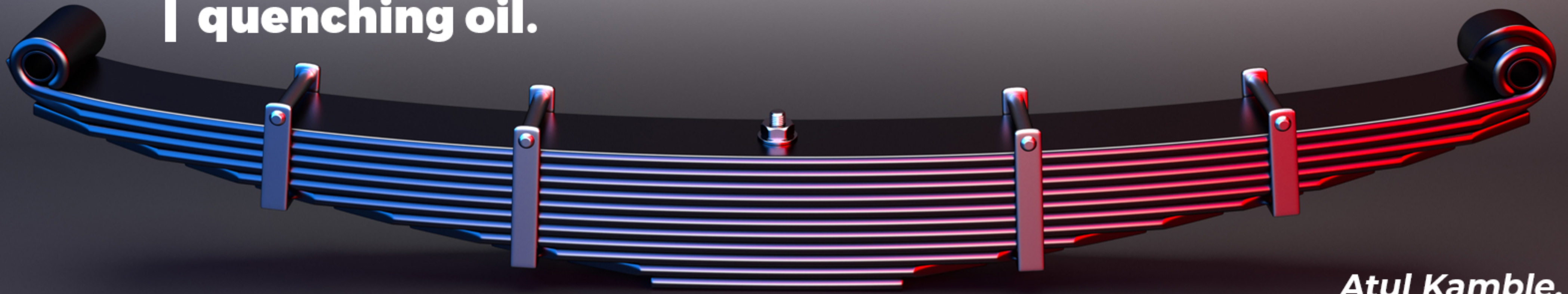


Study and Review of Leaf Spring Properties after Quenching in Oil Like Polymer Quenchant to successfully replace the conventional quenching oil.



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We know that the spring plays very essential part in every automobile from suspension point of view. Leaf spring is the main type of suspension system which is used in many light and heavy vehicles. Leaf spring are used in many vehicles as they have following characteristics.



Uniform load distribution



Lower cost



Sturdiness

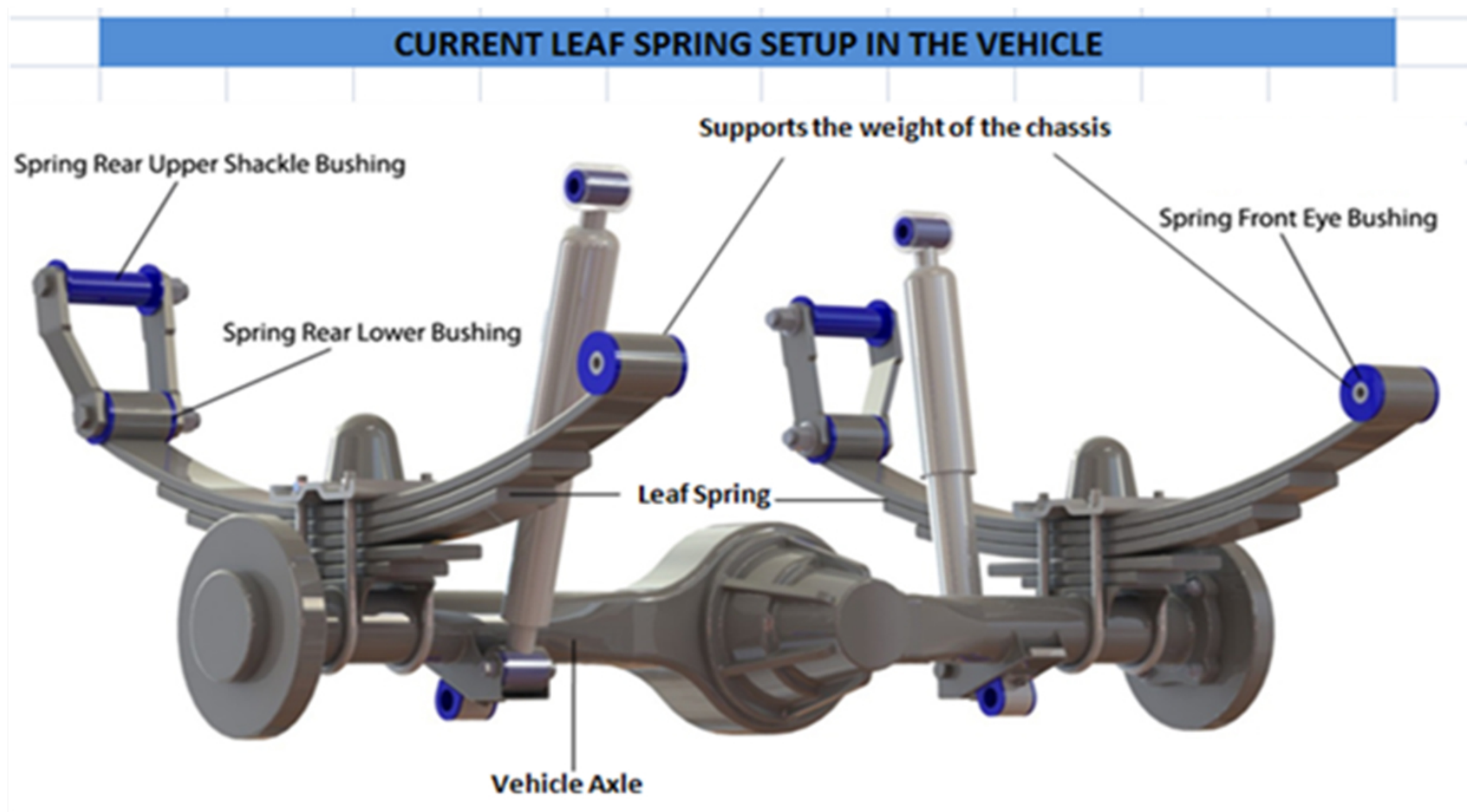
Today every automobile company has been working towards increasing efficiency by reducing the weight without compromising any load carrying capacity. In this paper we would like to review effect of some important parameters of leaf spring like hardness, fatigue properties tensile test and microstructure when quenched in oil like polymer. The paper is based on material composition, heat treatment process and experimental testing.

