General Classification Number 621.793.3:629.12.004.67 (075) ______
Category ____
State Register Number ________________________________
Inv. No ____

Ministry of Education and Science of Ukraine

Odessa National Marine University

Scientific Research Institute of Basic and Applied Researches

65029, Odessa, ul. Mechnikova 43, tel. (0482) 236165, fax (0482) 235588

CONFIRMED:
Pro-rector, Odessa National Marine University, Director of Scientific Research Institute of Basic and Applied Researches, Candidate of Technical Sciences, Professor
(signature) O.I. Stalnichenko
__.__. 2003

(stamp: Ministry of Education and Science of Ukraine, Odessa National Marine University)

REPORT
ON SCIENTIFIC RESEARCH

DEFINITION OF EFFICIENCY OF RVS TECHNOLOGY

Work number 98/02

Dean of Faculty
Candidate of Technical Sciences, professor (signature) A.A. Voloshin

Supervisor of Scientific Research
Candidate of Technical Sciences, professor (signature) O.I. Stalnichenko

Odessa – 2003

Manuscript ready on August 1st, 2003

LIST OF AUTHORS

Director of Department of Material Technology, Candidate of Technical Sciences, professor	(signature)	O.I. Stalnichenko (Introduction, onclusions, Recommendations)
Senior Researcher Candidate of Technical Sciences, assistant professor	(signature)	V.P. Matveenko (Parts 1, 2, 3)
Researcher	(signature)	Ye.V. Genrikhsen (manufacturing specimens, fulfilling experiments, Statement on Measurement Methods)
Technician of I Category	(signature)	S.A. Kubyshchenko (fulfilling experiment)
Chief metrologist	(signature)	N.F. Laty
Inspector of Norm Conformability	(signature)	S.K. Kotlyarova

ABSTRACT

Report: 20 pages, 8 pictures, 3 tables, 2 appendices.

Research object: friction pair specimens, manufacturing of materials: steel – cast iron, bronze – steel, cast iron – cast iron.

Research purpose: to define what kind of effect the repair and restoration compound (the RVS Technology) has on wear of friction pair specimens when the compound is added in lubricants.

As a result of the research, it has been concluded that with identical research parameters: revolution velocity, external load on specimens, and time the wear is reduced 1.2- to 2-fold when the RVS compound is added in the lubricant in comparison with their use without the compound.

The RVS Technology can be applied in ships, ship-repairing yards, navy maintenance yards, and ports.

REPAIR AND RESTORATION COMPOUND (RVS TECHOLOGIES), FRICTION PAIR SPECIMENS, WEAR.

Conditions of getting the report: upon agreement. 65029, Odessa 29, ul. Mechnikova 34, Odessa National Marine University

LIST OF CONTENTS

INTRODUCTION

During the last decade, due to transitions in the society, a lot of new methods have been inculcated in the CIS countries, including Ukraine, as for instance methods for restoring machines and mechanisms without their disassembly.
The advantage of these methods lies in the fact they make it possible to

- increase the inter-repair operation period
- restore worn friction surfaces
- gain savings in fuel, lubricant, and energy costs

That is why the expediency of the use is obvious in marine and river transport. The special features of technical operation of marine equipment and mechanisms require reliable function during a long period of time in order to be able to fulfil the planned route task, including loading and unloading operations in ports.
Based on the positive experience on using the repair and restoration compounds (RVS Technologies) in industry, transport, and, taking into account the actuality of their introduction in the navy, in ports and ship-repairing yards, the present research was carried out in accordance with an agreement with OOO Novye Tekhnologii.
The objective of the present research is to examine the effect of adding the repair and restoration compound (RVS Technology) in oil on wear of friction pair specimens. The specimens have been manufactured of metal materials that are widely used in mechanical engineering, including shipbuilding, for manufacturing parts of friction joints .

1. MATERIALS AND LUBRICANTS TO BE EXAMINED

For carrying out comparative tests in a laboratory, friction pair specimens were manufactured of the following materials:

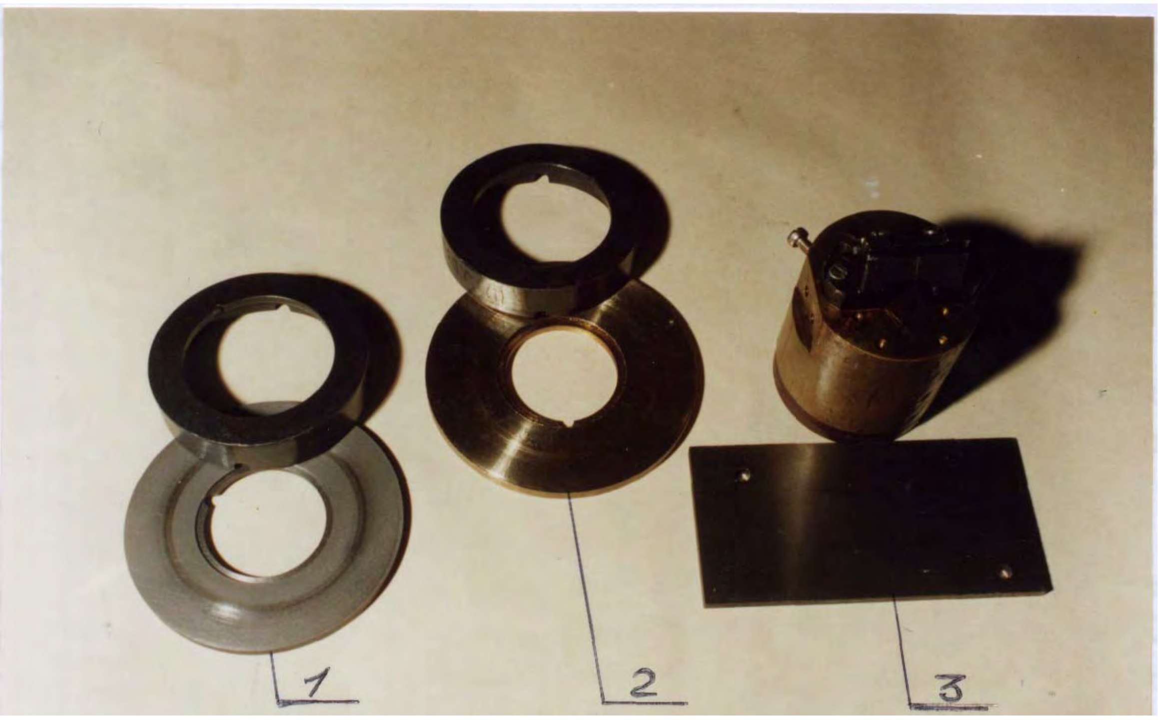
- Steel 40Kh – cast iron AChS-3 (ring – disk) – the first pair
- Bronze BrOTs10-2 – steel 40Kh (ring – disk) – the second pair
- Cast iron SCh25 – cast iron SCh25 – the third pair

The speciments are show in Picture 1.1.
The following oils were used as lubricants:

- DIZOLA M 3015 [M-10G_2(tss)] for the first specimen pair
- MS20 for the second pair
- DIZOLA M3004 [M-10V2(s)] for the third pair

The RVS compound was added in the lubricant in the amount of 0.2 percent of the oil capacity according to the instructions of the customer.

Picture 1.1: Friction pair specimens used in test



1. The first pair
2. The second pair
3. The third pair

2. RESEARCH METHOD AND EQUIPMENT

Comparative tribological researches were carried out with two AYe-5 friction machines (Picture 2.1) in the following way: sliding friction was studied with the ring and disk pairs, and back and forth motion sliding friction was studied by imitating piston ring and cylinder wall with a 77MT-1 type machine (Picture 2.2).

The friction pair specimens were lubricated in an oil bath. The experiment was carried out in two phases with all the machines: during the first one only with oil, during the second one with oil and the RVS compound added in it. Both phases consisted of five stages of different length, in which the sliding velocity and load on the specimens remained unchanged in the corresponding stages.

The oil temperature of the oil bath near friction surfaces was measured with a thermocouple (copper and constantane).

The friction moment was measured with equipment, with which it is possible to balance the forces on the rod lever, on the end of which the specimens are fixed. After that, the friction coefficient was calculated.

The wear rate of the specimens was defined artificially. For the definition, pyramid traces with square base were made on the friction surfaces with a hardness meter (Vickers apparatus) (Picture 2.3). With a microscope, the diagonal length of the square was defined before and after the experiment. The depth of the trace (Picture 2.4) was calculated with the formula:

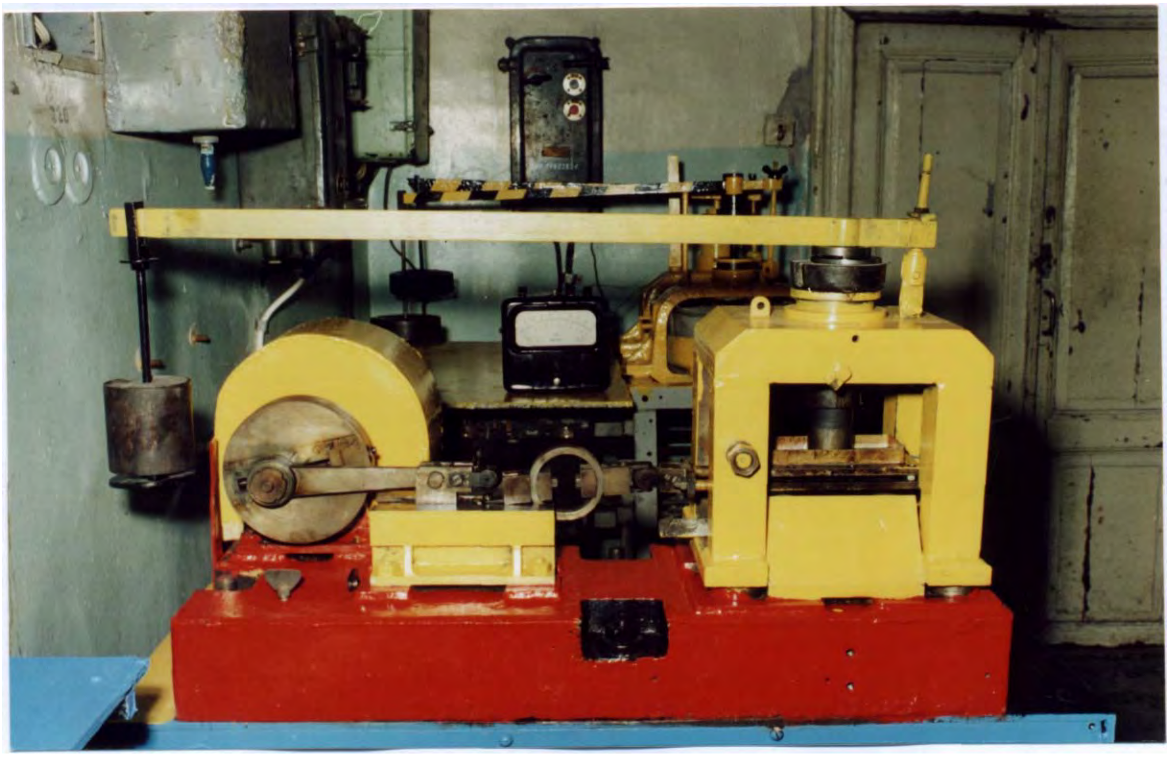
$$h = \frac{1}{2\sqrt{2}tg\,\frac{\alpha}{2}} \bullet d$$

where h = the depth of the trace
α = the angle of opposite edges at the peak, 136 °
d = the length of the diagonal

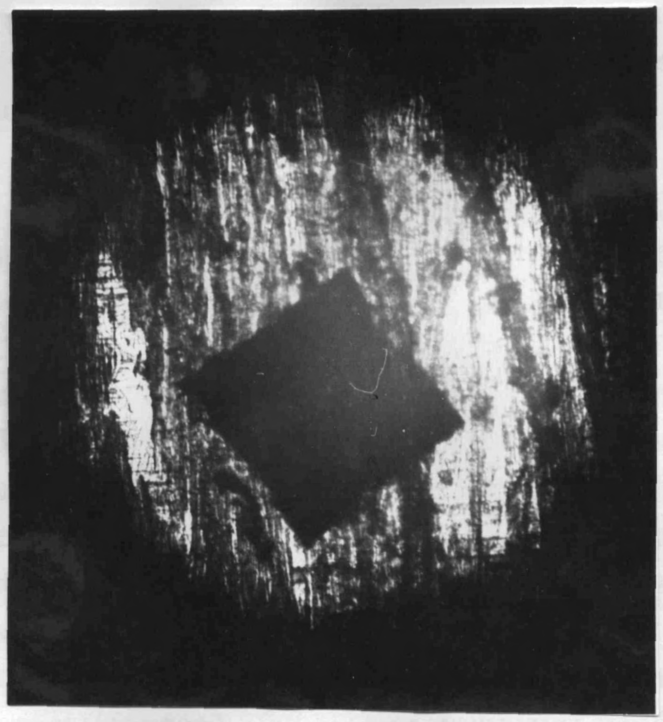
The value of linear wear of the flat surface was defined as the difference of the depth of the traces before and after the test work at every stage of the experiments. The accuracy of measuring h was ± 0,5 µm.

Picture 2.1: AYe-5 friction machines

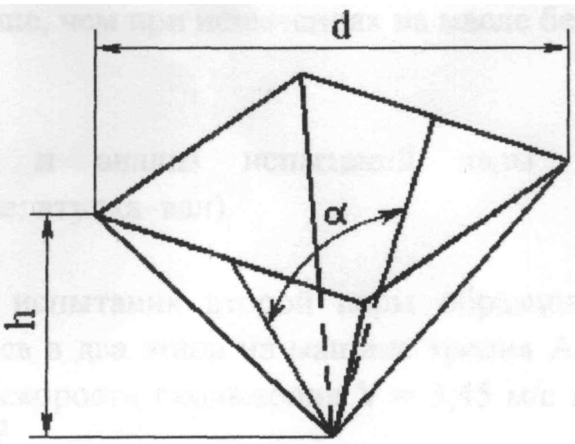
Picture 2.2: Friction machine of 77MT-1 type



Picture 2.3: Trace on friction surface



Picture 2.4: Formula of pyramid trace



3. RESULTS AND ANALYSIS OF COMPARATIVE TESTS

3.1 Results and Analysis of Ring – Disk Friction Pair (Shaft and Sliding Bearing Joint)

The comparative tests of the first specimen pair (steel 40Kh – cast iron AchS-3) were carried out in two phases with the AYe-5 friction machine for the ring – disk pair at the constant sliding velocity of V = 2.19 m/s and the average load on the specimens of P = 55 kg/cm^2.

