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APPLICATIONS OF SINGLE PHASE AND MIXTURE FLOW INTO LUBRICATION OF MILLING MACHINE TABLE

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ABSTRACT

Comparative cutting tests have been carried out on a horizontal milling machine, having the worktable fitted, in turn, with pressurized oil "single phase flow"bearings, pressurized mixture flow, and a conventional lubricational system. Special table and saddle for that machine were designed and manufactured to be capable for applying all methods of lubrication. A wide range of depth of cuts and feed rates were used. Both surface roughness and vibrational parameters were measured. The use of pressurized oil and mixture flow bearings slideways increase the machine stability and produced more fine surface roughness than conventional lubrication slideways.

INTRODUCTION

The need has been felt for an investigation to study the characteristics of using mixture flow as a lubricant for the separation of the moving parts of machine tool slideways. The mixture flow have the advantage that, it is exist in the machine cooling circuit known as a solbile oil. When using externally pressurized oil "single phase flow" bearings in the machine tool slideways loops are required, first for the lubricant, and the second for the coolant.

Conventional slideways of machine tools are subject to considerable static and dynamic frictional forces which make the accuracte positioning of the sliding elements is difficult. This difficulty is normally overcome, or partly so, by the provision of relatively massive driving members together with pwoerful motors, but this solution is not logical nor economical. In recent years, efforts has been directed to the reduction of slideways friction by the use of low frictional materials |1-5|, roller bearings |6-8| or externally pressurized bearings.|9-13|.

The use of externally pressurized bearing slideways eleminates stick-slip, reduces static and dynamic friction. Two phase flow as a lubricant in externally pressurized bearings were investigated in a several papers|14-16|.

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The use of mixture flow has no attention in machine tool slideways applications. The used fluid was the solbile oil 25% that was used in the cooling system in metal cutting process, the use of this fluid did not needs to separate scavenging requirements. It was decided to explore their possibilities in machine tool applications. The work on such mixture flow pressurized bearings applications has proved encouraging and has shown that a mixture flow as a lubricatnt of externally pressurized work table is capable of supporting work loads during normal machining operations. To compare this performance with that of stiffer pressurized oil slideways. Special supply system was built to carry out the comparative study. Finally the results indicates some success of using mixture flow as a lubricant fluid.

EXPERIMENTS

A milling machine was developed to be suitable for carrying out the experimental program.

A Series of machining tests was carried out on brass (57% Cu and 39.87% Zn) of 5 cm wide, 2 cm thick and 12 cm long under dry cutting condition.

Vibrations parameters "displacement, velocity and acceleration" were measured during cutting conditions.

No attempts were made to analyse the structural vibration modes of the machine casting; it was considered sufficient at this stage of development to comapre the normal cutting performance of the machine with that resulting from the use of the mixture flow supporting table. Even so, such variable as cutter sharpness and cutter eccentricity tends to prevent the closest correlation of results.

Generally, light finishing cuts up to 1 mm depth using 10 cm diameter helical slab mill of 12 teeth of high speed steel. Various feeds and speeds were used in these tests, ranging from 28 to 116 mm/min. and 71 to 355 r.p.m respectively. The surface roughness of the machined samples were measured using a Talysurf-5M-60 system taking centre line average as a reference for the comparison between the products. The surface roughness measurements were made in longitudinal direction of the feed. All the above procedure was made when using mixture flow as lubricant in externally pressurized milling machine slideways worktable, externally pressurized oil bearings and conventionally.

RESULTS AND DISCUSSION

The variation of surface roughness " CLA " with feed per tooth, depth of cut and traverse feed "mm/min" were determined under different methods of milling machine slides lubrication.

Externally pressurized mixture flow, externally pressurized oil and conventionally lubrication slides were used.

All these results are presented in the table (1)

I - The Effect of Feed Per Tooth.

