holding fixture is place. The plates having lapping wheels are attached at top and bottom side of upper & lower plate. On the supporting frame we have mounted induction motor and with the help of belt the shaft with job holding fixture is rotate. When this job holding fixture is rotate with full speed friction takes places on the surfaces of jobs under processing and the mounted job gets polished by removal its chip of work piece gets super finish. The lapping plate's surface made with the abrasive material which is used for the lapping process. Plate alignment is important for lapping applications where flatness and parallelism of the specimen will easy. Specimen quality is a direct result of plate condition & alignment therefore proper maintenance of the lapping plate is crucial in preparing high quality specimens. Double-sided processing is a, batch-type method which uses rotary action of job holding fixture.

6. DESIGN

6.1. Material Selection for Construction of Machine:

The machine is basically made up of mild steel.

Reasons:

1) Mild steel is readily available in market.

2) It is economical to use.

3) It is available in standard sizes.

4) It has good mechanical properties i.e. it is easily machinable.

5) It has moderate factor of safety, because factor of safety results in unnecessary wastage of material and heavy selection. Low factor of safety results in unnecessary risk of failure.

6) It has high tensile strength.

7) Low co-efficient of thermal expansion.

Properties of Mild Steel:

M.S. has carbon content from 0.15% to 0.30%. They are easily wieldable thus can be hardened only. They are similar to wrought iron in properties. Both ultimate tensile and compressive strength of these steel increases with increasing carbon content. They can be easily gas welded or electric or arc welded. With increase in the carbon percentage weld ability decreases. Mild steel serve the purpose and was hence was selected because of the above purpose.

6.2. Approach to Mechanical Design Of System.

In design the of parts we shall adopt the following approach;

Selection of appropriate material.

- Assuming an appropriate dimension as per system design.
- Design check for failure of component under any possible system of forces.

Mechanical Design:

In mechanical design the components are listed down and stored on the basis of their procurement in two categories.

- Design parts
- Parts to be purchased.

For designed parts detailed design is done and dimensions there obtained are compared to next dimensions which are already available in market. This simplifies the assembly as

well as the post production and maintenance work. The various tolerances on work are specified. The process charts are prepared and passed to manufacturing stage. The parts to be purchased directly are selected from various catalogues and are specified so as to have case of procurement. In mechanical design at the first stage selection of appropriate material for the part to be designed for specific application is done. This selection is based on standard catalogues or data books; e.g:- (PSG DESIGN DATA BOOKS) (SKF BEARING CATALOGUE) etc.

6.3. Motor Selection:

We know that,

Frictional force F (N)

Coeff. Of friction of disc. μ

Normal reaction force R_N (N)

$F = \mu . R_N$

$= 0.12 \times 9.81$

F = 1.1772 N.

Radius of rotation from center of plate r = 50 mm.

$T = F \times r$

$= 1.1772 \times 0.05$

T = 0.0588 N-m.   At motor shaft.

Thus selecting a motor of the following specifications

AC motor

Power = 50 watt

Speed= 0-8600 rpm (variable)

Motor is a AC motor, Power 50 watt; Speed is continuously variable from 0 to 8600 rpm. The speed of motor is variation by means of an electronic speed variation. Motor is a accumulator motor i.e., the current to motor is supplied to

motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variation; thereby the speed is also is changes. Motor is foot mounted and is bolted to the motor base plate welded to the base frame of the indexer table.

Motor Torque

$$P = \frac{2 \Pi N T}{60}$$

$$T = \frac{60 \times 50}{2 \Pi \times 8600}$$

T = 0.055 N-m

6.4. Design of Open Belt Drive:

Note: All Calculations are taking at full speed of motor.

