Retention of Lapping Paste for a Gear Lapping Machine

Sanchit S. Ingale, Dhananjay B. More, Akash B. Thube

Abstract: The Lapping Process of a Gear is used for providing a good surface finish to the gear. The current problem is that the lapping paste sticks onto the job and is wasted while washing the lapped job. In this paper we bring forward a solution to retain the lapping paste, resulting on considerable cost savings. Various methods were devised and the best one of them was applied to solve the current problem.

Index terms: Gear terminology, Lapping Process, Types of lapping Process, Lapping Paste, Abrasive Materials, Lapping Machine.

1. Introduction

Lapping is a machining process, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by the use of a machine. This can take two forms. The first type of lapping (traditionally Grinding) typically involves rubbing a brittle material such as glass against a surface like iron or glass itself with an abrasive material such as aluminium oxide, silicon carbide, diamond, etc. in between them. This produces microscopic fractures as the abrasive rolls about between the two surfaces and removes material from the both.

The other form of lapping involves a softer material such as pitch or a ceramic for the lapping, which is charged with the abrasive. The lap is then used to cut a harder work piece. The abrasive embeds within softer material which holds it and permits it to score across and cut the harder material. On a finer limit, this will produce a polished surface.

Types of lapping:

a) Surface lapping
b) Two piece lapping

About lapping paste:

Lapping paste is a mixture of hard abrasive particles in a suitable base like oil, grease or water based lubricant. The hard particles used are carborandum, aluminium oxide, silica, boron carbide, etc. The lapping pastes are graded from extra coarse to extra fine. The larger the grit rating of the lapping paste, the finer the paste.

Lapping of a gear:

In case of gears, the process of lapping is used to improve surface finish of already made teeth. In this process the gear to be lapped is run under load in mesh with cast iron toothed laps.

Abrasive paste is introduced between the teeth. It is mixed with oil and made to flow through the teeth.

2. Problem analysis:

After the process of gear lapping on a production line, the next step is to wash the lapped gear in a steam washing machine unit. During lapping, a large amount of paste is adhered to the job and it is carried into the washing machine. This results in wastage of the paste adhered to the job. Further, a large amount of steam is required to wash the job. Also the paste, after its removal from the job, clogs the washing machine filter, thus requiring frequent replacement.

Thus the objective is to devise a mechanism that will reduce the wastage of lapping paste thus resulting in cost savings.

3. Analysis:

In order to find the amount of lapping paste retained on the job, we carried out the weight analysis by weighing a sample of 10 jobs before and after the lapping process. [1] Following table shows the observations,

SR.NO.	Weight of job before lapping (gm)	Weight of job after lapping (gm)	Difference
1	9865	9905	40
2	9875	9920	45
3	9850	9885	35
4	9840	9895	55
5	9860	9900	40
6	9855	9895	40
7	9860	9895	35
8	9840	9875	35
9	9860	9900	40
10	9865	9900	35
		Total	**400**

Table 1: Observations of weight analysis

Average difference=400/10=40gm.

Therefore, amount of lapping paste wasted(per job)=40gm.

4. Possible solutions:

For the retention of lapping paste, we devised some solutions. These solutions along with their pros and cons are discussed below.

4.1:- Using sweeping mechanism:

Devising a mechanism that will sweep out the lapping paste from the gear. This arrangement will be provided in the machine itself. Lever that performs the sweeping action like a human arm, will remove the paste from the gears when the lapping process is complete.

Advantages:-

It will give an automated mechanism to remove paste, which will reduce human efforts Scrubbing pads can be forced into the complicated profile of the gear, resulting in efficiently removing maximum paste from the job.

Disadvantages:-

During operation time of the machine a lot of heat will be generated owing to the friction between the scrubbing pad and the component.

Furthermore the sweeping action is only required after the completion of the cycle and not in constant contact with the component. This increases complexity and also adding constraint to the worker while mounting and unmounting the component on the chuck.

Frequent replacement of the sweeping pad will increase the production cost and moreover the production time.