The variation of the products surf...

determined. A typical results for a samples that has been milled at traverse feed of 28 mm/min and depth of cut equals to 0.6 mm is shown in Fig.(1). It has been observed that the value of CLA of the machined samples, first decreases with an increase in feed per tooth to a minimum,about 0.7 µm for externally pressurized mixture flow lubricant, with a further increase in the feed per tooth the surface roughness slightly increases. This variation in the surface roughness values of that sample produced using externally pressurized mixture flow takes an intermediate values between that samples produced by using externally pressurized oil bearings and conventionally lubrication methods. When employing externally pressurized oil bearings the product surface roughness is the finest. Figure (2) present the variation of surface roughness with feed per tooth for larger values of traverse feed (88 mm/min.) and depth of cut equals to 0.6 mm.

From the figure, it is clear also in the case of using externally pressurized mixture flow slideways that this method of lubrication gives a mean values of the product surface roughness, while externally pressurized oil bearings give the most fine results and conventionally lubricated slideways give the most rough surfaces. When employing externally pressurized mixture flow slideways, the surface roughness are fluctuating with the increase in feed per tooth (between 1.3 µm and 0.55 µm).

These results may be due to the high damping of externally pressurized mixture flow slideways with respect to that of conventionally lubricated slideways, while the stiffness and damping of pressurized oil bearings is larger than that of mixture flow for the same slideway geometry, pressures, and thickness of films.

The vibration measurements helps successfully in the clearfication of the products surface roughness results.

Theoretical finding clears that as the feed per tooth increase the roughness of the machined samples increases.

2 - Effect of Depth of Cut.

The variations of surface roughness with the depth of cut at the different feeds per tooth, traverse feed rates and depth of cut for the different lubrications methods (Single phase "oil bearings", conventional and mixture flow slides" were found. Fig. (3) shows the relationship between the centre line average of the workpieces, that were machined at a feed of 81×10^{-3} mm/tooth, traverse feed of 88 mm/min. and depth of cut. It can be observed that the mixture flow method of lubrication gives averaging values of the produced surface roughness between conventionally method of lubrication and hydrostatic slideways results for the same cutting conditions. While the point of theoretical view as the depth of cut increase the surface roughness of the machined samples decreases and becomes more fine..

3 - The Effect of the Worktable Sliding Velocity.

The effect of traverse feed of the worktable on the surface roughness of the machined workpieces under all tests conditions were investigated, for constant tool revolutions and depths of cut.

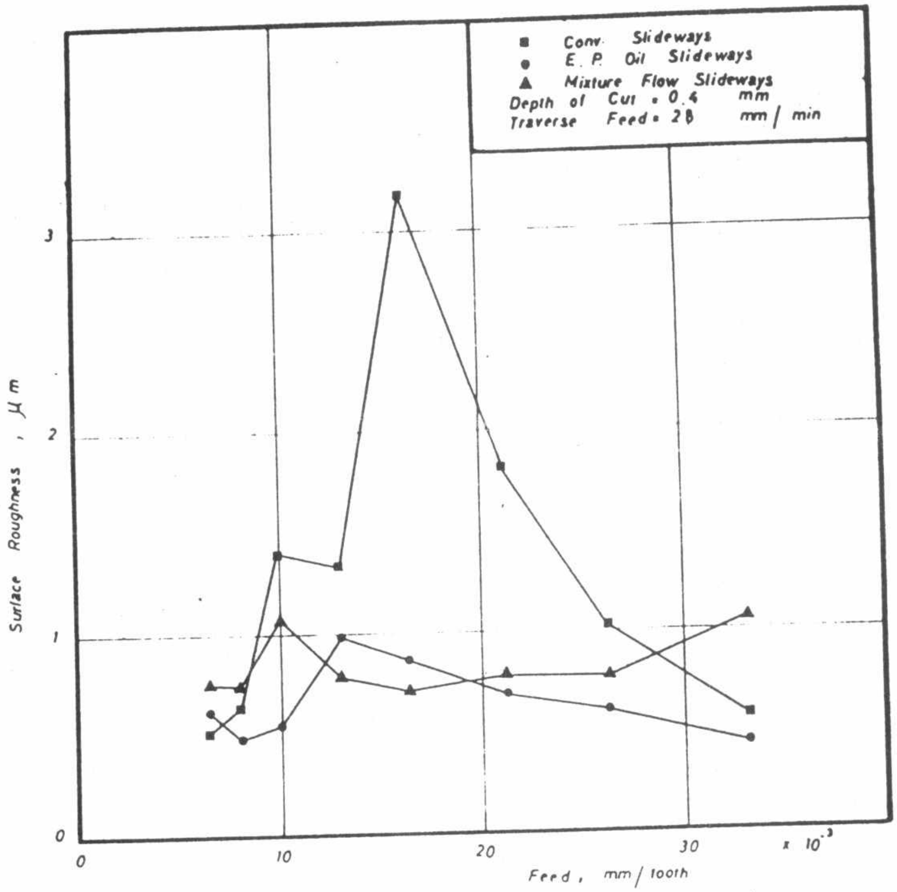

FIG. 1. Variation of surface roughness with feed per tooth.