Power is transmitted from the motor shaft to the input shaft by means of an open belt drive,

Torque at IP rear shaft = 2 x 0.055= 0.11 Nm

Speed of IP _ shaft pulley = 8600/2 =4300rpm

Motor pulley diameter **d** = 30 mm

IP _ shaft pulley diameter **D** = 60 mm

Reduction ratio = 2

Coefficient of friction = 0.23

Center distance **c**= 200

Let,

t= Thickness of belt= 5 mm

b= Width of belt=6mm

Velocity of belt is given by;

$$V = \frac{\Pi(d+t)n}{60 \times 1000}$$

$$V = \frac{\Pi(30+5) \times 8600}{60 \times 1000}$$

V=15.76 m/s   Linear velocity of

open belt drive

To find out tension in the belt is;

$$P = \frac{(F1-F2)V}{1000}$$

$$50 \times 10^{-3} = \frac{(F1-F2) \times 15.76}{1000}$$

F1 − F2 = 3.172 N   --------- (1)

Center distance between two pullies of motor &pullies of shaft C=**200mm.**

$$\alpha = \sin^{-1}\frac{D-d}{2\,C}$$

$$\alpha = \sin^{-1}\frac{(60-30)}{2 \times 200}$$

α = 4.30⁰   (In Degrees)

α =4.30 X (Π /180)

α =0.075ᶜ   (In Radians)

θ = Angle of lap of belt.

θ = Π − 2 α

  = Π – [2 X 0.075]

θ = 2.99ᶜ   (In Radians)

θ =171.40ᴼ   (In Degrees)

Now,

$$\frac{F1}{F2} = e^{\mu\theta}$$

$$= e^{0.23 \times 2.99}$$

$$\frac{F1}{F2} = 1.989$$ ----------------- (2)

F1= 1.989 F2   ----------------- (3)

Put Eq. (3) inEq. (1)

F1- F2 = 3.179

1.989 F2 - F2 = **3.179**

0.989 F2 = **3.179**

F2 = 3.207 N

Put in Eq. (3)

F1 = 6.379 N

Mass of belt per unit length is given by;

$$m = \frac{\rho \times b \times t \times 1}{10^6}$$

ρ= density of belt material = 950 kg/m³

$$m = \frac{950 \times 6 \times 5 \times 1}{10^6}$$

m= 0.0285 kg/m

Centrifugal force in belt is given by,

Fc = mV²

$=0.0285 \times (15.76)^2$

Fc = 7.078 N

6.5. Design of Shaft (ASME Code).

Since the loads on most shafts in connected machinery are not constant, it is necessary to make proper allowance for reduce the harmful effects of load fluctuations. According to ASME code permissible values of shear stress may be calculated from various relations.

For commercial steel shaft, Actual shear stress $\tau_{act} = 55 N/mm^2$

$$T = \Pi/16 \times \tau_{act} \times d^3$$

$$\Rightarrow \tau_{act} = \frac{16 \times T}{\Pi \times d^3}$$

$$0.11 \times 10^3 = \frac{16 \times 55}{\Pi \times d^3}$$

$$d^3 = 393.83$$

$$d = 7.33mm$$

d=8mm   **Assume d= 20mm.**   **Ref: - PSG Design data book.**

6.6. Selection of Shaft Ball Bearing:

In selection of ball bearing the main governing factor is the system design of the drive i.e.; the size of the ball bearing is of major importance; hence we shall first select an appropriate ball bearing. Taking into consideration convenience of mounting of ball bearing. As shaft diameter is 20mm to it &selected a pedestal ball bearing having shaft outer dia-20mm ball bearing to support the shaft of 20mm.