4.2:-Using a separate machine:-

A special purpose machine designed for the removal of lapping paste was thought to be setup on the production line.

Advantages:-

Maximum efficiency.

Modification in the existing machine not required.

Disadvantage:-

High initial cost.

High operating cost as separate manpower required for the machine

Frequent replacement of filters and other components of machine as the amount of lapping paste involved in the machine is very large because single machine is used to remove paste from all the jobs produced on the production line.

4.3:-Use of spinning action:-

This method comprises of rotating the component at very high speed after the completion of lapping cycle. High speed rotation causes the paste to get removed from the component due to centrifugal action.

Advantages:-

No modifications have to be done in the existing machine unlike previous two solutions.

Less initial cost & operating cost.

Disadvantage:-

The lapping paste is scattered all over the machine and not concentrated in the intended area; this makes collection of the paste difficult.

Moreover a large amount of paste is retained on the job, hence less efficient.

4.4:-Use of compressed air:-

A current of compressed air is made to flow over the periphery of the crown wheel resulting in the removal of paste due to the velocity of compressed air. The air is blown for a period of 10 seconds after the completion of lapping cycle.

Advantages:-

Compressed air lines are readily available all over the production line.

Operator is not subjected to any extra work load.

No physical contact unlike scrubbing pads, hence no wear.

Very less maintenance is required as well as air gives self-cleaning effect.

Good efficiency.

Disadvantages:-

High operating cost.

The comparative advantages and disadvantages of the above solutions is discussed in the table below:

	Scrubbing pad Mechanism	Special Purpose Machine	Spinning Action	Compressed Air
Design	Complex	Special Design required	Not Required	Simple
Operator Fatigue	Moderate	High	No Fatigue	No Fatigue
Efficiency	High	High	Less	High
Maintenance	High	Very High	Moderate	Very Less
Accessories	Rubber Pads, Scrub Pads, Brushes	New Setup	Cycle Modification	Nozzle, valves
Initial Cost	High	Very High	Low	Moderate
Operating Cost	High	High	Low	Moderate
Key Factors	Frequent Replacement, High wear rate	Extra space and manpower require	Retains small amount of paste, collection of paste difficult	No such Disadvantages

Table 2: Relative comparison of solutions

From the above table, it is clear that **the 'use of compressed air' is the best solution for the retention of lapping paste.**

5. Implementation of the compressed air solution:

The procedure followed in implementing the compressed air mechanism included the following steps:

1. Firstly we supplied compressed air on the lapped crown wheel by detaching it from the lapping machine. The air was supplied from various positions and angles as shown in the image below.

Figure 1: Trial test of compressed air on Lapped Job

2. As a first step towards implementing the above solution, weight of a set of 10 manufactured crown wheels was taken before lapping them.

3. Now, this same set of crown wheels were lapped on the machine and their weight post lapping was taken. The difference in the weight of the crown wheel before and after lapping gave us the weight of paste retained on it. On an average this was found to be 40gm per crown wheel.

4. Now using the compressed air on the actual lapping machine on same set of crown wheels through appropriate positions, their weight after lapping and supplying compressed air was taken again.

By carrying out the above procedure, it was found that on an average basis 15gm of paste is retained on the job. Also, we know that on an average 40gm of paste is retained on the job after lapping;

Thus, amount of lapping paste (average) saved per job by the application of compressed air =40-15=25gm.

6. Costing involved:

The compressed air costing chart in an industry is given in the table below[1]:

Cost of Compressed air leakages						
Size of opening		Air leakage	EQ. value in KWH	Equivalent value in KWH / YEAR	Cost /Year in Rs	CO2 Emission per year in TONS
mm dia	inch dia					
0.4	1/64"	0.4	0.1	875	7008	1.0
0.8	1/32"	1.6	0.3	2678	21024	2.9
1.6	1/16"	6.4	1	8760	70080	9.6
3.2	1/8"	26.1	3.9	34164	273312	37.6
6.4	1/4"	104.2	15.6	136656	1093248	150.3
9.5	3/8"	234.7	35.2	308352	2466816	339.2
12.7	1/2"	417.1	62.6	548376	4387008	603.2

Figure 2: Chart showing cost of compressed air[1]

Here we will be considering nozzle openings with diameters of 9.5mm and 12.7mm only.