Key words: Leaf Spring, Material Compositions, Polymer Properties, Experiments



Application	Axle	Width (mm)	Weight (kg)
VOLVO	FRONT	100	117,46





INTRODUCTION

A leaf spring is the simple form of spring commonly used for the suspension in wheeled vehicles. Leaf spring is mainly made up of steel, but due to issue of weight today most of the automobile companies used composite materials for the manufacturing of leaf springs.

The classification of leaf spring included as Elliptical, Semi Elliptical, Three quarter Elliptical, Quarter Elliptical, and Terraservers. The leaf spring mainly consists of different parts like master leaf, centre bolt, central clamp, eye, and rebound clip.

Material based study is used for light weight transformation of vehicles at various loading conditions used for working and checking of load durability. The paper mainly focusses on the comparative study of oil like polymer quenchant with conventional oil to establish oil like polymer quenchant as the replacement to the conventional oil quenching.

QUENCHING OIL Hiquench MF W

HIQUENCH MF (W) is medium fast quenching oil which provides fast and uniform quenching. In addition, it is also highly stable having high flash points and optimum viscosity for quenching. Oil soluble agents in HIQUENCH MF (W) wet out work rapidly, preventing the formation of vapour pockets. HIQUENCH MF (W) provides a controlled, fast quenching speed and a consequent high, uniform, oil quenched hardness.

OIL LIKE POLYMER
HIQUENCH P50

HIQUENCH P 50 does not contain mineral oil or nitrite and no other hazardous materials.

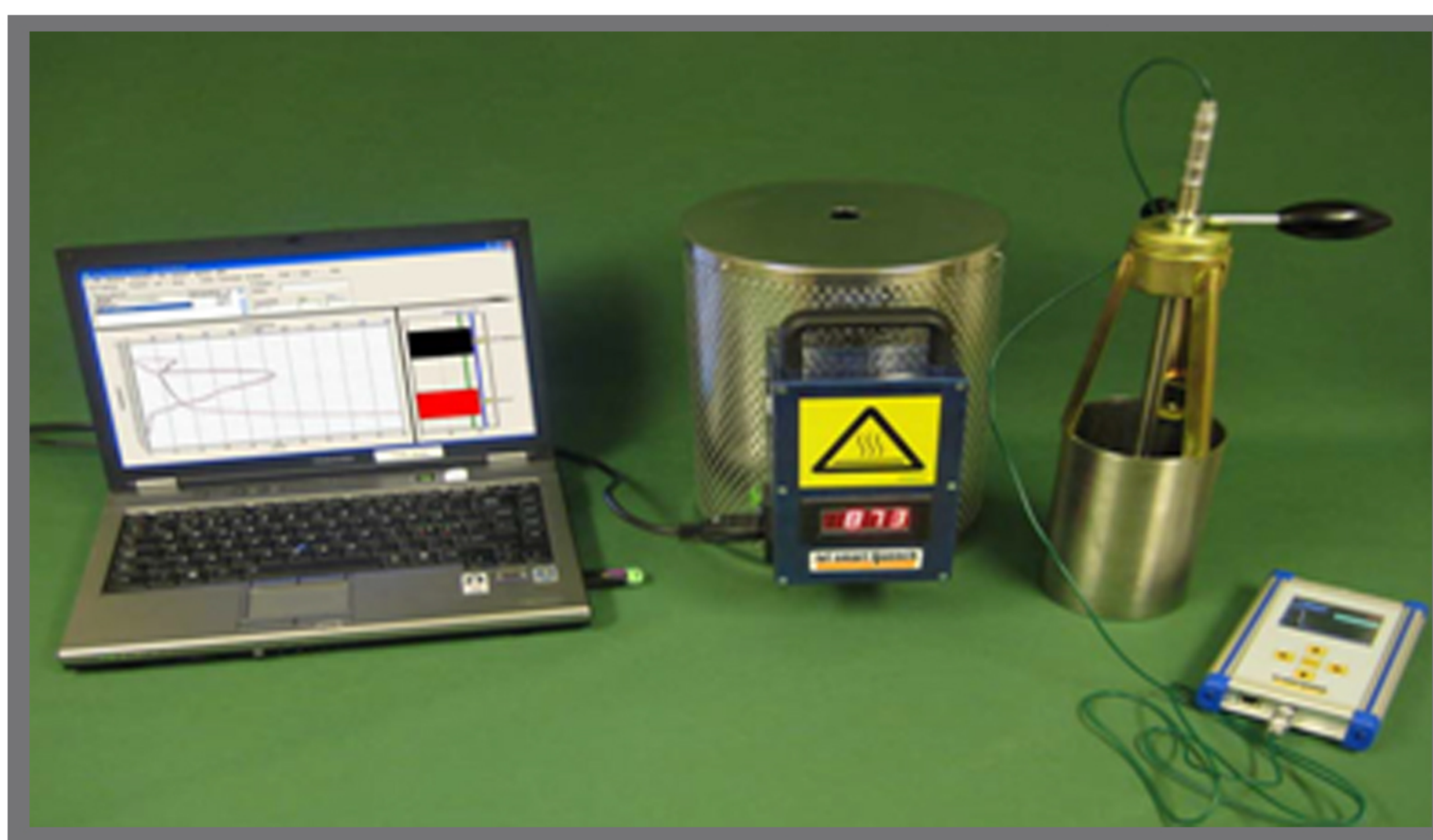
HIQUENCH P 50 is the first water - based quenchant which has oil-like quenching characteristics. Solutions are absolutely non-combustible. Fire hazards and formation of unpleasant smoke or soot are therefore avoided.

