From Eye to Insight

INDUSTRIAL MANUFACTURING TECHNICAL REPORT

Leica DVM6 Digital Microscope: Work Up to 3x Faster in Inspection, Quality Control, Failure Analysis, and Research

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More efficient workflow with digital microscopy

The data presented in this report demonstrates how the Leica DVM6 enables users to work up to three times faster compared to "standard" digital microscopes.

Digital microscopes, which are optical microscopes without eyepieces where the image is observed on a monitor, have proven to be very practical for inspection, quality control and assurance (QC/QA), failure analysis (FA), and research and development (R&D). They are used in diverse industries, such as automotive, aerospace, microelectronics, precision engineering, and biomedical devices [1-5]. Recently, dramatic improvements in technology have made digital microscopy even more powerful in helping users to work more efficiently, even up to three times faster.

The Leica DVM6 makes inspection and analysis workflows more efficient because of:

> Simple, rapid way to change magnification over the entire range with a one handed objective change;

> Intuitive software for microscope operation and analysis with one-click report creation;

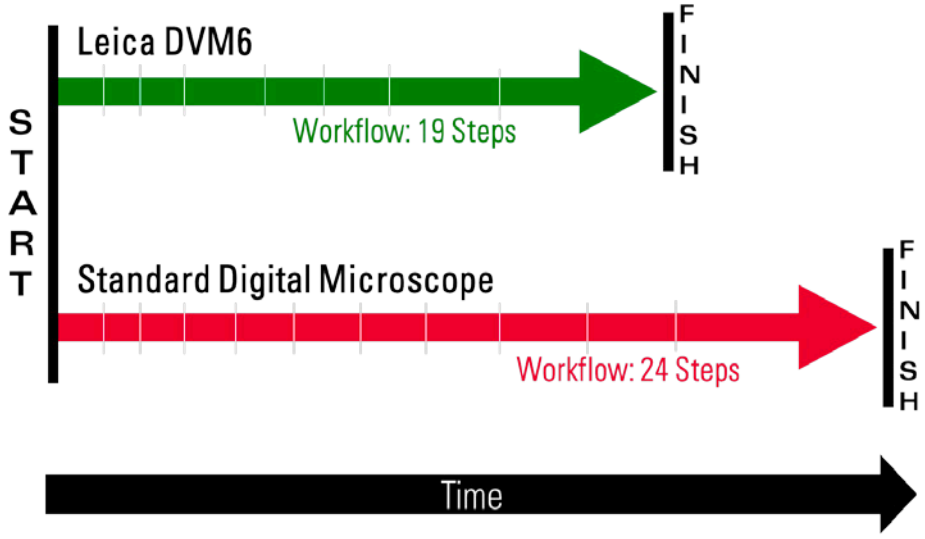
> Automated tracking and storing (encoding) of important parameters with one-click recall;

> Fast microscope head tilting and sample rotation with one hand; and

> Integrated ring light and coaxial illumination for easy, versatile contrast lighting of the sample.

To show how a typical workflow can be performed faster with the Leica DVM6, a workflow based upon the analysis of a sample with a digital microscope over the whole magnification range has been defined.

The time measured for users to complete each step for both the Leica DVM6 and a standard digital microscope have been recorded and compared. The results indicate that users, irrespective of their microscopy experience level, can complete the workflow on average up to three times faster when using the Leica DVM6.



Schematic comparison of the number of steps and approximate average duration of the steps based upon the results observed with 4 different users.