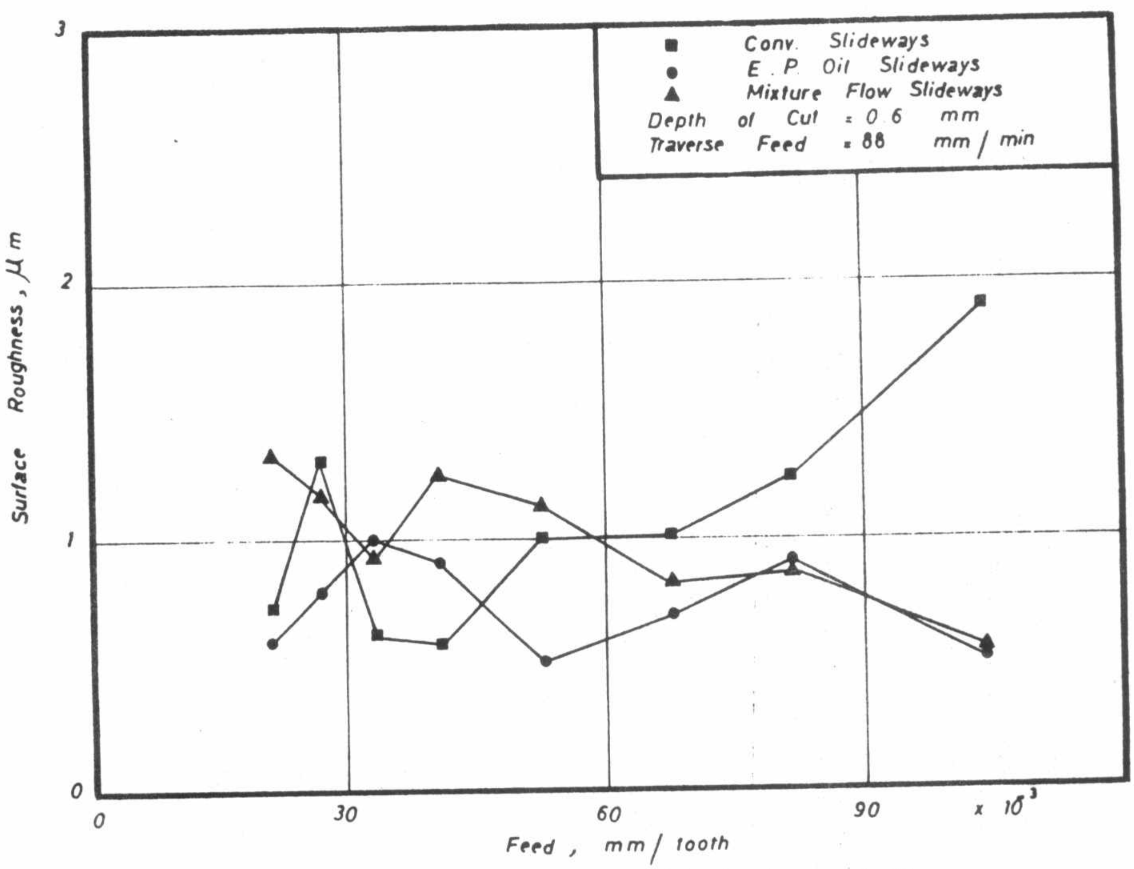

FIG. 2. Variation of surface roughness with feed per tooth.

