Design & CFD Analysis on Heat Transfer of CPU with Varying Fins

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ABSTRACT

In present work, CFD prediction is done for thermal performance evaluation of square cross section fins arranged in inline manner by using FLUENT 14.0 solver. The standard K epsilon model and pressure based solver was used for completing the analysis and getting the desired thermal effects in heat sink. Aluminum was used as a solid material of fins for its high thermal conductivity and lower cost, air was used as a fluid for doing the operation. It is observed from all the figures that the boundary conditions are satisfied asymptotically in all the cases which support the accuracy of the numerical results. In this thermal analysis, temperature variations with respect to distance at which heat flow occur through the fin is analyzed. The extensions on the finned surfaces are used to increase the surface area of the fin in contact with the fluid flowing around it. In this work, parallel plate heat sink of the same volume as that of square cross section fins are compared with parallel pate straight fins for higher heat transfer rate. This research work proposed that square cross section fins give better result of heat transfer under the same boundary conditions with higher efficiency.

.**Keyword** -*Ansys fluent, K-epsilon model, Heat sink, Square fins.*

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1. INTRODUCTION

The electronic industry requires increased forced-air cooling limits to cool high-end server CPUs adequately. Improving air-cooled heat sink thermal performance is one of the critical areas for increasing the overall air-cooling limit. The utilization of fins is an effective method to enhance the heat dissipation from a surface. Applications for finned surfaces are widely seen in air-conditioning and refrigeration, aerospace, chemical processing plants, and in the thermal control of electronic and electrical devices. There are various types of fins available in industry. Among them, square fins are especially important for compact heat exchangers due to higher surface area. From the thermal designer's point of view, it is of significance to search for an optimum fin design. There are two categories of optimization that pertain to single fin design. The first category of optimization is to determine the best profile and dimensions that yield minimum weight or mass for a specified heat flow and a given fin shape (e.g. longitudinal, radial and pin fins.However, the mathematical solutions to these kinds of optimum design resulted in fin profiles with sharp curved surfaces which are difficult or costly to fabricate. Therefore one alternative way is to fix a suitable simple profile (e.g. rectangular, triangular, parabolic, trapezoidal, etc) and then determine the dimensions of the fin so that it dissipates the maximum amount of heat for a given amount of mass. The present work falls into the second category. A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. Extensions on the finned surfaces is used to increases the surface area of the fin in contact with the fluid flowing around it. So, as the surface area increase the more fluid contact to increase the rate of heat transfers from the base surface as compare to fin without the extensions provided to it. Types of extension provided on fin such as (a) Rectangular extensions, (b) Trapezium extensions, (c) Triangular extension, and (d) Circular Segmental extension.

2. LITERAURE SURVEY

R. Srikanth, C. Balaji [1] carried out Experimental investigation on the heat transfer performance of a PCM based pin fin heat sink with discrete heating,they found that A heat sink with single plate heater and discrete uniform heating yield the same performance and discrete non uniform heating has a significant effect on the thermal performance of the heat sink.

Adeel Arshad, Hafiz Muhammad Ali Muzaffar Ali [2] experiments were conducted to evaluate the effect of pin-fin thickness of PCM based heat sinks for input heat fluxes of 1.58 kW/m2, 1.98 kW/m2, 2.38 kW/m2, 2.78 kW/m2, and 3.174 kW/m2. This experimental study concludes that effectiveness of a PCM based heat sink relies on the amount of PCM and number of fins For certain height of fins at 9% volume fraction of pin-fin metals for larger sizes. The number of the fins.

N.H.S. Tay, et al. [3], developed and validated a computational fluid dynamic (CFD) model for tubes in a phase change thermal energy storage system with experimental results.. A three-dimensional CFD model using Ansys code was developed and validated with experimental results. This model endeavored to describe both the freezing and melting processes of the PCM.

R. J. Yadav and A. S. Padalkar [4]analyzed that the heat transfer and temperature analysis for fully, partially decaying, and partly swirl flow using the Full Length Twisted Tape The performance of this insert was compared with those of the FLTT twisted-tape inserts and the Plain Tube. It was found that the heat transfer coefficient and the pressure drop in the tubes with the FLTT were 29–86% and203–623% greater than those in the case of the plain tubes without inserts.