PHYSICAL AND CHEMICAL PROPERTIES

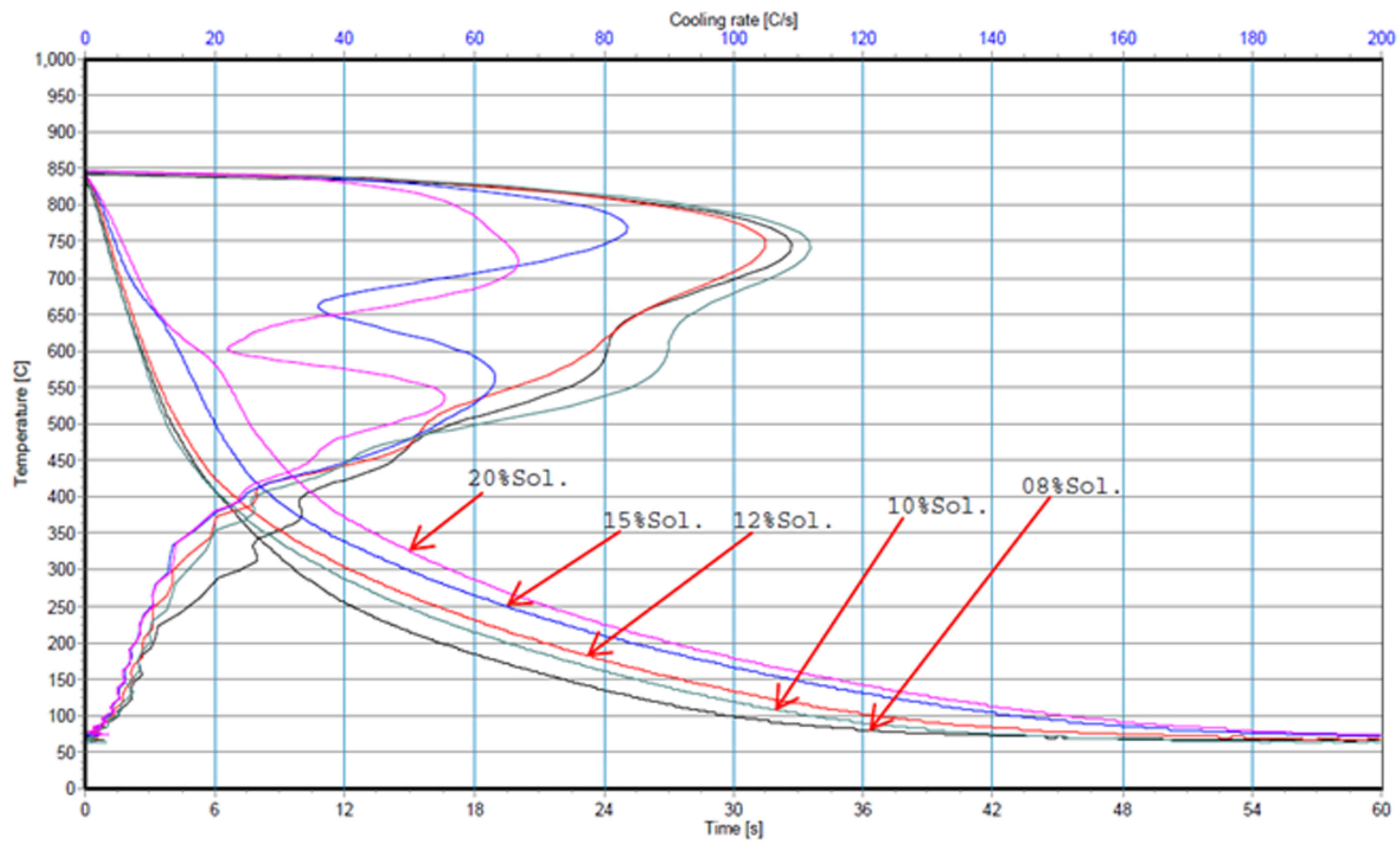
PROPERTIES	HIQUENCH MF (W)	HIQUENCH P50
COLPUR	GOLDEN YELLOW COLOUR OIL	HAZY PALE VISCOUS FLUID
SPECIFIC GRAVITY @30	0.84	1.05
KINEMATIC VISCOSITY @40	22 cSt	575 cSt
pH NEAT		9.5
PH OF 5% SOLN IN DM WATER		9.2
FLASH POINT, COC	178°C	NA