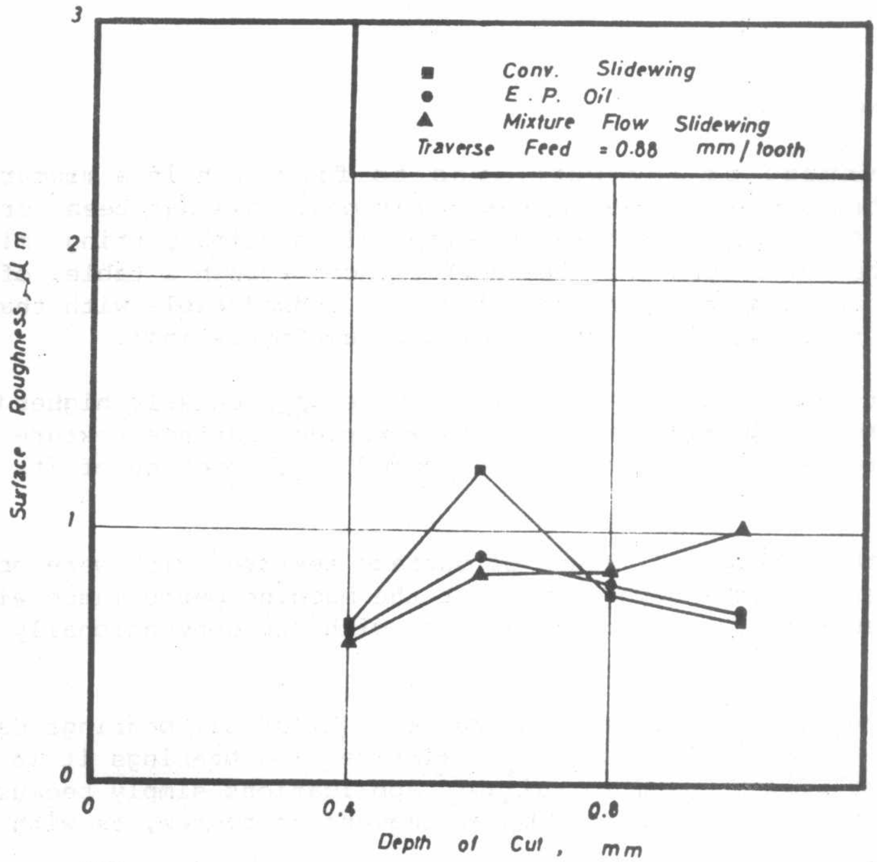

FIG. 3. Variation of surface roughness with depth of cut.

Fig. (4) presents a typical results for surface roughness against worktable sliding velocity under a tool revolution of (90) r.p.m and depth of cut of 0.8 mm. The results shows, that; the surface becomes more finer with the increase of the traverse feed "worktable sliding velocity" for externally pressurized mixture flow.