Total radial load on bearings are = F1 + F2 +Weight of radial disc + weight of shaft.

$$= 6.379 + 3.207 + 9.81 + 9.81$$

Total radial load on bearings   **= 29.209 N. (Assume = 30 N)**

Radial load on each bearings **Fr**   = 30/2 = **15 N.**

Equivalent dynamic load

Pe = V.Fr.Ka

    = 1 X 15 X 1.5

Pe = 22.5 N

bearing life is,

$$L^{10} = \frac{Lh10 \times 60 \times n}{10^6}$$

L_{h10} from graph 4.6 PSG Design data book for 16000 rpm maximum speed of ball bearing is 315000 Hours.

$$L^{10} = \frac{31500 \times 60 \times 4300}{10^6}$$

L^{10} = 8127 millions of revolutions.

$$L^{10} = \left(\frac{C}{Pe}\right)^{\left(\frac{10}{3}\right)}$$
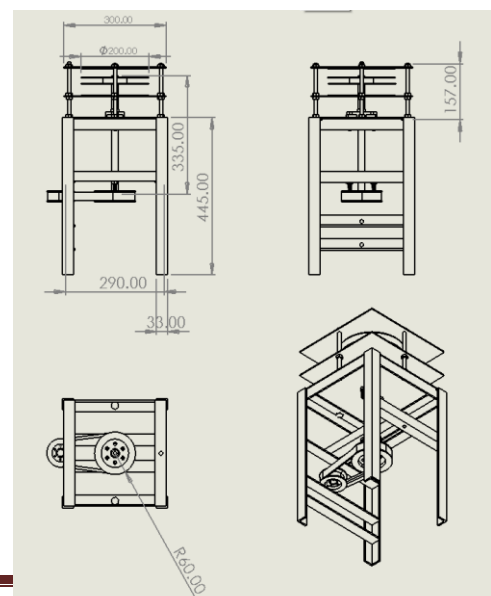
$$C = (L10)^{\left(\frac{10}{3}\right)} \times Pe$$

$$C = (8127)^{(0.3)} \times 22.5$$

C = 335.09 kN.

1. Cad Design

Fig 7.1:-3D Design of Lapping Machine

COST OF STD PART = 2,755/-

Fig7.2:- Detail drawing of cad model

7.COST OF MATERIAL

7.1. Total Cost of Material:

Part Name	Material	Wt in kg	Rate / kg	Total Rate
Square plate 300 X 2 mm	M.S	3	100	300
Round plate Ø200 X3 mm	M.S	2	100	200
Base Square Plates	M.S	2	100	200
Shaft	M.S	1	60	60
Supporting frame	M.S	8	60	48

TOTAL COST OF MATERIAL = 808 /-

7.2. Cost of Machining:

Machine Name	Using Time (min)	Rate /hr	Total Rate Rs/-
Gas cutting	30	200	100
Lath m/c	35	500	300
Power Hacksaw	160	200	500
Welding	75	400	550
Grinding	30	100	50
Drilling	95	200	350

TOTAL COST OF MACHINENING = 1,850/-

7.3. Cost of Std Part:

Sr.No.	name	Qty.	Cost	Total Cost
1	Motor	1	1500	1500
2	VFD	1	700	700
3	Nut	8	15	120
4	Bearing	2	150	300
5	Big pulley	1	80	80
6	Small pulley	1	30	30
7	Belt	1	25	25

7.4. Cost of Transportation & Overhead = 1,500/ -

7.5. Cost Of Project =

Cost of material + Cost of machinating + Cast of STD part + Cost of transportation & overhead

= 808 +1850 + 2755 +1500

= 6,913/- Rs.

8 ADVANTAGES & LIMITATIONS, APPLICATION

Advantages:

1) Machine work on the low power consumption as compare to the old Lapping machine.

2) It provides multiple polishing sizes of the metallic Jobs.

3) The operation of the new lapping machine is well controlled.

4) Complex shapes can be finished as per requirement easily.

5) Very thin material can remove easily.

6) Well balanced system.

7) It approximately having higher efficiency that of old lapping machine in low cost application machine.

9) It minimizes misalignment &Less floor space is required.

10) Only simple support structures are required design & fabrication is easy.

11) It is a faster process of lapping.

12) Wide variety of materials can be polished easily.

13) Highly accurate profiles and good surface finishing can be easily obtained.