V.B. Swami, et al. [5] analyzed the experimental and numerical investigation of forced convective heat transfer in an optimized rectangular micro-channel heat sink (MCHS) is using water as the working fluid. The Optimized micro-channels geometry has a width of 700 µm and a depth of 2100 µm, and is separated by a 350 µm wall. The microchannels are made on cooper plate by using a wire Electro Discharge Machining.

Y. Sui, et al. [6], studied laminar liquid–water flow and heat transfer in three-dimensional wavy microchannels with rectangular cross section by numerical simulation. The flow field is investigated and the dynamical system technique (Poincare section) is employed to analyze the fluid mixing. The results show that when liquid coolant flows through the wavy microchannels, secondary flow (Dean Vortices) can be generated. It is found that the quantity and the location of the vortices may change along the flow direction, leading to chaotic advection, which can greatly enhance the convective fluid mixing, and thus the heat transfer performance of the present wavy microchannels is much better than that of straight microchannels with the same cross section.

Veysel Ozceyhan, et al. [7], did numerical study for investigating the heat transfer enhancement in a tube with the circular cross sectional rings. The rings were inserted near the tube wall. Five different spacing between the rings were considered asp = d/2, p = d, p = 3d/2, p = 2d and p = 3d. Uniform heat flux was applied to the external surface of the tube and air was selected as working fluid. The results obtained from a smooth tube were compared with those from the studies in literature in order to validate the numerical method. Consequently, the variation of Nusselt number, friction factor and overall enhancement ratios for the tube with rings were presented and the best overall enhancement of 18% was achieved for Re = 15,600 for which the spacing between the rings is 3d.

Kwang Yong Kim and Mi Ae Moon [8] A Stepped circular pin-fin array is formulated numerically and optimized with Kriging metamodeling technique to enhance heat transfer performance. The problem is defined by two non-dimensional geometric design variables composed of height of the channel, height of smaller diameter part of the pin-fins, and smaller diameter of the pin-fins, to maximize heat transfer rate.

Alessandro Barba, et al. [9] analyzed the thermal investigation of a polymeric Microchannel heat sink designed for the active cooling of small flat surfaces. Its performance, pressure drop, temperature distribution, and thermal resistance are evaluated. The bottom side of the heat sink receives a uniform heat flux, while the top side is adiabatic. Considering a gas flow with low Prandtl and Reynolds numbers, the temperature distribution is given by the sum of a linear function (in the stream direction) and a numerical solution obtained in 2-D coordinates resorting to a finite element software, based on the Rayleigh–Ritz–Galerkin method, with user-defined error tolerance

Afzal Husain and Kwang Yong Kim [10] optimized a 3-D rectangular micro-channel heat sink geometrically for minimum thermal resistance using surrogate models. Three different surrogate models, i.e., Response Surface Approximation, Kriging and Radial Basis Neural Network are employed for the optimization. The three surrogate models yielded somewhat different optimum geometries, but predicted almost the same objective function values. The objective function is found to be more sensitive to channel width to depth ratio than fin width to depth ratio around the optimal point.

3. PROBLEMS FORMULATION

Through study of the works carried out by the various researchers during last 20 years show that there is void area in the replacement of fins used in experimental method to the different fin while doing analysis on cfd .Therefore in this present work we replaced pin fins used in experimental method to the square fins by doing analysis on cfd while comparing results with plate fins.

4. RESERCH OBJECTIVE

The main objectives of the thesis are as follows:

(1)To increase the heat transfer rate of fins by increasing the offset between fins so as to get higher air flow area between fins.(2)To replace the parallel plates straight rectangular fins heat sink in CPU by square cross section fins so as to get higher heat transfer rate as well as with low cost.(3) To reduce the power consumption of fan by reducing its velocity.