Digital microscopes

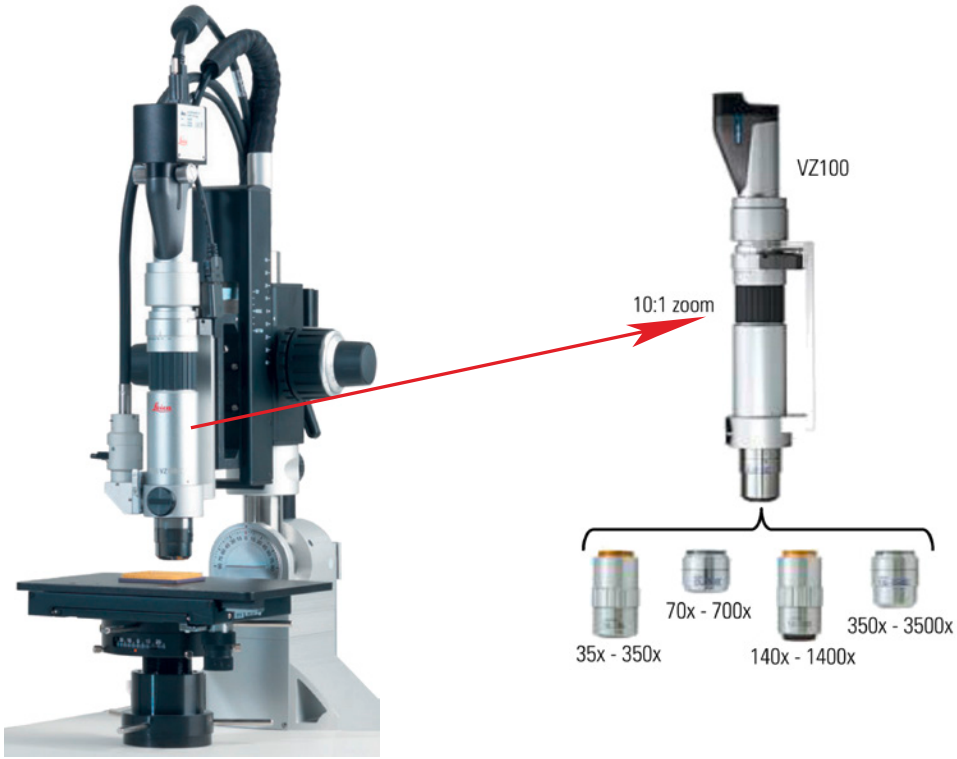
Leica DVM6

The Leica DVM6 has a 16:1 zoom and three objective lenses, which span a magnification range of 12x to 2,350x. The objectives slip in and out of the objective slot quickly and easily, as shown in this video and the figure below.

Leica DVM6 digital microscope and the low, middle, and high magnification objective lenses.

Standard digital microscope

The standard digital microscope in this study is represented by the Leica DVM2500 with VZ100 zoom optics. It has a 10:1 zoom and four objective lenses, which span a magnification range of 35x to 3,500x. The objectives screw into the bottom of the optics tube as seen in the figure below.



Leica DVM2500/VZ100 digital microscope and four objective lenses.

Defined Workflow and Users

The following workflow was performed by 4 different users and the time for each step was measured and recorded.

The microscope users were:

1. User 1: digital microscopy expert;
2. User 2: extensive optical microscopy experience, limited digital microscopy experience;
3. User 3: no optical and digital microscopy experience; and
4. User 4: microscope design experience, limited optical and digital microscopy operation experience.

An example workflow for operation of a digital microscope is defined below.

Workflow: observing a sample from lowest to highest magnification (N.B.: steps with significant differences between the digital microscopes are marked red)	
Leica DVM6	**Standard Digital Microscope**
Time recorded to complete each step	
1. Install lowest magnification objective	1. Install lowest magnification objective
2. Set zoom to lowest value	2. Set zoom to lowest magnification value
3. Adjust stage height and put sample on stage	3. Adjust stage height and put sample on stage
4. Manual coarse adjustment to position stage to find the area of interest on the sample	4. Position sample manually with stage x-y micrometers to find area of interest on the sample
5. Zoom to highest value, manually focus, zoom out to lowest magnification	5. Zoom to highest value, manually focus, zoom out to lowest magnification
6. Double-click to center sample area in live image	6. Manually center sample area of interest in live image
7. Capture image	7. Capture image
8. Zoom to highest magnification value	8. Zoom to highest magnification value
9. Capture image	9. Capture image
10. Change to middle magnification objective	10. Change to next highest magnification objective
11. Zoom to highest magnification value, manually focus, zoom out to lowest magnification	11. Zoom to highest magnification value, manually focus, zoom out to lowest magnification
12. Capture image	12. Capture magnification
13. Zoom to highest magnification value	13. Zoom to highest magnification value
14. Capture image	14. Capture image
15. Change to highest magnification objective	15. Change to next highest magnification objective
16. Zoom to highest magnification value, manually focus, zoom out to lowest magnification	16. Zoom to highest magnification value, manually focus, zoom out to lowest magnification
17. Capture image	17. Capture image
18. Zoom to highest magnification value	18. Zoom to highest magnification value
19. Capture image	19. Capture image
	20. Change to highest magnification objective
	21. Zoom to highest magnification value, manually focus, zoom out to lowest magnification
	22. Capture image
	23. Zoom to highest magnification value
	24. Capture image