The first stage of the test was carried out with plain oil. In the second stage, RVS compound was added into the oil (0.2 percent of the oil volume). Both stages consisted of five test and measurement periods . The results of the tests are shown in Table 3.1. The curves of the wear of the specimen surfaces and the change of temperature and friction coefficient related to the time of both stages are shown in Picture 3.1.

An analysis of the obtained results shows that, when working with oil, the greatest average values of wear intensity occur during the first thirty hours, i.e. in the process of running-in: 0.5 µm/h (the ring) and 0.13 µm/h (the disk). After that, a stabilisation state is reached, of which the decreases of the temperature, friction coefficient and wear velocity are a prove. The results of tests with RVS compound added oil show that the wear of the specimen friction surfaces of the steel ring have decreased by 30 percent, and that of the cast iron disk by 37.5 percent after the first 30 hours.

At the following test stages, i.e. after the stabilisation, the absolute wear of the steel ring was 2 or 2.5 times and that of the cast iron disk on the average three times slower than in the tests with oil without RVS compound.

3.2 Results and Analysis of tests Ring – Disk Friction Pair (Bushing and Shaft Joint)

The comparative tests of the second friction pair of specimens (bronze BrOTs10-2 – steel 40Kh) were made in two stages with AYe-5 friction machine for ring – disk specimens at the constant sliding velocity of V = 3.45 m/s and the average load on the specimens of P = 12 kg/cm^2.

The first stage of the test consisted of work with oil. At the second stage, RVS compound was added in the oil (0.2 percent of the oil volume). Both stages consisted of six test and measurement periods . The results of the tests are shown in Table 3.2. The curves of the wear of the specimen surfaces and the change of temperature and friction coefficient related to the testing time of both stages are shown in Picture 3.2.

Table 3.1: Results of comparative tests of specimens of the first pair: ring – disk with AYe-5 friction machine

No of Stage / Condition	Ring material	Disk material	Oil make	Sliding velocity V, m/s	Load P, kg/cm^2	Time τ, h	Temperature t, °C	Friction moment M, kgm	Friction coefficient f	Wear of ring Δh, μm	wear of disk Δh, μm
1 / 1	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 [M10G$_2$(tss)]	2.19	55	30	130 - 90	0.2 - 0.10	0.12 - 0.06	15.5	4
1 / 2	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 [M10G$_2$(tss)]	2.19	55	18	90	0.1	0.06	2.5	1.5
1 / 3	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 [M10G$_2$(tss)]	2.19	55	24	87	0.1	0.06	2.5	1.5
1 / 4	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 [M10G$_2$(tss)]	2.19	55	12	85	0.1	0.06	2	1.5
1 / 5	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 [M10G$_2$(tss)]	2.19	55	12	85	0.1	0.06	2	1
2 / 1	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 + RVS Gel	2.19	55	30	100 - 85	0.2 - 0.075	0.12 - 0.045	11	2.5
2 / 2	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 + RVS Gel	2.19	55	18	85 - 80	0.075 - 0.05	0.045 - 0.03	1	0.5
2 / 3	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 + RVS Gel	2.19	55	24	80 - 75	0.05 - 0.025	0.03 - 0.015	1	0.5
2 / 4	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 + RVS Gel	2.19	55	12	75 - 70	0.025	0.015	0.5	0
2 / 5	Steel 40Kh	Cast iron AChS-3	DIZOLA M3015 + RVS Gel	2.19	55	12	70	0.025	0.015	0	0

Picture 3.1: Curves of specimen wear: ring (⊙) – disk (●), changes of friction coefficient (×) and temperature (△) in relation with test time (τ); ____________ = work with oil, __ __ __ __ = work with oil and RVS compound