5. METHODOLOGY

3D modeling of parallel plate straight fins and square fins of same mass and volume is done on CFD FLUENT 14.0 for thermal analysis

5.1. Geometry details

5.1.1 Parallel plate straight fins and inlet velocity of air 10 m/s

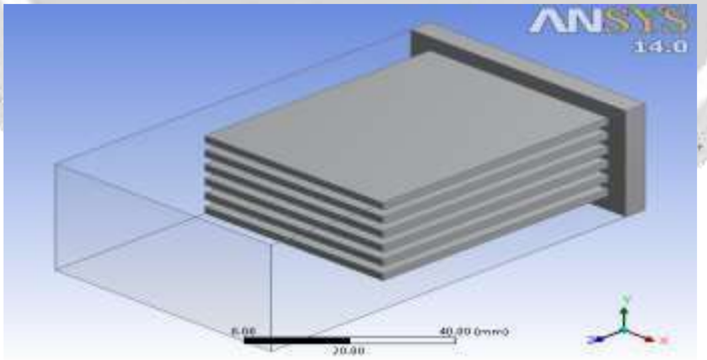

Figure 5.1.1 Geometry of parallel plate fins

Geometry parameters in mm

Its parameters are as follows

1) Base plate
   Material –aluminum
   Origin – (0, 0, 0)

Dimension – (57.5, 37.5, 5)

2) Parallel plate straight Fins
   Material –aluminum
   Origin- (7, 7, 5)
   Dimension – (47.5, 2.5, 60), Offset – 9 mm.

5.1.2 Square fins with base plate

5.1.2.1 Square fins offset 9 mm between fins and inlet velocity of air 10m/s

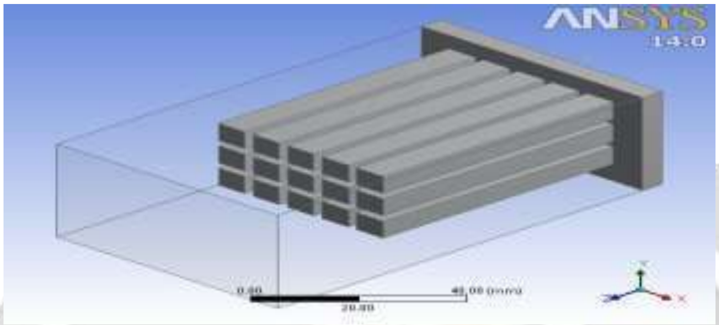

Figure 5.1.2.1 Geometry of Square Fins Offset 9 mm between Fins and inlet velocity of air 10m/s

Geometry parameters in mm

Its parameters are as follows

1) Base plate
   Origin – (0, 0, 0)
   Dimension – (57.5, 37.5, 5)
   Material - Aluminum
2) Fins
   Origin- (7, 7, 5)
   Dimension – (6.89, 6.89, 60), Offset - 9 mm.
   Material – Aluminum

5.1.2.2 Square fins offset 9.25 mm between fins and inlet velocity of air 10m/s

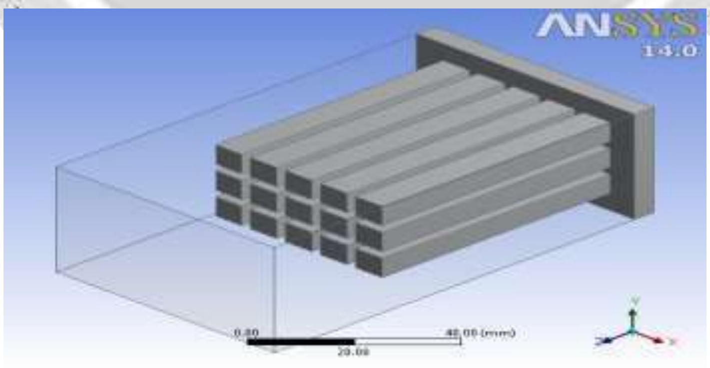

Figure 5.1.2.2 Square fins offset 9.25 mm between fins and inlet velocity of air 10 m/s

5.1.2.3 Square fins offset 9.25 mm between fins and inlet velocity of air 4m/s

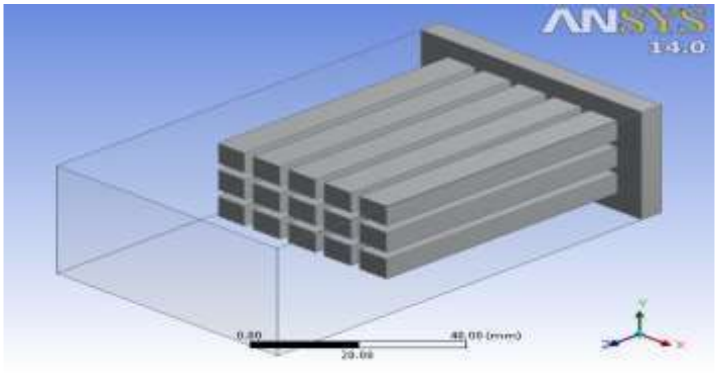

Figure 5.1.2.3 Square fins offset 9.25 mm between fins and inlet velocity of air 4m/s

5.2 Meshing details

Meshing is done on fluent 14.0 using following meshing conditions.