Hiquench P50 cooling rates comparison with variation in concentration

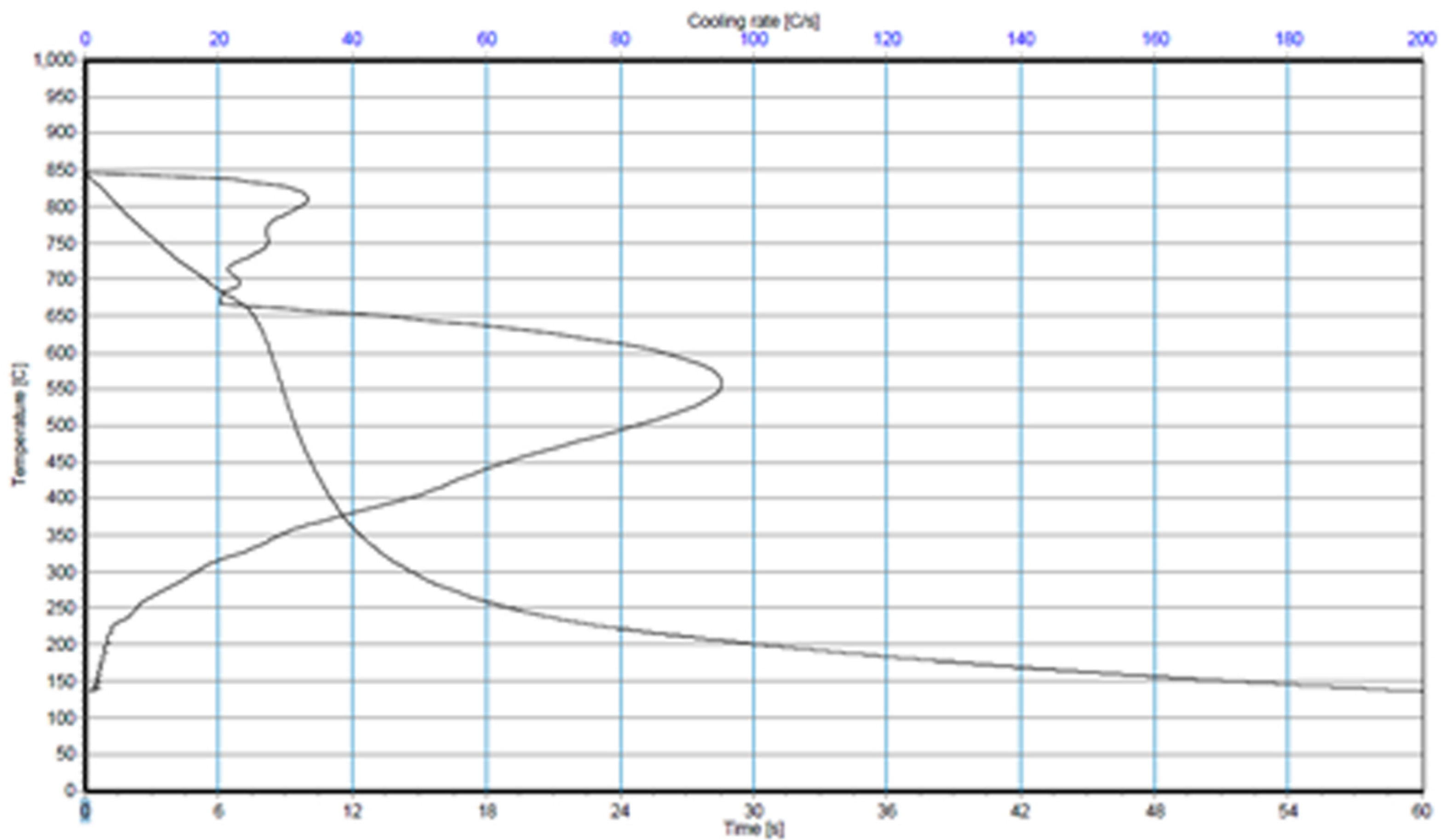
Cooling curves plotted using IVF probe as per standard ASTM D 6482-06 Tensi Method.



IVF Equipment for determination of Cooling Curve



Cooling Curve of Hiquench P50 at various concentrations 8%, 10%, 12%, 15% and 20%



Cooling Curve of Hiquench MF (W) with IVF probe at 60 °C oil temperature

From above two cooling curve we can easily conclude that polymer quenchant has much wider range of cooling compared to oil by varying the concentration

Let's compare the other Properties of Polymer Hiquench P50 Vs Hiquench MF W

Property	Hiquench MF W	Polymer Hiquench P50 Concentration (%)					Remark
		8	10	12	15	20	
Maximum Cooling Rate (°C/s)	95.32	108.97	111.86	104.89	83.6	66.76	Cover the Range of all oils
Temp. at Max. Cooling Rate (°C)	555.41	749.19	738.31	751.43	770.22	723.14	Higher the temp of Max cool rate better the phase transformation
Temp at Start of Boiling (°C)	673.66	843.15	845.89	846.12	847.16	847.31	Higher Boiling Point better the transformation
Temp at Start of Convection (°C)	275.25	391.98	393.58	405.49	660.97	603.06	Higher temp.at start of Convection phase & slow cooling will reduce distortion and crack
Cooling Rate at 300 °C (°C/s)	17.04	23.81	16.35	13.53	12.63	13.15	Lower cooling rate lower the distortion and less crack
Time to 600 °C (s)	8.33	2.6	2.51	2.77	4.35	5.28	
Time to 400 °C (s)	11.02	6.23	6.3	6.92	8.66	10.68	
Time to 200 °C (s)	30.36	16.37	19.49	21.2	25.22	27.08	

When we compare polymer quenchant and oil as regards to environment and safety, answer is obviously polymer quenchant.