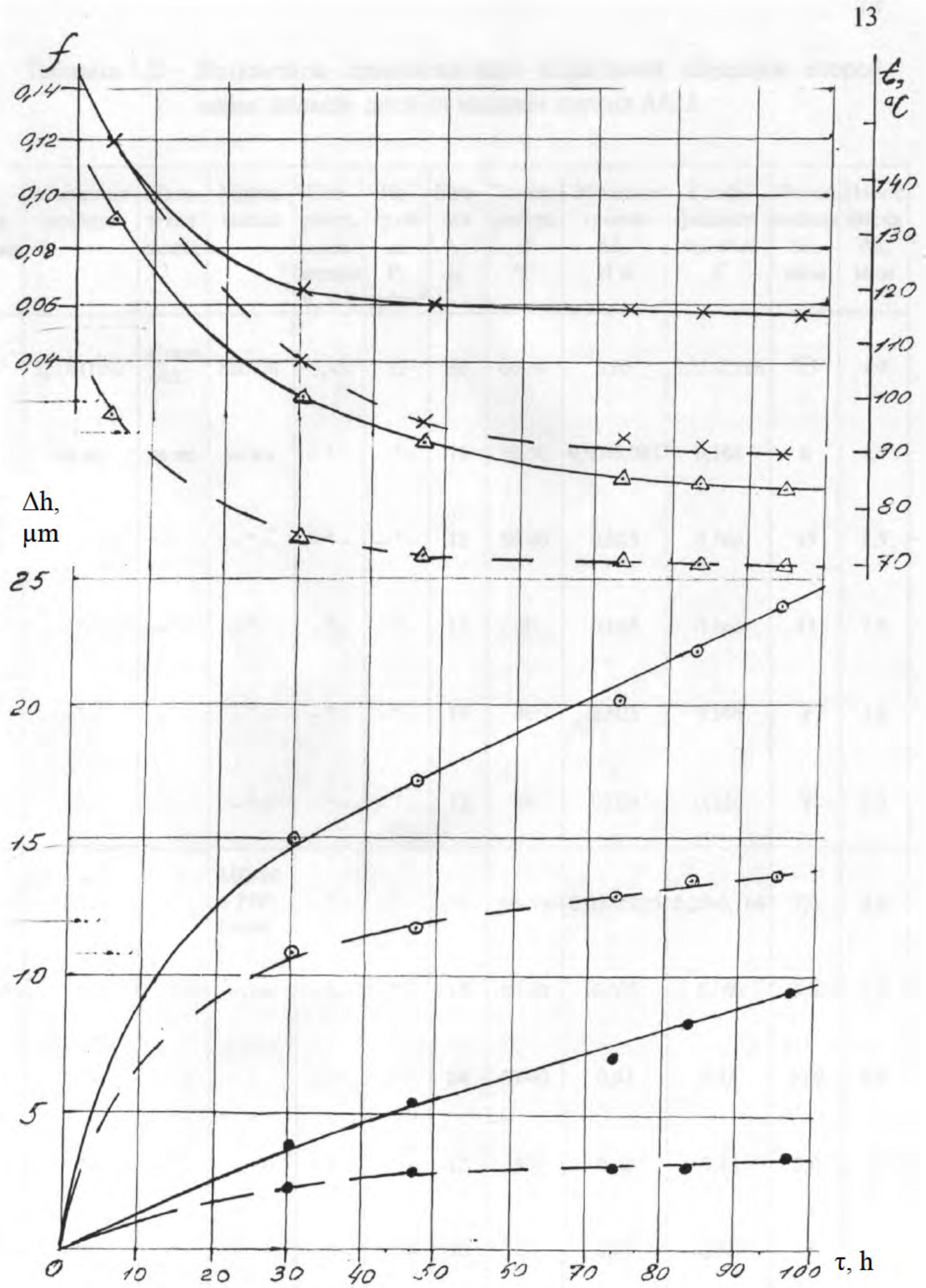


Table 3.2: : Results of comparative tests of specimens of the second pair: ring – disk with AYe-5 friction machine

No of Stage / Condition	Ring material	Disk material	Oil make	Sliding velocity V, m/s	Load P, kg/cm^2	Time τ, h	Temperature t, °C	Friction moment M, kgm	Friction coefficient f	Wear of ring Δh, μm	wear of disk Δh, μm
1/1	BrOTs10-2	Steel 40Kh	MS-20	3.45	12	30	60 - 50	0.05	0.25 - 0.166	7.5	4
1/2	BrOTs10-2	Steel 40Kh	MS-20	3.45	12	18	60 - 50	0.05 - 0.025	0.166	6	4
1/3	BrOTs10-2	Steel 40Kh	MS-20	3.45	12	12	50 - 40	0.025	0.166	15	2.5
1/4	BrOTs10-2	Steel 40Kh	MS-20	3.45	12	12	40	0.025	0.166	12	2
1/5	BrOTs10-2	Steel 40Kh	MS-20	3.45	12	12	40	0.025	0.166	7	1
1/6	BrOTs10-2	Steel 40Kh	MS-20	3.45	12	12	40	0.025	0.166	7	0.5
2/1	BrOTs10-2	Steel 40Kh	MS-20 + RVS Gel	3.45	12	30	60 - 50	0.05 - 0.025	0.25 - 0.166	7	4
2/2	BrOTs10-2	Steel 40Kh	MS-20 + RVS Gel	3.45	12	12	60 - 50	0.025	0.166	3.5	1
2/3	BrOTs10-2	Steel 40Kh	MS-20 + RVS Gel	3.45	12	24	50 - 40	0.02	0.15	10	0.5
2/4	BrOTs10-2	Steel 40Kh	MS-20 + RVS Gel	3.45	12	12	40	0.02	0.15	5	0.5
2/5	BrOTs10-2	Steel 40Kh	MS-20 + RVS Gel	3.45	12	10	40	0.01	0.007	1.5	1.5
2/6	BrOTs10-2	Steel 40Kh	MS-20 + RVS Gel	3.45	12	10	40	0.01	0.007	1	1

An analysis of the result shows that during 48 hours the wear intensity of the bronze ring is similar with and without the RVS compound in the oil. As the stabilisation stage is reached, the wear of the ring with RVS compound in the oil decreased by 20 percent.