Advanced size function – on: curvature , Relevance center – coarse , Initial size feed – active assembly , Transition – slow

Smoothing – medium

5.2.1 Meshing of parallel plate straight fins having air inlet velocity 10m/s

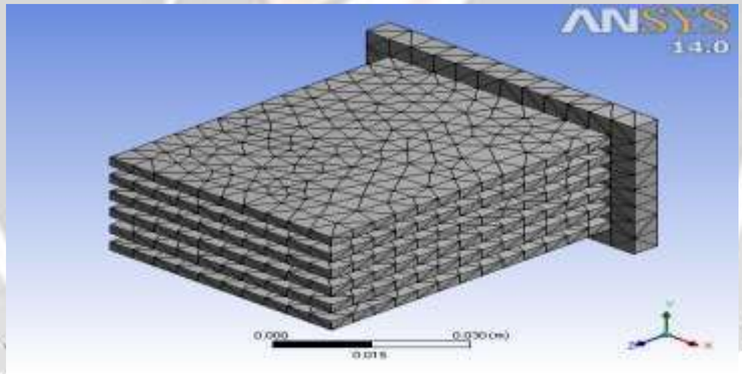

Figure 5.2.1. Meshing of Parallel Plate Fins

5.2.2 Meshing of square fins with offset between fins 9 mm and inlet velocity of air 10m/s

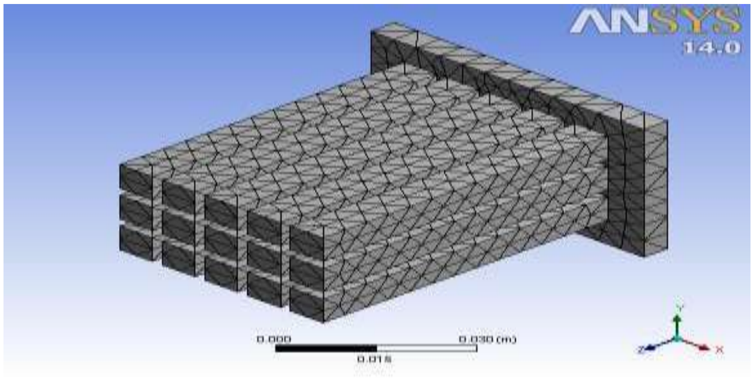

Figure 5.2.2 Meshing of square fins with offset between fins 9 mm and inlet velocity of air 10m/s

5.2.3 Meshing of square fins with offset between fins 9.25 mm and inlet velocity of air 10m/s

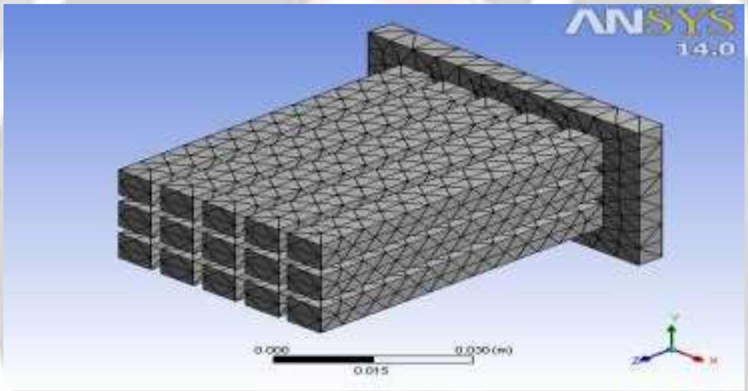

Figure 5.2.3 meshing of square fins with offset between fins 9.25 mm and air inlet velocity 10 m/s