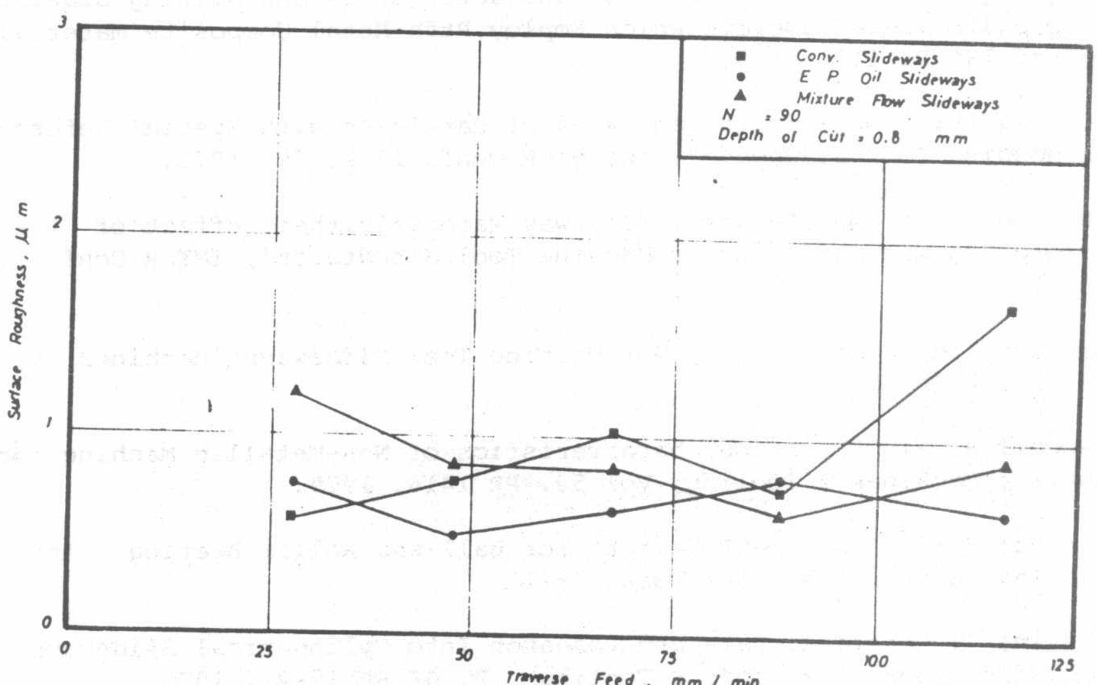

FIG. 4. Variation of surface roughness with traverse feed

CONCLUSIONS

The main purpose of the work was to find out if a mixture flow using as a lubricant was a feasible propositions. This has been verified on one machine a fairly small single traverse, climb-climb cutting milling machine. It has been also that the performance of such a table, of moderate stiffness and damping characteristics, is considerable with that of an oil-supported table of higher stiffness and damping ratings.

Since the stiffness of arbor and over-arm were appreceiably higher than that of either of two pressurized tables, the workpiece surface texture would have been better when using the oil-supported table because of its higher stiffness.

Neverthless, the numberical values of surface texture which were obtained from the different tests have shown that the machine performance with the mixture flow supported table is as good as with the conventionally lubricated table.

Mixture flow bearings indicates some success whilst oil bearings can normally provide greater stiffnesses than mixture flow bearings it is possible that the latter will be used in suitable applications simply because of their clean in use, needing no complex scavenging system, as with oil bearings,

The mixture flow system needs to a great deal of pumping power than that of oil flow,that may be more expensive in running cost of the machine.

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Table (1)

Traverse feed	Depth of cut mm.	C.L.A. produced using conv. method inlubrication method. Tool ratational speed r.p.m. 71	90	112	140	180	224	280	355
28 mm/min.	0.4	0.649	1.112	1.839	3.231	1.352	1.401	0.660	0.514
	0.6	0.863	2.319	1.468	2.414	1.193	3.936	1.151	1.584
	0.8	0.580	0.574	0.595	0.615	1.876	1.556	0.761	0.619
	1.0	0.694	1.330	0.846	1.843	1.151	1.253	0.783	0.696
48 mm/min.	0.4	0.454	1.043	0.536	2.737	1.162	0.447	0.757	1.053
	0.6	0.446	0.849	0.431	0.938	0.771	0.565	0.598	1.184
	0.8	1.119	0.771	0.651	1.436	0.920	0.649	1.949	1.009
	1.0	0.932	2.019	1.466	0.864	1.145	0.997	1.457	0.923
68 mm/min.	0.4	0.807	1.508	1.084	1.337	0.811	1.432	1.002	0.507
	0.6	0.693	1.062	0.507	0.431	0.719	1.884	1.060	1.337
	0.8	1.336	1.065	1.167	1.553	1.288	0.623	0.431	3.057
	1.0	0.654	0.447	1.084	0.824	1.116	0.471	1.165	1.054
88 mm/min.	0.4	0.693	0.950	0.652	0.766	0.541	1.678	0.845	0.985
	0.6	1.943	1.234	1.019	1.054	0.592	0.648	1.328	0.767
	0.8	0.638	0.772	0.846	0.771	1.446	0.819	1.729	1.875
	1.0	0.962	0.648	0.664	1.650	1.650	0.916	1.194	1.184
116 mm/min.	0.4	0.504	1.416	0.922	0.887	0.364	0.425	0.398	-----
	0.6	0.893	2.153	0.766	0.729	0.468	0.282	0.287	-----
	0.8	1.706	1.562	1.611	0.918	0.695	0.442	0.432	-----
	1.0	0.783	0.889	0.767	2.971	0.329	0.443	0.237	-----