The wear velocity of the steel disk during the first 30 hours was also similar with and without the RVS compound in the oil. However, in the latter case the stabilisation took place earlier, and the absolute values of the wear have decreased by 50 percent, which is proved by the decreased friction coefficient and the temperature.

3.3 Results and Analysis of Tests of Ring – Plate Friction Pair (Piston Ring – Cylinder Wall Joint)

The comparative tests of the third specimen pair (cast iron SCh25 – cast iron SCh25) were made in two stages with a reversible friction machine of the 77MT-1 type that kept the reversible movement velocity constantly at V = 0.3 m/s and the load on the specimens at P = 112 kg/cm^2.

The first stage was carried out with plain oil.

The second stage was carried out with RVS compound added oil (0.2 percent of the oil volume). Each stage consisted of five test and measurement periods. The test results are shown in Table 3.3. The curves of specimen surface wear and the temperature and friction coefficient change related to the testing time are shown in Picture 3.3.

An analysis of the results shows that, when working with oil, the ring wears more intensively than the plate in all the conditions. After the RVS compound was added in the oil and after forty hours of testing time, the wear process of the ring was stabilised, the wear velocity decreased, and the values of the absolute wear are 50 percent lower than with plain oil. The absolute wear values of the plate in the first work condition with oil are close to those of the ring. During the following test and measurement periods, the wear of the plate decreases in comparison with the ring by 80 to 100 percent.

When working with RVS compound added oil, the wear velocity of the plate is significantly lower than when working with plain oil, and after 50 hours of work it is stabilised at both stages. The absolute wear values of the plate, when working with the RVS compound added oil, decrease by 50 to 60 percent.

Picture 3.2: Curves of specimen wear: ring (⊙) – disk (●), changes of friction coefficient (×) and temperature (△) in relation with test time (τ); _____________ = work with oil, __ __ __ __ = work with oil and RVS compound