5.2.4 Meshing of square fins with offset between fins 9.25 mm and air inlet velocity 4m/s

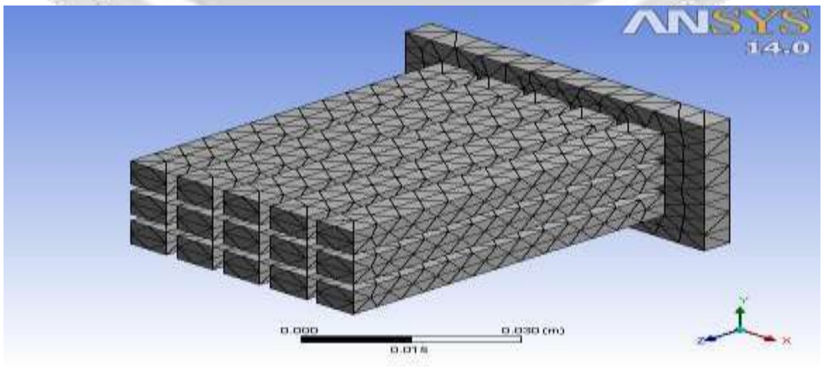

Figure 5.2.4 Meshing of square fins with offset between fins 9.25 mm and air inlet velocity 4m/s

5.3 Solution & solver set-up

5.3.1. Solution set-up for parallel plate straight rectangular fins, fins having offset 9mm & air inlet velocity 10m/s, fins having offset 9.25mm & air inlet velocity 10m/s, Fins having offset 9.25mm & air inlet velocity 4m/s.

Table 5.3.1: Solution setup for all fins, only air velocity is varied 10m/s, 4m/s respectively

General	Solver – pressure based Time – steady Velocity formulation – absolute Gravity – 9.81m/s^2
Models	Energy Equation – on Standard K- epsilon model C1- epsilon = 1.44 C2- epsilon = 1.92 Energy Prandtl number = 0.85 Thermal k-epsilon Prandtl number = 1.0 Near wall treatment – standard wall functions
Materials	Fluid – air Solid – aluminum
Boundary Conditions	Velocity at inlet = 10 m/s Pressure outlet (gauge pressure) = 0 Temperature at the fin base =370 k Temperature at the air outlet = 330 k Atmospheric temperature = 300 k Wall motion – stationary wall Shear condition – no slip Wall roughness constant – 0.5 Wall heat flux = 800 w/m^2

6. RESULTS

6.1 Results of parallel plate straight fins

After 500 iterations solution gets completed & we get the results in following contours and vector form.

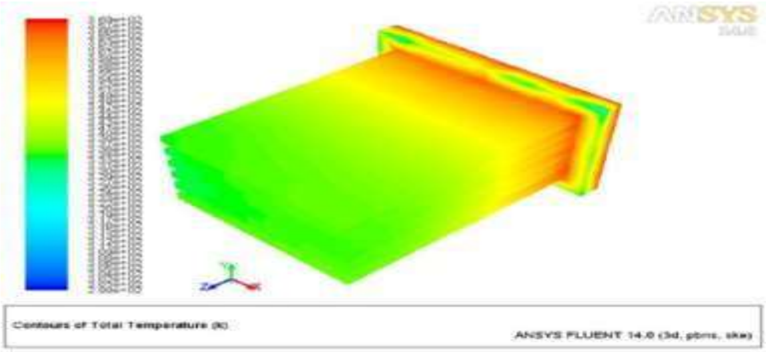

Figure 6.1Variation of total temperature of parallel plate fins & inlet velocity of air 10 m/s

6.2 Results of square fins offset 9 mm and air inlet velocity 10 m/s results

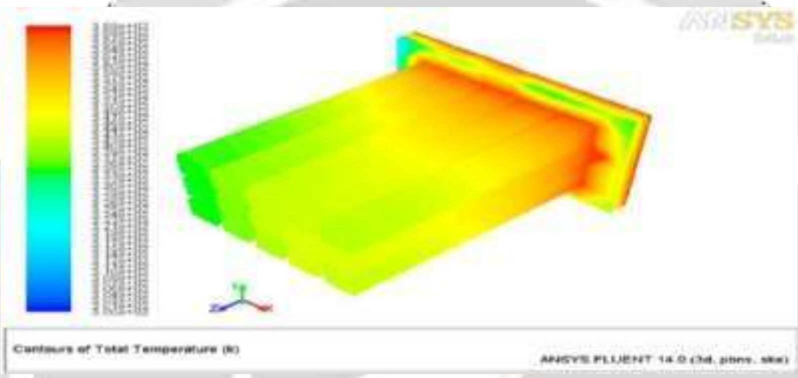

Figure 6.2 Variation of total temperature of square fins offset 9 mm and inlet velocity of air 10 m/s