Traverse feed	Depth of cut mm.	C.L.A. produced using mix. flow pressurized slideways. Tool ratational speed r.p.m. 71	90	112	140	180	224	280	355
28 mm/min.	0.4	1.040	0.818	0.812	0.756	0.805	1.135	0.777	0.771
	0.6	0.975	0.777	1.078	0.946	0.539	0.932	0.791	1.118
	0.8	0.924	1.414	0.842	0.914	0.798	0.653	0.923	1.297
	1.0	1.440	1.284	0.973	1.297	0.916	0.709	1.103	0.927
48 mm/min.	0.4	1.313	1.121	0.961	1.067	1.122	0.777	0.812	0.992
	0.6	1.001	0.838	1.058	1.089	0.816	1.001	1.162	0.950
	0.8	1.192	1.080	1.195	1.054	1.025	1.047	1.122	0.592
	1.0	1.029	0.993	0.921	0.859	0.626	1.002	0.888	0.562
68 mm/min.	0.4	0.782	1.300	0.957	0.825	1.411	1.008	0.836	0.856
	0.6	1.169	0.836	0.634	0.655	0.931	1.001	0.898	0.820
	0.8	0.521	1.051	1.115	1.107	0.784	0.780	1.161	1.098
	1.0	0.568	1.231	1.672	1.052	1.322	0.188	1.062	1.485
88 mm/min.	0.4	1.108	0.561	1.060	0.824	0.664	0.619	1.101	1.144
	0.6	0.599	0.890	0.835	1.130	1.276	0.922	1.219	1.326
	0.8	1.109	0.824	0.585	1.178	1.202	0.685	0.926	0.979
	1.0	1.006	1.009	0.827	0.613	1.032	0.786	1.380	1.050
116 mm/min.	0.4	0.927	0.960	0.692	1.006	0.628	0.899	0.689	-----
	0.6	0.759	0.653	0.786	1.021	0.858	0.837	1.181	-----
	0.8	1.004	1.012	0.974	0.879	0.512	0.754	1.132	-----
	1.0	1.016	1.065	0.832	1.014	0.908	0.644	0.848	-----

Traverse feed	Depth of cut mm.	C.L.A. produced using pressurized oil slideways. Tool ratational speed r.p.m. 71	90	112	140	180	224	280	355
28 mm/min.	0.4	0.444	0.635	0.732	0.894	1.011	0.552	0.479	0.674
	0.6	1.763	1.055	0.757	0.474	0.854	0.566	0.937	0.620
	0.8	1.885	0.776	1.499	0.728	0.786	1.392	0.620	1.572
	1.0	0.796	0.747	0.957	0.737	0.706	0.601	1.177	0.625
48 mm/min.	0.4	0.601	0.706	0.481	0.847	0.686	1.177	0.456	0.757
	0.6	0.854	1.177	1.674	0.641	0.476	0.691	1.007	1.704
	0.8	0.747	0.516	0.987	0.551	0.471	0.977	0.601	0.737
	1.0	1.184	0.566	0.576	1.112	1.263	1.218	0.591	0.672
68 mm/min.	0.4	1.407	1.008	0.848	0.978	0.624	1.342	1.079	0.654
	0.6	0.514	1.132	0.908	0.673	0.639	0.469	0.806	0.786
	0.8	0.943	0.658	0.658	1.067	0.524	0.554	1.326	0.698
	1.0	0.813	1.018	0.683	0.768	0.858	1.013	0.415	0.654
88 mm/min.	0.4	0.728	0.615	0.608	0.469	0.591	0.937	0.527	0.493
	0.6	0.532	0.908	0.640	0.522	0.918	1.011	0.415	0.640
	0.8	0.492	0.791	0.596	0.449	0.532	0.605	0.547	0.767
	1.0	0.635	0.767	1.345	0.781	0.615	0.859	0.415	0.469
116 mm/min.	0.4	0.703	0.508	0.872	0.892	0.657	0.887	0.551	-----
	0.6	1.001	0.669	1.158	0.732	0.897	0.827	0.912	-----
	0.8	0.645	0.688	0.598	1.981	1.529	1.133	0.486	-----
	1.0	0.557	1.006	0.662	0.541	1.191	0.642	0.607	-----