Results

To compare the total workflow times for the Leica DVM6 and standard digital microscope (SDM), the ratio, $R_{SDM/DVM6}$, of average times (over all four users) to complete the entire workflow can be used:

$$R_{SDM/DVM6} = \frac{\text{total time workflow SDM}}{\text{total time workflow DVM6}}$$

This ratio shows how much longer it takes to complete the workflow with the standard digital microscope versus the Leica DVM6. Equivalently, one sees how much faster the users can complete the workflow with the Leica DVM6 compared to the standard digital microscope.

Workflow completion time

The completion time data for the defined workflow are below:

Workflow Total Completion Time Results									
Leica DVM6					**Standard Digital Microscope (SDM)**				
	User 1	User 2	User 3	User4		User 1	User 2	User 3	User 4
	time (s)					time (s)			
total all steps	131	175	281	180	total all steps	345	388	507	414
average time / user	191.8 s				average time / user	413.5 s			
standard deviation	63.4 s				standard deviation	68.5 s			
standard error	31.7 s				standard error	34.3 s			
$R_{SDM/DVM6}$ = 413.5 s / 191.8 s = 2.2									

Time ratio by user	User 1	User 2	User 3	User 4	Avg
$R_{user\text{-}SDM/DVM6}$	2.6	2.2	1.8	2.3	2.2

From the data above, $R_{SDM/DVM6}$ for the average workflow completion time is 2.2. This value can be compared with the average of the time ratios for each user, $R_{user\text{-}SDM/DVM6}$, also shown in the table above, where:

$$R_{user\text{-}SDM/DVM6} = \frac{\text{user's total time workflow SDM}}{\text{user's total time workflow SDM}}$$

Data analysis with the t-distribution

The data can be further analyzed with the student's t-distribution, often used for analysis of small data sets (two or more data points) [6].

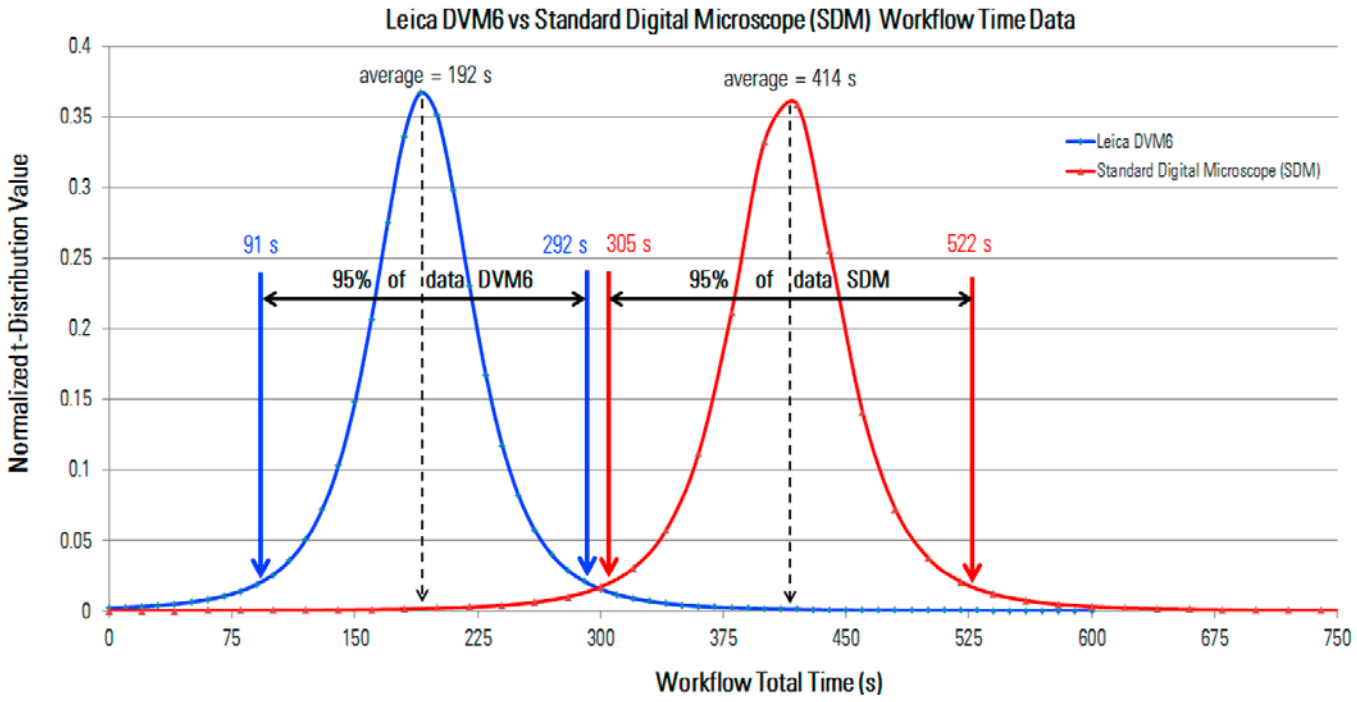
Using the average value, the standard deviation, and the standard error of the mean (standard error) of the data set plus the degrees of freedom (number of data points minus one), then the range of data falling within 95% of the area under the t-distribution curve (two-sided approach, so 2.5% of the curve area from the two tails is excluded) can be determined.