Let us observe cooling rate of oil like polymer at 300°C (where slow cooling is desirable for less distortion and no quench cracks) from below table.

Concentration(%)	Cooling rates at 300 °C (°C/s)
8	23.81
10	16.35
12	13.53
15	12.63
20	13.15

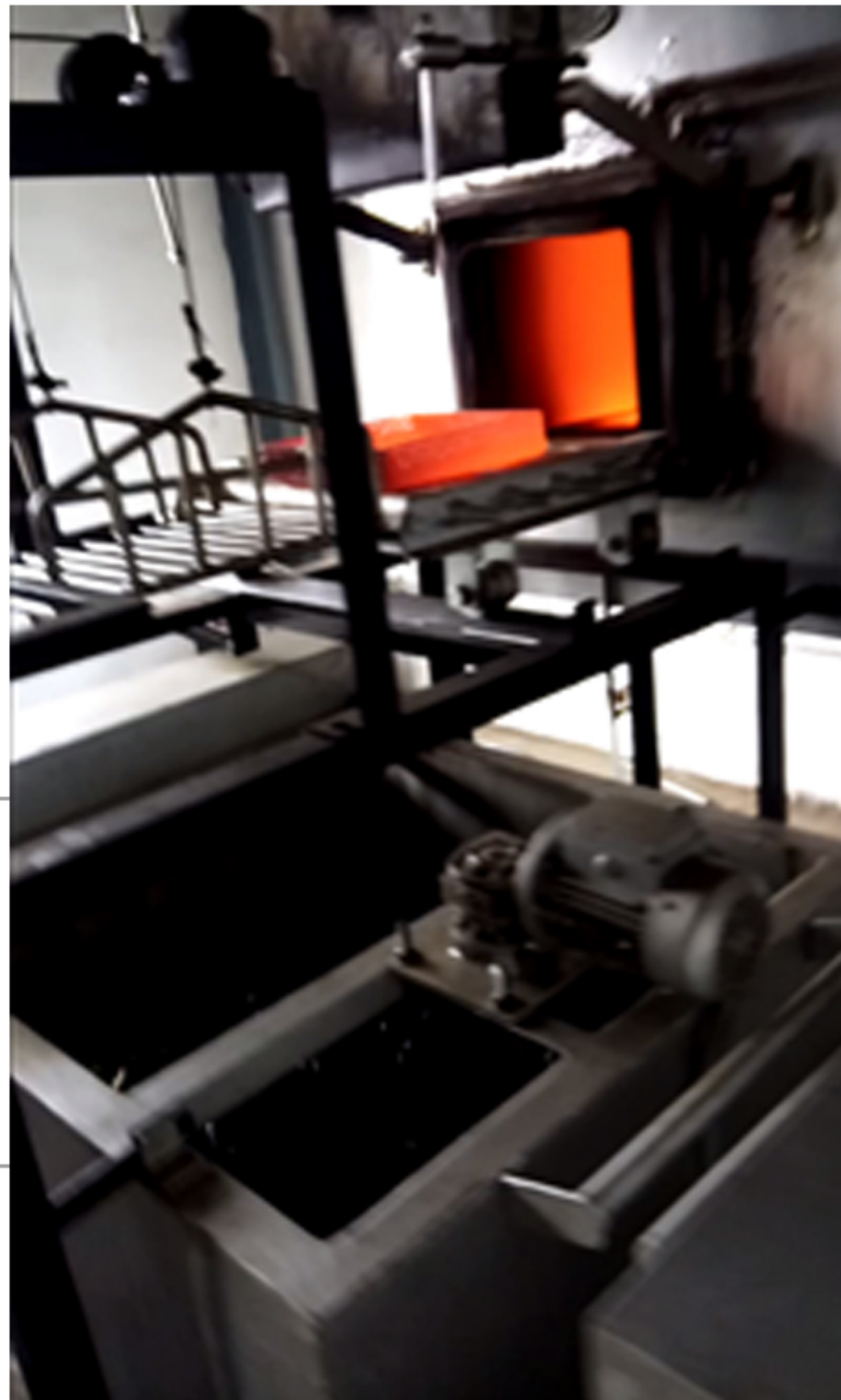
As medium fast quenching oil Hiquench MF (W) has a cooling rate of 7.04 at 300°C and Hiquench P50 has much higher cooling rate at various concentrations, it gives sufficient reason to try oil like polymer quenchant against quenching oil.