6.3 Results of square fins offset 9.25mm and air inlet velocity 10m/s

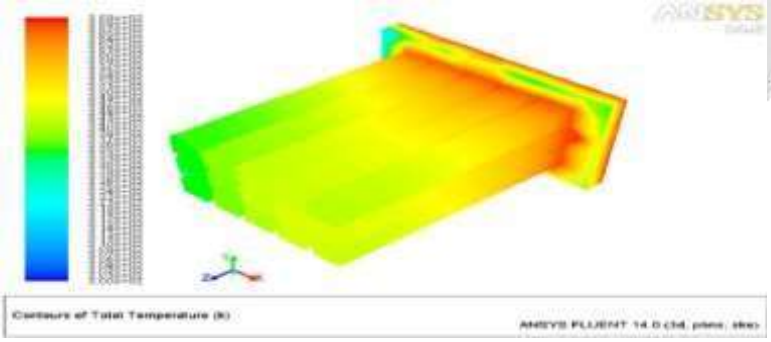

Figure 6.3 Variation of total temperature of square fins offset 9.25 mm and inlet velocity of air 10 m/s

6.4 Results of square fins offset 9.25 mm and inlet velocity of air 4 m/s

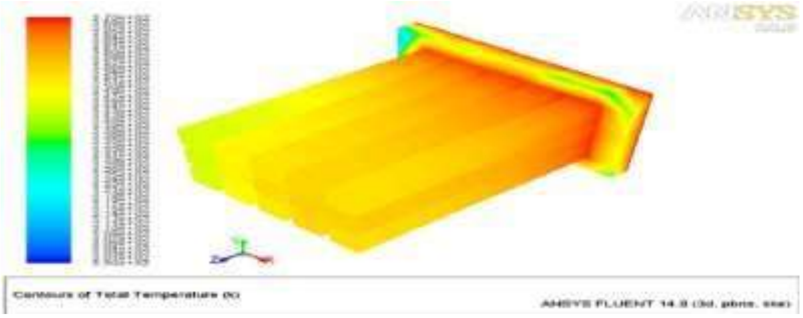

Figure 6.4 Variation of total temperature of square fins offset 9.25 mm and inlet velocity of air 4 m/s

6.5 Summary of results

With the help of several Figures & fluent flux report, we have found out that the fins of offset 9.25 mm and air inlet velocity 4 m/s is efficient to be used in the micro heat exchangers of computer CPU

Table 6.5: Heat transfer rates of all the cases used in this research analysis in watts

Sr. Number	Description of the fin arrangement	Heat transfer rate (watts)
1	Parallel plate straight fins and inlet velocity of air 10 m/s	-0.39247894
2	Square fins offset 9 mm and inlet velocity of air 10 m/s	-0.062614441
3	Square fins offset 9.25 mm and inlet velocity of air 10 m/s	-1.3370819
4	Square fins offset 9.25 mm and inlet velocity of air 4 m/s	-0.49378204

7. CONCLUSIONS

1. Generally parallel plate fins with 10 m/s inlet air velocity & get an overall heat removal rate of -0.39247894 watts ("-ve" sign shows heat removal rate) in the computer CPU heat sink. If we use a set of square fins with offset 9.25mm between them & velocity inlet of air 4 m/s, in same material volume , we can get a much higher heat removal rate of -0.49378204 watts (around 1.5 times more than from parallel plate fins).
2. Replacement of the number of square fins arrangement gives better and efficient thermal results in various forms for increasing the heat transfer rate
3. The present analysis helps the understanding of fluid transport and heat transfer behavior in micro-channels heat sinks and benefits the design of heat sinks having different shapes and designs.
4. Improvement and increase in the life of finned tubes if it arranged according inline arrangement manner.
5. Due to higher heat transfer rate, less accumulation of heat on fins is achieved. Hence we also get increased fins life.

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