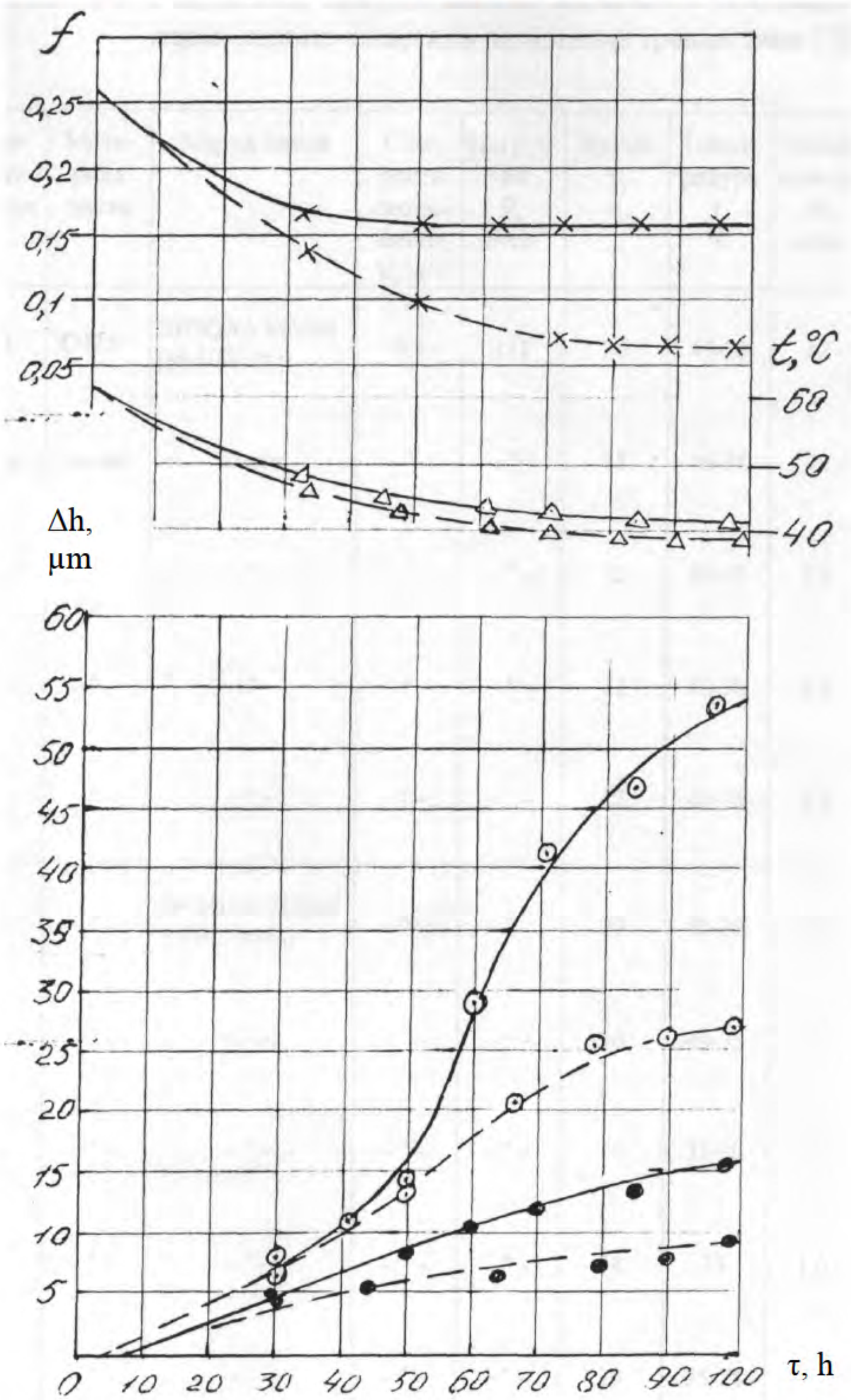
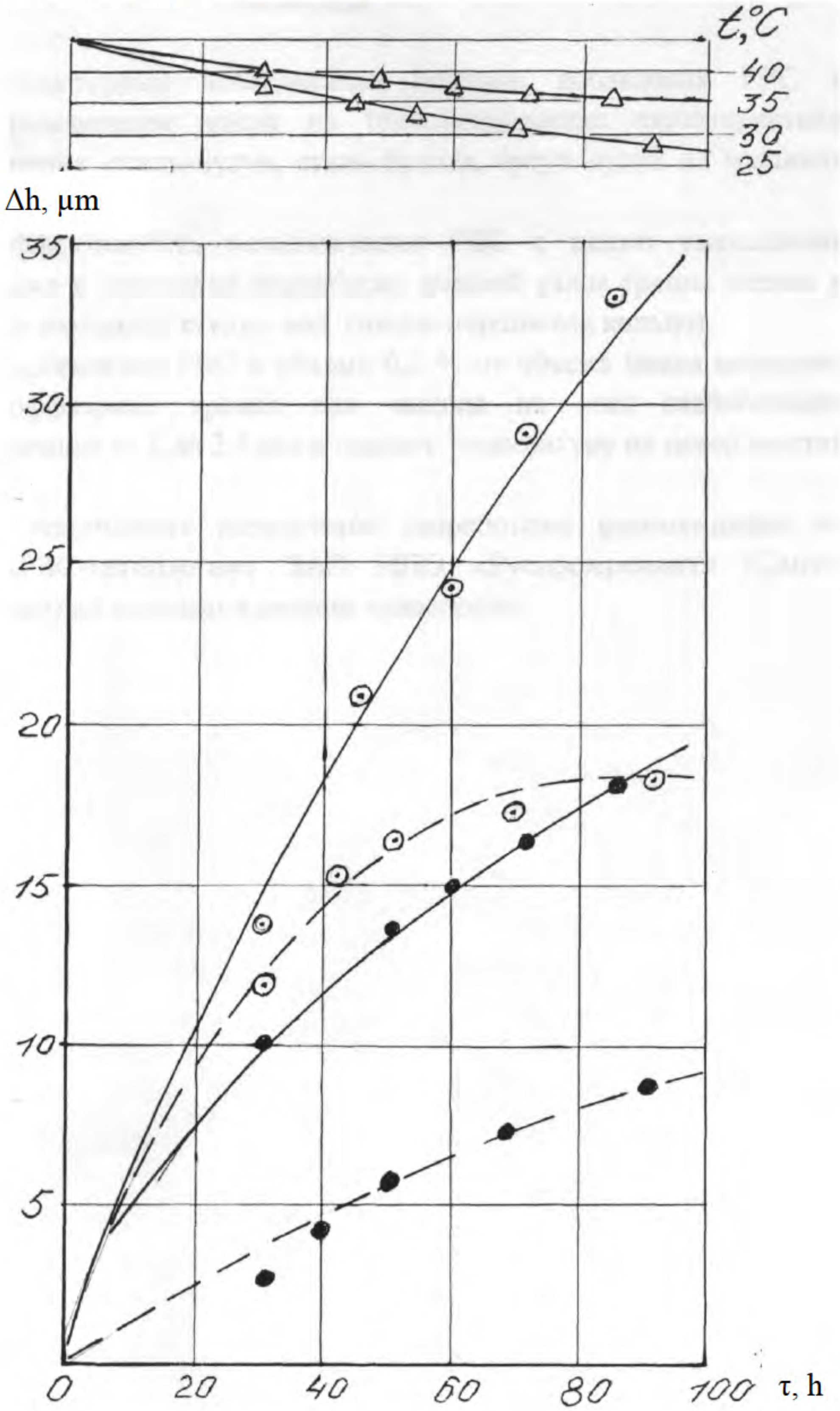