LAB EXPERIMENTS

Laboratory Trials for Spring Leaf Materials SUP 11 and SUP9



Photograph of Spring Material

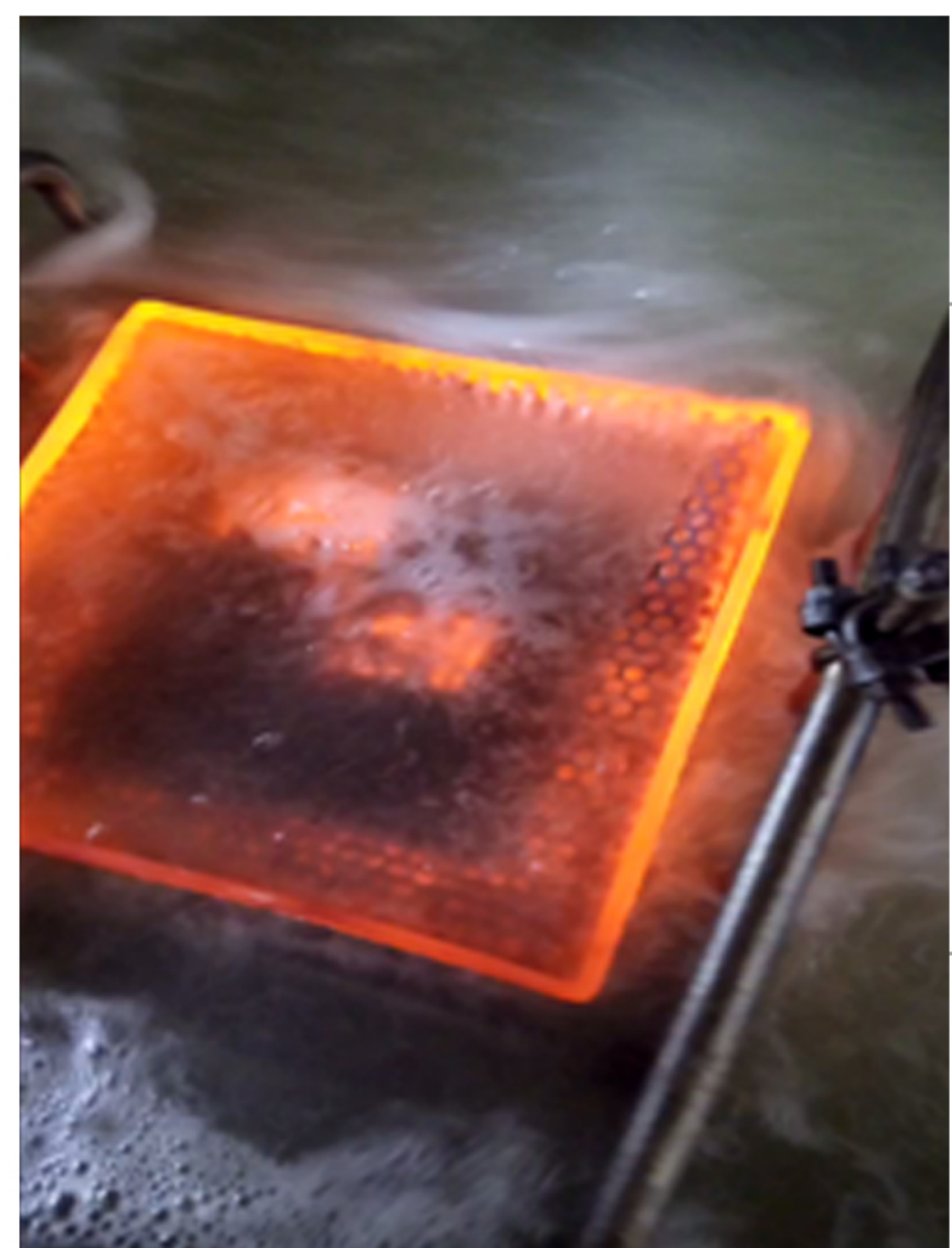


Furnace

Cooling of Spring flats in Polymer



Loading / Unloading tray



Photograph of Laborotory furnace where Hardening is conducted in Hiquench MF (W) and Hiquench P50

Spring Steel Grade SUP11

Spring Leaf Material SUP 11 with thickness 16 mm quenched in Hiquench MF (W) and Polymer Hiquench P 50 in various concentration and following result observed. Heat Treatment cycle is 850°C soaking time 30 minutes and quenched with medium agitation (100 rpm). Hardness throughout the cross section is as below in HRc

SUP11		Hiquench P50 -Concentration			
Distance From Surface	Hiquench MF W	P50 -7.4%	P50 -12.4%	P50 -14.2%	P50 -19.8%
0.5	64.7	65	63.5	64.5	63.3
2	64.3	64.9	63.8	63.1	63.1
4	64	65.4	65	64.1	64.5
6	64.3	65.2	64.9	63.8	64.1
8	64.3	64.7	65.2	64.1	60.4
10	64.7	64.1	63.9	60.1	60.7
12	64.9	64.6	61.9	58.1	61.3
14	64.8	64.5	60	59.9	63.9
15.25	64.2	64.8	60.9	62.1	63.7
Average	64.5	64.8	63.2	62.2	62.8
Variation	0.9	1.3	5.2	6.4	4.1

In Hiquench MF W uniform hardness and less variation from top to bottom observed.

Surprisingly Hiquench P 50 showed low hardness compared to oil at same temperature, time and agitation. This anomaly with polymer quenchant was corrected during actual trials by optimising agitation speed.

Spring Material SUP9

Hardness comparison in HRc with material having 10 mm thickness

SUP9		Hiquench P50 -Concentration			
Distance From Surface	Hiquench MF W	P50 -7.4%	P50 -12.4%	P50 -14.2%	P50 -19.8%
0.5	64.3	64.7	64.3	63.3	65.2
1	64.6	64.8	63.3	65.6	63.7
2	64.8	64.2	65	65	63.1
3	61.3	64.9	65.3	64.5	58.9
4	56.9	65.2	64.4	64.2	55.9
5	56.3	65.8	65.3	61.3	54.9
6	55	64.6	61.6	57.8	52.6
7	55.3	63.2	61.1	55.7	51.9
8	55.8	62.5	59.5	57.5	51.1
9	56.3	63.4	59.8	58.1	52.4
9.25	56.7	64.1	60.4	58	52.6
Average	58.8	64.3	62.7	61.0	56.6
Variation	9.8	3.3	5.8	9.9	14.1