On the basis of the t-distribution analysis, normally any value that falls within the 95% interval is considered to be a probable total workflow time when users operate the Leica DVM6 or standard digital microscope. From this premise, a maximum and minimum ratio of the time values (from the right and left tails) can be used to define the range.

Analyzing the data above with the t-distribution yields:

Workflow Data Analysis with t-Distribution			
Leica DVM6 data		**SDM data**	
average	191.8 s	average	413.5 s
standard error	31.7 s	standard error	34.3 s
95% confidence interval 2 sides of t-distribution			
time value right side	292 s	time value right side	522s
time value left side	91 s	time value left side	305 s
range of $R_{SDM/DVM6}$			
max $R_{SDM/DVM6}$	522 s / 91 s =		5.7
min $R_{SDM/DVM6}$	305 s / 292 s =		1
avg $R_{SDM/DVM6}$	413.5 s / 191.8 s =		2.2

Below are the t-distributions for the Leica DVM6 and standard digital microscope workflow time data



Data of total time for each user to complete the workflow defined above for the Leica DVM6 and standard digital microscope (SDM) and corresponding t-distributions. The 95% confidence intervals for two sides of the curves are indicated.

Faster workflow completion with the Leica DVM6

So from the analysis, 95% of the workflow time data fall between 91 s and 292 s for the Leica DVM6 and 305 s and 522 s for the standard digital microscope. Looking at the data analysis table above, the range of values for $R_{SDM/DVM6}$ is from 1 to 5.7, where 2.2 is the ratio of the average workflow times. Therefore, completion of the workflow above with the Leica DVM6 can be as **much as 5.7x faster** than with a standard digital microscope.

In fact, if users complete the workflow in a time of 480 s with the standard digital microscope, just 16% over the average time (414 s), and a time of 161 s with the Leica DVM6, just 16% under the average time (192 s), then:

$$R_{user\text{-}SDM/DVM6"} = \frac{480\ s}{161\ s} = 3$$

Therefore, this simple analysis example shows that it is likely users can complete the workflow **three times faster** with the Leica DVM6 compared to a standard digital microscope.

Conclusions

More efficient, reliable inspection, quality control and assurance, failure analysis, and research & development can be attained with the Leica DVM6 digital microscope. The results reported here show that it is possible to work up to **three times faster** with the Leica DVM6 than with standard digital microscopes currently available. The faster workflow is due to Leica DVM6's many practical features, such as a convenient way to change magnification rapidly over the full range from 12x to 2,350x. Faster workflow efficiency leads to faster reliable data acquisition and analysis for more rapid inspection, QC/QA, FA, and R&D.

The workflow designed for this study allows for a more straightforward comparison of the Leica DVM6 to standard digital microscopes. However, in daily practice, changing the magnification range of a standard digital microscope could require a replacement of the entire zoom optics body, including the unplugging of cables and removal of the camera. For this case, it is possible that the workflow above could be performed with the Leica DVM6 even faster than indicated by the results reported above. However, changing the zoom optics is normally too complicated and time-consuming for many users and, as a result, is often not done. The magnification change over the full range with the Leica DVM6 is significantly faster compared to standard digital microscopes, mainly because it is done in a much simpler way.

Acknowledgements

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Additional Reading

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6. Student's t-distribution, Wikipedia

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