Average number of jobs produced per month=5221 [1]

The number of jobs produced annually=5221*12=62,652

Lapping paste saved per job=25gm.

Thus lapping paste saved per year=(25/1000)*62652=1566.3kg.

Cost of lapping paste= 211/kg

Amount saved due to retention of lapping paste= 3,30,489 per year.

A) Diameter of opening for compressed air = 9.5mm

EQ value = 35.2 KWH

Air supply duration = 10sec /job

= 626520 sec /year

Annual air supply = 174.033 hours /year

Thus EQ value of air = 35.2*174.033 = 6125.96 KWH /year

Per unit cost of air considered = 8

Thus annual cost of air = **49007.70 /year**

B) Diameter of opening for compressed air = 12.7mm

EQ value = 62.6 KWH

Air supply duration = 10sec /job

= 626520 sec /year

Annual air supply = 174.033 hours /year

Thus EQ value of air = 62.6*174.033 = 10894.46 KWH /year

Per unit cost of air considered = 8

Thus annual cost of air = **87155.72 /year**

Cost saved by using 9.5mm diameter opening = cost of lapping paste saved – annual cost of air = 2,81,482 /year

Cost saved by using 12.7mm diameter opening = cost of lapping paste saved – annual cost of air = 2,43,334 /year.

7. Model:

The model for the piping inside the lapping machine is given below:

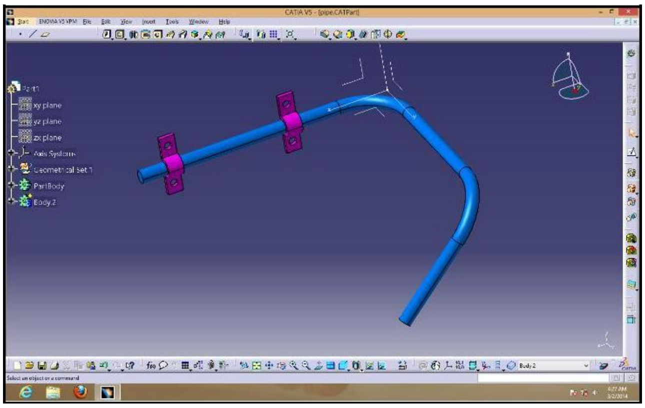

Figure 3: Piping Model to be implemented on the Lapping machine

The compressed air is provided at the end of process cycle at the periphery of the lapped job for about 10 sec at a pressure of about 6 bar.

8. Conclusion:

Thus the provision of compressed air on the periphery of the job at the end of cycle results in significant cost savings annually. Also, it increases the life of washing machine filter as now the job has less amount of lapping paste on it which in turn reduces the clogging of paste on the filter of the washing machine. The solution does not increase the work and fatigue of the operator. Also the production time is not hindered by a significant amount.

Acknowledgement:

We thank all the senior engineers and staff of the rear axle line at TATA Motors Pvt. Ltd. Pimpri works. We thank the department of Mechanical Engineering, JSPM's Rajarshi Shahu College of Engineering for their support. Also we would like to thank Prof. V.S. Mahajan for his co-operation and co-ordination.

References:

[1] Rear Axle Line (C3) at Tata Motors, Pimpri works.

Sanchit S. Ingale is pursuing undergraduate course Bachelors of Mechanical Engineering at JSPM's Rajarshi Shahu College of Engineering.

Dhananjay B. More is pursuing undergraduate course Bachelors of Mechanical Engineering at JSPM's Rajarshi Shahu College of Engineering.

Akash B. Thube is pursuing undergraduate course Bachelors of Mechanical Engineering at JSPM's Rajarshi Shahu College of Engineering.