In SUP 9 which has less hardenability the variation in hardness in oil is more compared to Polymer at lower concentration. Top to bottom hardness variation observed in both oil and Polymer

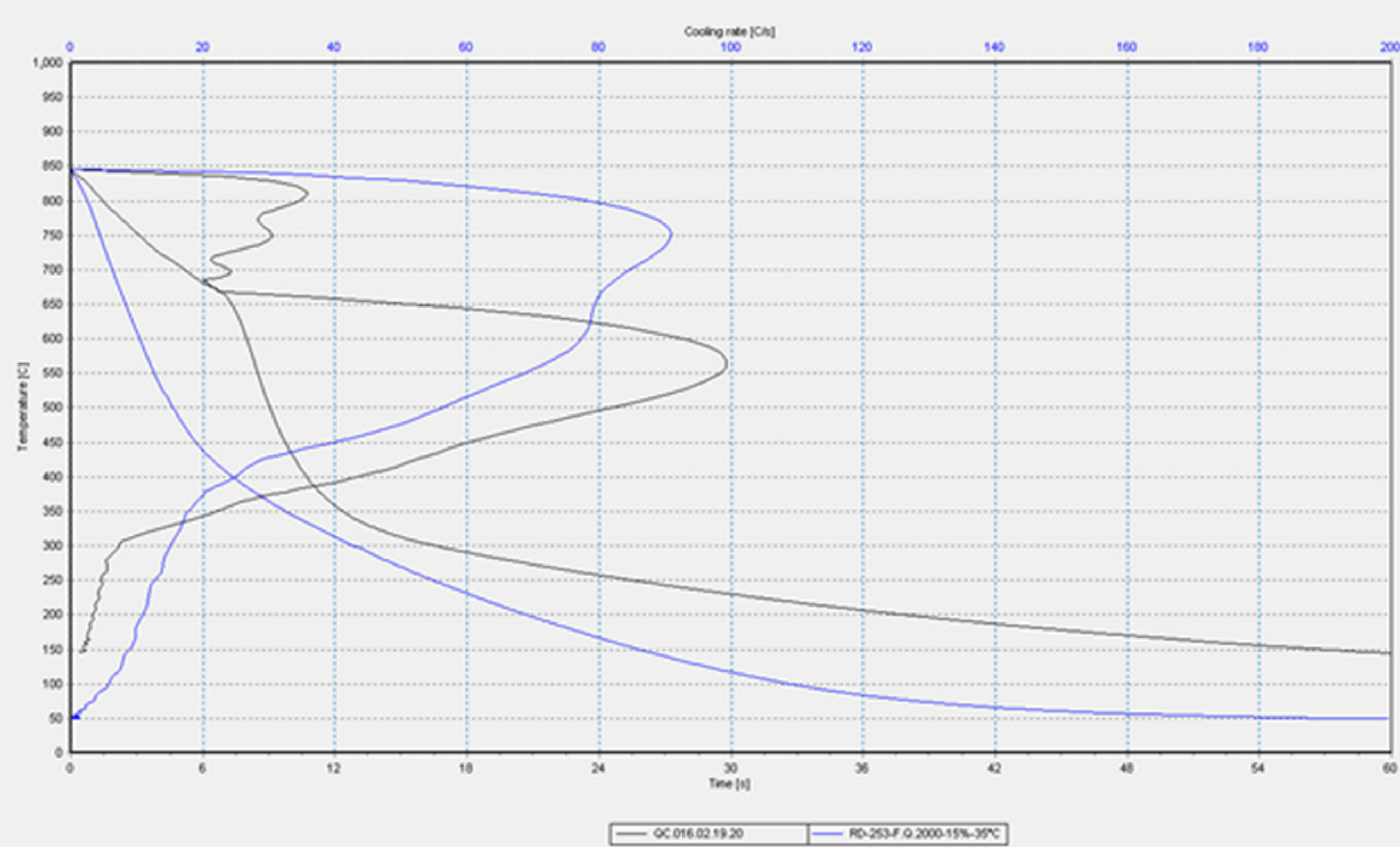
ON SITE TRIALS

FINAL EXPERIMENT OF
POLYMER QUENCHANT
AT 15% CONCENTRATION

Product	HIQUENCH MF (W)	HIQUENCH P 50
Concentration	Neat	15% SOL
Agitation	Nil	1500 rpm
Temperature degC	60	30

Cooling Curve	Cooling Curve Data of Hiquench Mf @60°C	Cooling Curve Data of Hiquench P 50 = 15% Sol.@35°C
Curve No.	QC.016.02.19.20	RD-253
Maximum cooling rate: °C/s	99.38	90.84
Temp. at maximum cooling rate, °C	567.61	746.84
Temp. at start of boiling, °C	675.74	846.36
Temp. at start of Convection, °C	304.3	335.96
Cool rate at 300°C	7.6	15.12
Time at 600°C	7.98	3.14
Time at 400°C	10.72	7.33
Time at 200°C	37.88	20.21
HP	894.81	277.71