14) Metal removal cost &Initial investment is low.

15) Operation is noiseless.

16) More accurate and economical in mass production.

17) A finished work pieces are made within less time.

18) It increases the safety and working condition.

Limitations:

1) Dimensional accuracy of cutting lapping is depends on the clearance of lapping sheet to job.

2) Production rate for lapping is depend on speed of the motor.

3) Constant monitoring is required to avoid the material scrap.

4) Balancing problem of lapping die may affect the surface finishing of job.

5) Depth of surface finishing is depending on abrasive sheet height approximately.
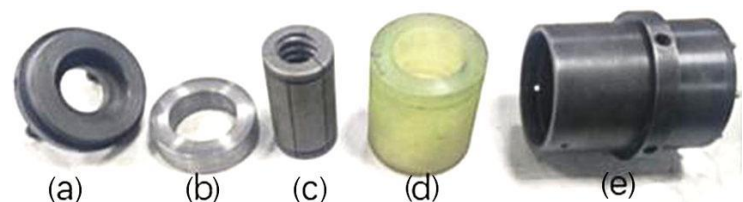
Application:

1) It is used for Surface finish for ball and roller bearings racers.

2) Surface finishing for Gears surfaces.

3) It is used in Engine valve finishing.

4) It is used in lapping of Press work dies.

5) It is used in metrology and quality department to obtain required surface finishing of job.

Fig 6.1. Application of lapping

(f)   (g)

9.FUTURE SCOPE

The project included very simple type of Machine parts requiring very less component than conventional lapping machinery. As work was successful studying & completing the results of this lapping m/c with solving other types of conventional lapping machine problems associated with machine that can be implemented from higher to lower unit's cost. Its lowermost requirement of maintenance can again be beneficial for keeping cost down. This machine uses less electricity during operation. This few out of very large no of rows can project this m/c across the investment. As per Indian content is concern this machine can be very beneficial for virtually all type of lapping units as it has very low capital investment. This machine may form a simple solution for lapping in the future. This machine also can be controlled by using automation in system. The project can be used directly in the industry where lapping process is done. The project in self as it is can be implemented verity wherever the material to be cut fulfills the range of specification of raw material the project is designed for currently the model that forms the project in capable of lapping works. In this way we can use this machine in industry for lapping special purpose metal bushes, pins. Pipes end etc. this project can be implement in several working mode.

If the industry has completely done automation more particularly then this project along with the automation can be also used within such type of industry for this all-lapping purposes. The automated unit may require some type of interfacing along depending upon the automation system used in the industry. The size of the material to be polished right is changed as per requirement. We can replace manual operated lapping machine can directly by automatic double-sided machine. This machine preferably will get attach at the end of production line on whenever required depending on plant layout production process, production type etc.

10.CONCLUSION

Double-sided lapping tests were performed on the following substrates Lapping and polishing is a process by which material is precisely removed from a work piece (or specimen) to produce a desired dimension, surface finish, or shape. The process of lapping and polishing materials has been applied to a wide range of materials and applications, ranging from metals, glasses, optics, semiconductors, and ceramics. Lapping and polishing techniques are beneficial due to the precision and control with which material can be removed. Surface finishes in the nanometer range can also be produced using these techniques, which makes lapping and polishing an attractive method for materials processing. While concluding this report, we feel quite fulfill in having completed the project assignment well on time, we had enormous practical experience on fulfillment of the manufacturing schedules of the working project model. We are, therefore, happy to state that the in calculation of mechanical aptitude proved to be a very useful purpose.

Although the design criterions imposed challenging problems which, however, were overcome by us due to availability of good reference books. The selection of choice raw materials helped us in machining of the various components to very close tolerance and thereby minimizing the level of wear and tear. Needless to emphasis here that we had lift no stone unturned in our potential efforts during machining, fabrication and assembly work of the project model to our entire satisfaction.

11.REFERENCE PAPERS

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