Table 3.3: Results of comparative tests of the specimens of the third pair: ring – plate with the 77MT-1 type friction machine

No of Stage / Condition	Ring material	Plate material	Oil make	Sliding velocity V, m/s	Load P, kg/cm^2	Time τ, h	Temperature t, °C	wear of ring Δh, µm	Wear of plate Δh, µm
1/1	SCh25	SCh25	DIZOLA M3004 [M10V2(s)]	0.3	112	30	40 - 38	12	10
1/2	SCh25	SCh25	DIZOLA M3004 [M10V2(s)]	0.3	112	18	40 - 38	10	3.5
1/3	SCh25	SCh25	DIZOLA M3004 [M10V2(s)]	0.3	112	12	40 - 35	3	1.5
1/4	SCh25	SCh25	DIZOLA M3004 [M10V2(s)]	0.3	112	12	40 - 38	4	1.5
1/5	SCh25	SCh25	DIZOLA M3004 [M10V2(s)]	0.3	112	12	40 - 35	4.5	1.5
2/1	SCh25	SCh25	DIZOLA M3004 + RVS Gel	0.3	112	30	40 - 38	9	2.5
2/2	SCh25	SCh25	DIZOLA M3004 + RVS Gel	0.3	112	10	40 - 35	6.5	1.5
2/3	SCh25	SCh25	DIZOLA M3004 + RVS Gel	0.3	112	10	35 - 30	1	2
2/4	SCh25	SCh25	DIZOLA M3004 + RVS Gel	0.3	112	18	35	1	1
2/5	SCh25	SCh25	DIZOLA M3004 + RVS Gel	0.3	112	20	35 - 28	1	1.5

Picture 3.3: Curves of wear of specimens: ring (⊙) – plate (●), changes of temperature (△) in relation with test time (τ); ____________ = work with oil, __ __ __ __ = work with oil and RVS compound



CONCLUSIONS

1. Laboratory studies on the effect of adding the RVS compound in motor and aviation oil on tribotechnical properties of friction pair specimens (steel – cast iron, steel – bronze, cast iron – cast iron) with AYe-5 and 77MT-1 friction machines have been carried out.
2. The efficiency of using the RVS compound for decreasing the friction parameters and speeding up the running-in of friction parts of machines and mechanisms (shaft – bearing shell, bushing – shaft, cylinder – piston ring) has been determined.
3. It has been found out that, when the wear velocity stabilises, adding the RVS compound in the amount of 0.2 percent of the oil volume reduces the friction coefficient by 50 to 60 percent and the temperature on friction surfaces.
4. On basis of the results, the recommendations for applying the RVS Technology in marine and river transport.

RECOMMENDATIONS

for applying the RVS Technology in ship and port technique, as well as in ship-repair yards of Ukraine

Name of machine part	Cases of applying the RVS compound	Purpose of applying the RVS compound
1. Cylinder groups and piston of diesel engines and compressors	a) After replacing or machining piston pin, replacing piston rings and/or flushing engine etc. b) During operation	Improving surface quality, decreasing wear, shortening running-in process, preventing seizing and extensive wear, restoring normal friction conditions without disassembling the object Increasing useful life
2. Shaft journals and bearings (main, driving bar, end) of diesel engines, compressors, pumps, deck mechanisms etc.	After replacing, refilling, or coating bearings	Improving surface quality, shortening running-in process preventing pre-stress of babbit etc. Lengthening inter-repair period
3. Bushing bearings, small shafts, pins, hinge joints etc.	a) After replacing parts of repairing b) At lubricant change	Improving running-in quality decreasing wear, preventing seizures, lengthening useful life, lengthening oil change interval
4. Roller bearings (ball, roller, needle)	a) At very repair or check before assembling b) During operation	Improving running-in quality, decreasing wear, preventing seizures etc.
5. Gear transmissions and worm-gearings	a) At every repair, maintenance, and check before assembling b) During operation	Decreasing wear, preventing jamming and pitting etc.
6. Friction joints on the deck (support structures of booms, tackles, rollers, hatches etc.)	a) At every check or repair before assembling b) At removal of lubricant or corrosion etc.	Decreasing wear, preventing seizures, preservation of mobility etc.
7. Ground surfaces (valves, couplings etc.)	a) At every check before assembling b) When grinding the surfaces	Decreasing wear, lengthening useful life Improving grinding quality

8. Cutting instruments (blades, drills, scrapers, threading taps and dies, saws etc.)	When cutting	Improving durability and working speed, decreasing working temperature, improving working accuracy
9. Lathe equipment (guides, driving shafts, screw spindles, turning machine centres, bearings, gearings etc.)	a) At every check and repair before assembling b) When noise or shock occurs in the operation	Decreasing wear, preventing seizures and jamming, decreasing noise