Study of
cooling curve



Part ID : Spring Leaf

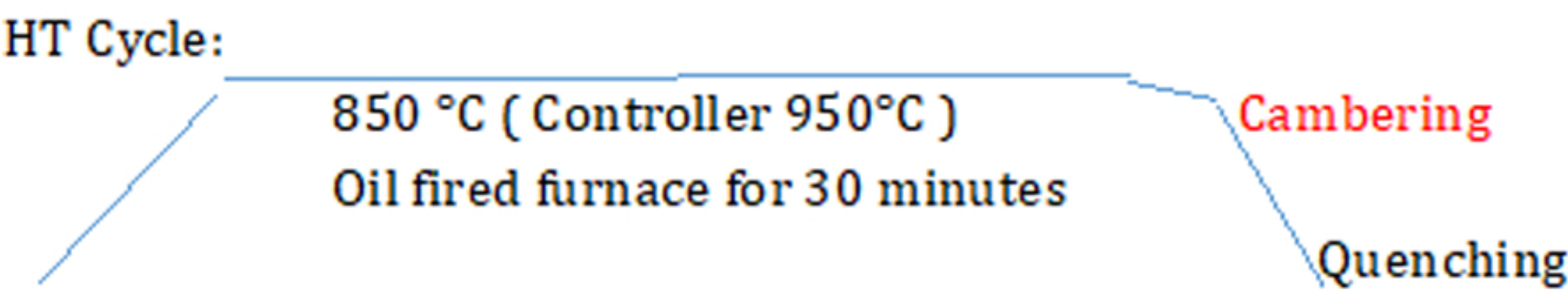
Material SUP9

- 1. 45X6- 3nos
- 2. 70X8- 5 Nos

Material SUP11

- 1. 90X25- 3 Nos
- 2. 80X20 -3 Nos
- 3. 80X15 - 5 Nos
- 4. 90x16- 3 noS

Heat treatment cycle



Observations



Continuous Furnace loading



Unloading



Cambering before quenching



Polymer quench Tank



Quenching



Sup9 Spring leaf

Preparation for Trial



Agitation is provided by pumping quenchant around spring leaf with pump and pipes with holes

Tray is placed in quench tank for parts handling

Oil quenchant heat treatment cycle is kept without any change for polymer quenchant i.e 850°C for 30 minutes (Control Panel setting 950°C) , and Tempering at 500°C.

Polymer: Hiquench P50, Batch No JAN20/24, Concentration: 15%, at room temperature. Agitation provided with pump and spray in tank.

Total Tank volume 2000Litre. Quenchant volume 1500 Litre

Hardness observations are as follows

Steel Grade SUP9

Hardness Specification 363-429 BHN (2.95-3.20)

Sample ID	Leaf Size	As Quench Hardness				As tempered Hardness			
		Impression Dia		Hardness (BHN)		Impression Dia		Hardness (BHN)	
		Dia1	Dia2	BHN1	BHN2	Dia1	Dia2	BHN1	BHN2
1	70X8	2.35	2.40	683	653	3.05	3.0	401	415
2	70X8	2.25	2.40	710	653	3.05	3.05	401	401
3	70X8	2.50	2.65	601	534	3.10	3.20	388	363
1	70X8	2.45	2.35	627	683	3.05	3.05	401	401
2	70X8	2.70	2.70	514	514	3.1	3.10	388	388
3	45X6	2.30	2.25	710	730	3.00	3.00	415	415
4	45X6	2.30	2.30	710	710	3.0	3.0	415	415
5	45X6	2.25	2.30	730	710	3.0	3.0	415	415

As quench hardness observed on higher side in comparison with oil quenchant, as tempered hardness found within specification. One sample checked for microstructure found 95% martensite which shows better hardness. One sample checked with bending on both side.

No visual crack observed in any sample.

Steel Grade SUP11

Hardness Specification 363-429 BHN (2.95-3.20)

Sample ID	Leaf Size	As Quench Hardness				As tempered Hardness			
		Impression Dia		Hardness (BHN)		Impression Dia		Hardness (BHN)	
		Dia1	Dia2	BHN1	BHN2	Dia1	Dia2	BHN1	BHN2
1	90X16	2.7	2.6	514	555	3.05	3.0	401	415
2	90X16	2.55	2.55	578	578	3.0	3.0	415	415
3	90X16	2.7	2.7	514	514	3.05	3.10	410	388
1	90X25	2.4	2.5	653	601	3.0	3.0	415	415
2	90X25	2.45	2.55	627	578	3.0	3.1	415	388
3	90X25	2.6	2.55	555	578	3.0	3.0	415	415
1	80X20	2.6	2.6	555	555	3.1	3.05	388	401
2	80X20	3.0	3.05	415	401	3.20	3.20	363	363
3	80X20	2.85	2.95	461	429	3.15	3.20	375	363
1	80X15	2.40	2.45	653	627	3.0	3.0	415	415
2	80X15	2.40	2.50	653	601	3.05	3.0	401	415
3	80X15	2.75	2.70	495	514	3.05	3.1	410	388
4	80X15	2.50	2.40	601	653	3.0	3.0	415	415
5	80X15	2.55	2.50	578	601	3.05	3.1	410	388

All hardness observed within specifications. No visual crack observed in any sample

Conclusion

All trial conducted with various thickness of leaf spring samples and steel grade SUP9 and SUP11 in oil like Polymer quenchant HIQUENCH P50 shows hardness and microstructure within specifications.

No visual cracks observed during trial.

Further bend test was performed and no cracks detection.

Summary

As a result of investigation carried out it has been concluded that with oil like polymer HIQUENCH P50 the correct microstructure, mechanical properties, tensile strength, hardness, & fatigue strength at 15 % concentration for spring steels SUP 9 & SUP11 material are achieved.

The implementation of this technology could bring radical change in heat treatment of leaf spring industry. Thus resulting in to measurable economic, environmental and health benefits.